“Winter Operations; the most important job you do all year, are you ready?
Agenda Today

- Operational Advantages to being Proactive (Anti-Icing)
- Tools to Achieve Performance
- Where is Snow and Ice Operations Heading?
- Chemicals Options and how best to use them
- Why we do the things we do
## Weather Impacts on Safety

*Annual average from 1995-2008*

<table>
<thead>
<tr>
<th>Road Weather Conditions</th>
<th>Crashes</th>
<th>Injuries</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Pavement</td>
<td>1,128,000</td>
<td>507,900</td>
<td>5,500</td>
</tr>
<tr>
<td>Rain</td>
<td>707,000</td>
<td>330,200</td>
<td>3,300</td>
</tr>
<tr>
<td>Snow/Sleet</td>
<td>225,000</td>
<td>70,900</td>
<td>870</td>
</tr>
<tr>
<td>Icy Pavement</td>
<td>190,100</td>
<td>62,700</td>
<td>680</td>
</tr>
<tr>
<td>Snow/Slushy Pavement</td>
<td>168,300</td>
<td>47,700</td>
<td>620</td>
</tr>
<tr>
<td>Fog</td>
<td>38,000</td>
<td>15,600</td>
<td>600</td>
</tr>
<tr>
<td><strong>Total Attributable to Weather</strong></td>
<td><strong>1,511,200</strong></td>
<td><strong>629,300</strong></td>
<td><strong>7,130</strong></td>
</tr>
</tbody>
</table>

*The sum of the crashes under each road weather condition does not equal the total number attributable to weather; crashes may be double counted, e.g. wet pavement and rain.*

**Source:** [http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm](http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm)
Weather Impacts on Mobility

<table>
<thead>
<tr>
<th>Weather Conditions</th>
<th>Freeway Traffic Flow Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Speed</td>
</tr>
<tr>
<td>Light Rain/Snow</td>
<td>3% - 13%</td>
</tr>
<tr>
<td>Heavy Rain</td>
<td>3% - 16%</td>
</tr>
<tr>
<td>Heavy Snow</td>
<td>5% - 40%</td>
</tr>
<tr>
<td>Low Visibility</td>
<td>10% - 12%</td>
</tr>
</tbody>
</table>

- On signalized arterial routes, speed reductions can range from 10% - 25% on wet pavement and from 30% - 40% with snowy or slushy pavement

Source: [http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm](http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm)
Snow and Ice Removal

This is the most important operation done by MassDOT; It affects the most and is observed by everyone
Winter Operations

• Professionalism
  – Respect (Customers and Operators)
  – Documentation (State Policy)
    • Established Levels of Service
  – Integrity and Accountability
• Continued Communications
What are Levels of service?

- **Snow Policy**
  - High Levels of Service (Interstates)
  - Snow Roads (Secondaries)

- **Economic Benefits**

- **Public Expectations**
Policy Decisions

§ What amounts of material to use for various storms and conditions (240 lb/lane-mile)
§ Closed Loop Controllers required
§ When to apply materials for best results
§ Guidelines (Blue Application Guidelines)
<table>
<thead>
<tr>
<th>Current Pavement Temp. (°F)</th>
<th>Forecasted Pavement Temp.</th>
<th>Severity/ Precipitation Type</th>
<th>Application Rate lbs/tn/mile</th>
<th>Recommended Treatment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 32</td>
<td>Higher ▲</td>
<td>Light - Rain, Sleet or Wet Snow</td>
<td>240</td>
<td>Initial application, then reapply with pre-wetted salt as needed</td>
<td>Do not pre-treat roadway with calcium chloride if temperature is above 32°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate to Heavy - Rain, Sleet or Wet Snow</td>
<td></td>
<td></td>
<td>Pre-wet salt application @ 8-10 gals/ton</td>
</tr>
<tr>
<td>25 to 32</td>
<td>Higher ▲</td>
<td>Light - Freezing Rain, Sleet or Snow</td>
<td>240</td>
<td>Initial application, then reapply with pre-wetted salt as needed</td>
<td>Pre-treat roadway with calcium chloride @ 20-30 gals per lane mile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate to Heavy - Freezing Rain, Sleet or Snow</td>
<td></td>
<td></td>
<td>Pre-wet salt applications with calcium chloride @ 8-10 gals per ton</td>
</tr>
<tr>
<td>20 to 25</td>
<td>Higher ▲</td>
<td>Light - Sleet, Dry Snow or Wet Snow</td>
<td>240</td>
<td>Initial application, then reapply with pre-wetted salt as needed</td>
<td>Pre-treat roadway with calcium chloride @ 20-30 gals per lane mile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate to Heavy - Sleet or Snow</td>
<td></td>
<td></td>
<td>Pre-wet salt applications with calcium chloride @ 8-10 gals per ton</td>
</tr>
<tr>
<td>15 to 20</td>
<td>Higher ▲</td>
<td>Light - Sleet or Dry Snow</td>
<td>240</td>
<td>Initial application, then reapply with pre-wetted salt as needed</td>
<td>Pre-treat roadway with calcium chloride @ 20-30 gals per lane mile</td>
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<tr>
<td></td>
<td></td>
<td>Moderate to Heavy - Sleet or Dry Snow</td>
<td></td>
<td></td>
<td>Pre-wet salt applications with calcium chloride @ 8-10 gals per ton</td>
</tr>
<tr>
<td>15 or Below</td>
<td></td>
<td>Plow as needed and apply sand if necessary</td>
<td>240</td>
<td>Monitor pavement temperature and discuss conditions with supervisor</td>
<td>Apply pre-wet salt when temperature continues to rise above 15° F</td>
</tr>
</tbody>
</table>

