

A photograph of a paved road winding through a winter forest. The road is dark with a white dashed line down the center. The trees on both sides are heavily covered in snow, and the sky is a clear, bright blue. The overall scene is peaceful and serene.

# Safe and *Sustainable* Snowfighting



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— *The* —

## Snowfighter's Handbook

*A Practical Guide for Snow and Ice Control*



*Dedicated to the people  
who provide safety and mobility  
on roads in winter — **the snowfighters***



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PUBLISHED BY THE SALT INSTITUTE: The Salt Institute is a North American based non-profit trade association dedicated to advancing the many benefits of salt, particularly to ensure winter roadway safety, quality water and healthy nutrition. See [saltinstitute.org](http://saltinstitute.org) and [safewinterroads.org](http://safewinterroads.org) for more information.



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## FOREWORD

**T**his manual, prepared by the Salt Institute, is dedicated to the thousands of men and women in public works agencies at all levels whose task is providing safe streets and highways during winter storms.

The modern snowfighter must be accountable for meeting the community's needs for safety and mobility, as well as the safeguarding of our environment.

We commend all those agencies practicing the Safe and Sustainable Snowfighting approach to snow and ice control, which emphasizes getting the most from every application of deicing salt while maintaining the safest roads possible in the most economical way, and protecting the environment.

Every winter, over 115,000 people are injured and over 1,000 are killed on snowy or ice American roads. Clear roads protect lives and commerce and salt is a necessary strategic resource.

- Road salting and effective plowing can reduce injury crashes by up to 88%.

- The economic impact of snow-related closures far exceeds the cost of timely snow removal. A one day major snowstorm that shuts down roads can cost a state between \$300 and \$700 million in direct and indirect costs.

- Deicing pays for itself within the first 25 minutes after salt is applied.

Modern strategies to effectively deal with winter road hazards depend upon having the most up-to-date information regarding expected weather conditions, the timely deployment of anti-icing to prevent ice-pavement bonding, properly calibrated application of road salt, improved equipment, automatic spreader controls, sufficient covered storage, and stockpile logistics to make salting of roads the most effective and safest customer-driven method for snow and ice control.

Environmental problems concerning use and storage of salt need not exist if there is a balanced and sustainable approach to the use of salt for snow and ice control – one that demonstrates excellent practices in achieving safety, mobility and care for the environment.

The Snowfighter's Handbook was originally published in 1967. It has been widely accepted as a recommendation for proper salting procedures and techniques.

The purpose of this manual is to provide the snowfighter with information and suggestions for combatting winter storms.

The Sustainable Snowfighting methods contained in this manual are the cornerstones of an effective winter maintenance program which will help snowfighters provide the public with the most effective snow and ice control program possible at the lowest overall cost and least impact on the environment.

Two other practical publications, Road Salt and the Environment and the Safe and Sustainable Salt Storage Handbook, are also available from the Salt Institute. Two websites, [saltinstitute.org](http://saltinstitute.org) and [safewinterroads.org](http://safewinterroads.org), are further resources. ❄



# 1 WHAT IS SUSTAINABLE SNOWFIGHTING?

**S**ustainability has become a bit of a slippery word – it seems to mean all sorts of different things to different people. That makes it very difficult if you are trying to make some of your practices sustainable, since different people may well have different views of what constitutes sustainability.

Originally, and ideally, sustainability is defined as the practice that balances societal, economic, and environmental outcomes according to the needs of the community being served by the practices in question. It can be represented as the area of overlap between three circles, one each for the three outcomes. But even this is a little tricky to get our hands around.

In winter maintenance, sustainable practice can be defined as practice that meets the societal needs of a community, for example safe roads that can be used for transportation of goods and people during winter time, with economic constraints. Because nobody has an infinite budget, we must take care not to burden the environment by the actions taken to meet the societal needs within the economic constraints. Even that is a bit difficult to grasp but a few things come from it pretty directly.

