Winter Maintenance
Snow and Ice Control
– Module 4 –

OPERATIONS/
IN-SEASON ACTIVITIES

PRESENTED BY:
DELWARE T² CENTER
Introduction

In this module:
- Chain of command
- Inspect road conditions
- Safety meetings
- Plowing techniques
- Abrasives and freeze point depressants
- Weather information
- Recordkeeping
- Special areas

- Worst case weather scenarios
- Disabled, inoperative, abandoned vehicles
- Disposal of snow/environmental concerns
- Safety
- Day versus night operations
- Meals
- Dealing with the public
Game Day

- Planning – done
- Pre-season preparations – done
- Forecast – snow and ice
- Time to suit up
First Things First

- Weather – find out what’s coming
- Put the troops on alert – details to follow
- Brief elected officials, press, public
- Take inventory
  - Check your fuel reserves
  - Verify equipment condition
    - Update maintenance priorities
  - Roll call
- Team meeting
- Chain of command
Safety Briefing

- Tailgate or field office meeting
  - No need to belabor the point, but...
  - Brief reminders about safety
    - Climbing in and out of equipment
    - Dangers of walking around the operations yard
    - Safety vests whenever out of the equipment
    - Periodically cleaning off lights, emergency strobes/beacons
    - Speed regulation
    - No texting or phone calls while driving
    - Lookout for motorists and pedestrians
    - Responsible breaks
    - Black ice concerns
Staying Up To Date

- Traveling visuals
- Operator reports
- Traffic cameras
- Other reports
- Weather reports
Plowing

- **Driving considerations**
  - Defensive driving
  - Speed management
  - Heightened awareness
    - Other motorists
    - Pedestrians
    - Downed or drooping utility lines, trees, poles
    - Abandoned vehicles
    - Other plows and emergency equipment
  - Keep a sharp look up ahead at all times
  - Allow extra time to stop or take evasive maneuvers
  - A spotter or second seater can be handy to help on this front
Plowing

Equipment

- Bigger not always better
- Big, high HP equipment
  - Tandem dump trucks with plows and spreaders
  - Main lines and wider streets
  - Heavy accumulations
- Smaller, more nimble equipment
  - 1-ton and smaller trucks with plows, maybe spreaders
  - Narrower streets, cul-de-sacs
  - Light to medium accumulations
- Specialty equipment
  - Loaders, backhoes, motor graders, industrial snow blowers and commercial mower platforms, skid steers

“You go to war with the Army you have – not the Army you might want or wish to have at a later time...” former Defense Secretary Donald H. Rumsfeld
Plowing

- Plows of all kinds are available

Winter Planning & Organization – LTAP and Salt Institute

Winter Maintenance Training – Delaware T² Center
• Priorities
  ○ Remember the first goal of snow/ice removal – public safety
  ○ Provisions to accommodate emergency response comes first
  ○ Clear the primary streets first and keep them clear
  ○ Clear the secondary streets next and keep them passable
  ○ Tertiary streets can be responded to quickly if primary and secondaries remain passable
    ▪ Quaternary, quinary, senary, septenary, octonary, nonary, and denary streets? – well, these have to wait until later
  ○ Maintain close contact with emergency dispatchers
    ▪ If there’s a call on a tertiary street, dispatch plows to that area and make sure the streets are passable ahead of the ambulance, etc.
Plowing

- Multi-lane highways (multiple lanes, one direction)
  - Critical issues
    - High priority roadways
    - Managing windrows
    - Snow storage
    - Wind
    - Median storage (or lack)
  - Close echelon plowing (multiple trucks)
    - Multiple lanes cleared at once; other vehicles do not pass
    - Helps control windrows
  - Tandem plowing (multiple trucks)
    - 1-1½ lanes cleared at a time – other vehicles can maneuver around
Plowing

- Two lane, two way highways
  - Critical issues
    - Narrow/non-existent shoulders
    - Managing windrows
    - Snow storage
    - Wind
  - Start at centerline, push everything to the right
    - Four passes may be necessary to clear one lane in each direction
    - Get snow back off the shoulder early if you can, particularly if another storm or melt/freeze is anticipated
  - Tandem or echelon plowing (multiple trucks)
    - Never drive wrong way in the opposing lane
Plowing

Iowa Department of Transportation

Video

Winter Maintenance Training – Delaware T² Center
Plowing

- Tandem plowing

Video
Plowing

• Urban streets
  ○ Critical issues
    ▫ One lane or two, one way or two way
    ▫ Narrow/non-existent shoulders
    ▫ Adjacent sidewalks
    ▫ Adjacent parking
    ▫ Intersections
    ▫ Managing windrows and piles, snow storage
    ▫ Adjacent utility poles, overhead utility lines
  ○ Intersections – carry the snow around to the right; then clean up the center with other equipment or subsequent passes
  ○ Heavier storms – contingency for loading it out

Photo: Andrew Ciscel

AASHTO Guide for Snow and Ice
Winter Maintenance Training – Delaware T³ Center
Plowing

Video

Iowa Department of Transportation

Winter Maintenance Training – Delaware T^2 Center
Plowing

Video

Plow Power – New England Chapter APWA

Winter Maintenance Training – Delaware T^2 Center
Plowing

Video

Iowa Department of Transportation

Winter Maintenance Training – Delaware T² Center
Plowing

- On-street parking
  - Local regulations
  - Snow emergency routes
  - Consistent enforcement
  - Alternate side of the street parking
    - Removal in days afterward
    - Skid steer, backhoe, loader
  - Tow contracts
    - Makes for cranky owners
    - In for a penny, in for a pound
Plowing

- Sidewalks
  - Who is responsible for snow/ice?
    - Establish clearly by ordinance
  - ADA says someone must be – don’t leave as a question
  - Don’t make it worse with street plowing
    - Slow down the street plows
  - Sidewalk maintenance can be automated
    - Just ask UD’s Grounds Services
    - 25 miles of pedestrian pathways – 4’-16’ wide
    - Walk behind snow blowers
    - Mowers with plows and brooms
Plowing

- Sidewalks
  - Small equipment can be versatile
Plowing

- Cul-de-sacs
  - Lighter equipment typically better – maneuverability is key in these tight places
  - There are so many types of cul-de-sacs
    - Large and small
    - With and without center island
    - Centered, off-centered left or right
    - Lots of driveways or few
  - There’s no one, cookie cutter, always works great method
  - Most cul-de-sac methods end up violating either the “never back up rule” or the “never travel the wrong way rule” – if you can avoid breaking these rules, great, but...
Plowing

- **Cul-de-sac approaches**
  - **Inner island**
    - With a one-way plow, plow the main line just past the cul-de-sac street, back up carefully, enter the street and then enter the cul-de-sac itself **the wrong way**, pushing snow to the right and inward to the island; then re-enter the island the normal way and push snow to the right and outside, catching your windrows as best as you can
  - **Inner island**
    - With a reversible plow, you can do much the same but always travel in the correct direction (enter on the right of the cul-de-sac), moving the plow left and right
  - **No island**
    - Back up to the rear of cul-de-sac; make several passes forward
Plowing

Iowa Department of Transportation

Video

Winter Maintenance Training – Delaware T® Center
Plowing
Plowing

- Alleys
  - Special safety concerns
  - Smaller equipment
  - Materials in the way
- Dead ends
  - Similar to cul-de-sacs
  - Storage problems
  - Obtain right of way or easement for T-turnaround if you can
- Take these slowly
Plowing