Notes: If snow is blowing off the roadway do not apply any materials. Plow areas where drifting snow is collecting and discuss conditions with supervisor. If ice has bonded to the roadway to form pack, call your supervisor immediately. Do not apply Calcium Chloride on pack unless applied with salt.
<table>
<thead>
<tr>
<th>Cubic Yards of Salt</th>
<th>120 Lbs Per Single Lane</th>
<th>240 Lbs Per Single Lane</th>
<th>480 Lbs Per Two Lanes</th>
<th>720 Lbs Per Three Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.6</td>
<td>8.3</td>
<td>4.3</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>33.3</td>
<td>16.6</td>
<td>8.6</td>
<td>5.4</td>
</tr>
<tr>
<td>3</td>
<td>49.9</td>
<td>24.9</td>
<td>12.9</td>
<td>8.1</td>
</tr>
<tr>
<td>4</td>
<td>66.5</td>
<td>33.2</td>
<td>17.2</td>
<td>10.8</td>
</tr>
<tr>
<td>5</td>
<td>83.1</td>
<td>41.5</td>
<td>21.5</td>
<td>13.5</td>
</tr>
<tr>
<td>6</td>
<td>99.7</td>
<td>49.8</td>
<td>25.8</td>
<td>16.2</td>
</tr>
<tr>
<td>7</td>
<td>116.3</td>
<td>58.1</td>
<td>30.1</td>
<td>18.9</td>
</tr>
<tr>
<td>8</td>
<td>132.9</td>
<td>66.4</td>
<td>34.4</td>
<td>21.6</td>
</tr>
<tr>
<td>9</td>
<td>149.5</td>
<td>74.7</td>
<td>38.7</td>
<td>24.3</td>
</tr>
<tr>
<td>10</td>
<td>166.0</td>
<td>83.0</td>
<td>43.0</td>
<td>27.0</td>
</tr>
</tbody>
</table>
The Basic Principle

It’s much easier to remove snow when it isn’t frozen to the pavement
De-icing

• A reactive approach (old school)
  – Chemicals are applied after the snow has accumulated on the road surface
  – Salt is spread on the top of packed snow and ice that has bonded to the road surface

Costs 6X-10X to melt snow and ice from the top down vs. from the bottom up. (CRRL)
Anti-icing Strategy

The application of chemicals at the start of a precipitation event in an attempt to prevent or weaken the bond of ice to the pavement by reducing the freezing point of water.
Anti-Icing with Brine
Anti-Icing With NaCl Brine

- Application Rate 20-30 Gallons per Lane Mile.
- Lasts on the Road for up to 48 hrs.
- Dries on surface leaving “Spray Lines”
- Does not have the same Chemical Residue that MgCl₂ and CaCl₂ have
- More flexible for Pre-Treating Roads
- Has to be monitored for Dilution Of Solution
Anti-Icing Strategies

• Require pre-wetting of material, 8–10 gallons per ton;

• Direct liquid applications, 20 – 30 gallons (depending on chemical selected) per lane mile. (check calibration)

• Do Not over apply (MgCl$_2$ or CaCl$_2$). Only apply when below 32 degrees, and not below 10 degrees
Anti-icing Benefits

• Provides safer roads quicker than deicing
  – Produces black pavement right after storm
  – Less labor and fuel cost
• Uses less chemicals
  – Saves money
  – Less environmental impact
• Reduces wear on equipment, easier to remove snow and ice when not frozen to road surface
When Do You decide to go out?

