HANDBOOK

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Minnesota Snow and Ice Control

Field Handbook for Snowplow Operators
Second Revision

Minnesota LTAP
CENTER FOR TRANSPORTATION STUDIES
University of Minnesota

Minnesota Department of Transportation

Minnesota Local Road Research Board

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Field Handbook for Snowplow Operators

Second Revision

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This field handbook is dedicated to the plow operators who keep our roads safe all winter long. It is based on the *Manual of Practice for an Effective Anti-icing Program,* produced by the Utah LTAP Center.

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Purpose of this Handbook

The purpose of this field 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.

Less material on roads means less material in lakes and streams.

Practices such as anti-icing, prewetting, and pretreating are emphasized in this field 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 field handbook you will find environmental tips shown with this fish symbol  . These tips are provided to help you reduce environmental impacts from snow and ice control operations.

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 field handbook.

Basic Concepts

Weather

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. Temperature trend

Monitor the weather closely so that you are available and prepared to act early in storm situations.

Weather information sources

- Phone 511 to get road condition and travel information or visit the Web: www.511mn.org.
- Subscribe to a value-added meteorological service (VAMS). These are useful for viewing weather forecasts and pavement temps.
- Check the National Weather Service.
- Check all available weather sources.
- Check MnDOT's Road and Weather Information System (RWIS) site: www.rwis.dot.state.mn.us.

Pavement temperature

Most weather stations measure temperature and other conditions 30 feet above ground, which means 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 changes in pavement temperature first on bridge decks and ramps; pavement temperatures will also be lower in shady areas.

Measuring with sensors or RWIS

There are various ways to measure pavement temperatures: with sensors or with a Road Weather Information System (RWIS).

Sensors can be hand-held, truck-mounted, or mounted on a structure near a road.

- Hand-held infrared laser sensors are pointed at the pavement to get a pavement or surface temperature while your vehicle is stopped or moving slowly.
- 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.
- A structure-mounted sensor is non-invasive and provides temperature readings, chemicals present, and grip or friction values.

If you do not have road sensors in your truck or on your roads, you can subscribe to a real-time weather forecasting system. Or, you can look up the road temperature from the closest state highway on RWIS (www.rwis.dot.state.mn.us). This will give you an idea of the local road temperatures. RWIS is a predictive system that consists of a network of towers and temperature sensors embedded in state highways.

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. These data are automatically forwarded to MnDOT maintenance supervisors, who can better respond to any weather related events.

To read more about MDSS/AVL, go to:
http://ihub/maintenance/mdssavl/index.html
http://www.meridian-enviro.com/.

Before the Winter

Take some time before the season to plan your routes and learn the plowing policies. A little planning up-front can help you do a more efficient job in keeping the roads safe.

Policies

- Make sure you have a plowing policy and meet to discuss it. Your level of service may be based on average daily traffic, environmental concerns, safety, mobility, economics, and other factors.
- Inform your citizens of policies.
- Learn to record what and how much you apply on each shift. Be prepared to analyze and make adjustments to your process based on what you learn.

Using less salt doesn't have to reduce safety, but it does protect our lakes.

Plan your routes

- During the fall, inspect and make sure ditches, culverts, and surfaces are free from obstructions and ready for the spring melt.
- Remove potential snow traps, such as tall grasses, that will catch and accumulate snow.
- Drive the assigned routes prior to winter to identify critical areas and find the most efficient way to cover the routes.
- Inventory all the areas prone to drifting and have a plan to manage them.
- Know your routes. Plan which way you will start.
- 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).

Calibrate your equipment

All good programs include calibration.

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.

If you don't calibrate your sander, the application rates will not be accurate.

- Because spreaders vary, calibrate each truck. Re-calibration is required if changes are made to the hydraulic system, if the augers have extensive wear or are resurfaced or replaced, or a different material is used.
- Follow the manufacturer's guidelines for calibration, and contact the manufacturer for training.
- Calibrate separately for salt/sand mix vs. salt or sand only.
- Determine flow rate or calibrate liquid application systems at the same time as the dry systems.
- Remember: The auger plate must be in place during calibration. You are not calibrating the truck properly if the material is gravity-flowing.
- 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.

