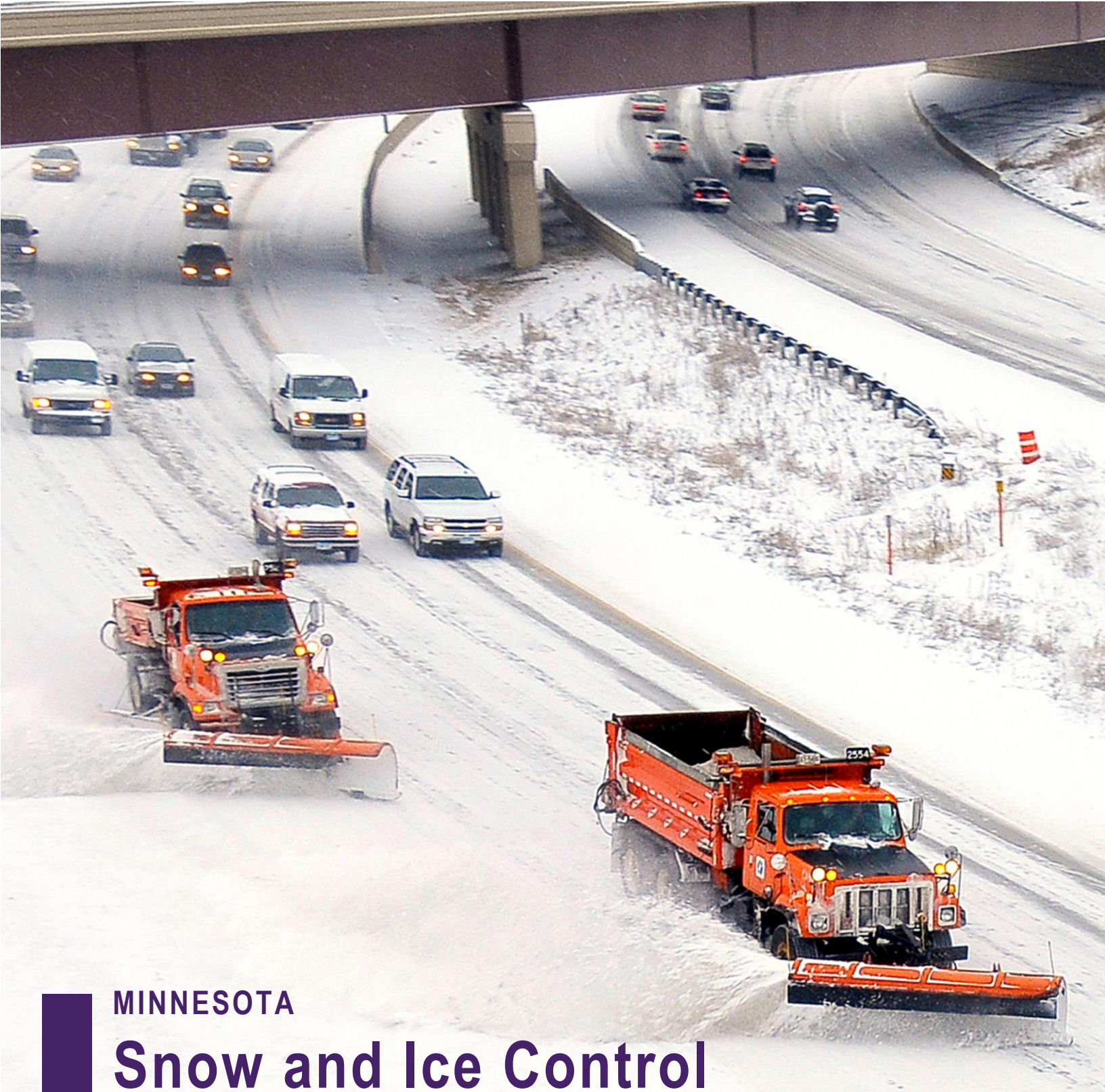

MINNESOTA

Snow and Ice Control

Handbook for Snowplow Operators

2022RIC01
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Acknowledgments

This handbook is dedicated to the snowplow operators who keep our roads safe all winter long.

Writing

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Purpose of This Handbook

The purpose of this handbook is to help promote the understanding of the tools, best practices, and limitations for snow and ice control. The handbook will also help you understand when to use—and when not to use—these tools and practices. In addition, it encourages progressive changes in snow and ice control practices that will help you reduce salt/sand use and environmental impacts while meeting the safety and mobility needs of roadway users.

Practices such as anti-icing, prewetting, and pretreating are emphasized in this handbook. Various research projects and reports are cited to support recommended practices. Also included are standard best practices expected in a quality snow and ice control program.

Throughout the handbook you will find environmental-related tips shown with this fish symbol. These tips are provided to make you aware of and encourage you to reduce environmental impacts from snow and ice control operations.

This symbol indicates environmental-related tips.

A blanket approach will not work for the broad range of conditions Minnesota experiences; different strategies are needed for different regions and different conditions. We encourage you to continue to test, document, and refine the practices from this handbook.

Links to the sources cited in this handbook are on the MnLTAP website:

mnltap.umn.edu/topics/snow

Basic Concepts

Weather Conditions to Monitor

Knowing existing and potential weather conditions is very important for a successful snow and ice control operation. Six pieces of information are especially valuable:

1. Start of precipitation
2. Type of precipitation
3. Total precipitation expected/storm intensity
4. Expected event length
5. Wind conditions (speed, gusts, directions)
6. Air and pavement temperature trend

Monitor the weather closely so that you are available and prepared to act early in storm situations. Keeping a record of the weather forecast—as well as the weather conditions experienced—is also helpful for documentation of the winter event.