First, different communities have different needs and so should, if they wish to be sustainable, have different approaches to their winter maintenance. Put another way, when it comes to sustainable Snowfighting, one size does not fit all! That is not to say that we cannot use good practices and be sustainable, but rather that the end goals in one community may be very different than those in another, and so the practices of those two communities will differ.

Because sustainable Snowfighting is, of necessity, community dependent, it might sound as if it would be impossible to tell if you are doing it or not! However, by using a checklist of practices it is possible for an agency to determine whether they are using the practices that best move them toward accomplishing the end goals appropriate to their community and its societal needs.

The Salt Institute provides such a checklist as part of our Safe and Sustainable Snowfighting Award program. Agencies can

use this as a way to determine areas of practice where they are doing well, as well as to identify areas where improvements can be made.

The key thing to remember about winter maintenance and sustainability is that it is not just about the environment. Instead, it is about balancing three things – societal needs, economic constraints, and environmental stewardship. Safe and sustainable Snowfighting allows agencies to do that balancing act. ❄️



## 2 HOW IMPORTANT IS THE WINTER MAINTENANCE FUNCTION?

**S**now and ice control is often the single largest cost item in the maintenance budget for streets and highways. In a recent year, snow removal in 33 snow belt states accounted for 20-25% of total maintenance costs and almost 5% of all highway expenditures.

For this reason, and because of its impact on public safety and essential mobility, snow and ice control deserves special attention from top highway management as well as from those in maintenance at all levels.

With more than 300 million motor vehicles registered in the U.S. and more than four million miles of roads and streets, more must be done with the winter maintenance dollar than simply providing traction over ice and snow.

Most Canadian road authorities have an even tougher job than their U.S. counterparts. Canada's commerce and industry depend upon safe transportation and communication throughout the vast nation. Yet, Canadian winters threaten for six months every year, with colder temperatures and more frequent snows than in the United States.

The common practice for snow and ice control on many miles of streets and highways is removal of these substances as soon as possible to provide safe pavement through Sustainable Snowfighting. Nearly every state, province, city and toll road in the snow belt has some mileage on a clear pavement program. These facts about our motorized economy show why:

- Motorists now travel more than three trillion vehicle miles each year.
- More than 75% of workers who commute drive to work.
- More than 80% of intercity travel is by motor vehicle.
- Suburban growth has drastically increased traffic densities on most street and highway systems.

- Access to retailers, service establishments, and other businesses is often wholly dependent on auto or truck transportation.
- Just-in-time manufacturing practices require reliable highway access for economic efficiency and competitiveness in snow belt areas.
- Web-based sales are pushing incredible parcel delivery growth.
- Increasing traffic volumes, the reliance of our society on daily mobility, and the urgency of moving emergency vehicles without delay demand efficient snow and ice removal to keep traffic moving all year around.

Sustainable Snowfighting provides safe pavement in an environmentally sensitive manner. By preventing the bonding of snow and ice to pavements and clearing all snow and ice from pavements as soon as possible, snow fighting materials are used most efficiently with minimal loss to the environment. Benefits of this high maintenance are apparent:

- Traffic keeps moving.
- Commerce and industry go on at near normal pace.
- There are fewer accidents, injuries, and deaths.
- There is minimal environmental impact.
- Emergency vehicles get through.

The public is less tolerant of failure in snow and ice control than in any other highway or street department function. A snowstorm affects the entire community – often entire states. Unless a storm is handled capably by the maintenance forces, it can upset considerably the daily routines of individuals, endangering public safety and adversely affecting business and commerce. ❄️



# 3 LEVELS OF SAFETY AND SERVICE

There is an old saying, that “if you don’t know where you’re going, you’ll end up somewhere else.” Setting levels of safety and service for your agency ensure that you will not find yourself in that unintended other place!

So how do you set those levels of service, and what should they be? Well, first for most agencies, the levels of service are set by the elected officials with the oversight of the road agency. But, having said that, the elected officials will almost certainly listen to the folks charged with meeting those levels of service (that means you!).

A side note here – in some Canadian provinces, in addition to any local political requirements, there are also minimum maintenance standards that must be met. However, no such minimum maintenance standards exist in the US and it can be argued that such a top down approach is inherently unsustainable, since it does not take into account the needs and concerns of the local community.