Calibration resources:

- Clear Roads has links to manufacturers' calibration instructions and a comprehensive calibration guide: http://clearroads.org/researchprojects/05-02calibration.html
- MnDOT also has calibration instructions: www.dot.state.mn.us/maintenance/training.
- For sander calibration training, contact the Minnesota Circuit Training and Assistance Program (CTAP) instructor at www.mnltap.umn.edu/about/programs/ctap.
- For liquid calibrations, see the *MnDOT Anti-icing Guide* at www.dot.state.mn.us/maintenance/training.

Before the Storm

Anti-icing

Anti-icing can be a cost-effective strategy that optimizes chemical usage. It is a proactive approach that should be first in a series of strategies for most winter storms. By applying chemical freeze-point-depressant materials before a storm, you can prevent snow and ice from bonding to the pavement.

For guidance on which anti-icing chemical is most cost effective for your agency/location, see the MnDOT Cost Benefit Analysis Tool. For guidance on how to begin or expand an anti-icing program, see the *MnDOT Anti-Icing Guide*. Both can be found at www.dot.state.mn.us/maintenance/training.

Clear Roads online cost-benefit analysis toolkit

Anti-icing can provide significant cost, safety, and environmental benefits. To help determine cost savings, use the Clear Roads toolkit available at www.clearroads.org (click on research projects).

Anti-icing can reduce airborne dust and salt particulates.

Guidelines for anti-icing

- Anti-icing is often effective for heavy frosts.
- 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 wear away material.
- Similar applications of pretreated salts will also work. Use the lowest possible setting, less than 100 lbs/two-lane mile; apply as close to the start of event as possible.
- See the Application Rate Guidelines on page 16 of this field handbook.

What to do

- Apply liquids only with stream nozzles 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

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

temperature and conditions could produce frost or black ice.
- Consider spot-applications on hills, curves, and intersections if predicted conditions warrant.
- Use appropriate chemical for your pavement temperature range. See the chart on page 19 of this field 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.

What not to do

- Don't anti-ice under blowing 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 or after a prolonged dry spell, apply liquids at half the rate (not half the concentration). On dry roads, liquids tend to 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*: www.dot.state.mn.us/maintenance/training.html

Pretreating and prewetting salt and sand

Dry material bounces or blows off the road, so everyone should be either pretreating or prewetting dry material. Liquids also increase salt's effectiveness by jump-starting the melting process. Depending on the liquid used, it may lower salt's effective working temperature.

If you must use dry material, follow best practices to reduce bounce and scatter.

Because pretreating and prewetting cause material to stick to the road, 20 to 30 percent less material is used—saving money and reducing 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. You can also switch from dry application to wet application immediately—just turn down the application rate.

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

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.
- Because leach risk at a stockpile is increased, store it covered on an impervious pad.

Sand stockpile

- Pretreat the stockpile to keep it flowable.
- Apply to stockpile at 4 gallons of salt brine/ton sand.
- Store the stockpile *under cover.*

Apply wisely. We will never have a chance to recover the chlorides applied.

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, magnesium chlorides, and acetates may be used as prewetting agents.
- The usual application rate is 8 to 14 gallons/ton for salt brine.
- Prewetting with other chemicals at the spinner can help reduce the application rate.
- Below 15˚ F, salt brine becomes less effective; below 0˚ F, it may freeze hoses and valves.
- Salt brine should be mixed at 23.3%.
- Verify concentration of liquids you're using:
  Salt brine: 23.3%
  $CaCl_2$: 29.8%
  $MgCl_2$: 21.6%
  CMA: 32.5%
  KAC: 49%
- MnDOT completed the laboratory phase of a research project in 2012 comparing the ice-melting capacity and the cost-benefit of various pre-wetting chemicals. A second phase of this project, testing of chemicals on actual road surfaces, will begin in 2013. Information is available at www.dot.state.mn.us/maintenance/training.
- Super-saturated salt or slurry is a method in which a high volume of liquid is added to the granular salt. Two- to 400-gallon tanks, located within the box, pump brine at roughly 90 pounds of liquid/210 pounds of salt, resulting in a salt slurry that activates very rapidly.

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.