• Reliable Weather Reports
  – Location Specific Forecast (21 areas)
  – Weather Service (Schneider Electric)

• Pavement Temperature Devices

• Decisions should be made on proper information available

• Improved Communications between Districts
MassDOT Districts
Treatment Factors

• Pavement temperature
  *Key to Success
• Road conditions
• Weather
  – Precipitation type
  – Storm length and intensity
• Traffic volume and timing
  – Use to your advantage
What’s available

• Rock Salt-Mined and Solar
• Sodium Chloride (NaCl) 23.3 %
• Blended NaCl  85% NaCl:15% MgCl₂
• Pre-Mix 4:1 (80% NaCl- 20% Flake CaCl₂)
• Corrosion Inhibited Magnesium Chloride (MgCl₂) 26%-30%
• Sand in emergencies-Rapidly diminishing benefits; costly to manage
Why Anti-ice?

• Creates a brine layer on pavement surface
  – Allow snow and ice to be plowed off road easier and quicker
• Prevent ice and snow from bonding to the pavement!
When?

- Anti-Icing Strategy
  - Under what conditions?
  - What are key indicators?
  - Can I reapply?
    - Yes or No and Why?
    - Dos and Don’ts
Operational Strategies

• Applications will need to be more frequent at lower temperatures or higher snowfall rates

• Dilution drives the application rate

• More moisture:
  – More pounds per lane mile
  – More frequent applications
Why do you have to use Chemicals?

- Safe roads quicker
- Clear the roads of snow and ice faster
- Less Work Period
- Less accidents
- Saves Money
  - Cost effective
Have to Know how Much you Apply!
Environmental Impact

[Diagram of water cycle and environmental impact factors]
Environmental

Laurene Poland, Salt Remediation Program Supervisor
Cate Kenna, Program Coordinator
Mike Pelletier, Program Engineer
What are some of the environmental impacts associated with road salt?
Environmental Fate of Road Salt

Application

Road Surface
melt ice/snow

Dissolve and runoff to receiving waters and/or soils

Groundwater and soils

Impacts:
Drinking water supply, discharge to surface water, vegetation

Pavement Surface

Bounce, spray, or plow to roadside

Surface Water

Impacts:
Toxicity to aquatic life, streams, lakes, wetlands

Excess dries to powder on pavement

Washed away by precip. Resuspended as dust

Settle on land surfaces

Impacts:
Vegetation, soil, groundwater, etc.
Negative Impacts of Excess NaCl in Drinking Water

• Health Concerns
  - High Blood Pressure
  - Hypertension
  - Kidney Disease
  - Heart Disease

• Corrosion

• Aesthetics (e.g. Taste)
How much salt does it take to contaminate 5 gallons of water?

1 teaspoon

Sooooo......

If you use one less load this winter, you could protect up to 8 million gallons of water from being contaminated!
The 2016 winter was a relatively mild winter and the effects of the anti-icing and other efficiency measures were not as evident or dramatic as in previous years with the exception of District 1, which still showed considerably lower salt use than that predicted.
MassDOT takes a proactive approach to S&I which saves money and helps minimize environmental impacts. What are some of the measures we take to help achieve this?

<table>
<thead>
<tr>
<th><strong>BMPs</strong></th>
<th><strong>OPS IMPROVEMENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Good Housekeeping</td>
<td>• New Technologies:</td>
</tr>
<tr>
<td>• No overloading spreaders</td>
<td>(Closed Loop Circulation; Loader Scales; GPS-AVL)</td>
</tr>
<tr>
<td>• Training</td>
<td>• Calibration</td>
</tr>
<tr>
<td>• Reduced Salt Zones</td>
<td>• Pre-treating</td>
</tr>
<tr>
<td>• Check Gate Openings</td>
<td>• Pre-wetting</td>
</tr>
<tr>
<td>• Overlaps</td>
<td>• RWIS</td>
</tr>
</tbody>
</table>
2015 – 2016 Recap

Summary

• New Policies & Equipment utilized in last 6 years have resulted in more efficient use of road salt

• Statewide data suggests an average salt use reduction of 28 percent on per ln-mi basis compared to 2001 to 2010 usage

• Three most effective measures: Pre-Wetting, Pre-treatment & Closed-loop controllers
Reminders

• Continue to focus on BMPs and good housekeeping

• Check gate openings

• Pay attention to detail (especially in Reduced Salt Zones)

• Consistency with material data reporting

• We are held accountable for our actions!
Anti-Icing Operations
Environmental Impacts
Important Facility Procedures

• Good House Keeping
• Don’t Overload Spreaders
• Safety
  – Back-Up Alarms
  – Lights
  – Hard Hats and Vests
Have to Pay Attention to Details!
What’s Your Best Snow and Ice Tool?
Answer -

PLOW, PLOW, PLOW!!
Corrosion Issues
Equipment!
What Are You Doing?

• Plowing, not melting! (Especially below 15 degrees)
  – plowing removes 90% of the snow and ice
• Spread patterns are critical
• Must calibrate to ensure you’re spreading how much you want and where
How do you know **When** to apply salt?