Typically, the first step in determining levels of service involves setting priorities. Some roads in an agency’s jurisdiction are more important than others, and so should receive priority treatment over other roads. Setting of priorities can be done in several ways, but typically average daily traffic is considered (the more traffic per day, the higher the priority) along with other factors such as school bus routes, emergency access routes, and areas that face particular challenges in the winter time (e.g. hills and bridges).

One example of setting priorities is shown here, taken from the Snow Plan for the City of West Des Moines:

*In order to make the most efficient use of available resources, the City has established priorities using the assumption that the severity of a storm is not beyond the normal capabilities of the City’s snow removal resources. Depending on the nature of the snowstorm, deviations could occur. The established priorities are as follows:*

Arterials - The minimum network which must be kept open to provide a transportation system for police, fire and rescue squad units.	<b>1st Priority</b>
All remaining Streets including Cul-De-Sacs	<b>2nd Priority</b>
Alleys and Parking lots	<b>3rd Priority</b>

Having determined the priorities of the roads in your care, the next step is to figure out what to do with each priority level. Put another way, what is the end result that you want to achieve for that priority of road? It is not enough to say that this sort of road is your highest priority – you have to set goals for your activities during and after the winter storms you will face.

Again, there are lots of ways of doing this. And the decisions made here will to a large degree determine the costs of your winter maintenance program. The higher the end level of service that you want to achieve, the more equipment, material, and manpower it takes to get to that end point. Many agencies express the desired end point in terms of photographs of road conditions. So you can see here, the level of service increases from the top left through to the bottom right. Which of these end points is right for your agency? Does every road need to be as clear as an Interstate (bottom right), or could some of your residential streets make do with some residual snow left on them (top left)?

Of course, the level of service an agency has for a given priority group of roads will impact the costs of clearing those roads. And it is important that your elected officials understand that – if they decide they want all their residential streets to look like an Interstate after a storm, there will be additional costs associated with that. There will also be additional safety benefits – a cleaner road is a safer road, but remember that nobody should be driving at interstate speeds on residential streets anyway!

There are three other important factors to consider with levels of service. First, the level of service will be easier to attain with some storms than with others. Another way of thinking about this is that an inch of snow is easier to handle than an inch of ice! You need to build into your levels of service enough leeway to account for different storm conditions. This need not be complex – a statement like “Depending on the nature of the storm, deviations in the level of service may occur,” would likely be enough.

Second, just as cities grow and change, so too should your levels of service. Including a periodic review of your level of service, which involves your elected officials and the public that you serve, can be a very effective way of keeping your officials and your public (your customers, in other words) informed about what you do.

Third, the levels of service that you have can, depending on the law in your state or province, provide you with a degree of risk management. With this in mind, it is important that you do not exceed your levels of service on a regular basis – for example, if your plan says you do not plow residential streets until after the storm is finished, then you should stick to that. It may be that your plan needs to change (or it could be just fine), but the time to decide that is not in the thick of a snow storm because a resident is complaining! ❄️





# 4 MATERIALS USAGE

If your levels of service include attaining bare pavement, then you will need to use materials to get there. And using materials effectively and sustainably requires that you consider some questions. Later sections of the handbook will dig into some tactics for materials application in more detail, but a few ground rules can be very helpful in this regard.

First of all, how you apply the material makes a big difference. You can use solids or liquids or pre-wet solids. Each has a place, but making sure you are using materials in the right form for your agency is important.

Second, the amount of material you apply should be a function of three things: the pavement temperature, the type of storm you are fighting, and the cycle time of your trucks (when another truck will be along to apply more material, if needed, to the place where you are right now – and that other truck might be yours!).

Third, having the right materials to apply is critical. This too is one of those sustainability issues – every agency has different needs and expectations, so there will be many “right answers” out there. Lots of guidance is available, and one recent example would be the NCHRP Report 577, which has a method for determining what are the most effective and efficient materials for an agency.