- Use an appropriate amount of salt. Most oversalting can be prevented by using calibrated, speed-synchronized spreaders and good judgment in selecting application rates and truck speed.
- It is not necessary 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.
- See the Application Rate Guidelines on pages 17–19 of this handbook.
- Dilution of Solution (see page 15) also applies to deicing.

The goal is not to melt everything. The goal is to penetrate through the ice and snow and break the bond so the pavement can be plowed.

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

Using abrasives

Use winter sand and other abrasives when temperatures are too cold for deicing chemicals to be effective. But be aware that sand does not melt anything. It provides temporary traction, and only when it is on top. Sand also clogs sewers, ditches, and streams. As a result, avoid sand use as much as possible.

A 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 limited situations such as a freezing rain event where the salt is washed away quickly. A 25 to 50 percent sand/salt mix has been documented as effective in increasing friction by sticking the sand to the surface, like sandpaper.

- Use abrasives in slow-moving traffic areas such as intersections and curves.
- If your purpose is melting, use salt only.
- Salt is ineffective in cold weather, so use sand or an alternative chemical.
- Sand is not cheap when you consider the handling, clean-up, and disposal costs.
- Sweep up sand frequently, after each event if feasible.

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.

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 (sodium chloride) at below 20˚ F pavement temperature. It will not melt fast enough to help and it will blow off the road into the ditch.
- Below 20˚ F, switch to other tools like $CaCl_2$ and $MgCl_2$ at curves, hills, and intersections to obtain maximum melting. If unavailable, use sand for traction.
- Adjust your spinner speed to the lowest setting possible, except at intersections.
- Don't let the traffic dictate your speed. Drive at the slowest possible speed—17 to 25 mph—to keep material on the road.
- On high-speed roads, apply deicers in the center of the road or high side of the curve.

Sand that washes into a stream or lake may smother some small aquatic organisms.

- Set spinners lower to the ground or use a chute to reduce bounce and scatter. See www.dot.state.mn.us/maintenance/training.html and www.mnltap.umn.edu/about/programs/opera/fact/documents/washingtoncad.pdf for chute-building instructions.
- Turn off auger when stopped, even briefly.

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

Loading/hauling

- Set up and load under cover and on a level surface wherever possible.
- Maintain loading area. Keep it clear and smooth.
- Don't overload. Avoid spilling on units.
- Watch for co-workers/pedestrians in or near the loading area.
- Good housekeeping and material storage recommendations are at www.dot.state.mn.us/maintenance/training.

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

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.

- 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; use of underbody blades helps remove compacted or slushy snow.
- Make use of carbide, flexible, or rubber-encapsulated plow blade edges. For research information on cutting edges, see www.clearroads.org/research-projects/07-01carbideinsert.html.
- Adjust blade angle to maximize cutting efficiency or snow throwing capabilities.

Once chlorides enter the ground or surface water, they never go away.

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.

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

- 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, stop lights, overhead structures, power lines, etc.
- Know the height of your truck box. Raise 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.

Snow cloud

Be aware of wind conditions and potential problems. Snow clouds can form during any plowing operation. A very slight snow cloud can temporarily block out any lighting configuration 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, and clear snow from crosswalks to allow pedestrian access. Americans with Disabilities Act (ADA) access must also be considered. For further guidance on cleanup prioritization, see www.dot.state.mn.us/maintenance/manual.html.
- 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 piles on an impervious pad and cover them. This includes salt and salt/sand mixes.

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

Standard practices

Documenting and charting

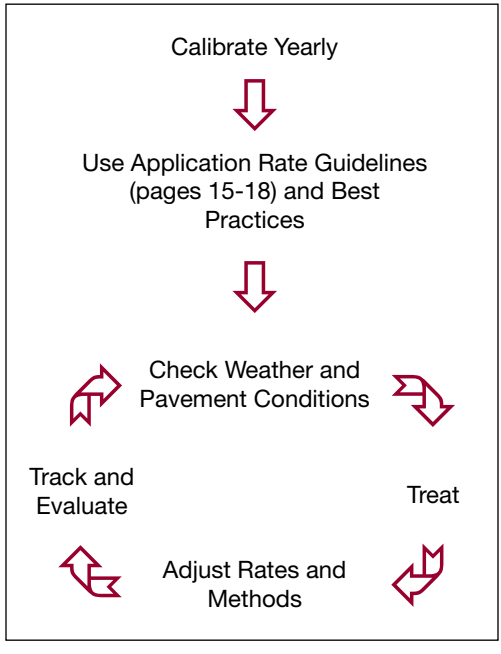
Good documentation helps you use less material, reduce costs and environmental impacts, and run a more effective snow and ice control program. Unless you document and chart, you can't measure what you are doing.