- One way streets
Plowing

- Bridges
  - Bridges freeze before roadways – act accordingly
  - What’s under the bridge?
    - What does the snow hit when it goes over the rail?
    - Another road, vehicles?
    - Slow down to minimize throwing snow over
  - Drainage
  - Melt water control
Plowing

- Parking lots
  - Get to them before folks arrive – life is sweeter
  - Watch the wheel stops – know where they are
  - Don’t back into light posts – obvious but important
  - Melt water – pile the snow at the downhill side to avoid a skating rink
  - But...don’t create a drainage problem on the neighbor
  - Push boxes can be very effective
Plowing
Plowing
Plowing

- Blowing/drifting snow
  - Where it’s a routine problem, think about snow fence or a line of bushes or trees that might bring similar result
  - For routes that can be cut off, without another entry point, have an established contingency plan
  - Loaders are a terribly slow proposition
  - Don’t create the problem
    - If light, fluffy snow is coming down, try to cast it with the wind rather than against it - i.e., send it where it want to go
Plowing

Video

Salt Institute

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Plowing

- Controlling melt water
  - Superelevated curves
    - Plow to the low side
    - Plow beyond the shoulder break on the high side
  - Keep drainage facilities cleared
    - Storm drains
    - Ditches
    - Outfalls
    - Shoulder pathways to ditches

- Managing windrows
  - Good plowing techniques will take care of most of the time
  - Intersections can leave windrows and piles more easily
Plowing

- Snow storage
  - Problem areas
    - Cul-de-sacs
    - Dead ends
    - Alleys
    - Adjacent sidewalks
    - Parking areas/lots
  - Adjust plowing techniques/patterns where you can
  - Think about where melt water will go
  - Have a contingency plan for when the big one hits and you’re out of room along the routes
Loading, Hauling, Disposing Snow

- Usually need only in severe storms
- Avoid where you can (obviously), but be judicious
- Usually a post storm activity, but not always...
- Alleys
- Cul-de-sac and dead end streets
- Narrow channel areas
- On-street parking areas
- Environmental considerations when disposing
  - Once scooped up, snow, chemicals, and abrasives are pollutants – consult DNREC if in doubt about disposal
• Speed
  o Reasons to care
    ▪ Safety
    ▪ Effectiveness
    ▪ Productivity
    ▪ Minimize problems beyond roadway
  o Plowing
    ▪ Faster broadcasts snow better but threatens mailbox posts
    ▪ Slower places less snow on sidewalks and protects pedestrians
  o Spreading abrasives and FPDs
    ▪ Match your speed to your distributor – based on calibration
  o Generally, slower is better
- **Beyond the roadway**
  - **Sidewalks**
    - First rule – do no harm
  - **Curb ramps**
    - Historically left to defend for themselves
    - They resolve themselves thermally
    - They get piled up with snow and ice
    - No one owns them, it seems
    - We need a better plan
  - **Commercial and private entrances**
    - Encourage residents to toss their snow downstream of their entrance to minimize what you carry over
Commercial and private entrances

- Help residents to help themselves
- This reduces, but doesn’t eliminate, carry over into driveway
Plowing

• Mailboxes
  o Less of an issue in urban environment
  o Failure modes
    ▪ A direct hit from a snow plow
    ▪ The plume of broadcast snow
    ▪ Wind from the storm itself (some of these are on their last leg as it is)
    ▪ Someone else hitting it
    ▪ It was just its time
  o Different philosophies
    ▪ Agency assumes total responsibility
    ▪ Partial responsibility – e.g., direct hit by plow only
    ▪ Agency assumes no responsibility
  o Postal service access (beyond normal plowing)
    ▪ Typically left to the owner to dig out
Plowing

- Sensitive roadside features
  - Planters, decorative plantings, landscaping effects
  - Fire hydrants
  - Wetlands
  - Historic elements
- First priority is safety and mobility of the public
- Where you can
  - Move things back
  - Protect things
  - “Adopt a Hydrant” programs
  - Slow or redirect plows and material spreaders
Plowing

- Disabled, inoperative, stuck, disabled, abandoned vehicles
  - Agency has authority to remove private vehicles?
    - Under what circumstances and where?
    - Communicate this to the public – don’t allow surprises
  - Tow company contract?
  - Who deals with irate owner? How do they find car?
  - Other means to move – loader bucket full of snow?
  - Insurance and training
Back To Our Storm...

- So, the storm is in full swing and your troops are at it
- You briefed your stakeholders before the storm
- Time to do it again
  - Elected officials
  - Senior management
  - Press
  - Public
Back To Our Storm...

• Talking to the outside world
  o Control expectations
  o Remind them of established Levels of Service (LOS)
  o Elevate relationship of chemicals and abrasives with environmental protection
  o Remind them that you’re trying to be mindful of their tax dollars
  o Remind them to clear their sidewalks
    ▪ And curb ramps, maybe?
    ▪ And maybe fire hydrants?

Photo: Andrew Ciscele
Table 2-1. Snow and ice control materials.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Snow and Ice Control Material</th>
<th>Primary Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride Salts</td>
<td>Sodium Chloride (NaCl)</td>
<td>Na, Cl</td>
</tr>
<tr>
<td></td>
<td>Calcium Chloride (CaCl₂)</td>
<td>Ca, Cl</td>
</tr>
<tr>
<td></td>
<td>Magnesium Chloride (MgCl₂)</td>
<td>Mg, Cl</td>
</tr>
<tr>
<td></td>
<td>Calcium Magnesium Acetate (CMA)</td>
<td>Ca, Mg, C₂H₂O₂</td>
</tr>
<tr>
<td></td>
<td>Potassium Acetate (KA)</td>
<td>K, C₂H₂O₂</td>
</tr>
<tr>
<td>Organic Products</td>
<td>Agricultural By-Products</td>
<td>Complex sugars</td>
</tr>
<tr>
<td></td>
<td>Manufactured Organic Materials</td>
<td>Varies with product (i.e. glycol, methanol)</td>
</tr>
<tr>
<td></td>
<td>Nitrogen Products</td>
<td>Urea</td>
</tr>
<tr>
<td></td>
<td>Abrasives</td>
<td>Varies with the source of the material</td>
</tr>
</tbody>
</table>

Table 2-2. Chloride salts, general properties.

<table>
<thead>
<tr>
<th>Material</th>
<th>Chemical Formula</th>
<th>Forms Used</th>
<th>Optimum Eutectic Temperature °C (°F) % Concentration¹</th>
<th>Common Sources</th>
<th>Approximate Annual usage Tonnes (Tons) North America</th>
<th>Median Cost (USD) per Ton (survey of Internet contracts)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride</td>
<td>NaCl</td>
<td>Primarily solid, but increasing use of liquid</td>
<td>-21 (-5.8) @ 23.3%</td>
<td>Mined from natural deposits, solarization of natural brines</td>
<td>21,080,000 (22,291,000) (Salt Institute)</td>
<td>$36</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>CaCl₂</td>
<td>Mostly liquid brine, some solid flake</td>
<td>-51 (-60) @ 29.8%</td>
<td>Natural well brines, by-product of the Solvay process</td>
<td>Not Available</td>
<td>$120</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>MgCl₂</td>
<td>Mostly liquid brine, some solid flake</td>
<td>-33 (-23) @ 21.6%</td>
<td>Solarization of natural brines, natural well brines, by-product of metallurgical process</td>
<td>Not Available</td>
<td>$95</td>
</tr>
<tr>
<td>Blended Chlorides</td>
<td>Varies with product</td>
<td>Solid and liquid</td>
<td>Varies with product</td>
<td>Natural well brines, solarization of natural brines, mined from natural deposits</td>
<td>Not Available</td>
<td>$142</td>
</tr>
</tbody>
</table>

Table 2-3. Organic products, general properties.