Finally, there is sand or abrasives. Remember that sand will not melt snow or ice – it simply provides a temporary increase in friction on the snow or ice covered road. If you have a level of service goal that calls for bare pavements or bare wheeltracks, sand will not get you there. So, only use sand when it makes sense (when pavement temperatures are too low for your other materials to work for example) and remember that a sand-salt mix is always half wrong. If you need salt, put down salt. If not, don't. ❄️

Pounds of Ice Melted Per Pound of Salt	
Temperature Degrees F	One Pound of Sodium Chloride (Salt)
30	46.3 lb of ice
25	14.4 lb of ice
20	8.6 lb of ice
15	6.3 lb of ice
10	4.9 lb of ice
5	4.1 lb of ice
0	3.7 lb of ice
-6	3.2 lb of ice

Application of Salt	
Rate of Application Per Two-Lane Mile	Coverage Per Cu. Yd. of Salt Per Two-Lane Mile
800 lb	2 1/2
700 lb	2 3/4
600 lb	3
500 lb	4
400 lb	5
300 lb	6
200 lb	10

Note: Salt meeting ASTM Specification D632 weighs approximately 80 lb per cubic foot.



# 5 ANTI-ICING

The idea behind anti-icing is relatively simple – if you stop the snow or ice from freezing to the pavement, it becomes much easier to remove it with a plow than if it has frozen to that pavement. That means you have to get a thin layer of ice control material at the pavement surface and keep it there.

Anti-icing is a proactive process, with an initial goal of placing brine at the road surface and a subsequent goal of maintaining a layer of brine at the surface by additional applications of either brine or solid, pre-wet salt during the storm. Various studies have shown that using anti-icing and being proactive rather than reactive can reduce costs substantially (by up to 90% in some studies) and also reduce the total quantity of salt used during a storm by up to a factor of four.

Hydrometer/Salometer Chart for Salt Brine		
% Salt	Hydrometer Specific Gravity	Salometer Using 0-100%
0	1.000	0
1	1.007	4
2	1.014	7
3	1.021	11
4	1.028	15
5	1.036	19
6	1.043	22
7	1.051	26
8	1.059	30
9	1.067	33
10	1.074	37
11	1.082	41
12	1.089	44
13	1.097	48
14	1.104	52
15	1.112	56
16	1.119	59
17	1.127	63
18	1.135	67
19	1.143	70
20	1.152	74
21	1.159	78
22	1.168	81
23	1.176	85
24	1.184	89
25	1.193	93
26	1.201	96
27	-	100

## Anti-Icing Advantages

- Anti-icing returns road surfaces to normal faster, resulting in fewer accidents and delays.
- Anti-icing can reduce airborne dust and salt particulates.
- Salt needs moisture to be effective. Applying brine jumpstarts the melting process.
- Brine sticks to the road surface. It will not be as easily blown off the road by wind or traffic, so material is more efficiently and sustainably used.
- If the storm is delayed, salt residue remains on the road ready to begin work when precipitation begins.
- Crews can begin treatment in advance of a storm. Because anti-icing prevents the bonding of snow and ice to pavement, snowfighters have less work to maintain safe roadways as the storm progresses.
- Increased efficiency results in the use of less ice control material and manpower, thereby lowering the cost of maintaining safe road conditions. The use of less materials also minimizes environmental concerns and highlights the sustainable nature of anti-icing.

As indicated above, a liquid is needed for the first part of anti-icing. Five products are typically used: salt (sodium chloride) brine, calcium chloride brine, magnesium chloride brine, potassium acetate, and calcium magnesium acetate. In addition, a number of agencies are blending their brines with carbohydrates to enhance persistence on the road surface, and some of the blends include mixtures of the above mentioned five products as well as the carbohydrates.

Each product and blend has its own advantages and disadvantages. The most common material in use is sodium chloride brine (or salt brine as it is commonly called) made from a mixture of rock salt and water. Salt brine is effective at pavement temperatures above 15° F and is a proven anti-icing agency in use throughout the snow-belt.