- Track your material use.
- Understand the storm conditions and the target level of service for each route.
- Refine your procedures and material use based on observations.
- Share observations to improve operations and learn from each other.
- Use forms like those shown in the appendix of this field handbook to record and track your work and observations.

Some fish species are affected by impaired water, which is equivalent to about 1 to 1.5 tablespoons of salt in 5 gallons of water.

- Complete forms at the end of your shift.
- Turn in documentation forms to your supervisor.
- Use Clear Roads online cost benefit analysis toolkit (2012) to examine costs and benefits of new and existing practices, equipment, and operations at http://clearroads.org/research-projects/08-02costbenefitanalys.html.

Fine-tuning your program



Application Rate Guidelines

Develop your own application rates using the guidelines on pages 15–18 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 field 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 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 *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.

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

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

At temps below 15 degrees, it may be more cost-effective to use a chemical other than NaCl.

See research at www.dot.state.mn.us/maintenance/training

Deicing Application Rate Guidelines

24' of pavement (typical two-lane road)

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

			Lbs/ two-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	80 (40/lane mile)	70	100*	Not recommended
	Frz. rain	Apply chemical	80 – 160	70 – 140	100 – 200*	Not recommended
30° ↓	Snow	Plow & apply chemical	80 – 160	70 – 140	100 – 200*	Not recommended
	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
	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
	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
	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
	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 frz. 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

*Dry salt is not recommended. It is likely to blow off the road before it melts ice.

**A blend of 6 – 8 gal/ton $MgCl_2$ or $CaCl_2$ added to NaCl can melt ice as low as -10˚.

Application Rate Guidelines

The following are examples of application rate charts used in Minnesota.

Temperature	Maintenance Action	Spinner Speed	Salt %	Pounds Per Lane Mile
30	Light sleet, light rain, or light snowfall stopped.	low	100%	100 to 200
	Light freezing rain or light snow continuing.			150 to 300
25	Heavy freezing rain, sleet, or snowfall continuing.	low	100%	200 to 400
	Light snowfall continues at 1/8" to 1/4" per hour.	low	100%	150 to 300
20	Heavy snowfall, repeat salting at lower rate.	low	100%	200 to 350
	Light snow falling at trace to 1/4" accumulation.			150 to 300
15	Light snowfall continues at 1/8" to 1/4" per hour.	low	100%	200 to 300
	Heavy snowfall, repeat salting at lower rate.	off	80%	
10	Snow stopped and sun is going to come out.	low	100%	200 to 300
	Light snowfall continuing or sun is going to come out.		80%	200 to 300
5 to 10	Light snowfall continuing or sun is going to come out.	low	70%	150 to 300
	Light snowfall at trace to 1/4" accumulation.		25%	200 to 400
0 to -15	Light snowfall at trace to 1/4" accumulation.	low	25%	400 to 600
	Light snowfall at trace to 1/4" accumulation.			
0 to -15	Snow stopped and roads have hard pack.	off	25%	400 to 600
	Snow stopped and roads have hard pack.			
	*Concentrate salt with low spinner speed *Rates are per lane			

Use a higher % of sand in cold temps or use 200 to 400 lbs treated salt below 15 temp

Rates are for units with salt settings of 100, 150, 200, 250, 300, 350, 400, 450, 500, 600.

Credit: Anoka County Highway Department

BEFORE & DURING SHIFT, CONSULT RWIS™ BEFORE APPLYING *ANY* CHEMICALS OR MATERIALS!