Weather information sources

- Call 511 or visit 511mn.org to get road condition and travel information.
- Subscribe to a value-added meteorological service. These are useful for viewing weather forecasts and pavement temps.
- Check the National Weather Service.
- Check all available weather sources.

Pavement Temperature

Most weather sources measure temperature and other conditions 30 feet above ground; these conditions can differ substantially from pavement temperatures. Thus, use the pavement temperature—not the air temperature—to determine what material to use and the application rate.

Pavement temperatures can be substantially lower or higher than air temperatures.

You'll notice a drop in pavement temperature first on bridge decks and ramps. Pavement temperatures will also be lower on overcast days, on concrete surfaces, and in shady areas.

Measuring with sensors or R/WIS

There are two main ways to measure pavement temperatures: with infrared sensors or with a Road and Weather Information System (R/WIS).

The most effective sensors are mounted on a truck or on a structure near a road such as an R/WIS station. R/WIS stations provide information about weather and roadway conditions, which can help you stay informed, make timely decisions, and improve traffic safety.

- Truck-mounted temperature sensors measure pavement or surface temperatures while your truck is moving. Ideally, every agency should own at least one truck-mounted unit. Certain truck-mounted sensors can also provide friction values.
- A structure-mounted sensor is noninvasive and provides temperature readings, chemicals present, and grip or friction values. These can be purchased or leased.
- Hand-held infrared laser sensors are pointed at the pavement to get a pavement or surface temperature while your vehicle is stopped.

Other tools: MDSS and AVL

Maintenance Decision Support Systems (MDSS) help transportation agencies make better decisions about their winter maintenance activities by providing reliable weather and road conditions and recommending the most cost-effective treatments.

Automated Vehicle Location (AVL) systems help support the MDSS by continuously recording plow truck locations and other pertinent information such as pavement temperature, material spread rate settings, travel speed, and plow down. The system can be set up to automatically forward data to operations and maintenance teams/supervisors, who can better respond and make adjustments in preparation for or during winter weather events.

Before the Winter

To provide the best use of resources and maximize traffic movement during snow events, take some time before the season to plan your routes and learn your agency's plowing policy.

Policies

- Meet with crew members to discuss your policy. A policy may include activity start, plowing direction, snow removal, snow storage, use of chemicals/liquids, priority routes, and more.
- Know the level of service for your routes. This may be based on traffic volume, environmental concerns, safety, mobility, economics, and other factors.
- Inform your citizens of policies.
- Learn to record what and how much material you apply on each route/shift. After each winter event, analyze the data and adjust your process based on your observations.

Model ordinances and MPCA requirements

The Minnesota Pollution Control Agency (MPCA) partnered with the Nine Mile Creek Watershed District, TetraTech, and several cities and watershed organizations to develop a suite of model ordinances that communities can choose to implement. Several options are intended to assist with reducing salt pollution.

- Be flexible. Conditions could change the way you plow your route.
- Consider implementing a route optimization/decision support tool, such as MDSS or AVL (see page 2).

The MPCA requires some Municipal Separate Storm Sewer System (MS4) communities to document the amount of deicer used each season.

Plan Your Routes

- During the fall, inspect and make sure ditches, culverts, and surfaces are free from obstructions and ready for the spring melt.
- For culverts that tend to freeze up, you may need to install heat tape or plan to use a steamer to melt a blockage. Never use salt to melt a frozen pipe.
- Drive the assigned routes prior to winter to identify hazards and critical areas and to find the most efficient way to cover the routes.
- Remove potential snow traps—such as tall grasses—that will catch and accumulate snow.
- Inventory all the areas prone to drifting and have a plan to manage them. Use the University of Minnesota's Blowing Snow Control Tools.
- Plan a place for snow storage that doesn't drain into a sensitive area. Never store snow in a holding pond!

Smart salting doesn't reduce safety—and it protects our lakes.

Calibrate Your Equipment

Calibration is an essential procedure to measure the amount of material applied to the roadway at various auger settings in relation to truck speed. No matter how sophisticated or simplified your operations, always calibrate or verify calibration yearly.

- Because spreaders vary, calibrate each truck. Recalibration is required if changes are made to the hydraulic system, if the augers have extensive wear or are resurfaced or replaced, or if a different material is used.
- Follow the manufacturer's guidelines for calibration and contact the vendor for training.

Electronic scale used for calibration

- Calibrate separately for all materials—salt, treated salt, sand/salt mix, and sand.
- Remember: The auger plate must be in place during calibration. You are not calibrating the truck properly if the material is gravity-flowing.
- Clean up and sweep the area after calibrating.
- Determine the flow rate or calibrate liquid application systems at the same time as the dry systems.
- For manual sander controls, place a chart in your truck to see how much material is applied at each setting at various speeds.
- There are two types of automatic sander controllers. Open-loop controllers monitor only truck speed during operation; closed-loop controllers monitor both truck speed and spreader discharge. Closed-loop controllers are preferred.
- Agencies should define the settings on the controller. If not, you could have a range that ends in 1,000 pounds/mile, which is way too much for any condition. Some restriction is appropriate, but allow enough of a range to apply materials as needed and also prevent gross overuse. A starting point for salt would be 100 to 600 pounds/mile in increments of 50 with blast set at 500. A starting point for salt/sand would be 100 to 1,000 in increments of 100 with blast set at 800.