Some agencies use calcium chloride brine or magnesium chloride brine both of which are effective at pavement temperatures colder than 15°F. However, for most of North America these sorts of pavement temperatures are unusual during or just before storms. Further, these other brines are more than six times more expensive than salt and are more difficult to handle. Also, calcium and magnesium chloride brines leave a residue on road surfaces that can attract moisture at lower relative humidity than salt, resulting in potentially slippery conditions in certain limited circumstances.

## Salt Brine Manufacture

One of the reasons so many agencies use salt brine is that it can be easily made by mixing rock salt or solar salt with water. The process is simple: the resulting brine should be approximately 23% NaCl.

The proportion of salt to water is critical to the effectiveness of the brine. Too much or too little salt affects the freeze point depressing qualities of the brine. The proper brine mixture is 23.3% salt content by weight. This is the concentration at which salt brine has the lowest freezing point, -6° F, also known as the eutectic point. If we keep adding salt at this point we do not lower the freezing point any further. If we add more salt it will start to come out of solution as salt crystals. When we are making salt brine, we can measure the percentage of salt with a salometer, a specialized hydrometer, and when the salometer reaches a measurement of 88.3% we have reached the optimal 23.3% salt content.

Some road agencies have built their own brine makers, while others are purchased from brine maker manufacturers, of whom there are now several in North America who specialize in the winter maintenance market. Brine is usually made at the local maintenance facility sites and stored in large tanks in locations convenient for loading into saddle tanks on the sides of V-box spreaders or into other anti-icing equipment.

## Application Equipment

There are a number of ways in which brine can be placed onto the road surface. Some agencies use specialized trucks or slide-in units on their dump trucks. Other agencies use tow-behind trailers. Typically the brine is pumped onto the road surface by a spreader bar and nozzles. Most agencies recommend streaming rather than spraying the brine onto the pavement – that is, feeding it through a tube from the nozzle down onto the pavement rather than spraying it into the air from the nozzle. Control should be available to vary spreading rates from 25 to 60 gallons per lane mile.

If large, horizontal tanks are used in the design, consider installing baffles inside the tanks to help prevent the liquid from suddenly shifting in the tank, which may create a hazardous control situation for the operator.

## Application

Accurate weather and road surface information are critical for the efficient use of anti-icing materials. Road surface temperatures, precipitation amounts and form, wind conditions, and road environment (sunlight exposure, surface condition, bridges, etc.) all affect the use and application of anti-icing measures.

The phase diagram of the salt-water system, shown here, indicates what happens when we place brine on the pavement surface. We place the brine at 23.3% solution (the eutectic solution). As moisture collects on the pavement surface, we dilute out the brine (move to the left on the phase diagram) so that our solution drops below 23.3%. Eventually we cross the line into the area labelled “Too little salt – refreezing occurs” and at that point, the snow and ice on the pavement will begin to freeze to the pavement – the very thing we are trying to avoid by anti-icing. We cannot stop this dilution process – it is in fact how the brine stops the snow and ice freezing to the pavement, but we have to recognize that it will happen.

