Material Application Methodologies Guidebook

Prepared by

WASHINGTON STATE UNIVERSITY

Prepared for

CLEAR ROADS
research for winter highway maintenance

PREFACE & CONTENTS

Preface

Winter road maintenance materials and application methods have significantly improved in the last 10–20 years due to advances in the science and technology related to materials, equipment, and weather forecasting. This guidebook will aid superintendents and supervisors in determining the most sustainable and effective material types, application timing, methods and rates for the particular snow and ice conditions they encounter. Additionally, operators can refer to the single-page handouts that are provided for guidance. This guidebook is based on best practices from interviews with state and local agencies.

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1. INTRODUCTION

Keeping roadways safe and usable during winter weather by effective snow and ice practices is the most important function of many state, local and special authority transportation agencies. Timely plowing and proper application of selected deicing materials and temporary traction-enhancing abrasives improve safety and mobility during winter storms.

One of the keys to effective snow and ice control materials application is to apply the right amount of materials, in the right place at the right time.

These materials are primarily used to prevent snow and ice from bonding to the pavement or provide temporary traction; they also help break up the snow/ice remaining after plowing. The purpose of this guidebook is to provide best practices for materials and their application.

In determining what materials to use and when, winter road maintenance managers and supervisors must consider various factors such as timing and rates of material applications, levels of service, road and weather conditions, cycle times, traffic, material cost and availability, environmental concerns, and corrosion to fleet and infrastructure.

Pavement Condition Definitions for Level of Service Considerations

Different Levels of Service are depicted showing "best" or "highest" on the left (bare pavement) and minimally acceptable for low-volume streets and roads on the far right (plowed with navigable snowpack remaining).

Bare Pavement | **Bare Wheel Paths** | **Plowed & Treated** | **Plowed to Snowpack**

Source: Minnesota LRRB Snow & Ice Control Guidebook (link)

1 INTRODUCTION

Material Application and Level of Service

- Level of service (LOS) is a policy decision; performance goals are based on expectations of the traveling public, formalized by the agency and approved by the governing body. LOS decisions are a set of operational guidelines and procedures that establish the timing, type, and frequency of required treatments.
- LOS policies are usually directly tied to the **priority** ranking of streets, roads and highways. This is typically based on the classification by **traffic volume and importance.** Customer expectations or travel speed may also impact LOS.
- **Roads with higher LOS typically require more materials and equipment** to achieve bare lanes.

Application rates will be discussed later in this document.

Level of Service Options	
Option 1 (easier to define)	**Option 2 (preferred, but more difficult)**
Define Actions/Level of Effort Required	**Define Results/Pavement Condition**
Define the level of effort (plowing and material application) for a specific road classification before, during and after a winter event. **Examples:** LOS A route: plow continuously, apply chemical as needed to prevent snowpack. LOS B route: plow continuously between 4 am – 10 pm, apply chemicals to keep snow workable and minimize bonding but don't attempt to melt all snow or keep highway wet. LOS C route: plow between 4 am – 10 pm, longer plow routes, apply materials at spot locations (intersections, curves, hills, bridges), keep road navigable.	Define the desirable pavement condition for a roadway segment at specific times during and after storms and adjust the response (plowing and material application) based on the desired pavement condition and winter storm type. **Examples:** LOS A route: bare pavement during storm 75% of time and within 3 hours after a storm. LOS B route: travel at safe speeds during a storm and bare pavement within 3 – 6 hours after a storm LOS C route: passable during a storm and bare pavement 9 – 36 hrs. after a storm.

2. WEATHER EFFECTS

It is important to understand when to best use liquids and when to use solid materials or the combination. Deicing chemicals have different effective temperature ranges and the snow density/water content affects the dilution speed.

Climatology is important for determining how much, where and what materials to stockpile before winter. Geography influences the length and severity of your locale's winter. Northern regions and mountainous areas typically have longer winters, greater snow accumulations and lower temperatures than more southern regions and lower elevations. Nonetheless, any area may experience an unusual severe winter. It's important to **understand the range of typical and extreme winter conditions for your locale**. Experience, research and a knowledge of local topography and conditions are valuable in formulating strategies for dealing with any foreseeable situation.

Road weather determines material use during a storm (when to start, what to use, how much to use). Critical road weather parameters that affect material application are:

- pavement temperature: (which can be significantly different than air temperature)
- precipitation type and intensity.

Pavement Temperature: Pavement temperature and trend (rising or falling) is a critical factor in deciding what materials to use and when. It is important to understand that pavement temperatures can differ significantly from air temperatures.

- Pavements tend to cool and warm at a slower rate than air.
- Pavements and the sub-bases are warmer at the beginning of a winter season, and cool as winter progresses. Conversely, in late winter, and during occasional "false springs," the air may be warmer than the pavement causing frost to come out of the ground making it difficult to clean pavements.
- Sunlight heats up asphalt pavement faster than concrete pavements. Concrete pavements tend to stay colder longer.

How to measure Pavement Temperature

- There are many different methods and ways of measuring pavement temperatures. Truck mounted pavement sensors are the most common and essential tools. Other types of pavement temperature devices used include pucks embedded in pavement, infrared sensors mounted on roadside poles or towers, and subsurface temperature probes. Pucks measure temperature at the pavement surface, which may be under snow or ice. Infrared, non-contact sensors report surface temperature, which may be bare pavement surface or surface of snow, ice, or water. Subsurface temperature is an indicator of temperature trends and is used to help in forecasting pavement surface temperature. To ensure materials are applied at the proper time and rate, managers and operators need to know the pavement temperature. Some agencies have one type, while others have a combination of all of the above.

Pavement Temperature Measuring Devices

Sources: Vaisala (top left and bottom right), Champion Industrial Equipment (top right), Boschung America (bottom left)

Weather Forecasts:

An accurate and site-specific weather forecast is essential to determining the best course of action. Without knowing the potential type, timing and intensity of a winter event, agencies cannot properly plan and execute the most effective strategy and tactics to achieve desired results. Failure to implement preventive operations in a timely manner may result in the formation of frost, black ice, snow pack (snow bonded to the pavement surface) or ice.

- **The importance of knowing precipitation type and intensity:** Winter precipitation can be classified as rain, freezing rain, sleet, frost, flurries, snow, etc. Combinations may also occur such as rain/sleet and rain/snow. Various state DOTs and local public works agencies use different cut-off values for light–moderate–heavy snow. The definitions of winter storms based on precipitation type and intensity for this Guidebook are at the right. Other definitions can be obtained from the National Weather Service; www.weather.gov.

Winter Storm Type
Light Snow
<1 inch/hour, <4 inches in 24 hrs., visibility >½ mile
Moderate Snow
1–2 inches/hour; 4–8 inches in 24 hrs. visibility ¼ – ½ mile
Heavy Snow
>2 inches/hour; >8 inches in 24 hrs. visibility <¼ mile
Freezing Rain
Supercooled rain that freezes when it contacts any surface below 32°F
Other:
Frost, flurries, freezing fog, blowing snow

Winter Severity Index and Micro-Climates: Clear Roads Winter Severity Index shows the general variation in winter severity across the continental US. Within each zone, certain locales may experience more or less snow and ice depending on proximity to large bodies of water (i.e., lake effect snow showers) and sharp differences in elevations. Winter severity index is useful as a planning tool or financial analysis of post-season costs. River valleys, high hills, mountains and wide-open land all create micro-climates that may lessen or exacerbate the severity of a particular event. Micro-climates affect material application during particular routes and storms.

2 ROAD WEATHER

Current and Forecast Weather Resources: The **National Weather Service** (NWS) is the primary free source for comprehensive forecasts and current conditions, especially radar and satellite imagery.

Many agencies use private weather services for site-specific, precise forecasts coupled with alerts and notifications. Forecasts are subject to change as conditions may evolve as a storm approaches. These changes are reported to supervisors by the following:

- Custom Reports
- Pavement Forecast
- E-Mail Alerts
- Phone Calls/Texts

Television and the Internet are also good sources for local weather.

Key components of a useful weather report:

- *Expected temperatures rising or falling*
- *Snowfall type, rate and intensity*
- *Timing of the event*
- *Expected duration is critical for storm planning.*

NWS and local sources do not provide pavement temperature information; thus RWIS is extremely valuable.