Calibration resources

- Clear Roads has links to manufacturers' calibration instructions and a comprehensive calibration guide.
- MnDOT also has calibration instructions on its maintenance training website.
- For sander calibration training, contact the Minnesota Circuit Training and Assistance Program (CTAP) instructor.
- For liquid calibrations, see the *MnDOT Anti-Icing Guide*.

Before the Storm

Anti-icing

Anti-icing can provide significant cost, safety, and environmental benefits. It is a proactive approach that should be the first in a series of strategies for most winter weather events. By applying chemical materials that lower the freezing point before an event, you can prevent snow and ice from bonding to the pavement, optimizing chemical usage.

Anti-icing can reduce airborne dust and salt particulates.

Guidelines for anti-icing

- Anti-icing is often effective for frost.
- Anti-icing works best when combined with accurate road weather information.
- Because motorists have difficulty perceiving how slippery light freezing drizzle and light frost can be, early application is important in these conditions.
- Liquids are the most efficient and may be applied days in advance of an event, but the closer to the event start time the better, as tire action and wind both wear away material.
- Applications of pretreated salts will also work—especially on steep hills and/or if freezing rain is forecast. Apply at the lowest possible setting, less than 100 lbs./two-lane mile; apply as close to the start of event as possible. Apply the material to the centerline with the spinner off.
- See the Application Rate Guidelines on page 15 of this handbook.

Anti-icing truck

What to do

- Apply liquids only with stream nozzles—or rubber hoses positioned as close to the pavement as possible—to maintain some bare pavement between sprayed areas to reduce slipperiness. Fan spray is not recommended.
- Schedule applications on bridge decks and critical areas if temperature and conditions could produce frost or black ice.
- Consider spot-applications on hills, curves, and intersections if predicted conditions warrant.
- Use the appropriate chemical for your pavement temperature range. See the chart on page 19 of this handbook.
- Apply an anti-icing product during non-rush-hour traffic periods.
- When frost on the shoulder starts to move into the travel lanes, reapply anti-icing product.

Use wisely. Chlorides can increase the salinity of soil, which can lead to compaction and erosion.

What not to do

- Don't anti-ice under blowing snow conditions, in areas prone to drifting, and anywhere else you would refrain from using salt. Be aware of areas that are prone to wind issues.
- Reapplication isn't always necessary if there is still a residual. The residual effect can remain for up to five days after application if precipitation or traffic wear-off does not dilute the initial application.
- Remember that the surface can refreeze when precipitation or moisture in the air dilutes the chemical.
- Don't apply $MgCl_2$ or $CaCl_2$ to a warm road (above 28˚F pavement temperature). It can become slippery and cause crashes!
- Don't apply before predicted rain.
- For the first application of magnesium or calcium—or after a prolonged dry spell—apply liquids at half the rate (not half the concentration). On dry roads, liquids can mix with oil from vehicles and cause slippery conditions.
- Over-application of liquid chemicals may make the road become slippery. Less is better. Always follow manufacturers' application recommendations.

Equipment

See the *MnDOT Anti-Icing Guide.*

Pretreating and Prewetting Salt and Sand

Dry material easily bounces or blows off the road, so granular material should always be prewet. Because salt must be dissolved to melt ice, liquids increase its effectiveness by jump-starting the melting process. Depending on the liquid used, it may lower salt's effective working temperature. Prewetting and pretreating salt can reduce overall application rates, thereby helping to save money and reduce environmental impacts.

Guidelines for pretreating

Pretreating is mixing a liquid into the stockpile of salt or sand before it is applied. Unlike prewetting, it does not require equipment changes and requires no new capital investment for equipment.

If you must use dry material, drive slowly, apply on centerline, and turn off spinner to reduce bounce and scatter.

Salt stockpile

- Treat the salt stockpile with a liquid deicing chemical. It may be purchased pretreated or mixed on site by the vendor or your crew.
- When treating the stockpile at the shop, apply at 4 to 6 gallons/ton. Salt must be very dry for the chemical to stick.
- If treating salt outside the shed, sweep residual material back into the shed.
- Because leach risk at a stockpile is increased, store salt covered on an impervious pad and use perimeter control (e.g., fiber log) if runoff is observed.

Sand stockpile

- Pretreat the stockpile to keep it flowable.
- Apply to stockpile at 4 gallons of liquid deicing chemical/ton of sand.
- If treating sand outside the shed, sweep residual material back into the shed.
- Store the stockpile under cover and use perimeter control (e.g., fiber log) to prevent runoff.

Chemicals leaching from a stockpile into groundwater is a common problem.

Guidelines for prewetting

Prewetting is adding a liquid to the salt as it is being applied—either at the spinner or through a soaker pipe in the auger box—to help it stick to the road better. Although prewetting requires some equipment changes, it provides flexibility to switch the chemical makeup depending on conditions.

- Salt brine, calcium chloride, magnesium chloride, and various blends may be used as prewetting agents.
- A typical application rate is 8 to 14 gallons/ton.
- Prewetting with calcium or magnesium blends can help reduce application rates.
- Below 15˚F, salt brine becomes less effective.
- Below 0˚F, brine may freeze in hoses and valves.
- The amount of active chemical is very important. Verify the concentration of liquids you're using:

  Salt brine – 23.3%
  $CaCl_2$ – 29.8%
  $MgCl_2$ – 21.6%
  CMA – 32.5%
  KAc – 49%

Apply wisely. Excess chlorides will soak into groundwater or run off to surface waters.

Slurry applications

Super-saturated salt or slurry is a method in which a high volume of liquid is added to the granular salt, resulting in a salt slurry that activates very rapidly. Because of rapid activation, slurry applications can help to reduce the overall amount of salt used.