<table>
<thead>
<tr>
<th>Material</th>
<th>Chemical Formula</th>
<th>Forms used</th>
<th>Optimum Eutectic Temperature °C (°F) % Concentration¹</th>
<th>Common Sources</th>
<th>Approximate Annual usage Tonnes (Tons) North America</th>
<th>Median Cost (USD) per Ton (survey of Internet contracts)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Magnesium Acetate</td>
<td>CaMgAc</td>
<td>Mostly liquid with some solid</td>
<td>-27.5 (-17.5) @ 32.5%</td>
<td>Reaction of Highly Concentrated Acetic Acid with Dolomite Limestone</td>
<td>Not Available</td>
<td>$1280</td>
</tr>
<tr>
<td>Potassium Acetate</td>
<td>KAc</td>
<td>Liquid only</td>
<td>-60 (-76) @ 49%</td>
<td>Reaction of Highly Concentrated Acetic Acid with potassium hydroxide (KOH). This reaction produces potassium acetate and water.</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Agricultural By-Products</td>
<td>NA</td>
<td>Liquid only</td>
<td>Usually blended with chloride-based products</td>
<td>Refined from Agricultural base materials</td>
<td>Not Available</td>
<td>Blends $5 108</td>
</tr>
<tr>
<td>Other Organic Materials</td>
<td>Glycols Methanol</td>
<td>Liquid only</td>
<td>Varies with product</td>
<td>Varies</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

¹ Source: (2) ² As of October 2003
Abrasives & Freeze Point Depressants

- Sand
- Freeze point depressants (FPDs)
  - Rock salt (NaCl)
  - Calcium magnesium acetate (CMA)
  - Magnesium chloride (MgCl)
  - Calcium chloride (CaCl)
  - Potassium acetate (KA)
- Modified salts
  - Magic Salt
  - Ice Ban®
  - Safe-Walk
  - Sugar beet molasses (desugared)
- Brines
- Sand/salt mixtures
Abrasives & Freeze Point Depressants

• Storage
  o Solid materials
    ▪ e.g., rock salt
  o Liquid materials
    ▪ e.g., salt brines
    ▪ Typically, CaCl₂, MgCl₂
    ▪ Most organic products
  o Sand or abrasives
Abrasives & Freeze Point Depressants

• Application strategies
  o Materials selection
  o Timing
  o Rate
  o Frequency
  o Anti-icing
  o Deicing
  o Pre-wetting
  o Abrasives
### Table 2-12. Application rates for various snow and ice control strategies.

<table>
<thead>
<tr>
<th>Strategy/Method</th>
<th>Materials</th>
<th>Pavement Temperature Ranges</th>
<th>Application Rates&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-Icing</td>
<td>Liquid Chemicals, Solid Chemicals, Pre-wet Solid Chemicals</td>
<td>0°C to -12°C (32°F to 10°F)</td>
<td>18-110 Kg/Lane/Km (65 – 400 Lbs/Lane/Mile)</td>
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<tr>
<td>Deicing</td>
<td>Pre-wet Solid Chemicals, Dry Solid Chemicals</td>
<td>0°C to -18°C (32°F to 0°F)</td>
<td>113 – 400 Kg/Lane/Km (200-700 Lbs/Lane/Mile)</td>
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<tr>
<td>Abrasives</td>
<td>Pre-wet Abrasives, Dry Abrasives</td>
<td>No limits</td>
<td>225 – 2,700 Kg/Lane/Km (500-6,000 Lbs/Lane/Mile)</td>
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<tr>
<td></td>
<td>Abrasive/Salt Mixes</td>
<td>0°C to -18°C (32°F to 0°F)</td>
<td>225 – 2,700 Kg/Lane/Km (500-6,000 Lbs/Lane/Mile)</td>
</tr>
</tbody>
</table>

<sup>1</sup> Source: (6)  
<sup>2</sup> Source: (6, 7)
Abrasives & Freeze Point Depressants

- Compare rates

TABLE A-6  Equivalent application rates for five ice control chemicals

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>NaCl 100%</th>
<th>23%</th>
<th>CaCl₂ 92%</th>
<th>32%</th>
<th>MgCl₂ 50%</th>
<th>27%</th>
<th>KAc 100%</th>
<th>50%</th>
<th>CMA 100%</th>
<th>25%</th>
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<td>Solid</td>
<td>Liquid</td>
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<td>165</td>
<td>104</td>
<td>57</td>
<td>96</td>
<td>51</td>
<td>139</td>
<td>37</td>
<td>139</td>
<td>37</td>
</tr>
</tbody>
</table>

**Notes:**
- Typical percent concentrations of the solid and liquid forms with the balance being largely water.
- General Notes:
  1. The above application rates are normalized to 100 lb/LM of dry solid NaCl. The application rates corresponding to a dry solid NaCl rate other than 100 lb/LM are determined by multiplying the equivalent chemical application rates for a given temperature by the ratio of the desired dry solid NaCl rate to 100 lb/LM. For example, if a 200 lb/LM of dry solid NaCl application rate were recommended at a temperature of 20°F, then switching to a 90 to 92 percent concentration of solid CaCl₂ would require a slightly higher application rate of 216 lb/LM.
  2. The above application rates were derived from the freezing point (ice melting) data of the five chemical solutions. As such, the data are more conservative (larger) than field data would suggest for anti-icing operations.

**Chemicals:**
- NaCl: Sodium chloride.
- CaCl₂: Calcium chloride.
- MgCl₂: Magnesium chloride.
- KAc: Potassium acetate.
- CMA: Calcium magnesium acetate.
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Video
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- Deicing
  - Typically, dry NaCl – 100-500 #/lane mile
  - Reactive strategy
  - Chemical applied on top of already bonded snow, ice, frost
  - Solid chemical scattered by traffic can result in significant loss of product without productive effect
  - On study (Montana) – deicing uses 5X chemical vs. anti-icing
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- Deicing
Abrasives & Freeze Point Depressants

- **Deicing**
  - V-box spreader
  - Tailgate spreader
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- **Deicing**
  - Small V-box spreader
  - Front dump with front mounted spreader
  - Tow behind spreader
  - Zero velocity spreader
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- **Anti-icing**
  - Proactive strategy
  - Materials applied *before* snow, ice, frost
  - Prevents bonding of precipitate with the pavement surface, ideally – at a minimum, can weaken the bonds
  - Can be dry or liquid applications
  - Dry applications better where little or no traffic action (sidewalks, parking lots)
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- **Anti-icing**
  - Tools for brine making
  - Commercial brine makers available
  - Can make your own

### Table 2-13. Typical chemical application rates for anti-icing activities at -10°C to -0°C (15°F to 32°F).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Dry chemical spread rate, kg/lane-km (lb/lane-mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light icing</td>
</tr>
<tr>
<td>“Manual of Practice for an Effective Anti-Icing Program” FHWA/CRREL(2)</td>
<td>7.36 (25-130)</td>
</tr>
<tr>
<td>“Manual of Practice for Anti-Icing of Local Roads” New Hampshire T2 (8)</td>
<td>18.36 (65-130)</td>
</tr>
</tbody>
</table>

NCHRP Report 577; Salt Institute Snowfighters Handbook

Winter Maintenance Training – Delaware T° Center
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- Anti-icing
Abrasives & Freeze Point Depressants