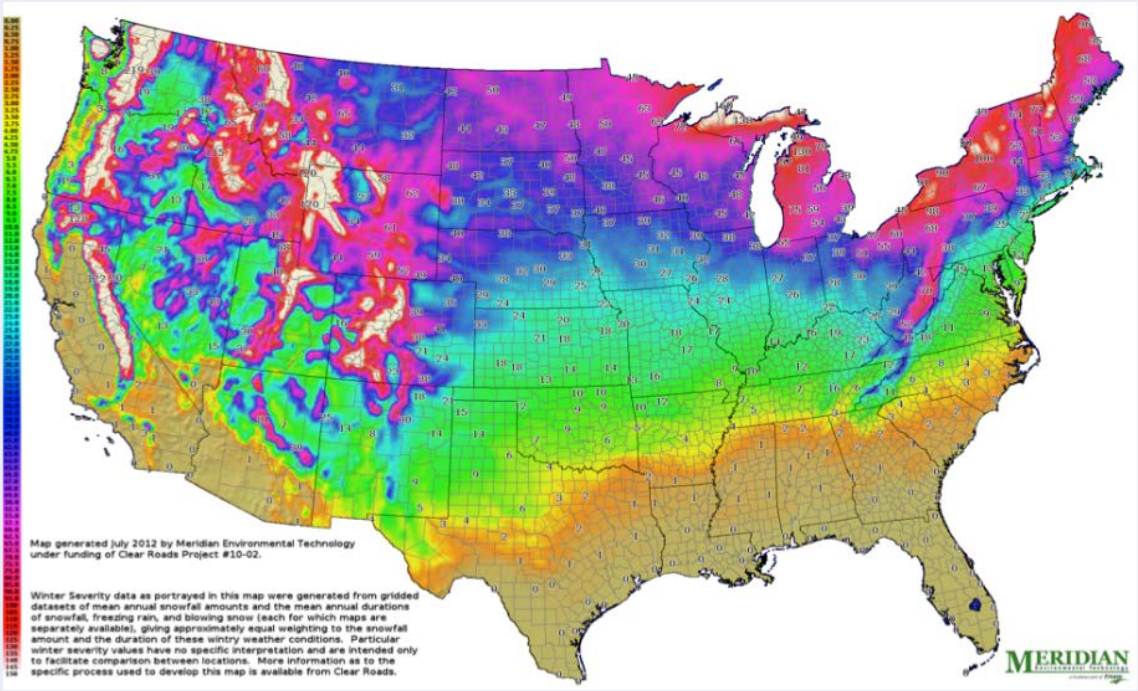
Road Weather Information Systems (RWIS): Most state agencies have RWIS

towers located strategically throughout their roadway system. RWIS information is valuable in storm operations as it provides: *air and pavement temperature, humidity, wind speed and direction, precipitation rate, and pavement salinity in real time.*

RWIS station cameras give visual confirmation of precipitation type, intensity and travel conditions.

Clear Roads color-coded winter severity map (below) illustrates the typical greater winter severity in mountainous and northern regions. The color scale on the left of the map has mild severity on top and increasing severity going down. Several mountain ranges are evident (Cascades, Sierra Nevadas, Rockies and Appalachians), as well as areas of many states (Minnesota to Maine) affected by the Great Lakes. Additionally, 28 state-focused versions of winter severity maps are also available from Clear Roads (http://clearroads.org/project/14-08/).

Clear Roads Winter Severity Index Map (Meridian, 2012)



Source: Clear Roads

OPERATOR HANDOUT

Know your winter weather
● Understand winter weather basics: how and when storms form and what direction they usually come from.
● Be familiar with the typical seasonal precipitation types, normal storm patterns, chronic trouble spots and the usual material applications for specific conditions in your area.
● Use several reliable sources of weather information.

Weather Forecasting
● Keep informed of weather forecasts; begin planning 48-72 hours ahead.
● Stay aware of changing predictions as storm nears and begins.
● Learn how to “read the radar.”
● Be alert to unexpected changes in the storm type, intensity, movement and duration and adjust operations as needed.
● RWIS provides spot-specific data, especially vital for problem locations such as bridges, curves, steep grades.

Road Weather & Pavements
● Current and trending (rising or falling) pavement temperature is a critical factor in deciding what materials to use and when.
● Pavement temperature can differ significantly from air temperature. Use infrared temperature sensors mounted on side mirrors to know real-time pavement temperature on your route.
● Know how relative humidity affects hygroscopic liquid materials (e.g., mag. chloride and calcium chloride).
● Pavement moisture may accelerate the melting rate of certain dry materials.
● Rough pavement, steep grades and cross-slopes may benefit from different material types than smooth pavements.

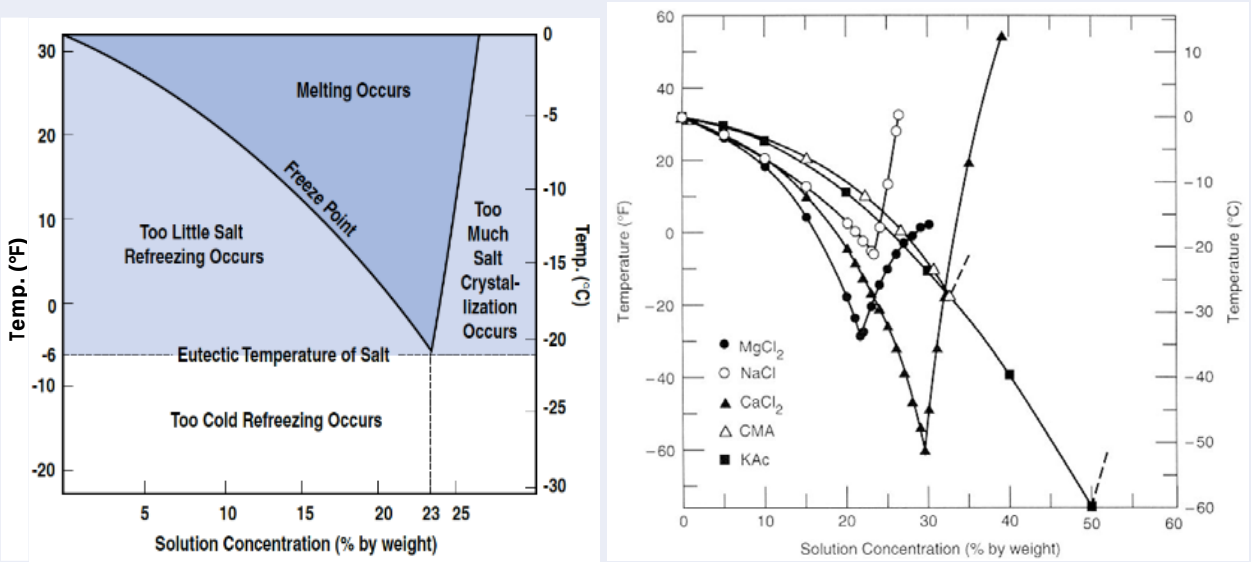
3. MATERIALS USED FOR WINTER OPERATIONS

Salt has been used for snow and ice control in the United States since at least the 1930s. Salt is the most widely used deicing material because of its availability and low cost. Other deicers include: calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) plus Agro-based additives (proprietary products derived from beet, corn, cheese, beer brewing, etc. by-products), and used for a limited purpose, potassium acetate (abbreviated as KAc) and calcium magnesium acetate (CMA).

The newest trend is to blend multiple chemicals to adjust to specific temperature and locations needs, such as adding either $CaCl_2$, $MgCl_2$, or Agro-based additives to a 23.3% NaCl brine.

The following phase diagrams indicate how specific chemicals work. It is important to understand–how the Dilution of Solution (DOS) affect the performance of the applied chemicals.

Phase Diagram of Winter Chemicals
Left: NaCl with melt/freeze regions; Right: Chloride and Acetate Deicers



Source: Left, Salt Institute Snowfighter's Handbook (link) and Right, FHWA Anti-Icing Manual (link)

Chemistry of Deicers: A phase diagram shows the freezing-point temperature vs solution concentration, highlighting when melting occurs and when ice or salt crystals form. Eutectic temperature is the lowest freezing point of a solution. The lowest practical or effective temperature is not shown on phase diagrams, but is based on a consensus of field experience. When choosing chemicals to use in winter operations it is critical to understand how they work and how they will integrate with your operations. Just because a chemical has a low eutectic temperature does not necessarily mean it's the best chemical for your operations.

Solids

The most commonly used solid deicer is road salt (NaCl). Abrasives are also common, particularly in rural areas. The hidden costs of using abrasives have been widely publicized in the last few years. The environmental impact of abrasives has caused many agencies to reduce usage. Abrasives can be used on unpaved roads but on paved roads, accumulated abrasives can clog drainage systems, impact water bodies and create airborne particulates and dust.

Additionally, abrasives create poor riding surfaces, increase drainage system maintenance, decrease pavement markings visibility, increase frequency of sweeping operations and "Street Sweeping Disposal" costs.

Solid $MgCl_2$ and $CaCl_2$ are expensive and require special storage and handling, making them impractical. Sodium acetate and sodium formate are commonly used on airport runways, but not on roads, primarily because they are more expensive than salt.