**ADDITIONAL PRECIPITATION ALWAYS RESULTS IN A DILUTION OF BRINE AT THE ROAD SURFACE.**

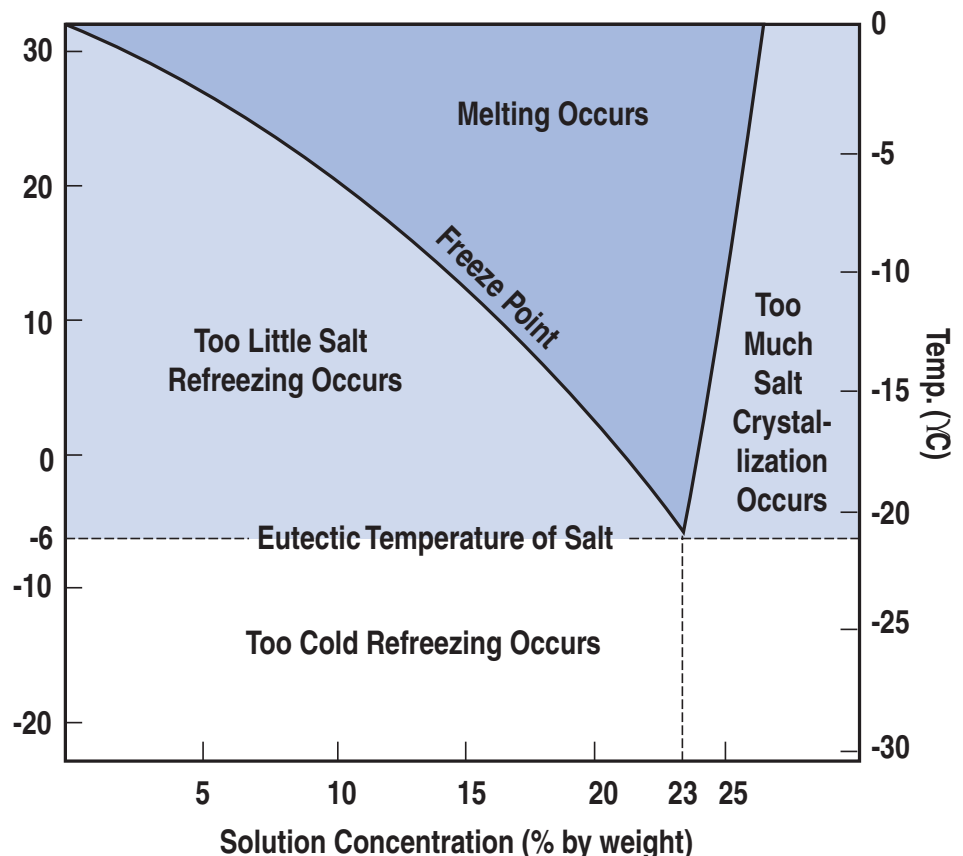
Put another way, the clock starts ticking as soon as precipitation begins to fall on our brine-treated pavement. The strategy of anti-icing depends not only on the initial pretreatment with a brine before the storm but on subsequent treatments (most often with pre-wet solid salt) during the storm, in conjunction with plowing.

The proactive nature of anti-icing means that good weather forecasts are absolutely critical. And a very important part of those forecasts are pavement temperature forecasts, which the National Weather Service does not

supply. In addition to forecast information, some agencies use Road Weather Information Systems (RWIS) to track pavement temperatures in real time and some also use traffic cameras and cameras in trucks to monitor road conditions visually. These tools help to determine the right application of anti-icing materials, and when best to make that application.

Do not apply anti-icing brine under blowing conditions, particularly in areas prone to drifting as the blowing snow may stick to the brine, dilute it, and create ice. Don't apply too much brine or the roadway may become slippery. Always follow application recommendations.

## Phase Diagram for Salt



## Summary

Anti-icing measures are an important weapon in the sustainable snowfighter's arsenal. The appropriate use of anti-icing techniques results in:

- Returning to bare pavement conditions more quickly, saving lives and reducing property damage due to fewer accidents, as well as the reduction of traffic delays and the resulting reduction of losses to local economies;
- Reduction in the quantity of ice control material used, resulting in cost savings and fewer environmental concerns; and
- Reduction in the manpower necessary to maintain safe road conditions, resulting in less overtime costs, less operator fatigue, and safer working conditions. ❄️



## 6 PRE-WETTING

Let's begin with a definition of pre-wetting. It is applying liquid brine to rock salt prior to the salt being placed on the road surface. Pre-wetting can be done in three ways. You can pre-wet the stockpile of salt you have (this is sometimes called pre-treating the salt), you can pre-wet the salt in the back of the truck by using a shower type system (essentially wetting the whole load in one single wetting event), or you can pre-wet the salt as it is applied to the road, either in the augur or on the spinner of the spreading unit.

Which method is best? Experience suggests that pre-wetting at the augur or spinner is the best of the three methods. But, that method involves having tanks on your trucks as well as equipment to mix the brine with the salt either in the augur or at the spinner. Some agencies do not have that capability.