Video
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- Pre-wetting
  - Injecting/spraying liquid chemical to solids
  - Enhance effectiveness and reduce material loss
  - Applied to chemical (i.e., NaCl), can expedite formation of brine; once brine formed, more likely to stay on roadway
  - Danish study – 90% retention of salt from brine
  - Applied to abrasives, adds weight, cushions impact, may help material stick to roadway
  - Montana study – prewetting abrasives can reduce application by 50% in cold temperatures
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- Pre-wetting

<table>
<thead>
<tr>
<th>Precipitation Type</th>
<th>Road Surface Temperature Range °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warmer than -5° (23°) Kg/lane-km (Lbs/lane-mile)</td>
</tr>
<tr>
<td>Frost</td>
<td>25 (97)</td>
</tr>
<tr>
<td>Light snow</td>
<td>35 (136)</td>
</tr>
<tr>
<td>Heavy snow</td>
<td>65 (253)</td>
</tr>
<tr>
<td>Freezing rain</td>
<td>65 (253)</td>
</tr>
</tbody>
</table>

Source: (10)
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- Pre-wetting
Typical Scatter of Road Salt

100% salt spread in center 1/3 of road

1/3

46% in center

12%

15% off road
Typical Scatter of Prewetted Road Salt

100% prewetted salt spread in center 1/3 of road
Efficiency of Prewetted Road Salt

Winter Maintenance Materials – LTAP and Salt Institute

Winter Maintenance Training – Delaware T³ Center
Advantages of prewetting salt

- Reduced salt usage
- Reduced cost of deicing materials
- Reduced labor costs
- Increased deicing efficiency and faster melting action
- Increased safety to motorists
Abrasives & Freeze Point Depressants

- Liquid storage
  - Inside, outside
  - Underground, above
  - Secondary containment
  - Corrosion resistant materials
    - Polyethylene
    - Stainless steel
    - Glass fiber
  - Corrosion inhibitors, agitation, circulation, filtration
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- **Dry abrasives/chemical mixes**
  - Common, popular strategy
  - Typically, 1:1 mixture of abrasive and salt
  - Has not been found to be as cost-efficient as chemicals only
  - Less effective at reducing accidents
Abrasives & Freeze Point Depressants

- **Abrasives**
  - Sanding – strategy of choice for many agencies
  - Visible, low cost to manage friction
  - But placed dry, only short term friction effect
  - Roadway speeds >30 mph, little benefit
  - Particle size matters
    - Natural sand – 10% retention
    - Manufactured coarse sand – 50%
  - Insurance claims and env impacts with sand

**Table 2-15. Abrasive use.**

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Use of Dry Abrasives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways</td>
<td>Inappropriate</td>
</tr>
<tr>
<td>Rural roads, paved</td>
<td>Inappropriate</td>
</tr>
<tr>
<td>Rural roads, gravel</td>
<td>Only on low speed sections (perhaps hills and curves)</td>
</tr>
<tr>
<td>Rural intersections</td>
<td>Only on low speed approach length of gravel roads</td>
</tr>
<tr>
<td>High speed urban roads</td>
<td>Inappropriate</td>
</tr>
<tr>
<td>Low speed urban roads</td>
<td>Only in certain locations and when snowpack will persist</td>
</tr>
<tr>
<td>Urban intersections</td>
<td>Only when snowpack will persist</td>
</tr>
</tbody>
</table>

Source: (12)
Abrasives & Freeze Point Depressants

- Application strategies – analyses
  - Idaho DOT study
  - Tradition methods (deicing, NaCl, abrasives) replaced with liquid anti-icing on US 12
  - Sharp reductions in labor, abrasives, and accidents

Table 2-17. Idaho results.

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Labor Hours</th>
<th>Average Annual Abrasives Used</th>
<th>Average Annual Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1997</td>
<td>650</td>
<td>1475 cu. M</td>
<td>16.2</td>
</tr>
<tr>
<td>Percent Reduction</td>
<td>62%</td>
<td>83%</td>
<td>83%</td>
</tr>
</tbody>
</table>

Source: (15)
Abrasives & Freeze Point Depressants

- Application strategies – analyses
  - Colorado DOT study
  - Tradition methods (deicing, NaCl, abrasives) replaced with liquid anti-icing
  - Focus – particulate matter reduction


<table>
<thead>
<tr>
<th>Year</th>
<th>Sand (tons/mile)</th>
<th>Salt (NaCl) (tons/mile)</th>
<th>Liquid Deicer (gallons/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0.25</td>
<td>1.1</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>1993</td>
<td>0.20</td>
<td>0.9</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>1994</td>
<td>0.17</td>
<td>1.3</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>1995</td>
<td>0.29</td>
<td>0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>1996</td>
<td>0.19</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1997</td>
<td>0.23</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1998</td>
<td>0.17</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1999</td>
<td>0.09</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2000</td>
<td>0.04</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: (13)
Abrasives & Freeze Point Depressants

- Application strategies - analyses

<table>
<thead>
<tr>
<th>Strategies and Tactics</th>
<th>Within-event LOS</th>
<th>After-event LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Anti-icing</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Deicing</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical and Abrasives</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical and Anti-icing</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical and Deicing</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical and Prewetted Abrasives</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Anti-icing for Frost/Black Ice/Icing Protection</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mechanical and Abrasives Containing &gt; 100 lb/LM of Chemical</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Chemical Treatment Before or Early in Event, Mechanical Removal During Event, and Deicing at End of Event</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Abrasives & Freeze Point Depressants

- **Stockpile treatment**
  - Abrasives or chemicals treated to avoid clumps
  - “Frost proofing”
  - Clumping makes materials difficult to handle and apply
  - Typically, liquid or solid chlorides added at 5% (by weight)
  - Solid chemicals tend to attract moisture – causing lumps and workability problems
    - “Frost proof” with small amount of liquid chemical with a lower eutectic temperature

---

Eutectic point – the point at which a solution achieves a maximum salt concentration. The solubility of salt in water decreases with decreasing temperature. Below the eutectic point, salt will begin to leave the solution and raise the freezing point. At the eutectic temperature, ice, saltwater, and solid salt exist in equilibrium. For water, the eutectic temperature is -6°F.
- **FPD impact on the environment**

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Road Salt (NaCl)</th>
<th>Calcium Chloride (CaCl₂)</th>
<th>Magnesium Chloride (MgCl₂)</th>
<th>Acetates (CMA and KA)</th>
<th>Organic Biomass Products</th>
<th>Abrasives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Quality/Aquatic Life (Section 3.4)</strong></td>
<td>Moderate: Excessive chloride loading; heavy metal contamination; ferrocyanide additives.</td>
<td>Moderate: Excessive chloride loading; heavy metal contamination.</td>
<td>Moderate: Excessive chloride loading; heavy metal contamination.</td>
<td>High: Organic content leading to oxygen demand; nutrient enrichment by phosphorus and nitrogen; heavy metals.</td>
<td>High: Turbidity; increased sedimentation.</td>
<td>High: Organic content leading to oxygen demand; nutrient enrichment by phosphorus and nitrogen; heavy metals.</td>
</tr>
<tr>
<td><strong>Air Quality (Section 3.8)</strong></td>
<td>Low: Leads to reduced abrasive use.</td>
<td>Low: Leads to reduced abrasive use.</td>
<td>Low: Leads to reduced abrasive use.</td>
<td>Low: Leads to reduced abrasive use.</td>
<td>Low: Fine particulate degrades air quality.</td>
<td>High: Fine particulate degrades air quality.</td>
</tr>
<tr>
<td><strong>Soils (Section 3.5)</strong></td>
<td>Moderate/High: Sodium accumulation breaks down soil structure and decreases permeability and soil stability; potential for metals mobilization.</td>
<td>Low/Moderate: Improves soil structure; increases permeability; potential for metals mobilization.</td>
<td>Low/Moderate: Improves soil structure; increases permeability; potential for metals mobilization.</td>
<td>Low/Moderate: Improves soil structure; increases permeability; potential for metals mobilization.</td>
<td>Low/Moderate: Improves soil structure; increases permeability; potential for metals mobilization.</td>
<td>Low/Moderate: Improves soil structure; increases permeability; potential for metals mobilization.</td>
</tr>
<tr>
<td><strong>Vegetation (Section 3.7)</strong></td>
<td>High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicity.</td>
<td>High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicity.</td>
<td>High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicity.</td>
<td>Low: Little or no adverse effect; osmotic stress at high levels.</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect.</td>
</tr>
<tr>
<td><strong>Animals (Section 3.9)</strong></td>
<td>Low: Sodium linked to salt toxicity and vehicle kills; magnitude unclear.</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect.</td>
</tr>
</tbody>
</table>