Solid Materials

Salt, sodium chloride (NaCl) — Lowest Effective Pavement Temperature 15 to 18°F

- Rock salt is the most commonly used deicer. The primary advantage of NaCl is its abundance and relatively low cost (purchase price ranges from $34 to $160, averaging about $75/ton, depends significantly on local availability and transportation costs).
- It can be used with or without additives.
- Agencies that use abrasives often mix in some salt (typically 5–10% but as high as 1:1) to keep the stockpile free-flowing and, at higher mixing rates, help de-bond snowpack. If mixed in a stockpile the pile should be covered to prevent leaching out of the NaCl into the groundwater.
- NaCl alone is generally ineffective when the pavement temperature is below 15°F, but if pre-wet with $CaCl_2$, $MgCl_2$, Agro-based blends or other enhanced brines it may still be cost-effective to use salt below 15°F.
- Most salt used for deicing is mined (aka: rock salt) or dried (aka: evaporated salt or solar salt).
- Untreated and treated salt products are available.

Source: left: Rock salt mine (Morton Salt), right: MnDOT salt storage

Calcium Magnesium Acetate (CMA) –Lowest Effective Pavement Temp. 20 to 23°F

- CMA was tried by several agencies in the 1990s when it was first developed as an alternative to salt to reduce corrosion and environmental concerns.
- It is not frequently used now because of its high cost and limited effectiveness.
- Typically requires 50% more by weight than salt for CMA to achieve the same LOS, and it performs poorly in thick accumulations of snow and ice and/or when the temperature is below 23°F (-5 °C).

Abrasives/Winter Traction Sand

- Abrasives such as sand, fine gravel, or cinders provide only temporary traction improvement. They are inert and have no chemical ability to melt snow or ice.
- While abrasives have the lowest purchase price of all materials---at around $10–20/ton---sand is heavier than salt and normally applied at higher rates, so spreaders can't travel as far with a load.
- Crushed or angular particles are most effective for enhancing traction. Abrasives larger than 1/2 inch may damage motor vehicles and injure pedestrians if not applied properly.
- Abrasives have limited effectiveness, particularly when applied at high speeds or on roads with speed limits above 45 mph because they quickly bounce and scatter to the side of the road.

Source: Winter sanding on Montana highway (MDT)

- Abrasives should be pre-wetted with liquid material (salt brine, $CaCl_2$, $MgCl_2$, Agro-blends or enhanced brines) at 6–8 gallons per yard to help abrasives embed onto snowpack and remain longer.
- Consider using abrasives only at very cold temperatures (below 10–15°F) when salt is less effective.

Deicing Liquids

Deicing liquids are commonly used on roads before and during a storm event (anti-icing strategy). Pretreatment is defined as spraying liquid or spreading solid deicer materials prior to or at the immediate onset of a storm. Pre-wetting is the act of spraying liquid deicing chemicals onto salt or abrasives and sometimes onto the stock pile. Treatments at the end of a storm to melt thin layers of ice/snow can be either a brine or a solid deicer. Use of liquids for winter maintenance has increased dramatically over the last ten years.

Proper selection and application of deicing liquids can reduce the amount of chlorides used thereby allowing agencies to be more environmentally responsible while saving money and time.

Advantages: Prevent snow and ice from bonding to pavement, reduce bounce & scatter of solids, helps solids work quicker, helps abrasives/sand embed into snowpack, improves cold-temperature performance of salt, lower overall material costs, and reduce environmental impacts. Make agencies more responsive.

Disadvantages: Potential for re-freeze because of Dilution of Solution (DOS), require specialized equipment (liquid applicators, on-board pre-wetting systems, storage tanks, etc.), windy conditions may cause dry snow to stick to pavement surfaces instead of blowing across, and excessive applications may create slippery pavement.

Liquid Deicers

Salt Brine, sodium chloride (NaCl)
Eutectic -6°F, 23%, Lowest Effective Pavement Temperature 15 to 18°F

- Most common liquid deicer and typically lowest cost ($0.10–$0.25/gallon), although additives to reduce corrosion or improve performance can increase cost.
- Can be purchased as liquid or made locally with solid salt, water, and brining system.
- When used for anti-icing it usually dries out, leaving a visible, harmless, white residue/powder on the road surface.
- Most practical liquid for areas with winter storm temperatures generally above 15–20°F.
- Regions with colder winters tend to use $CaCl_2$ or $MgCl_2$, although they may also use NaCl if space, equipment and budgets can accommodate multiple liquids.

Source: Iowa DOT brine maker; liquid tanks at Butler County Engineer's Office

Calcium Chloride ($CaCl_2$)
Eutectic -60°F, 30% — Lowest Effective Pavement Temp. -17 to -20°F
Magnesium Chloride ($MgCl_2$)
Eutectic -28°F, 22% — Lowest Effective Pavement Temp. 5 to -4°F

- $CaCl_2$ and $MgCl_2$ are more effective than NaCl, due to their ability to attract moisture and stay on the road.
- Costs for $CaCl_2$ and $MgCl_2$ vary significantly, but in general are about $1/gallon.
- $MgCl_2$ is more corrosive to (and more difficult to wash off) automobile components than NaCl. $CaCl_2$ is also very corrosive to metals and caustic to skin.
- Both $CaCl_2$ and $MgCl_2$ cause damage to concrete through long-term chemical reactions but may cause less freeze-thaw physical damage to concrete than NaCl.
- $CaCl_2$ and $MgCl_2$ should not be applied to warm pavement (above 28°F); at high humidity levels they can attract too much moisture and at low humidity levels they can slowly transition to a slippery phase. Conditions can be particularly unsafe at the beginning of winter when more oils and debris may be on the road.

Agro-Based Deicers (Additives) — variable effective temperatures

- Agro-based deicers are always used in conjunction with chloride-based chemicals and have several benefits: reduces corrosion, improves adherence to the road surface, provides longer residual effectiveness after plowing, and lowers the freezing point of salt brine.
- There is a variety of sources/agro-components, such as beet juice, corn syrup, de-sugared molasses, cheese-production and beer brewing by-products.
    - Check with Clear Roads website for products on the approved products list http://clearroads.org/.
- Cost is variable, as well as percentages blended into chloride brines.
- Get references or find other agencies that have used agro-based additives for specific information about temperatures and application rates.
- Combining agro-blended brines with NaCl brines can make the product more versatile by lowering the overall freezing point.
- The ice melting capability of agro-based products varies widely and is typically not significantly greater than NaCl. They generally are not selected for their ice-melting capacity, but rather their ability to prevent snow–pavement bond and speed activation of solid salt.
- Caution-- Environmental Impact: As they biodegrade in water they can lower the oxygen levels (biological oxygen demand, BOD) – do not use near water during low-flow conditions. New products with lower water quality impacts are being developed.


Source: Agro-brine (beetjuicesalt.com); Lincoln, NE Agro-brine (roadsbridges.com)

Potassium Acetate (KAc)
Eutectic -76 °F, 50% — Effective Temp -15 °F

- Potassium acetate is more commonly used on airport runways than on highways.
- It is much more expensive than NaCl, $CaCl_2$ or $MgCl_2$. Because of its cost it's not an effective deicer for large road systems.
- On roads it is usually only used in special situations, such as new concrete bridge decks or in Fixed Automated Spray Technology (FAST) systems.
- Research indicates a greater negative impact of acetates than initially perceived, especially damage to asphalt and concrete pavements, structures and water quality.

Pre-Wetted/Pre-Treated Solids

Adding liquid deicers to coat solid materials (salt or abrasives) is called pre-wetting; it is most commonly done with pre-wetting systems on spreader trucks.

Pre-wetting truck

Source: Polk County Highway Department

On-board systems consist of tanks, pumps, hoses and nozzles. Many agencies have purchased kits to retrofit spreaders or included systems with newly purchased vehicles. Though on-board prewetting is the most effective method, pretreated solids can be purchased from vendors or dry material can be pre-treated at the stockpile. Pre-wetting can also be applied while loading spreader trucks during operations.

Pretreated Salt

Source: Southshore Landscape Supply (left), Nate's Landscape Company (right)

Advantages: Can reduce application rates compared to dry solids, 30% reduction in bounce & scatter of solids (Michigan Study, https://freshwater.org/wp-content/uploads/2013/02/Tim-Croze.pdf), helps salt work faster, helps abrasives/sand embed into and remain longer on snowpack, improves cold-temperature performance of salt.

Disadvantages: Requires purchasing and storing liquids. Requires solids to be covered and stored properly. May require specialized spreading equipment.