If you do not have the ability to carry liquid on your trucks and to pre-wet the rock salt as it is applied to the road, the second best option is to pre-treat your whole salt stockpile. This is typically done prior to the winter season, and uses some sort of pug mill to ensure the rock salt is thoroughly coated. The drawback with this method is that you cannot vary the pre-wetting rate (which sometimes can be very helpful for you as discussed below).

Of the three methods, pre-wetting the whole load is the least desirable, since the pre-wetting tends to be very non-uniform, and if all the salt that has been pre-wet this way is not used in a given storm, there may be some issues with returning it to the stockpile.

BUT, and this is important, any of these three methods is MUCH, MUCH better than not pre-wetting at all. That is a strong statement, so let's unpack it a bit and explain why.

Back in the 1970s, Michigan DOT looked at how salt bounced and scattered from the back of a truck as it was spread on the road. What they found surprised them. They applied salt at a rate of 400 pounds per lane mile, with the truck traveling at 30 mph, down the center lane

of a three-lane road (it was closed to the public at the time). They found that dry (i.e. non-pre-wet) salt scattered so much that fully 30% went into the ditch rather than into any of the three lanes of the road. When they pre-wet with only 6 gallons per ton of salt, they found that they lost only 4% of salt into the ditch.

And that is the primary, number one, do not miss, reason you should pre-wet your rock salt with brine prior to spreading it on the pavement - unless you can afford to waste 30% of your salt. However, it turns out that this is not the only reason for pre-wetting.

For salt to be effective as an ice control material, it needs moisture. If it is pre-wet it has that moisture already and "gets to work" right away. If it is put down dry, it will not start working as quickly and thus it is more prone to being swept off the road before it can do any good.

More recent work is showing that pre-wetting can be even more effective if the rate of pre-wetting is increased. A number of agencies have been investigating using pre-wet rates as high as 50 gallons per ton, and finding that this works extremely well, especially on heavy-traffic routes. The slurry that this high pre-wet rate forms splats onto the pavement (rather than bouncing in any way) and is effective essentially immediately. This is another reason for having the capability to pre-wet on your trucks - slurries are incredibly effective in normal winter maintenance operations and have resulted in substantial increases in performance.

So, pre-wetting works and it is a critical part of a safe and sustainable winter maintenance program. If you are not pre-wetting, please start taking steps so that you can. ❄️



# 7 DE-ICING

**E**ven if your agency has an anti-icing strategy for your winter maintenance operations, it will occasionally happen that a storm occurs during which you are not able to prevent the bond forming between the snow (or ice) and the pavement. The most common example of this sort of storm is an ice storm, but it can happen during other winter storms too. When it does, you need to switch from an anti-icing mode to a de-icing strategy. That means you will have to break the bond that has formed, by using some sort of ice control material, and taking steps to get that material to the snow-pavement bond as quickly as possible.

More than a dozen compounds have been tested for de-icing use. The most common products used are sodium chloride, calcium chloride, and magnesium chloride. Sodium chloride in the form of rock salt or brine is by far the most commonly used material in de-icing operations, due to its lower cost and proven effectiveness. Therefore, in the words of the transportation Research Board in its 1992 analysis of de-icers, salt remains the “de-icer of choice.”

Abrasives have no melting effect for de-icing operations; in fact research by the Strategic Highway Research Program (SHRP) and the University of Wisconsin suggests that sand inhibits the melting process of de-icing materials.

## Applying the Materials

As discussed in the previous chapter, salt can be applied as a pre-wet solid or as a liquid brine. Application methods are determined by weather and road conditions as well as equipment available. Salt needs moisture to provide melting action and break the bond. When we are in a de-icing situation and the bond between snow and pavement has formed, we typically have to melt through some snow or ice before we can begin to break the bond. Once we have done that, the removal operations can be successful in restoring bare pavement conditions.

Direct application of liquids is not recommended for packed snow as the liquid destroys surface friction and the brine may become so diluted before melting action is completed that refreezing can occur. When packed snow exists, then pre-wet salt is typically the optimal approach. If the issue is black ice or frost, however, direct application of liquids is very effective.