Generally, liquid-to-salt applications above 30 gallons/ton are considered salt slurry. Follow manufacturers' recommendations for liquid-to-granular ratios.

400-gallon tanks for slurry applications

During the Storm

Deicing

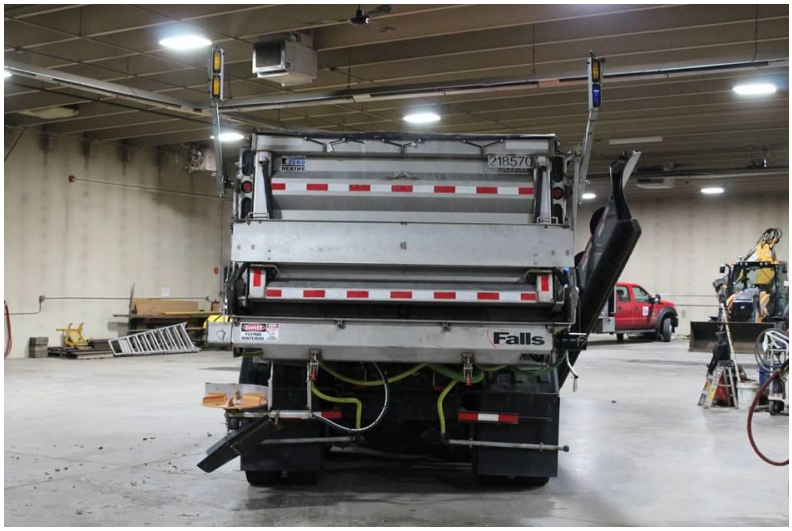
Deicing is a reactive operation in which a deicer is applied to the top of an accumulation of snow, ice, or frost that is already bonded to the pavement surface.

Use cautiously. Many chemicals contain trace metals including cyanide, arsenic, lead, and mercury.

Removing ice that has already bonded to the pavement can be difficult, and removing it mechanically can damage equipment and roads. Generally, enough ice must be melted chemically to break the bond between the ice and the pavement, which requires larger quantities of chemical than anti-icing.

The goal is not to melt everything. The goal is to penetrate through the ice and snow and break the bond so the compaction can be scraped off.

- Use an appropriate amount of salt. Most oversalting can be prevented by using calibrated, speed-synchronized spreaders—along with good judgment in selecting application rates and truck speed.
- You do not need to melt all the snow or ice on the road with salt. This is an overuse of materials. Apply just enough to loosen the bond between the road and the ice so it can be plowed off.
- Apply chemical in a concentrated line in the wheel path near the crown of the road using low or no spinner speed. A chute off the sander can also be used to help concentrate the application of chemical.
- See the Application Rate Guidelines on pages 15–19 of this handbook.



Salt chute

Dilution of solution

Be aware that as the deicing chemical melts snow and ice on the road, the solution will become more diluted. Unless additional treatments are made or the snow and ice is plowed off, refreeze will occur.

Using Abrasives

Use winter sand and other abrasives when temperatures are too cold for deicing chemicals to be effective. However, be aware that sand does not melt anything. It provides temporary traction, and only when it is on top of the snow or ice. Winter sand adds a minimal amount of chemical to the environment but can clog pipes and ditches. Sand can also have a negative impact on aquatic organisms in lakes and streams. Therefore, avoid sand use as much as possible.

Winter abrasives use has been documented as an air pollution concern.

A 50/50 salt/sand mix is generally not recommended. Salt reduces the effectiveness of sand, and sand reduces the effectiveness of salt. However, a salt/sand mix may be helpful in situations such as a freezing rain event where the salt is washed away quickly. A ratio of 75/25 to 50/50 salt/sand mix has been documented as effective in increasing friction by sticking the sand to the surface, like sandpaper.

If you use a 50/50 salt/sand mix, you're generally either half right or half wrong. Using a salt/sand mix leads to overapplication of both materials.

- Use abrasives in slow-moving traffic areas such as intersections and curves.
- If your equipment has prewetting capabilities, using it will further help the sand stick to the roadway.
- If your purpose is melting, use salt only.
- Salt is ineffective in cold weather, so use sand or an alternative chemical that is effective at colder temperatures.
- Sand is not cheap when you consider the handling, clean-up, and disposal costs.
- Sweep up sand frequently, after each event if feasible.

Standard Practices

- Know the pavement temperatures and trends to help you use the right application at the right time. Generally, use less chemical when temperatures are rising and more when they are falling.
- Don't apply dry salt at below 15˚F pavement temperature. It will not melt fast enough to help, and it will blow off the road into the ditch.
- Below 15˚F, switch to other tools such as $CaCl_2$, $MgCl_2$, or other additives to obtain maximum melting. If these are unavailable, use sand for traction at curves, hills, and intersections.
- Adjust your spinner speed to the lowest setting possible, except at intersections where a wider spread pattern may be helpful.
- Don't let the traffic dictate your speed. Drive at the slowest possible speed to keep material on the road.
- Apply deicers in the center of the road, wheel path, or high side of the curve.
- Set spinners lower to the ground or use a chute to reduce bounce and scatter.
- Turn off the auger when stopped, even briefly.

Sand that washes into a stream or lake may smother fish eggs and other aquatic organisms.

Loading/hauling

- Set up and load under cover and on a level surface wherever possible.
- Maintain the loading area. Keep it clear and smooth.
- Don't overload. Avoid spilling on units.
- Watch for coworkers/pedestrians in or near the loading area.
- Keep material contained to prevent contamination or dilution.

Never use calcium chloride to open drains—it is extremely toxic to aquatic systems. Use steamers instead.