Pre-Wetted Solids
Pre-Wet Salt
o Pre-wetted solids will have reduced bounce and scatter effect and work faster than dry solids as the liquid deicer provides the liquid needed to initiate the ice melting process. o Michigan test demonstrated 80% of pre-wetted salt remained on a road surface after 100 vehicles at 38 mph, while only 15% remained for dry salt. Pre-wet solids last longer for low-speed traffic as well. o In theory, prewetting liquid needs to just coat the surface of the solid material, the amount depends on the gradation of the material. o The typical prewetting rate ranges from 8 to 12 gallons per ton of dry material, with 10 gal/ton being the most common. o It is critical for proper calibration be done each year (chapter 7). It should be checked periodically during the season, especially when new solid material is delivered, as the gradation specifications for salt and sand can vary. o High pre-wetting liquid-to-solid application rates (over 30 gal/ton) mixed with fine salt (crushed before loading spreader or use on-board slurry generator) create slurries with the consistency of oatmeal and can work even faster than conventional pre-wet salt. o Many manufactured, pre-treated rock salts are available to improve performance below 15°F and/or reduce corrosion; they are typically colored (blue, reddish, etc.)
Pre-Wet Abrasives
o Prewetting abrasives reduces bounce and scatter and helps sand embed into the packed snow/ice surface to provide longer-lasting traction improvements. o However, it is important to use the appropriate liquid-to-solid application rate. No more than 10 gal/ton is recommended to prevent abrasives from melting too far into snowpack and no longer able to provide tire traction. Excessive liquid can also create potholes in the snowpack.

OPERATOR HANDOUT

Liquids
● Salt Brine, 23.3% NaCl Best choice for temperatures above 20°F
● Calcium chloride or Magnesium chloride brine: 32% $CaCl_2$ or 26% $MgCl_2$: Use one of these products at temperatures below 20°F to pre-wet solid salt or abrasives
● Agro-based additives: Many different agricultural-by-products are processed for use as a deicer additive Helps brine stick to road longer and provides longer-lasting residual benefit Usually requires monthly agitation of storage tanks Can be more viscous and more difficult to use, especially at colder temperatures, potentially clogging filters and nozzles in spreader trucks
● Potassium acetate, 50% KAc: Most expensive liquid product, but more concentrated and lowest effective temperature Best for new concrete bridge decks and specialty locations (FAST Systems)

Solids
● Salt Most common solid material used Most effective above 15°F Below 15°F mix in $CaCl_2$ or $MgCl_2$ solid or pre-wet with $CaCl_2$, $MgCl_2$ alone or combined with agro-based liquids
● Sand: Most common solid material used at temperatures below 15°F or when salt is not effective

Pre-Wetted Solids
● Prewet salt to reduce bounce and scatter and speed effectiveness of salt
● Most common pre-wetting rate is 10 gal/ton
● Use higher pre-wetting rates to speed up effectiveness. 20–30 gal/ton is still considered prewetting. At above 30+ gal/ton considered salt slurry
● Pre-wet abrasives to reduce bounce and scatter but do not apply too much liquid or the abrasives will melt too far below the snow to be effective

4. MATERIAL APPLICATION STRATEGIES

Various material application strategies are employed by agencies for maintaining safety and mobility during winter events. Depending on weather conditions, site-specific factors, and LOS goals, an agency's decisions should consider one or many methods and materials. There are two distinct material application strategies that make use of chemicals: anti-icing and deicing. They differ in their fundamental objectives; anti-icing is conducted to prevent the snow and ice from bonding to the road surface, whereas deicing is a reactive strategy in which chemicals are used to break the existing bond between pavement and snow/ice. Both strategies can use dry, pre-wet or liquid products to varying levels of effectiveness.

Anti-Icing

Source: Ontario Ministry of Transportation

Deicing

Source: Virginia DOT

Another common tactic used during winter storms is the use of abrasives when increased traction is necessary at very low temperatures on existing bonded snow and ice.

Sanding

Source: Montana DOT

Anti-icing Strategy

Anti-icing begins with the application of materials before a storm and continues during the storm in conjunction with plowing to prevent snow/ice from bonding to the pavement.

Anti-Icing Strategies
Before the storm:
o Anti-icing with liquids is the preferable method, but if rain is anticipated before snow, it is better to use pre-wet solids. (Caution: spreading granular salt on high speed roads will result in material blowing off road). Dry solids should not be applied to dry roads. o Pavement temperatures should be at least 15 °F (-9°C) if using liquids. o For colder pavement temperatures, use pre-wetted solids. o Anti-icing with liquids can be performed 24 to 48 hours before snowstorms, and ideally during non-disruptive, non-overtime hours to minimize costs. o Anti-icing with liquids is useful to prevent frost/icing/black ice situations. o As salt brine dries out, it leaves a white coating on the road. o $MgCl_2$ and $CaCl_2$ are hygro-scopic chemicals that attract moisture with the potential to make roadways damp. Application rates are critical and early-season applications may result in slippery conditions. Attention must be paid to humidity and dew point. Rising humidity levels can increase chances of slippery conditions. o Don't anti-ice with liquids if snow is blowing or drifting across the road because liquids will cause the snow to stick to the pavement.
During the storm
o Depending upon the particular conditions, subsequent applications of materials may be needed throughout the event to prevent snow/ice bonding to the pavement. o Using liquids *during* snowstorms is referred to as Direct Liquid Application (DLA), and can reduce overall material use and provide high LOS, but should only be used under specific conditions, such as temperatures above 25°F, less than ½" per hour of

snowfall and cycle times about 1.5 to 2 hours. Please refer to Clear Roads Research Project "Liquid Only Routes" for guidelines. http://clearroads.org/completed-research/

- For long lasting brine on roadways most agencies use coarse-graded salt. Fine-graded salt is generally used more often for anti-icing applications.
- Fine-graded salt dilutes faster and requires more frequent applications to prevent refreeze. It is more suitable for thin ice and frost prevention.

Deicing Strategy

Deicing is needed when snow or ice has already bonded to the pavement surface and remains after plowing. Deicing should be performed at temperatures above 15°F. Below 15°F, deicing may be conducted but material applications should be pre-wetted with chemicals like $CaCl_2$ and $MgCl_2$. Applications may be higher at cold temps due to the lack of available moisture.

Deicing
o Plowing should remove as much snow or loose ice as possible before applying materials, otherwise the snow will dilute them and decrease its effectiveness.
o Deicing with solid chemicals is more effective on heavier snow accumulations than liquid applications. Liquids have limited penetration ability and should not be used unless combined with solid chemicals.
o Heavy snowfall rates and long duration events will require deicing even if anti-icing operations were conducted before and during the storm.
o Deicing with liquids can be used on thin snow/ice if an event is tapering off and strong sunlight for at least several hours can provide a "finisher" to help roads dry.

Sanding Operations

Use of abrasives is still common in rural and less populated areas. Many states have transitioned from Sand-Priority programs to Salt-Priority programs. Agencies typically must mix some salt into sand stockpiles to keep them workable. It is important to comply with environmental mandates and regulations by covering mix stockpiles. Research shows that wet salt will leach out of uncovered stockpiles and contaminate groundwater.

Sanding
o Untreated sand provides minimal, only short-term traction improvement. o If placed on dry pavements, abrasives will bounce and scatter and be crushed by traffic. Most of material applied will be blown away from the wheel paths making it ineffective. It will also cause air pollution (PM-10) and clog storm drain systems. o Abrasives are temporarily effective when placed on packed snow or ice, but at warm temperatures it can be pushed below the surface by traffic. o When used at very low temperatures, abrasives should be pre-wetted with $MgCl_2$ or $CaCl_2$. o Abrasives should primarily be used at intersections, bridges, and curves, or for spot treatment where additional traction is needed. o Applications of abrasives create several post-storm environmental concerns, air pollution from the crushed particles and pollution of waterways from residue washed into storm drainage systems. o Ideally, to minimize impacts, roadways would be swept after each snow and ice event, but this may not be feasible. Every agency should sweep and collect waste to reduce environmental impacts, ideally during warm spells throughout and at the end of the winter season.