Pre-wet Material Chart

Application Rate Recommendation Chart

Pavement Temp	Weather Conditions	Pounds Per Two (2) Lane Mile			Actions & Application Recommendation
		100% Salt	50% Salt	Stock Pile	
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 w/ Stockpile

FROST: 15˚ & RISING: TREAT BY ANTI-ICING (Brine 20-40 G/LM) or 15˚ & FALLING: 100% SALT @ 150 #/LM

WIND CONDITIONS: PLOW, TREAT (TROUBLE SPOTS ONLY!) WITH 50/50 @ 300#/LM OR STOCKPILE @ 200-400 #/LM

IF EVENT/SHIFT TEMPERATURES WILL *RISE*, USE SALT INSTEAD OF SAND (& vise 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*: www.dot.state.mn.us/maintenance/training. For a list of vendor contacts and chemicals available on the Minnesota Approved Products list, see the MnDOT *Winter Chemical Catalog* at www.dot.state.mn.us/maintenance/training.

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 to 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.

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. Therefore, a guide for testing the effectiveness of chemicals was developed. See the Clear Roads report at http://clearroads.org (click on research projects, completed projects).

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

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 (MSDS) for specific gravity.

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, record weight on worksheet
2. Cook, once salt is dry weigh again, record dry weight
3. Do calculations on the worksheet

Salt Moisture Worksheet

(with scale zeroed out to account for container)

Date: Company:

P.O. #: Ticket #:

A. Weight of wet salt

B. Weight of dry salt

C. Weight loss (A-B)

Tested by:

Moisture Calculations:

C ÷ A x 100 = % moisture

Remarks:

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

Bibliography and Additional Resources

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University of New Hampshire Technology Transfer Center. *Manual of Practice*. www.t2.unh.edu/pubs/manofpractice_1.pdf

Utah LTAP Center. *Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance*. www.utaht2.usu.edu

Training and technical assistance

- The Circuit Training and Assistance Program (CTAP), a joint program of MnDOT and the Minnesota Local Technical Assistance Program (LTAP), brings training to your doorstep. For workshop registration visit www.mnltap.umn.edu/ctap.

- Minnesota LTAP offers a series of workshops around the state on a variety of topics. Visit www.mnltap.umn.edu.

- MnDOT Winter Maintenance Coordinator: 651-366-3500

Other Web resources

- Iowa Department of Transportation. *Anti-icing Equipment Manual* (with drawings for shop-made equipment). www.dot.state.ia.us/maintenance/manuals/equip/intro.htm

- Minnesota Department of Transportation. *Guide to Field-Testing Deicing and Anti-Icing Chemicals*. www.dot.state.mn.us/maint/research/chemical/chem_evaluation_guide.pdf

- Pacific Northwest Snowfighters.
  www.wsdot.wa.gov/partners/pns/default.htm

- Salt Institute.
  - *Practical Guide for Storing and Handling Deicing Salt*. www.saltinstitute.org/snowfighting
  - Calibration Instructions (with downloadable Excel worksheet) www.saltinstitute.org/snowfighting/6-calib.html

- Clear Roads Pooled Fund Project.
  ClearRoads.org

Appendix

Example Daily Salt/Sand Use Ticket

Operator		Shift		Date		
Truck No.		Capacity				
Weather				Temp.		
Stockpile	Route	Yards Sand	Yards Salt	Yards Used	Yards Returned	Liquid Gallons
TOTALS						

Example Loader Ticket: Daily Salt/Sand Issued

Operator _____ Shift _____ Date _____

Loader No. _____ Capacity of Bucket _____

Stockpile	Truck #	Yards Sand	Yards Salt	Stockpile	Truck #	Yards Sand	Yards Salt
TOTALS							

Example Documentation Form For Anti-Icing

Anti-icing Route Data Form				
Truck Station: Date:				
Air Temp.	Pavement Temp.	Relative Humidity	Dew Point	Sky
Reason for applying: Route: Chemical: Application Time: Application Amount: Observation (1st day): Observation (After event): Observation (Before next application): Name:				

Bare Lanes Data Collection Sheet

Event Began		Event Ended		Event Type	
Date Time		Date Time		(snow, rain, both, drifting)	
Description	Route #	Bare Lanes Lost		Bare Lanes Regained	
		Date	Time	Date	Time