*Conclusions based on the assessment of information reviewed in this study.*
Abrasives & Freeze Point Depressants

- FPD impact on concrete
  - Known to adversely affect concrete (roadways, sidewalks, bridge decks)
    - Physical deterioration of surface – scaling
    - Chemical reactions of salt/paste/aggregates – paste degrades
    - Diffusion of chloride ions – corrosion of reinforcing steel
  - Degree – some disagreement in the literature
  - CMA, urea, KA, glycols
    - Research of their impacts on concrete is limited
    - Primary use is to limit corrosion of aircraft parts, so they’re probably kinder to steel reinforcing
    - Still, they’re expensive
  - Moral? Use less when you can
Abrasives & Freeze Point Depressants

- FPD impact on concrete

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Road Salt (NaCl)</th>
<th>Calcium Chloride (CaCl₂)</th>
<th>Magnesium Chloride (MgCl₂)</th>
<th>Acetates (CMA and KA)</th>
<th>Organic Biomass Products</th>
<th>Abrasives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Corrosion to Metals (General)</td>
<td>High: Will initiate and accelerate corrosion.</td>
<td>High: Will initiate and accelerate corrosion; higher potential for corrosion related to hygroscopic properties</td>
<td>High: Will initiate and accelerate corrosion; higher potential for corrosion related to hygroscopic properties</td>
<td>Low/moderate: Potential to initiate and accelerate corrosion due to elevated conductivity.</td>
<td>Low: Potential to initiate and accelerate corrosion due to elevated conductivity claims of mitigation of corrosion require further evaluation.</td>
<td>Low: Probably little or no effect</td>
</tr>
<tr>
<td>Concrete Matrix (Section 4.1)</td>
<td>Low/moderate: Will exacerbate scaling; low risk of paste attack.</td>
<td>Low/moderate: Will exacerbate scaling; low risk of paste attack.</td>
<td>Moderate/high: Will exacerbate scaling; risk of paste deterioration from magnesium reactions.</td>
<td>Moderate/high: Will exacerbate scaling; risk of paste deterioration from magnesium reactions</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect</td>
</tr>
<tr>
<td>Concrete Reinforcing (Section 4.1)</td>
<td>High: Will initiate corrosion of rebar.</td>
<td>High: Will initiate corrosion of rebar.</td>
<td>High: Will initiate corrosion of rebar, evidence suggests MgCl₂ has highest potential for corrosion of chloride products</td>
<td>Low: Probably little or no effect.</td>
<td>Low: Probably little or no effect; claims of mitigation of corrosion require further evaluation</td>
<td>Low: No Effect</td>
</tr>
</tbody>
</table>

Conclusions based on the assessment of information reviewed in this study.
Abrasives & Freeze Point Depressants

**Temperature**
- What do we think of when we say temperature?
  - Air temperature?
- What about other temperature information?
  - Pavement surface temperature?
  - Subsurface temperature?
- Each of these temperatures (and other information) can affect the formation of ice on the roadways and the plowing/deicing/anti-icing techniques that will be most effective.
Abrasives & Freeze Point Depressants

• Salt (NaCl)
  ○ Our most common “freeze point depressant”
  ○ Meaning, sodium chloride (rock salt, road salt)
  ○ At 30°F (pave temp), 1# salt melts 40# ice
  ○ At 20°F (pave temp), 1# salt melts 8# ice
  ○ Salt melts ice as low as -6°F (pave temp)
  ○ But below ~15°F (pave temp) effect of salt greatly reduced
  ○ Most managers limit use of salt when temps are 20°F and falling
Abrasives & Freeze Point Depressants

- The freeze point depressing qualities of brine are important to its application as an anti-icing/deicing agent.
- The minimum freeze point of salt brine is -6°F at a concentration of 23.3%.
- The line represents the freeze point of the solution at a given temperature. The dark colored portion in the center of the chart shows the melting range of brine solutions.
- Area to the left shows a solution with too little salt; the road surface will refreeze unless more salt brine or deicing salt is applied.
- Area to the right shows too much salt, and once again the surface will freeze without the introduction of more moisture. Additional precipitation and heavy traffic can dilute the brine solution allowing the road to refreeze.

Stay in this range

**Phase Diagram for Salt**

- **Eutectic point** – the point at which a solution achieves a maximum salt concentration. The solubility of salt in water decreases with decreasing temperature. Below the eutectic point, salt will begin to leave the solution and raise the freezing point. At the eutectic temperature, ice, saltwater, and solid salt exist in equilibrium. For water, the eutectic temperature is -6°F.
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- Eutectic comparisons
  - Sodium chloride (rock salt)
  - Calcium magnesium acetate
  - Magnesium chloride
  - Calcium chloride
  - Potassium acetate
Eutectic versus Effective Temperature

- Where theory meets practice...

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Eutectic (°F)</th>
<th>Effective (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl (sodium chloride)</td>
<td>-6</td>
<td>+15</td>
</tr>
<tr>
<td>CaCl (calcium chloride)</td>
<td>-60</td>
<td>-25</td>
</tr>
<tr>
<td>MgCl (magnesium chloride)</td>
<td>-28</td>
<td>+5</td>
</tr>
<tr>
<td>KCl (potassium chloride)</td>
<td>+13</td>
<td>+25</td>
</tr>
<tr>
<td>Kac (potassium acetate)</td>
<td>-76</td>
<td>-15</td>
</tr>
<tr>
<td>CMA (calcium magnesium acetate)</td>
<td>-17</td>
<td>+21</td>
</tr>
</tbody>
</table>
Abrasives & Freeze Point Depressants

How Deicing Chemicals Work
Abrasives & Freeze Point Depressants

- So...
  - Not too much moisture and not too little – got to keep that concentration near optimal – brine can help
  - Not too cold –NaCl just sits there below -6°F (pave temp)
- So...
  - Below ~ 15°F (pave temp) or so, have to think about whether salt is doing much good at the moment
  - Below ~ 5-10°F (pave temp), hang it up, or go to sand, or apply brine, or go to calcium chloride (CaCl) or magnesium chloride (MgCl)
- Regardless...
  - Knowing just the air temperature doesn’t help you as much as also knowing the pavement temperature
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- Concentration dilution due to precipitation

**TABLE A-1 Precipitation dilution potential in the presence of precipitation**

<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 1 (powder)</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>2. Snow 2 (ordinary)</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>3. Snow 3 (wet/heavy)</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>4. Snow U (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>Low</td>
<td>Medium</td>
<td>(Same as type of snow)</td>
<td>Medium</td>
</tr>
<tr>
<td>10. Freezing rain with sleet</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Temperature and Ice Forming