OPERATOR HANDOUT

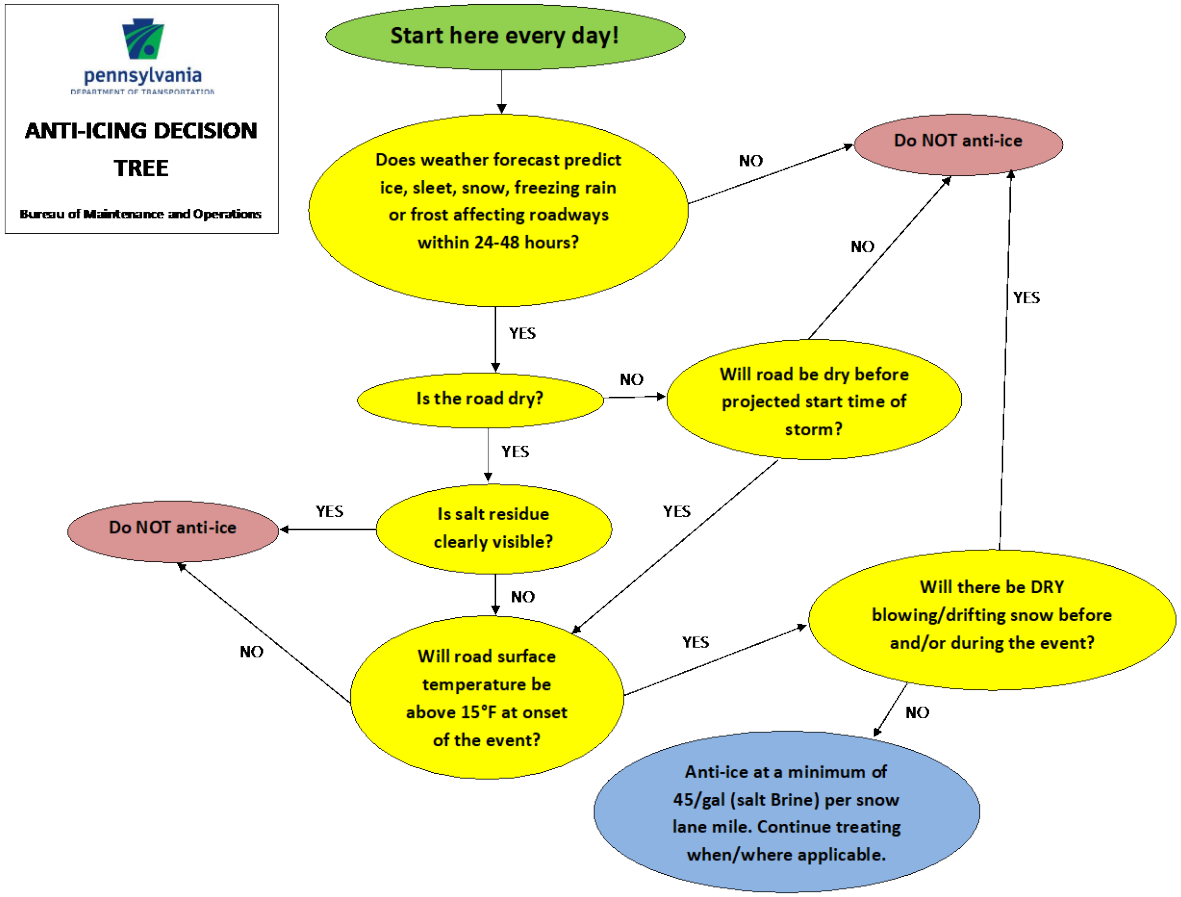
Anti-Icing Do's and Don'ts
● Do anti-ice when pavement temperatures are above 20 °F.
● Don't anti-ice if rain is anticipated before snow.
● If freezing rain or sleet is anticipated, anti-ice with pre-wet solids (do not use liquids).
● Use pre-wet or dry solids during moderate or heavy snow, sleet and freezing rain — do not use liquids during these conditions.
● Don't anti-ice on roads where wind causes blowing and drifting snow — liquids will cause the snow to stick to the road. Watch for these conditions when snow is present next to the road and wind speed is 15+ mph.

Deicing
● Plow first to remove as much snow accumulation as possible, then chemicals can be applied to the remaining snow to break the snow–pavement bond.
● Allow time for solid deicers to work (penetrate and undercut snowpack) before returning to plow. As a general rule, wait at least 30 minutes above 15°F and at least 90 minutes at below 15°F.
● Higher application rates are needed for longer cycle times, heavier snowfall and colder temperatures. Lower application rates can be used with shorter cycle times and lighter snowfall.

Sanding
● Abrasives are primarily applied on low-speed, low-volume snow-packed and icy roads and intersections. They are more common in rural areas, but may be used in urban areas when pavement temperatures are too low for chemicals to be effective
● As sand weighs more than salt and is applied at higher rates, fewer lane miles can be treated with a single load. This sometimes causes deadhead return trips.

Pre-wetting
● Pre-wetting at the spinner is most effective, but if trucks are not equipped, then solids can be pretreated at the stockpile or while loading trucks.

An example flow chart on the best practice of anti-icing can be seen below.



5. MATERIAL APPLICATION RATES

The application rates for deicers depend on a variety of factors, such as pavement temperature, the amount of snow on the pavement, the level of service required, cycle time and deicer type. Some agencies use software, for example MDSS – Maintenance Decision Support System, to determine route-specific application rates based on Federal Guidelines found in FHWA TE-28 project (Manual of Practice for an Effective Anti-Icing Program: https://www.fhwa.dot.gov/publications/research/safety/95202/index.cfm).

Suggested application rate ranges for the most common liquid products (NaCl, $MgCl_2$, and $CaCl_2$) and dry and pre-wet salt are shown in Tables 1 – 4. These ranges are a synthesis of practices derived from guidelines and experiences used by many state DOTs. These states use different cut-off values based on snow intensity and use of liquids below 15 or 20°F.

Use these rates as a starting point, but ultimately use what works for you. However, your rates should vary with temperature, precipitation type and cycle time in the same way as these rates do. In other words, warmer pavement temperatures require much less salt than colder temperatures.

Pre-wetted salt application rates tend to be lower than for dry salt. If using pre-treated salt, then an application rate between the dry and pre-wet rates should be used. Pre-wetting abrasives is recommended as it improves longevity on the road, but does not usually reduce applied amount.

5 Application Rates

Table 1: Application Rate Guidelines for Light Snow (<1 in/hr., <4" in 24 hrs.)

- Use lower end of range for lower LOS or shorter cycle times
- Use higher end of range for higher LOS, longer cycle times, or greater dilution potential
- Plow to remove as much snow or ice as possible before material application
- Abbreviations: lb/LM = pounds per lane mile, G/LM = gallons per lane mile, *NR* = Not Recommended

Pavement Temp. Range, Trend	Road Surface Condition	Material Application					
		Liquid (G/LM)			Solid (lb/LM)		
		NaCl	$MgCl_2$	$CaCl_2$	Dry NaCl	Pre–Wet NaCl	Abrasives (less than 20% salt added)
32°F steady or rising	Dry	*NR*			*NR*		
	Icy patches	20 – 40	15 – 35	15 – 35	120 – 160	110 – 150	*NR*
32°F or below is imminent	Dry (snow forecast)	20 – 40	15 – 35	15 – 35	*NR*	75 – 125	*NR*
	Slush or light snow	30 – 40	15 – 30	15 – 30	140 – 180	100 – 150	*NR*
25 to 32°F, remaining in range	Dry (snow forecast)	30 – 50	20 – 40	20 – 40	*NR*	100 – 125	*NR*
	Light snow cover	40 – 60	20 – 40	20 – 40	160 – 200	125 – 175	*NR*
20–25°F, remaining in range	Dry (snow forecast)	40 – 60	30 – 50	30 – 50	*NR*	125 – 175	*NR*
	Light snow cover	50 – 80	20 – 40	20 – 40	200 – 250	175 – 225	*NR*
15–20°F, remaining in range	Dry (snow forecast)	*NR*	40 – 60	45 – 65	*NR*	175 – 225	*NR*
	Light snow cover	*NR*	45 – 65	45 – 65	250 – 300	200 – 250	500 – 750
0–15°F, steady or falling	Dry (snow forecast)	*NR*			*NR*	200 – 250	*NR*
	Light snow cover	*NR*			*NR*	200 – 250	600 – 750
Below 0°F, steady or falling	Light snow cover	*NR*			*NR*	*NR*	600 – 750

Table 2: Application Rate Guidelines for Moderate Snow (1–2 in/hr., about 4–8" in 24 hrs.)