- **Chemicals depress the freeze point of water.**
- **If Salt is spread as a solid:**
  - Needs to dissolve in order to work
  - Takes Time, needs Heat and Moisture
- Spread Liquid Chemicals before an event, to form brine film on road (preventing Ice and Snow from freezing to surface)
- If brine film maintained, last plowing pass leaves a much cleaner road
## Know the lowest practical melting temperature for each material

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Lowest Practical Melting Temp.</th>
<th>Eutectic Temp.</th>
<th>Optimal Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride</td>
<td>15° F</td>
<td>-6° F</td>
<td>23%</td>
</tr>
<tr>
<td>MgCl₂ Magnesium Chloride</td>
<td>-10° F</td>
<td>-28° F</td>
<td>27 to 30%</td>
</tr>
<tr>
<td>CaCl₂ (Calcium Chloride)</td>
<td>-20° F</td>
<td>-60° F</td>
<td>30%</td>
</tr>
<tr>
<td>CMA (Calcium Magnesium Acetate)</td>
<td>20° F</td>
<td>-18° F</td>
<td>32%</td>
</tr>
<tr>
<td>KAc (Potassium Acetate)</td>
<td>-15° F</td>
<td>-76° F</td>
<td>50%</td>
</tr>
<tr>
<td>Blends</td>
<td>Talk to supplier</td>
<td>Talk to supplier</td>
<td>Talk to supplier</td>
</tr>
<tr>
<td>Winter Sand/Abrasives</td>
<td>Never melts -- traction only</td>
<td>Never melts -- traction only</td>
<td></td>
</tr>
</tbody>
</table>
Melting Rates - NaCl

Temperature in Degrees F

Pounds of Ice Melted Per Pound of Salt
Phase Chart for NaCl

Phase Diagram for Salt

- **Melting Occurs**
- **Freeze Point**
- **Too Little Salt Refreezing Occurs**
- **Too Much Salt Refreezing Occurs**
- **Eutectic Temperature of Salt**
- **Too Cold Refreezing Occurs**

Temp. (°F) vs. Temp. (°C)

Solution Concentration (% by Weight)
Phase Charts

Phase Diagrams of Five Brines

Possible Refreeze!

Active Melting

NaCL

MgCL

Over Application

DOS
When spread down the center of the road, only 70% of the rock salt stayed on the road, and 46% stayed in the center of the road.
When spread down the center of the road, 96% of the solid NaCl pre-wet with CaCl$_2$ stayed in the road, and 78% stayed in the center of the road.
Pre-wetting Benefits

• Higher levels of service
  – Starts melting faster
  – Melt 10-25% more ice with less material
• Less bounce and scatter
• More environmentally responsible
• More cost effective
This is WHY you need to Pre-Wet Salt

• Comparison of bounce and scatter, dry and prewetted salt

<table>
<thead>
<tr>
<th>Percent remaining on the road after traffic</th>
<th>Dry Salt</th>
<th>Wetted Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 vehicles at 38 mph</td>
<td>30%</td>
<td>93%</td>
</tr>
<tr>
<td>100 vehicles at 38 mph</td>
<td>15%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Source: Michigan DOT
Brine Film Maintenance

• Precipitation dilutes brine, and increases freeze point
• Plowing removes brine soaked in snow
• Bond formation minimized
• Usually need to reapply during storm to keep adequate film on the road
• Reapplication at lower than initial rate
What’s Really Happening?

1. Salt is spread on the ice or snow packed surface
2. Salt melts through the snow or ice forming a brine
3. Remaining snow or ice floats on the brine, breaking its bond with the road surface
4. Vehicular traffic breaks through the surface, reducing the snow/ice to plowable slush and moving it to the road side
What is in the future for Snow and Ice Operations?

- Closed Loop Ground Speed Material Controllers
  - Can save 30-50% of materials spread
- Mandatory Pre-Wetting Materials
  - More efficient use of materials
  - 30% Savings
- Integrate New Technology with Operations: GPS/AVL; Loader Scales
Snow and Ice Tool Box

- Accurate Weather Forecasts
- Pavement Temperature Sensors
- RWIS Stations (stationary & portable sites)
- Materials – Salt, Pre-Mix and Liquids
- Equipment – Spreaders, Plows etc.
- Personnel – Supervisors, Foremen, Operators
- Your Eyes are a very important tool to use.
Tow Plow!

Currently have 17 across the Commonwealth!
BrineXtreme
Brine Maker and Blending Unit
Non-Intrusive friction meters
Segmented Plow Blades
The 3 Ts

• **Timing is everything!**
  – Be prepared

• **Trust Technology**
  – New Gadgets do work

• **Training is essential at all levels**
  – Train operators as well as consumers

• **And be open to new ideas**
It Will Snow!

QUESTIONS?