Effective use of plows

Plow to remove snow and loose ice before deicing applications. If snow accumulates before or after applications, plowing directly before your next application will minimize product dilution.

When slush begins to stiffen and kicks to the rear from vehicle tires, it's time to plow and then reapply chemical.

- Plow first before applying deicers to avoid dilution of the salt.
- Coordinate plowing activities to eliminate windrows at intersections and prevent plowing off another operator's material.
- Remove snow from roads as quickly as possible to reduce compaction; using underbody blades helps remove compacted or slushy snow.
- Use carbide, flexible, or rubber-encapsulated plow blade edges.
- Adjust the blade angle to maximize cutting efficiency or snow-throwing capabilities.

Public safety/operator safety

- Perform your required CDL pre- and post-trip inspections.
- Make sure you're mentally and physically prepared to drive.
- Obey traffic laws. Use the seat belt. Clean lights and windows frequently.
- Flow with traffic as much as possible. Avoid sudden moves.
- Be alert to all surroundings.
- Demonstrate courtesy toward other drivers and pedestrians.
- Be aware of spinner discharge at all times.
- Avoid pushing snow over bridge rails and onto roads below.
- Be alert to hazards such as downed power poles, stoplights, overhead structures, power lines, etc.
- Know the height of your truck box. Raise the box only to move material to the back of the box. When raising the box, be certain no overhead obstacles are present.
- Be aware of changing braking abilities from a loaded box to an empty one.
- Keep others informed of changing conditions.
- Assist/report stranded motorists as necessary.

Chloride is a permanent pollutant that is toxic to aquatic life and does not break down or change over time.

Make sure an auger shield is in place to control the application or you'll overapply salt.

Snow cloud

Be aware of wind conditions and the potential for visibility problems. Snow clouds can form during any plowing operation. A very slight snow cloud can temporarily block strobe lights and increase chances of being hit from the rear.

- Reduce your speed to minimize snow clouds.
- Don’t plow just to plow. If shoulder plowing isn’t necessary when the wind is blowing, don’t do it.
- If you have created a snow cloud, do not brake or slow down—just lift plow and wing.

After the Storm

Begin cleanup operations once the roads are clear to the prescribed level of service. Then, evaluate what was done, how well it worked, and what could be changed to improve operations.

- Remove snow from bridge walls to prevent ramping.
- Remove or push back snow piles at intersection corners to improve visibility for drivers and access for pedestrians.
- Accurately record your material use at the end of your shift (see below).
- Attend a post-storm meeting in the shop to evaluate your operations.
- Look for opportunities to try new and improved practices.
- Clean and check all equipment.
- Report any hazards such as low-hanging branches, raised utilities, or other potential problems.
- At the end of the season, clean and maintain the truck, tanks, brine-making systems, and pumps according to manufacturer specifications.
- Place all winter maintenance piles on an impervious pad and cover them. This includes salt and salt/sand mixes.

Standard Practices

Documenting and charting

Thorough documentation is important for an effective snow and ice control program. Documentation can help to reduce material usage, costs, and environmental impacts. Unless you document and chart, you can't measure what you are doing.

You can't manage what you don't measure.

- Track your material use and compare it to your past winter events, as well as to use by other operators.
- Document the weather conditions for each storm event. Review the target level of service for each route and see if it was met or not.
- The main office should log all resident/motorist calls and emails to identify problem areas and see if there are areas of service that can be improved.
- Refine your procedures and material use based on observations.
- Share observations to improve operations and learn from each other.
- Use standardized forms to record and track your work and observations.
- Complete forms at the end of your shift and turn them in to your supervisor.
- Download the forms and post them in the break room so others can compare them for material usage.

Some fish species are affected by chloride-impaired water, which is equivalent to about 1 teaspoon of salt in 5 gallons of water.