- Use lower end of range for lower LOS, shorter cycle times
- Use higher end of range for higher LOS, longer cycle times, or greater dilution potential
- Plow to remove as much snow or ice as possible before material application
- Abbreviations: lb/LM = pounds per lane mile, G/LM = gallons per lane mile, *NR* = Not Recommended

Pavement Temp. Range, Trend	Road Surface Condition	Material Application					
		Liquid (G/LM)			Solid (lb/LM)		
		NaCl	$MgCl_2$	$CaCl_2$	Dry NaCl	Pre–Wet NaCl	Abrasives (less than 20% salt added)
32°F steady or rising	Dry	*NR*			*NR*		
	Icy patches	30 – 50	15 – 35	15 – 35	140 – 160	120 – 160	*NR*
32°F or below is imminent	Dry (snow forecast)	20 – 40	15 – 35	15 – 35	*NR*	75 – 125	*NR*
	Slush or light snow	*NR*	*NR*	*NR*	140 – 180	100 – 150	*NR*
25 to 32°F, remaining in range	Dry (snow forecast)	30 – 50	20 – 40	20 – 40	*NR*	100 – 150	*NR*
	Light snow cover	50 – 80	20 – 40	20 – 40	180 – 220	160 – 190	*NR*
20–25°F, remaining in range	Dry (snow forecast)	40 – 60	30 – 50	30 – 50	*NR*	150 – 200	*NR*
	Light snow cover	NR	NR	NR	250 – 300	220 – 260	*NR*
15–20°F, remaining in range	Dry (snow forecast)	*NR*	40 – 70	30 – 70	*NR*	200 – 250	*NR*
	Light snow cover	*NR*	40 – 75	30 – 70	325 – 375	275 – 325	500 – 750
0–15°F, steady or falling	Dry (snow forecast)	*NR*			*NR*	300 – 350	*NR*
	Light snow cover	*NR*			*NR*	300 – 350	600 – 900
Below 0°F, steady or falling	Light snow cover	*NR*			*NR*	*NR*	600 – 900

Table 3: Application Rate Guidelines for Heavy Snow (>2 in/hr. >8" in 24 hrs.)

- Use lower end of range for lower LOS, shorter cycle times
- Use higher end of range for higher LOS, longer cycle times, or greater dilution potential
- Plow to remove as much snow or ice as possible before material application
- Abbreviations: lb/LM = pounds per lane mile, G/LM = gallons per lane mile, NR = Not Recommended

Pavement Temp. Range, Trend	Road Surface Condition	Material Application					
		Liquid (G/LM)			Solid (lb/LM)		
		NaCl	$MgCl_2$	$CaCl_2$	Dry NaCl	Pre–Wet NaCl	Abrasives (less than 20% salt added)
32°F steady or rising	Dry	*NR*			*NR*		
	Icy patches	30 – 60	15 – 35	15 – 35	150 – 180	130 – 170	*NR*
32°F or below is imminent	Dry (snow forecast)	20 – 40	15 – 35	15 – 35	*NR*	100 – 150	*NR*
	Slush or light snow	*NR*	*NR*	*NR*	150 – 200	125 – 175	*NR*
25 to 32°F, remaining in range	Dry (snow forecast)	40 – 60	20 – 40	20 – 40	*NR*	125 – 175	*NR*
	Light snow cover	60 – 90	*NR*	*NR*	225 – 275	175 – 250	*NR*
20–25°F, remaining in range	Dry (snow forecast)	*NR*	30 – 50	*NR*	*NR*	200 – 250	*NR*
	Light snow cover	*NR*	*NR*	*NR*	275 – 325	225 – 300	500
15–20°F, remaining in range	Dry (snow forecast)	*NR*	40 – 70	*NR*	*NR*	200 – 250	*NR*
	light snow cover	*NR*	*NR*	*NR*	300– 350	275 – 325	500 – 750
0–15°F, steady or falling	Dry (snow forecast)	*NR*			*NR*	300 – 350	*NR*
	light snow cover	*NR*			*NR*	400 – 500	600 – 900
Below 0°F, steady or falling	light snow cover	*NR*			*NR*	*NR*	600 – 900

Table 4: Application Rate Guidelines for Freezing Rain

- Use lower end of range for lower LOS, shorter cycle times
- Use higher end of range for higher LOS, longer cycle times, or greater dilution potential
- Plow to remove as much snow or ice as possible before material application
- Abbreviations: lb/LM = pounds per lane mile, G/LM = gallons per lane mile, *NR* = Not Recommended

Pavement Temp. Range, Trend	Road Surface Condition	Material Application					
		Liquid (G/LM)			Solid (lb/LM)		
		NaCl	$MgCl_2$	$CaCl_2$	Dry NaCl	Pre–Wet NaCl	Abrasives (less than 20% salt added)
32°F steady or rising	Icy patches	*NR*			*NR*	125 – 175	*NR*
32°F or below is imminent	Slush or ice	*NR*			180 – 240	140 – 180	*NR*
25 to 32°F, remaining in range	Slush or ice	*NR*			200 – 275	180 – 225	*NR*
20–25°F, remaining in range	Slush or ice	*NR*			250 – 350	225 – 300	500
15–20°F, remaining in range	Slush or ice	*NR*			350 – 450	300 – 400	500 – 750
0–15°F, steady or falling	Slush or ice	*NR*			*NR*	*NR*	600 – 750
Below 0°F, steady or falling	Slush or ice	*NR*			*NR*	*NR*	750 – 900

6. EQUIPMENT FOR MATERIAL APPLICATION AND SNOW REMOVAL

New methods and technologies have been developed that improve snow-fighting efficiency. Better equipment can significantly reduce the amount of materials used, cover more roadway and minimize environmental impacts. Thus agencies can improve safety and mobility and reduce overall costs. A complete catalog of material distribution systems is available from Clear Roads (http://clearroads.org/project/12-05/)

Broadcast spreading

Source: New Hampshire Public Radio

The most common method for applying solid materials evenly over roadways is a rear spinner. Some agencies use spinners mounted mid-chassis under the body or side discharge ahead of drive wheels to provide better traction for the spreader truck on snowpack. The objective on most roads is to keep spread patterns tight and near the centerline if melting over the entire surface is not required. The exception is on multilane high-volume roadways. For a freezing rain event or black ice on the road, broadcast spreading is the appropriate pattern for deicing materials. If the entire road surface is snow-covered and deicing is required immediately to improve safety and mobility, salt (and sand if required) should be spread across all traffic lanes.

Applying material in a tight strip, or "windrow', on the road centerline provides a much higher concentration in a limited location. The continuous, narrow windrow of solid or pre-wetted salt is applied by dropping the material from a chute onto the centerline of the road or with a spinner turned off or only slowly rotating. This minimizes the loss of material due to bouncing or blowing off the road by passing traffic. A typical effective windrow pattern is a 4–8-ft strip along the centerline of a two-lane pavement with low to medium traffic volume.

Solid material spreaders

Solid Applicators
Hoppers or V-Box Spreaders
o Often referred to as "V-box" because of its shape viewed from back end. A hopper is inserted into a regular dump body, after the tailgate is removed, and strapped down. o A hopper can also be set on a flatbed or hook-lift truck. The hopper has a rear chute that drops the material onto a disk spinner. o The spinner should be no higher than 12-18" from pavement surface to minimize bounce and scatter and should also have movable flaps. o The hopper is removed and stored between winter seasons. o It can be set up for single or multi-lane application.

Source: Strapped V-Box Slide In (GoodRoadsInc.com)

Tailgate Spreaders

- Primarily for smaller trucks, a tailgate spreader hangs on the tailgate and has hydraulic connections for the spinner.
- Material is fed into the spreader chute by gravity; this requires raising the dump bed.
- Tailgate spreaders are generally less expensive than hopper spreaders

Source: Clear Roads Spreader Catalog (Delaware DOT, Shawano County)

- Rear conveyors or augers feed material to spinners or chutes:

Source: Clear Roads Spreader Catalog (Michigan DOT, Meyer Products)

Dual Dump (All Season Body)

- Functions as regular rear dumping body when not being used to apply winter maintenance materials.
- The dump body can be flat-bottomed or slightly concave with a conveyor in the floor. Removable plates cover the center conveyor when not needed for other work.
- Spinners are attached when the truck is being converted to snow duty. Spinners can be located rear or side.

Source: HI-Way Highway Equipment Company (left) Ontario Ministry of Transportation (right)

GI Body Dump

- Dump tips towards the front and applies material ahead of drive wheels.

Source: Pacific Northwest Snowfighters website

Spinners and chutes

- Spinners are the most common spreading equipment and are often located at the rear of a truck either on one side, in the middle, or both sides. Sometimes they are located behind the cab to provide the truck with better traction.
- Skirts or boots around the spinner are used to reduce bounce and scatter.

Source: Clear Roads Catalog of Spreader Types (Illinois DOT, Iowa DOT)

- Chutes are useful for concentrated, windrow application of salt:

Source: Clear Roads Catalog of Spreader Types (both Iowa DOT)

Liquid and Liquid/Solid Material Spreaders

Liquid and Liquid/Solid Applicators

Liquid-Only

- Single-axle and tandem-axle trucks can be modified to accommodate the liquid tanks and spray bars, which are connected to various nozzles, such as pencil-stream nozzles or a boomless nozzle.
- Liquid applicators can be mounted on trailers, including tow plow trailers.
- The bar and nozzles can be arranged for single and multi-lane applications.
- Baffles should be installed in the tanks to avoid excessive sloshing that can force the vehicle to sway.
- A cab-mounted control system adjusts the pressure according to desired application rates.