- Air temperature does not correlate to pavement temperature, generally
  - So, the “current temperature” (at least, by itself) doesn’t tell snowfighters what they really want to know
  - Frigid December day with subfreezing air temps – the pavement and subsurface can be substantially warmer, deicing efforts are light, and use of chemicals can be minimized
  - Mild early March night – air temps may be above freezing, but the surface and subgrade temps can frustrate deicing efforts

- Pavement and subsurface temperatures can help optimize use of chemicals/abrasives and improve performance
Temperature and Ice Forming

- If the pavement is at 32°F or below and there is precipitation, ice is a given; beyond that it gets trickier
- In the fall, subsurface temps are warmer, which tends to keep pavement temps warmer, even when the air temp is lower
- In the spring (depending upon what winter has wrought) subsurface temps are generally low, providing little protection for the pavement against ambient temps – may even contribute to lower pavement temps than even the ambient air
- Sun has strong influence
Black Ice

- Forms when the air temp is below freezing but warmer than the pavement temp (e.g., air at 30°F and pavement at 26°F)
  - So, when are we more likely to see black ice? Later in the winter, right?
- Moisture rapidly freezes and creates a thin layer of ice that may be transparent on the roadway
- Rain or snow not necessary – just need subfreezing pavement, slightly warmer air temps, and elevated humidity
- Look for times when the dew point and air temp converge
  - Air can no longer hold the moisture – condenses on the pavement
- May not be noticed by motorists until too late – hence, very dangerous condition
- Tends to be spotty – crops up here and there
- Watch bridges in particular
### Abrasives & Freeze Point Depressants

#### Table 8. Weather event: light snow storm.

<table>
<thead>
<tr>
<th>Pavement Temperature Range, and Trend</th>
<th>Initial Operation</th>
<th>Subsequent Operations</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 0°C (32°F), steady or rising</td>
<td></td>
<td></td>
<td>1) Monitor pavement temperature closely for drops toward 0°C (32°F) and below 2) Treat icy patches if needed with chemical at 28 kg/lane-km (100 lb/lane-mi); plow if needed</td>
</tr>
<tr>
<td>Above 0°C (32°F), 0°C (32°F) or below is imminent;</td>
<td></td>
<td></td>
<td>1) Applications will need to be more frequent at lower temperatures and higher snowfall rates 2) It is not advisable to apply a liquid chemical at the indicated spread rate when the pavement temperature drops below -5°C (23°F) 3) Do not apply liquid chemical onto heavy snow accumulation or packed snow</td>
</tr>
<tr>
<td>ALSO -7 to 0°C (20 to 32°F), remaining in range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10 to -7°C (15 to 20°F), remaining in range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below -10°C (15°F), steady or falling</td>
<td></td>
<td></td>
<td>1) It is not recommended that chemicals be applied in this temperature range 2) Abrasives can be applied to enhance traction</td>
</tr>
</tbody>
</table>

#### Notes

**CHEMICAL APPLICATIONS.** 1) Time initial and subsequent chemical applications to prevent deteriorating conditions or development of packed and bonded snow. 2) Apply chemical ahead of traffic rush periods occurring during storm.

**PLOWING.** If needed, plow before chemical applications so that excess snow, slush, or ice is removed and pavement is wet, slushy, or lightly snow covered when treated.

### Abrasives & Freeze Point Depressants

#### Table 9. Weather event: light snow storm with period(s) of moderate or heavy snow.

<table>
<thead>
<tr>
<th>PAVEMENT TEMPERATURE RANGE, AND TREND</th>
<th>INITIAL OPERATION</th>
<th>SUBSEQUENT OPERATIONS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Above 0°C (32°F), steady or rising</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry, wet, slush, or light snow cover</td>
<td>None, see comments</td>
<td>None, see comments</td>
<td></td>
</tr>
<tr>
<td><strong>Above 0°C (32°F), 0°C (32°F) or below is imminent;</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>Apply liquid or prewetted solid chemical</td>
<td>Plow as needed; reaply liquid or solid chemical when needed</td>
<td></td>
</tr>
<tr>
<td>Wet, slush, or light snow cover</td>
<td>28 (100)</td>
<td>28 (100)</td>
<td>28 (100)</td>
</tr>
<tr>
<td>28 (100)</td>
<td>28 (100)</td>
<td>28 (100)</td>
<td>28 (100)</td>
</tr>
<tr>
<td>55 (200)</td>
<td>55 (200)</td>
<td>70 (250)</td>
<td></td>
</tr>
<tr>
<td>-10 to -4°C (15 to 25°F), remaining in range</td>
<td>Apply prewetted solid chemical</td>
<td>Plow as needed; reaply prewetted solid chemical when needed</td>
<td></td>
</tr>
<tr>
<td>55 (200)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Below -10°C (15°F), steady or falling</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry or light snow cover</td>
<td>Flow as needed</td>
<td>Plow as needed</td>
<td></td>
</tr>
<tr>
<td>55 (200)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

**CHEMICAL APPLICATIONS.**
1. Time initial and subsequent chemical applications to prevent deteriorating conditions or development of packed and bonded snow.
2. Anticipate increases in snowfall intensity. Apply higher rate treatments prior to or at the beginning of heavier snow periods to prevent development of packed and bonded snow.
3. Apply chemical ahead of traffic rush periods occurring during storm.

**PLOWING.** If needed, plow before chemical applications so that excess snow, slush, or ice is removed and pavement is wet, slushy, or lightly snow covered when treated.
### Abrasives & Freeze Point Depressants

#### Table 12. Weather event: freezing rain storm.

<table>
<thead>
<tr>
<th>PAVEMENT TEMPERATURE RANGE, AND TREND</th>
<th>INITIAL OPERATION</th>
<th>SUBSEQUENT OPERATIONS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 0°C (32°F), steady or rising</td>
<td>None, see comments</td>
<td>None, see comments</td>
<td>1) Monitor pavement temperature closely for drops toward 0°C (32°F) and below. 2) Treat icy patches if needed with prewetted solid chemical at 21-28 kg/lane-km (75-100 lb/lane-mi)</td>
</tr>
<tr>
<td>Above 0°C (32°F), 0°C(32°F) or below is imminent</td>
<td>Apply prewetted solid chemical</td>
<td>Reapply prewetted solid chemical as needed</td>
<td>Monitor pavement temperature and precipitation closely</td>
</tr>
<tr>
<td>-7 to 0°C (20 to 32°F), remaining in range</td>
<td>Apply prewetted solid chemical</td>
<td>Reapply prewetted solid chemical as needed</td>
<td>1) Monitor pavement temperature and precipitation closely. 2) Increase spread rate toward higher indicated rate with decrease in pavement temperature or increase in intensity of freezing rainfall. 3) Decrease spread rate toward lower indicated rate with increase in pavement temperature or decrease in intensity of freezing rainfall</td>
</tr>
<tr>
<td>-10 to -7°C (15 to 20°F), remaining in range</td>
<td>Apply prewetted solid chemical</td>
<td>Reapply prewetted solid chemical as needed</td>
<td>1) Monitor precipitation closely. 2) Increase spread rate toward higher indicated rate with increase in intensity of freezing rainfall. 3) Decrease spread rate toward lower indicated rate with decrease in intensity of freezing rainfall</td>
</tr>
<tr>
<td>Below -10°C (15°F), steady or falling</td>
<td>Apply abrasives</td>
<td>Apply abrasives as needed</td>
<td>It is not recommended that chemicals be applied in this temperature range</td>
</tr>
</tbody>
</table>