Fine-tuning your program

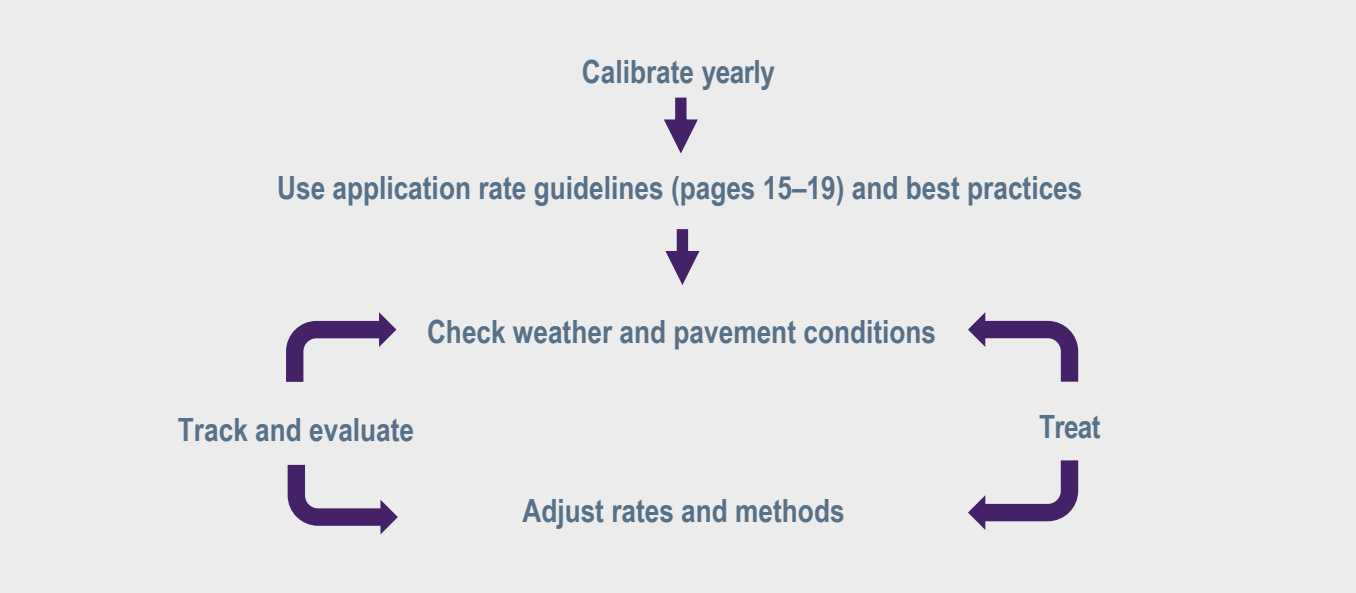


Figure 1: Fine-tuning Your Program

Application Rate Guidelines

Develop your own application rates using the guidelines on pages 15–19 as a starting point and modify them incrementally over time to fit your needs. You can summarize information gathered from your truck logs into application rates for your area. Be aware, though, that rate charts vary greatly. Make it a goal to apply only as much material as needed to keep the roads safe. You can reduce rates by following anti-icing and other strategies covered in this handbook.

Salt spray damages roadside vegetation.

Guidelines for Determining Application Rates

- Sand/salt mix isn't advised but may help in some situations such as freezing rain.
- Always plow before applying chemical.
- Generally, the first pass will require an application rate at the higher end of the range, with subsequent passes requiring less and less.
- On long routes where you'll only be able to make one pass, you may have to apply more material than what's recommended in the charts.
- High traffic volume will work salt into the snow and aid in melting—so use a lower rate.
- Higher traffic speeds will blow salt off the road and hinder melting—so increase the use of prewetted materials.
- Use sand for short-term traction only. It will never melt anything.
- It is usually not cost-efficient to apply salt (sodium chloride) at pavement temperatures below 15˚F.

Dilution: The Cause of Refreeze

An ice control product will work until product dilution causes the freeze point of the brine to equal the pavement temperature. At this point, the material will stop melting and you may experience refreeze if pavement temperatures are dropping. This process is the *Dilution of Solution*.

How long an application will last depends on five factors: pavement temperature, application rate, precipitation, beginning concentration, and chemical type. These factors explain why one application rate will not fit all storm events.

If your equipment is unable to deliver material at lower rates, consider exchanging the 9-inch-diameter auger for either a 6-inch or 9-inch special auger to deliver about two-thirds less material/revolution.

Anti-Icing Application Rate Guidelines

These guidelines are a starting point. Reduce or increase rates incrementally based on your experience.

Table 1: Anti-Icing Applications

Condition	Gallons/Lane Mile			Other Products
	$CaCl_2$	$MgCl_2$	Salt Brine	
1. Regularly scheduled applications	15 – 25	15 – 25	20 – 40	Follow manufacturers' recommendations.
2. Prior to frost or black ice event	15 – 25	15 – 25	20 – 40	
3. Prior to light or moderate snow	15 – 25	15 – 25	20 – 50	

Pounds of Ice Melted Per Pound of Salt

Table 2: Pounds of Ice Melted Per Pound of Salt

Pavement Temp. ˚F	One Pound of Salt (NaCl) Melts	Melt Times
30 25 20 15	46.3 lbs. of ice 14.4 lbs. of ice 8.6 lbs. of ice 6.3 lbs. of ice	5 minutes 10 minutes 20 minutes 1 hour
10 5 0 -6	4.9 lbs. of ice 4.1 lbs. of ice 3.7 lbs. of ice 3.2 lbs. of ice	Dry salt is ineffective and will blow or be scattered away before it melts anything.

At temps below 15˚F, it may be more cost-effective to use a chemical other than NaCl. See research at dot.state.mn.us/maintenance/training.

Deicing Application Rate Guidelines

24 feet of pavement (typical two-lane road)

These rates are not fixed values, but rather a starting point of a range to be selected and adjusted by an agency according to its local conditions and experience.

Table 3: Deicing Application Rate Guidelines—Pounds/Lane Mile

Pavement Temp. (˚F) and Trend (⇅)	Weather Condition	Maintenance Actions	Salt Prewetted/ Pretreated with Salt Brine	Salt Prewetted/ Pretreated with Other Blends	Dry Salt	Winter Sand (Abrasives)
>30° ↑	Snow	Plow, treat intersections only	100	100	100	Not recommended
>30° ↑	Frz. rain	Apply chemical	100 – 160	100 – 140	100 – 200	Not recommended
30° ↓	Snow	Plow & apply chemical	100 – 160	100 – 140	100 – 200	Not recommended
30° ↓	Frz. rain	Apply chemical	150 – 200	130 – 180	180 – 240	Not recommended
25 - 30˚ ↑	Snow	Plow & apply chemical	120 – 160	100 – 140	150 – 200	Not recommended
25 - 30˚ ↑	Frz. rain	Apply chemical	150 – 200	130 – 180	180 – 240	Not recommended
25 - 30˚ ↓	Snow	Plow & apply chemical	120 – 160	100 – 140	150 – 200	Not recommended
25 - 30˚ ↓	Frz. rain	Apply chemical	160 – 240	140 – 210	200 – 300	400
20 - 25˚ ↑	Snow or frz. rain	Plow & apply chemical	160 – 240	140 – 210	200 – 300	400
20 - 25˚ ↓	Snow	Plow & apply chemical	200 – 280	175 – 250	250 – 350	Not recommended
20 - 25˚ ↓	Frz. rain	Apply chemical	240 – 320	210 – 280	300 – 400	400
15 - 20° ↑	Snow	Plow & apply chemical	200 – 280	175 – 250	250 – 350	Not recommended
15 - 20° ↑	Frz. rain	Apply chemical	240 – 320	210 – 280	300 – 400	400
15 - 20° ↓	Snow or frz. rain	Plow & apply chemical	240 – 320	210 – 280	300 – 400	500 for freezing rain
0 to 15˚ ⇅	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	300 – 400	Not recommended	500 – 750, spot-treat as needed
< 0˚	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	400 – 600	Not recommended	500 – 750, spot-treat as needed