Liquid trucks and trailers

Source: Connecticut DOT; Michigan LTAP

Liquid and solid tow plow

Source: Colorado DOT

Pre-wet Systems / Options

- Pre-wetting systems on trucks apply liquid chemical to dry material (solid chemical, abrasives, or salt/sand mix) just as the mix is applied to the road.
- Pre-wetting systems are typically available with tanks either tailgate-mount, hopper side-mount, or mounted in front of the hopper.

Liquid tank mount options

Source: Gregson–Clark (left), Buyers Products Company (right)

- Alternatives to on-board prewetting include pre-treating stockpiles (lower left) or while loading trucks (lower right), pre-wetted materials can also be purchased from vendors.

Pre-treat options

Source: IceBGone website; Connecticut Transportation Institute website

Slurry Systems

- On-board slurry systems feed rock salt by conveyor or auger into a roller mill that grinds the salt into fine particles.
- The material is then sprayed with a brine to create a slurry dispersed by the spinner in a variable pattern. The slurry has quick melting activation and reduces the amount of salt per lane-mile.

Source: Henderson Products website

Snow Removal Equipment and Practices

Plowing snow is a critical component to a good snow and ice operation and improves the use of materials. Removing as much snow and ice by plowing prior to material application allows for faster melting action. Plowing can remove 90% of snow and ice. After materials have had enough time to work, plowing removes any remaining accumulation. Plowing too soon after applying deicing materials is inefficient and wasteful. As a rule, wait at least 30 minutes when temperatures are above 15°F and at least 90 minutes at below 15°F.

The size, shape, composition and functionality of plows and blades provide an extensive range of options to meet an agency's specific needs. Furthermore, advanced cab-mounted controls provide for precise positioning and operation. The following sections briefly describe the general types of plow configurations, combination plow/spreaders, and plowing and spreading practices.

Snow Removal Equipment

Front Plow

- The front-mounted snow plow is the most common type of snow plow used for winter maintenance operations.
- For single-axle trucks, 11' wide plows are most common, tandem-axle trucks often have 12'to 14' wide plows.

Source: Pacific Northwest Snowfighters

- Uni-directional (One Way) plows are shaped so that snow is continually cast to one side (shown in picture above). This tapered configuration, with one end larger than the other is predominantly used in "big snow country" and on high-speed roadways to cast snow further away from the pavement.
- Reversible plows are more rectangular and can be hydraulically positioned to straight, angled right or angled left depending upon the situation.

Wing Plows

- One or two wing plows can be used with front-mounted plows to cover adjacent lanes and push snow further away from the roadway.
- Wing plows are commonly mounted on the right side; some agencies mount wing plows on both sides in addition to front plows. On interstates and multi- lane roads left-side wings are mounted for efficiency.
- Wing plows cover part of an adjacent lane and are useful for cleaning shoulders and benching snow.

Source: Henderson Products website (left), Road Commission for Oakland County (right)

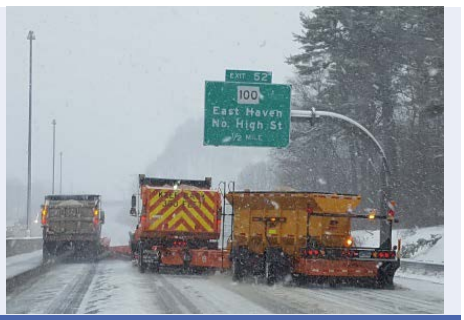
V-Plow

- V-plows can be mounted on trucks, wheeled front-loaders or road graders and are used to cut through very deep snow, especially in more open areas.

Source: US Municipal website

Tow Plow

- Tow plows are trailer-mounted plows towed behind and to the side of a front plow. (Check out YouTube for action video https://www.youtube.com/watch?v=Ya-k42GGJR4)
- Liquid or solid material spreaders (or pre-wet systems with both liquids and solids) are usually applied from the tow plow and the truck to spread across multiple lanes.
- The towing truck, with a front plow and spreader body, typically runs in the far-left lane of a multi-lane freeway or surface arterial; when needed, the operator uses the cab controls to swing the trailer into the adjacent lane. The tow plow needs to be offset so it does not plow away any material spread by the front truck.
- Snow is plowed to the right and moved further aside by one or more following trucks.



Source: Missouri DOT (left), Connecticut DOT (right)

Underbody Plow

Source: Meiren Engineering website

- An underbody plow or scraper is a plow installed under the truck body. It is useful for removing packed snow and ice because of the heavier pressure that is exerted due to the weight of the vehicle.
- Underbody plows may have a smooth or serrated blade and a hydraulically operated extension.
- Underbody plows are more common in colder regions.

Plowing Practices

Plowing & Spreading Practices

Single Truck

- Single-axle, tandem-axle or even smaller trucks fitted with plows and spreader equipment working alone usually on two-lane roads and streets.

Tandem Plowing (Two Trucks in Echelon)

- Tandem plowing on multi-lane arterials and expressways is a very common practice among state and local transportation agencies.
- Two trucks work together on adjacent lanes; the lead truck in the left lane with front plow angled to right (a few use a left-wing plow for the shoulder) and the trailing truck slightly behind also with front plow angled right. Many trailing trucks also deploy a right-wing plow for the shoulder.

Gang Plowing

- Gang plowing is an expanded version of tandem plowing for multi-lane arterials and freeways. Tow plows with liquid or solid material applicators are frequently deployed.

Source: Utah DOT

7. EQUIPMENT MAINTENANCE AND CALIBRATION

Maintaining vehicles and equipment in good working order improves operator safety, comfort and morale. Basic vehicle maintenance includes oil changes, tire rotation, air filter replacement, replacing belts and other vehicle components. Maintenance of application equipment involves routine inspection of valves, spreaders, belts, hydraulics and other components, and replacing/repairing parts as needed. Thorough equipment checks should be conducted daily during the winter season.

Calibrating Solids

Source: Clear Roads Calibration Guide

Also check during operations that spinner or chute is not plugged, that material is coming out of the spinner at the expected rate. More extensive pre-season inspections are vital to ensure vehicles and equipment will be ready well in advance of winter. Post-storm and post-season cleaning/washing is critical to reduce the corrosive effects of deicers.

Calibration and regular re-calibration of equipment is necessary to achieve consistent, precise control of the deicing materials. Over-application or under-application is inefficient, wasteful and often ineffective. Improper calibration can result in a truck over-applying and running

Calibrating Pre-Wetting Systems

Source: Clear Roads Calibration Guide

out of material before reaching the end of its route. “Deadheading” back for another load wastes time, fuel and reduces LOS. Conversely, applying too little due to poor calibration will not achieve the desired LOS thus requiring another trip and reapplication. Likewise, that is costly.

With ground speed controllers, computers and controllers that manage the spread pattern should also be calibrated to match the recommended application rates and ensure proper placement and amount.

For open loop systems, calibration is a must. The two-valve system has control over auger and spinner. When going slow, trucks spread more and when traveling at a faster rate trucks spread less, it is imperative that agencies know “How much is being spread”.

Factory calibrated is not calibrated! Good videos that show the calibration process:

https://www.youtube.com/watch?v=zz3JHC9ZhsA

https://www.youtube.com/watch?v=ilsHluJW-9M

NOTE: Contractors’ equipment must be calibrated to the same standards as agency trucks.

Calibration Benefits & Requirements

Calibration Benefits

- Regular calibration of spreader mechanisms ensures accurate application at all times.
- Uncalibrated or incorrectly calibrated devices that spread excessive material waste money and are counter-productive to agency policies regarding LOS, safety and environmental stewardship.
- The minimal costs of spreader calibration make it one of the most cost-effective ways to optimize material usage.
- Operations managers and supervisors must perform spot-checks during the season to make sure that the units are properly functioning and within calibration specs.
- Post-storm records of material usage for each vehicle should be reviewed to identify any significant deviations from the norm. Possible causes may be that the mechanism needs recalibration, mechanical problems or operator "override."