**Notes**

**CHEMICAL APPLICATIONS.** (1) Time initial and subsequent chemical applications to prevent glaze ice conditions. (2) Apply chemical ahead of traffic rush periods occurring during storm.
Abrasives & Freeze Point Depressants

Calibration of spreaders
- Application rate variables
  - Area of the gate opening in hopper box
  - Feed belt or auger speed
  - Truck speed
- Controls
  - None
  - Manual
  - Automatic
  - Computer controlled
- Automatic control
  - Control of rate achieved by ground-speed controllers
  - Operator can achieve a desired application rate at any speed
Abrasives & Freeze Point Depressants

- Calibration of spreaders
  - Calibration important regardless of type of spreader
  - Even new spreaders
  - Settings may change throughout season – recalibrate if in doubt
  - Need not be overly complicated
  - Calibration – calculating the pounds/mile actually discharged at various spreader rates and truck speeds
    - Count number of auger or conveyor shaft revolutions/minute
    - Measure the salt discharged in one revolution
    - Multiply these two and the rate it takes to travel one mile
### Calibration Chart

**Agency:** ____________________________  
**Location:** ____________________________  
**Truck No.:** ____________________________  
**Date:** ____________________________  
**By:** ____________________________

#### Gate Opening (Hopper Type Spreaders)

<table>
<thead>
<tr>
<th>Control Setting</th>
<th>Shaft RPM (Loaded)</th>
<th>Discharge Per Revolution (Pounds)</th>
<th>Discharge Rate (Lbs/Min)</th>
<th>5 mph</th>
<th>10 mph</th>
<th>15 mph</th>
<th>20 mph</th>
<th>25 mph</th>
<th>30 mph</th>
<th>35 mph</th>
<th>40 mph</th>
<th>45 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

#### Pounds Discharged Per Mile

**Minutes to Travel One Mile**

<table>
<thead>
<tr>
<th>5 mph</th>
<th>10 mph</th>
<th>15 mph</th>
<th>20 mph</th>
<th>25 mph</th>
<th>30 mph</th>
<th>35 mph</th>
<th>40 mph</th>
<th>45 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.00</td>
<td>6.00</td>
<td>4.00</td>
<td>3.00</td>
<td>2.40</td>
<td>2.00</td>
<td>1.71</td>
<td>1.50</td>
<td>1.33</td>
</tr>
</tbody>
</table>

*Data from Snowfighter’s Handbook, Salt Institute*
Abrasives & Freeze Point Depressants

- Calibration equipment
  - Tarp
  - Scale
  - Marker, pencil
  - Timer
  - Calculator
  - Calibration card
Abrasives & Freeze Point Depressants

• Calibration
  ○ 1. Load the truck
Abrasives & Freeze Point Depressants

Calibration

2. Remove the spinner
Abrasives & Freeze Point Depressants

● Calibration
  ○ 3. Mark end of the shaft
Abrasives & Freeze Point Depressants

- Calibration
  - On a V-box, calibration is done for each opening of the gate
Abrasives & Freeze Point Depressants

- Calibration
  1. Time RPMs of the shaft
Abrasives & Freeze Point Depressants

• Calibration
  ○ 5. Catch material from one revolution of the shaft
Abrasives & Freeze Point Depressants

- Calibration
  - 6. Weigh material
Abrasives & Freeze Point Depressants

- Calibration
  - 7. Fill in the chart
    - Copy in truck
    - Copy in office
Abrasives & Freeze Point Depressants

Video

Iowa Department of Transportation

Winter Maintenance Training – Delaware T Center
Abrasives & Freeze Point Depressants

- Automatic controls
- Computer operated systems
Spreading Abrasives and Chemicals

- Control the rate
  - Manager should adjust with conditions

- Control the distribution patterns
  - For 2-lane, 2-way traffic (including most urban streets), most effective technique (for dry or pre-wetted material) is to spread across the middle 2/3; let the cross slope and traffic distribute

- Give it time to work
  - As temp drops, more time needed
  - Don’t just plow it back off five minutes later
Spreading Abrasives and Chemicals

- Multi-lane highways – apply near full width
- Parking areas – spread evenly
- Hills/curves/intersections – higher application rate
- Bridges – higher application rate
- Banked curves – apply on high side
- High winds – dry material may not stick
Spreading Abrasives and Chemicals

- Special areas
  - At-grade railroad crossings
  - Interchanges
  - Super-elevated curves
  - Steep grades
  - Deep cuts
  - Shaded areas
- Drainage
  - Poor drainage/trapped areas
  - Closed drainage
  - Open drainage
Weather Basics

- Back to the weather
  - Plows at the ready and nice piles of salt and sand are important
  - Well trained and organized crews are essential
  - Safety must always be on everyone’s mind
  - And...

- Weather information is an important tool in your arsenal, too
  - Weather Channel – www.weather.com
  - NOAA local forecasts - http://www.erh.noaa.gov/phi/
  - DelDOT interactive weather - http://www.deldot.gov/traffic/map.ejs
• Tons of information as storms approach
• Click on your location on most maps and you’ll get very localized information
• Local text forecasts written largely laymen terms
DelDOT Weather

- Live
- 12 locations
- Air temps
- Pave temps
- Sub-surface temps
- Humidity
- Dew point
- Wind

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Vehicle-Based Weather Equipment

- Systems like these can give you real time, local information
  - Air temp
  - Surface temp
  - Relative humidity
  - Dew point
Weather Basics

- **Snow**
  - Ice crystals form gangs way up high and float down innocently
  - Sustained snowfall requires constant inflow of moisture
- **Ice**
  - Moisture gets on stuff that’s cold – nobody likes that
- **Black ice**
  - Forms when the air temp is below freezing but warmer than the pavement temp (e.g., air at 30°F and pavement at 26°F)
  - Look for when the dew point and air temp converge - air can no longer hold the moisture – condenses on the pavement
- **Sleet**
  - Cold, deep layer of air at surface cause raindrops as they descend
- **Freezing rain**
  - Water droplets fall from above-freezing layer to below-freezing layer
## Precipitation definitions

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Rain</td>
<td>Small liquid droplets falling at a rate such that individual drops are easily detectable splashing from a wet surface. Include drizzle in this category.</td>
</tr>
<tr>
<td>Moderate Rain</td>
<td>Liquid drops falling are not clearly identifiable and spray from the falling drops is observable just above pavement or other hard surfaces.</td>
</tr>
<tr>
<td>Heavy Rain</td>
<td>Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray from falling rain can be observed several inches over hard surfaces.</td>
</tr>
<tr>
<td>Freezing Rain</td>
<td>When rain freezes upon impact and forms a glaze on the pavement or other exposed surfaces.</td>
</tr>
<tr>
<td>Sleet (Ice Pellets)</td>
<td>Precipitation of transparent or translucent pellets of ice, which are round or irregular in shape.</td>
</tr>
<tr>
<td>Light Intensity of Sleet</td>
<td>Scattered pellets that do not completely cover an exposed surface regardless of duration. Visibility is not affected.</td>
</tr>
<tr>
<td>Moderate Intensity of Sleet</td>
<td>Slow accumulation on ground. Visibility reduced by ice pellets to less than 7 mi (13 km).</td>
</tr>
<tr>
<td>Heavy Intensity of Sleet</td>
<td>Rapid accumulation on ground. Visibility reduced by ice pellets to less than 3 mi (5.6 km).</td>
</tr>
<tr>
<td>Light Snow</td>
<td>Snow alone is falling and the visibility is greater than ½ mi (0.9 km).</td>
</tr>
<tr>
<td>Moderate Snow</td>
<td>Snow alone is falling and the visibility is greater than ¼ mi (³⁄₄ km) but less than or equal to ½ mi (0.9 km).</td>
</tr>
<tr>
<td>Heavy Snow</td>
<td>Snow alone is falling and the visibility is less than or equal to ³⁄₄ mi (1½ km).</td>
</tr>
<tr>
<td>Blowing Snow</td>
<td>When fallen snow is raised by the wind to a height of 6 ft (1.8 m) or more and is transported across a road.</td>
</tr>
<tr>
<td>None</td>
<td>No precipitation or blowing snow.</td>
</tr>
</tbody>
</table>