For residential streets: Plow and spot-apply material at hills, curves, and intersections at a rate of 100 to 300 lbs./lane mile.

Application Rate Charts Used in Minnesota

The application rate tables in this handbook are examples to be used as templates for developing your own. Rates are often based on materials you use, whether you use anti-icing and prewetting, level of service, route travel time, shift time, and local experience.

Table 4: Example Application Rate Chart—Anoka County

Pavement Temp. (˚F)	Maintenance Action	Spinner Speed	Salt %	Pounds Per Lane Mile
30	Light sleet, light rain, or light snowfall stopped	low	100%	100 – 200
	Light freezing rain or light snow continuing			150 – 300
25	Heavy freezing rain, sleet, or snowfall continuing	low	100%	200 – 400
	Light snowfall continues at 1/8” to 1/4” per hour	low	100%	150 – 300
20	Heavy snowfall: repeat salting at lower rate	low	100%	200 – 350
	Light snow falling at trace to 1/4” accumulation			150 – 300
15	Light snowfall continues at 1/8” to 1/4” per hour	low	100%	200 – 300
	Heavy snowfall: repeat salting at lower rate	off	80%	
10	Snow stopped and sun is going to come out	low	100%	200 – 300
	Light snowfall continuing or sun is going to come out		80%	200 – 300
5 to 10	Light snowfall continuing or sun is going to come out	low	70%	150 – 300
	Light snowfall at trace to 1/4” accumulation		25%	200 – 400
0 to -15	Light snowfall at trace to 1/4” accumulation	low	25%	400 – 600
	Light snowfall at trace to 1/4” accumulation			
0 to -15	Snow stopped and roads have hard pack	off	25%	400 – 600
	Snow stopped and roads have hard pack			

To concentrate salt, use low spinner speed.
Use a higher % of sand in cold temps or use 200 to 400 lbs. treated salt below 15˚F.
Rates are for units with salt settings of 100, 150, 200, 250, 300, 350, 400, 450, 500, 600.

Credit: Anoka County Highway Department

Application Rate Recommendation Chart

Before and during shift, consult R/WIS *before* applying *any* chemicals or materials!

Table 5: Application Rate Recommendation Chart

Prewet Material Chart

Pavement Temp. (˚F)	Weather Conditions	Pounds Per Two (2) Lane Mile (LM)			Actions & Application Recommendation
		100% Salt	50% Salt	Stockpile	
Above 30˚	Snow	150 – 300	Not recommended	Not recommended	Plow, treat hazards ONLY
	Freezing Rain	150 – 300	Not recommended	Not recommended	Apply as needed
	Snow	200 – 400	Not recommended	Not recommended	Plow & apply as needed
	Freezing Rain	200 – 400	Not recommended	Not recommended	Apply as needed
25˚ to 30˚	Snow	200 – 400	Not recommended	Not recommended	Plow & apply as needed
	Freezing Rain	200 – 400	Not recommended	Not recommended	Apply as needed
	Snow	300 – 500	Not recommended	Not recommended	Plow & apply as needed
	Freezing Rain	300 – 500	500 – 750	Not recommended	Apply as needed
20˚ to 25˚	Snow/Frz. Rain	300 – 500	500 – 750	Not recommended	Plow & apply as needed
	Snow	300 – 500	Not recommended	Not recommended	Plow & apply as needed
	Freezing Rain	400 – 500	500 – 750	Not recommended	Apply as needed
15˚ to 20˚	Snow	300 – 500	Not recommended	Not recommended	Plow & apply as needed
	Freezing Rain	400 – 500	500 – 750	Not recommended	Apply as needed
	Snow/Frz. Rain	400 – 500	500 – 750	Not recommended	Plow & apply as needed
Below 15˚	Snow	Not recommended	Not recommended	500 – 750	Plow, treat hazards with stockpile
Frost, 15˚F & *rising*: Treat by anti-icing (brine 20 – 40 G/LM). Frost, 15˚F & *falling*: 100% salt @ 150 lbs./LM.					
Wind conditions: Plow, treat (trouble spots ONLY!) with 50/50 @ 300 lbs./LM or stockpile @ 200 – 400 lbs./LM.					
If event/shift temperatures will rise, use salt instead of sand (and vice versa as temps fall).					