Requirements & Documentation

- Every spreader unit should be calibrated at least once a year, preferably pre-winter, and spot-checked during the winter season.
- Re-calibrate equipment after any repairs, when stockpiles are replenished (solid material gradation may vary throughout the season), or when materials calculations show a discrepancy,
- Equipment should be calibrated separately for all application methods – solid and liquid, and for each product type – sand, salt, salt brine, etc.
- Excellent calibration resources with steps and calculations include: The Salt Institute's "Snowfighter's Handbook" and Clear Roads Calibration Guide:

http://saltinstitute.org/wp-content/uploads/2015/02/SASS-Handbook-2016-1.pdf
http://clearroads.org/wp-content/uploads/dlm_uploads/05-02_WisDOT-0092-06-21_Calibration-Final-Calibration-Guide.pdf

OPERATOR HANDOUT

General Approach to Calibration
● **Safety**:
○ Know and follow your agency's safety regulations
○ Set spreader/spinner dials to zero/off before starting
○ All persons must be outside of truck before running auger/spreader
○ Take it slow – follow all steps carefully and it will go smoothly
● **Simulate operating conditions during calibration**:
○ Fully warm up truck hydraulics
○ Keep auger loaded/primed during tests

- ***What***: Calibrate every spreader unit and applicator unit. If equipment is transferred to another truck, modified, or repaired then recalibrate. In conjunction with calibration, spreader and sprayer equipment should be set up so that they are mechanically restricted from applying more than the approved maximum rate. Critical system components (as applicable) may include ground speed controllers, flight chain or belt, gate opening, chute, liquid nozzles, spinner and deflectors.
- ***When***: Every year prior to winter season at a minimum. Check and/or re-calibrate if operator or supervisor notices a problem or if application rates significantly change.
- ***How***: For solid spreaders, multiply: number of auger or conveyor shaft revolutions per minute x the material discharged in one revolution x the minutes it takes to travel one mile. For liquid applicator, collect the amount of liquid actually discharged over a given amount of time and compare against the specified rate and truck speed. Document the calibration verification form as a "proof" after a calibration, or to determine if a re-calibration is needed.

8. STORAGE AND HANDLING OF MATERIALS

Proper storage and handling of snow and ice control materials is a key component of managing an efficient and environmentally sensitive winter maintenance program. Indoor storage of solid materials is highly recommended. Wind can blow material off uncovered piles and off site, and rain causes a loss of sodium concentration in uncovered salt and sand/salt stockpiles. Solid and liquid products could be spilled during delivery, storage, production of brines, mixing of sand and salt, transfer to spreaders, during non-spreading transport to and from routes and off-loading unused materials at end of operations. Responsible best practices in material storage and handling can help reduce the amount of chemicals and abrasives that migrate into the environment.

Material Storage
Solid Chemicals (NaCl, $MgCl_2$, $CaCl_2$, CMA)
o Rock salt must be kept under cover, protected from precipitation, to prevent salt dissolving and running off site. Minimize snow drifting around doorways and keep precipitation out of the storage areas by determining winter wind direction; position structures and their opening to shelter loading operations.
o Wet salt creates large, hard "chunks" that must be broken up before loading into spreader trucks.
o Storage facilities need to be contained to mitigate runoff contamination to adjacent soil, water, or vegetation.
o Salt should be stored on an impermeable pad, with appropriate slopes, away from wells, reservoirs and groundwater supplies and must be covered by a permanent structure or a waterproof cover.

- Salt should be stored in structures with an impervious wall at least three feet high, or one foot higher than the salt contact zone, with walls free of gaps or cracks, for the best environmental protection.


Source: Connecticut DOT; Minnesota DOT

Abrasives

- Salt/sand mixtures need to be covered; if kept dry in containment structures, less material will be lost.

Liquids

- Liquid storage tanks should be protected from vehicle impacts and UV exposure. They should be installed with secondary containment such as double-walled tanks and/or containment dikes if required.
- It is recommended that the secondary containment capacities are in the range of 100 – 125% of the capacity of the largest tank, or 10% of total tank capacity. All valves, hoses, and pumps should be located within the secondary containment. Check with your local regulatory agency for specific requirements.

Source: Charlotte, NC shed (Armstrong Glen website)

- NOTE: some liquids may need to be stirred or circulated while in storage to prevent sedimentation or growth of organisms in agro-derived products.

Resources

- The Salt Institute has developed a Safe and Sustainable Salt Storage Handbook, providing information on pile size and storage capacity of buildings, loading and storage styles, and techniques.

http://www.saltinstitute.org/wp-content/uploads/2013/09/Salt-Storage-Handbook-2015.pdf)

- All storage and containment structures and apparatus should be checked on a frequent and regular basis throughout the year. Look for leaks, spills, lack of covering on solid stockpiles, structural failures or damage, etc.

OPERATOR HANDOUT

Safety
● Materials storage buildings generally includes an impermeable pad and waterproof covering.
● Check for roof leaks, tears and loose ends on fabric covers, check for cracks in the floor or damage on a routine basis and conduct any necessary repairs in a timely manner.

Environmental Considerations
● Responsible practices in material storage and handling can save material from being lost to erosion and keep the material workable.
● Prevent the materials from leaving the site as runoff and impacting the surrounding soil, plants, ground and surface water.
● All relief valves in secondary containment structures need to be kept closed except when releasing or collecting rainwater.
● All tank fittings, valves, and pumps should be subject to scheduled maintenance and any leaks should be addressed in a timely manner.
● Conduct regular assessment of the storage site with the site manager to ensure that issues are addressed in a timely manner.

9. MINIMIZING RISK AND ADVERSE EFFECTS

Recent years have seen increased awareness and concerns over the potentially negative impacts posed by the winter road maintenance materials to the natural environment. Sustainable winter road maintenance that provides safety and mobility during winter events is still the number one priority, but infrastructure and environmental impacts are being given more scrutiny.

Environmental impacts

Areas of greatest environmental concern included water quality and aquatic life, air quality, and vegetation impacts.

Contamination of drinking water supplies could occur under some circumstances, especially for wells located near material storage areas and roads with very frequent and high applications.

Direct effects on soils are generally less of a concern, but snow and ice control material can influence soil structure, and the presence of these materials in soil can further affect water systems and vegetation.

Informing the Public: What, When and Why

Agencies need to adopt a sustainable and realistic snow and ice plan for their community. It must have safety as its primary

purpose balanced with an environmental approach. The customers should be informed of plans by multiple means: Social Media, Regular Press Releases or local cable TV outlets. Agencies must be transparent on how winter operations are accomplished. What is the level of service provided, the cost to accomplishing the means, order in which roads are plowed, etc. All of these mean more communication, not less.

Training

It is essential that all employees and all contractors employed by the agency receive annual pre-season training on proper use and application of materials.

Refresher briefings are recommended periodically during the snow season.

Supervisors should make regular field checks to ensure that operators are following the agency's guidelines.

The more that operators understand about the agency's Policy and Procedures as well as the deicing, the better the overall operations. Agencies need a good understanding of weather and its impact on the effectiveness of the applied materials

10. NEW TECHNOLOGY

New technologies, especially in vehicles, plows, spreaders and applicators, communications and data transfer, that substantially improve winter road maintenance operations are rapidly gaining acceptance and implementation by local and state transportation agencies. Additionally, scientific advances in weather forecasting and use of deicing materials provide for more efficient and effective use of resources.

Pavement surface temperature sensors

Pavement temperature is more important than air temperature when selecting material type and application rate.

Surface temperature measurement devices generally use vehicle-based, non-contact infrared (IR) sensors.

This leads to optimizing the use of chemicals and improving the LOS.

Automatic Vehicle Location (AVL)

There are many types of equipment comprising automatic vehicle location (GPS/AVL) systems, including Ground Speed Controllers with data collection devices, communication plow sensors and software for managing and analyzing winter maintenance operations.

AVL systems can provide real-time information, such as: type of applied material, application rate, vehicle location, road surface condition, plow position, and pavement temperature.

Agencies using this technology can be more responsive and effective and help mitigate environmental concerns.

Material Application, Plow Control, and Plow Images

Digital technology has greatly improved the control systems for material application equipment, allowing operators to change settings with a touch of a screen or button.

When integrated with other technologies mentioned above, the systems will provide real-time precise applications of dry solid, liquid and pre-wetted materials. Also, truck-mounted CCTVs can send live video to central dispatch; supervisors can then determine if road, traffic and weather conditions necessitate specific actions.

Non-contact friction and surface state sensors

Non-contact friction sensors use optical spectroscopy to determine the presence and quantity of water, snow or ice on the road. Friction is estimated from this data using a mathematical algorithm.

Optical friction sensors are available for fixed RWIS sites and for mobile use on plows and patrol vehicles. Several commercially available optical friction sensors exist and many states have been using them.

Salinity measuring devices (detection – available, quantification – not yet available)

Salinity sensing devices detect the presence of a freezing-point depressant on the road surface. Puck-like sensors embedded in a road surface at RWIS locations monitor surface temperature and salt presence. Some non-contact friction and surface-state sensors report the presence of salt if moisture is detected when the surface temperature is below 32 °F (0 °C).

Sensors that quantify the concentration of salt on the road surface are in development. If agencies are able to easily obtain accurate and real-time measurement of the salinity of the pavement, then re-application rates may be optimized.