**Note:** An estimate can be made of the moisture content of falling snow as follows:

1. 1 = powder snow
2. 2 = ordinary snow
3. 3 = wet/heavy snow

Weather Basics

- Recognizing what **has** happened, what **is** happening, and what is likely **to** happen...
  - Snow
  - Ice
  - Black ice
  - Sleet
  - Freezing rain

- Helps guide us what to do at any given point in the storm
  - Start treatment
  - Change treatments
  - Stop
  - Pause
Weather Basics

- **Weather information to watch**
  - Temperatures
    - Air
    - Pavement
    - Subsurface
  - Dew point
  - Wind
    - Speed
    - Direction

- **Where do we find it**
  - Weather Channel/weather.com
  - NOAA
  - DelDOT
  - On-site weather station
  - Finger in the air?
Some Weather Scenarios

- From the Salt Institute
- Don’t be shocked if there’s an emphasis on salt use
- Nonetheless, these can be good starting guides

---

### Stormfighting Guidelines

The following chart is a guideline to combat various types of storms. Local conditions and policies will be the final determining factor.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature</th>
<th>Precipitation</th>
<th>Road Surface</th>
<th>Coverage Per 2 Cu. Yd. of Salt Per Two-Lane Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Near 30</td>
<td>30</td>
<td>Wet</td>
<td>2 1/2</td>
</tr>
<tr>
<td>2</td>
<td>Below 30</td>
<td>0</td>
<td>Wet or Sticky</td>
<td>2.34</td>
</tr>
<tr>
<td>3</td>
<td>Below 20</td>
<td>0</td>
<td>Dry</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Below 20</td>
<td>10</td>
<td>Wet</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Below 10</td>
<td>10</td>
<td>Wet</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Below 10</td>
<td>0</td>
<td>Dry</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Below 10</td>
<td>0</td>
<td>Wet</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: Salt meets ASTM Specification D662 weights approximately 40 lb per cubic foot.
Worst Case Weather Scenarios

- Excessive amounts water/ice
- Blizzard conditions
- Intense snowfall, wind, very cold temperatures
- Chemicals can become quickly diluted (remember the phase diagram?)
- Abrasives can be washed away or buried
Worst Case Weather Scenarios

- Blizzard with very low, sustained temps going in and coming out of storm...
  - Plowing alone may be best option – hold off on chemicals and abrasives
  - If post storm conditions are still favorable to icing, consider abrasives along with chemicals to buy time for them to work or for warmer conditions

- Blizzard with warmer temps going in and coming out of storm...
  - Consider ice control chemical before storm or early on
  - Plow mostly without salt or sand
  - Deice at end of storm
Worst Case Weather Scenarios

- Rapidly accumulating freezing rain...
  - Apply solid ice control chemicals at high rate on high side wheel path of each lane
  - Attempt to achieve at least one wheel path with sufficient friction to stop and steer
  - Watch for rapidly changing conditions

- Falling/blowing snow, near zero visibility (white out)
  - Get vehicles and equipment well off road, keep emergency lights active, communicate with operations base
  - Extra caution in operational yards as well
  - Wait it out – conditions may only be temporary
  - Operating in these conditions is a danger to everyone
• No test of government is more important to a citizen than the manner in which his or her request or complaint is handled
Taking Calls

- Request / Complaint Handling Procedure:
  - Receiving calls
    - Courtesy
    - Write it down – thoroughly
  - Prompt investigation & correction
    - Get the information to the right personnel
    - Request timeline for reporting back
  - Follow-up procedure for tracking
  - Response back to resident before checking off
    - Keep record of call and resolution, including times
    - Note satisfaction (or lack thereof) from caller
Crashes

- Take and keep photos of road conditions before and after crashes
- What can we tell from them?
- Driver error?
- Poor road conditions?
Record Keeping

- **Storm information**
  - Snow, ice, sleet, freezing rain, black ice?
  - What was the storm sequence – i.e., freezing rain started at 4 a.m., changed to wet snow at 5:30, changed to rain at noon...
  - Day of week, holidays, etc.
  - Other weather conditions (temps, sunshine, clouds, dew points, winds)

- **Manpower and equipment status**
  - Beginning of storm, throughout
  - Reasons for gaps (vacation, waiting on parts, funding)
  - Auxiliary personnel or equipment used

- **Notable problems/obstructions/interference**
Record Keeping

- **Performance**
  - Miles plowed (and/or material applied) per hour, possibly broken down by route and/or road type
  - Times when various roads were made passable
  - Abrasives and chemicals used (tonnage, per route)
  - Cutting edges consumed
  - Percentage of time LOS met
  - Crashes (fatal, non-fatal, pedestrians, property damage only)

- **Feedback**
  - Number of phone calls from public, elected officials
  - Public comment at meetings
  - News articles, letters to editors
Record Keeping

- Storm record

[Image of Weather and Pavement Condition Sheet and Example weather and pavement condition worksheet]
Record Keeping

- Storm record
- Other checklists can be found in the Snowfighter’s Handbook
Safety

Don’t miss a chance to remind
Establish a safety culture from the top down
For you, your crews, pedestrians, motorists, visitors to operational centers and yards...
Kids in snow banks, sledding, throwing snow balls
Even the delinquents

Day versus night operations
Rest...eat...drink (water) – don’t over-do it
Know when to cease operations temporarily
What is/are in the Other Modules?

• Module 1 – Introduction
  o General objectives of snow and ice control
  o Weather basics
  o Importance of training
  o Innovation and evolution
  o Safety, risk management, liability
What is/are in the Other Modules?

- Module 2 – Planning and Program Development
  - Snow and ice removal plan
  - Standard operating procedures
  - Route maps/assignments
  - Review and updating plans periodically
  - Budgeting
  - Acquiring and renting equipment
  - Recordkeeping
  - Preparing elected officials
  - Preparing the public
What is/are in the Other Modules?

- **Module 3 – Pre-Season Activities**
  - Personnel training and refreshers
  - Stakeholder briefings
  - Contracting and material acquisition
  - Storage and handling materials
  - Equipment readiness
  - Crew and equipment assignments; practice runs
  - Snow markers and passive control devices
  - Check/clear drainage ways
  - Calibrate spreaders and other equipment
  - Public service announcements and bulletins
What is/are in the Other Modules?

- **Module 5 – Post Storm Activities**
  - Push back shoulders
  - Clear drainage ways
  - Refreezing
  - Maintain and clean equipment
  - Restoring safety features and sight distances
  - Removal of snow
  - Asset inventory
  - Interim pavement repairs
  - Assess performance and debrief
What is/are in the Other Modules?

- **Module 6 – Post Season Activities**
  - Inventory equipment and materials
  - Clean and repair equipment
  - Store equipment
  - Review of performance and safety statistics
  - Brief elected officials and bean counters
  - Plan for replenishment of materials
  - Road and shoulder repairs
  - Assess the season
  - Calibrate plan accordingly

Winter Maintenance Training – Delaware T Center
Need More?

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http://www.ce.udel.edu/dct/T2.html

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