Materials and Quality Control

Chemical Melting Temperatures

Multiple products can be used in a snow and ice control program. This chart helps you choose the correct product and apply it at the correct times. For further guidance on blending chemicals, see the *MnDOT Anti-Icing Guide*. For a list of vendor contacts and chemicals available on the Minnesota Approved Products list, see the MnDOT *Winter Chemical Catalog.*

Table 6: Chemical Melting Temperatures

Chemical	Lowest Practical Melting Temperature	Concentration
*NaCl (Sodium Chloride)—Delivered as solid rock salt; also can be made into a brine. The basis of most deicing materials. Very corrosive. Inexpensive.	15˚F	23.3%
*$MgCl_2$ (Magnesium Chloride)—Delivered as flakes, pellets, or liquid. Often used to wet NaCl crystals to increase adherence to road and reduce melting points. Corrosive. Higher cost.	-10˚F	27% – 30%
*$CaCl_2$ (Calcium Chloride)—Delivered as flakes, pellets, or liquid. Powerful deicer but extremely corrosive. Sometimes used incorrectly to open storm drains. Higher cost.	-20˚F	30%
CMA (Calcium Magnesium Acetate)—Delivered as a powder, crystals, pellets, or liquid. Liquid CMA is used mainly on automated bridge deicing systems. Non-corrosive, biodegradable. Sometimes added to sodium chloride as a corrosion inhibitor. Alternative for areas where chloride use must be limited. Higher cost.	20˚F	32%
KAc (Potassium Acetate)—Delivered as a liquid. Used on automated bridge deicing systems. Use for anti-icing, deicing, and prewetting. Non-corrosive, biodegradable. Alternative for areas where chloride use must be limited. Higher cost.	-15˚F	50%
Winter Sand/Abrasives—Winter sand is sand-treated with brine or another blend. It is often used as an abrasive for low-temperature conditions when chemicals are not effective. Sand provides temporary traction and only works when it is on top of the ice.	Never melts—traction only	
Other Blends—Proprietary-purchased blends or blended in-house.	Varies	Varies

**Liquid chlorides are available with corrosion inhibitors.*

Material Conversions

The following quick-reference table and the formulas below will help you convert between tons and cubic yards. Weights will vary depending upon moisture content.

Loader operators determine the amount of material loaded by volume/yards. However, material used is recorded in tons.

Table 7: Material Conversions

Sand		Salt	
Yards	Tons	Yards	Tons
1	1.4	1	1.1
2	2.8	2	2.2
3	4.2	3	3.2
4	5.6	4	4.3
5	7.0	5	5.4
6	8.4	6	6.5
7	9.8	7	7.6
8	11.2	8	8.6
9	12.6	9	9.7
10	14.0	10	10.8
11	15.4	11	11.9
12	16.8	12	13.0
13	18.2	13	14.0
14	19.6	14	15.1
15	21.0	15	16.2
16	22.4	16	17.3
17	23.8	17	18.4
18	25.2	18	19.4
19	26.6	19	20.5
20	28.0	20	21.6

1. To convert tons of clean sand to cubic yards: #tons divided by 1.4 = cubic yards
2. To convert cubic yards of clean sand to tons: #cubic yards multiplied by 1.4 = tons
3. To convert tons of winter sand to cubic yards: #tons divided by 1.37 = cubic yards
4. To convert cubic yards of winter sand to tons: #cubic yards multiplied by 1.37 = tons
5. To convert tons of straight salt to cubic yards: #tons divided by 1.08 = cubic yards
6. To convert cubic yards of straight salt to tons: #cubic yards multiplied by 1.08 = tons

Materials Testing

It is important to understand how deicing chemicals will react on the roadway. See the Clear Roads *Field Guide for Testing Deicing Chemicals* (2009).

Test your materials to ensure that they are delivered as ordered and will perform as needed. Refer to your contract or Material Safety Data Sheet for specific gravity.

Protect our roadside vegetation. Chlorides can damage vegetation at concentrations greater than 70 parts per million (about 1/3 teaspoon of salt in 5 gallons).

Testing liquids

- Before unloading the tanker truck, use a clean container to obtain a small sample (about 2 cups).
- Measure the specific gravity or percent saturation using a hydrometer or salimeter.
- Make sure you have the correct hydrometer for your material.
- Salt brine should have a salimeter reading of 85% or a hydrometer reading of 1.176, which equates to 23.3% salt in the brine.
- If the specific gravity is not within specifications, don't unload, and notify your supervisor.

Testing sand

- Conduct a visual inspection of the material to make sure it is clean.
- Note that each user has its own specifications based on available materials.

Testing solid salt

- Make sure someone is present to watch the load being dumped and observe if it is wet.
- Test salt for moisture content. You are looking for a moisture content of less than or equal to 1.5%. (Check your agency's specification.)

How to measure the moisture content of rock salt:

- Supplies:
    - A calibrated scale, triple beam, or digital accurate to 0.1 grams.
    - A microwave with maximum wattage of 1,200. Higher power may be too hot and make salt pop, compromising weight of sample.
    - A sample of salt (about 1 cup). Ensure it is a good representation of the pile.

- Process:
    1. Weigh sample before cooking and record weight on worksheet (see next page).
    2. Cook. Once salt is dry, weigh again, and record dry weight.
    3. Do calculations on the worksheet.

Salt Moisture Worksheet

The scale is zeroed out to account for container.

Table 8: Salt Moisture Worksheet

Date: _____ Company: _____
P.O. #: _____ Ticket #: _____

A. Weight of wet salt _____ Moisture calculations: _____
B. Weight of dry salt _____ C ÷ A x 100 = _____ % moisture
C. Weight loss (A - B) _____ Remarks: _____
Tested by: _____

For complete instructions, go to dot.state.mn.us/maintenance/training.

Additional Resources

All the resources referenced in this handbook are on the MnLTAP website at mnltap.umn.edu/topics/snow. The page also has additional publications, resources, and training.

Other quick links:

- Minnesota Local Road Research Board: lrrb.org
- MnDOT Maintenance training: dot.state.mn.us/maintenance/training.html
- Clear Roads: clearroads.org