Ice control materials should be applied close to the crown or high point of the road. The resulting brine will run downhill from the crown to the rest of the surface. Spinner speed should be low enough to ensure that de-icing materials remain on the road surface. Spinner speed and application rates should be higher at intersections and other high traffic areas to spread de-icing material over a larger area or in higher concentrations as required by the conditions. However, use of the BLAST override on automatic controls while stopped at a stop sign or light is not appropriate.

Road conditions, pavement temperature, amount of snow and ice cover, storm progress, moisture content of precipitation and traffic conditions, all affect material application rates.

## Materials Selection

Generally, all ice control chemicals work in the same way. They depress the freezing point of water, and thus either prevent the formation of a bond between snow and pavement or melt that bond if it has already formed. If that bond is broken then the ice and snow can be plowed off the road relatively easily.

Agricultural by-products have been added to chloride-based ice control materials and they serve to enhance the performance of the chloride-based materials. While the agricultural by-products on their own would also serve to depress the freezing point of water (thanks to the carbohydrates in the by-products) their performance on their own in that regard is in general less than the chloride-based materials. One of the primary reasons for combining these by-products with the chloride-based materials is to enhance the persistence of the materials on the pavement surface. The

carbohydrates tend to make the materials sticky or tacky, and anecdotal reports suggest that ice control materials last longer on the road with such by-products than without.

Although these materials all work in essentially the same way, their performance can vary widely. The performance factors that are typically considered will include: effective temperature range, speed of action, amount of material required, duration of melting action, availability, cost, infrastructure and environmental impacts, and persistence on the pavement.

Each community will place a particular emphasis on each of these criteria to suit their own specific needs. Indeed, such local emphasis is a core part of a sustainable Snowfighting approach – in this regard one size does not fit all! Local needs may change over time, as political priorities shift. The ability to be able to make a rational decision on material selection to closely fit with ongoing needs is of tremendous importance to winter maintenance planners.

In order to come to grips with this issue, a consortium of state DOTs commissioned a study to develop an evidence-based decision tool for materials selection. This was published by the Transportation Research Board (TRB) of the National Academy of Sciences in May 2007. The full report (NCHRP Report 577) can be downloaded from the TRB website.<sup>1</sup>

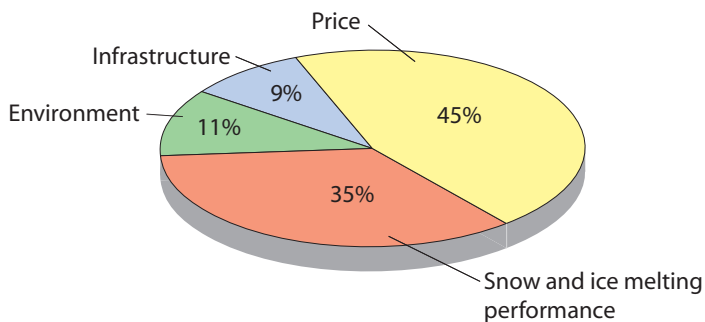
Now agencies can objectively compare the ice control materials they use in terms of the sustainable Snowfighting priorities that each agency defines and determines for itself. The computer program (called the Material Selection Wizard<sup>2</sup>) crunches the data based upon the agency's set of priorities. The following example demonstrates how the Wizard works.

A winter maintenance agency has had budget cuts and decides that the following priorities reflect their particular needs – see Chart 1.

<sup>1</sup> [http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp\\_rpt\\_577.pdf](http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_577.pdf)

<sup>2</sup> <http://www.trb.org/Main/Blurbs/158876.aspx>

Chart 1



Price is the primary concern (45%), snow- and ice-melting performance is almost but not quite so important (35%), while environmental (11%) and infrastructural (9%) are somewhat lower priorities for the agency at this time.

Using the Wizard, the data are input and the following results are obtained showing which material will fit the agency's needs for which temperatures – see Chart 2.

The Wizard presents an informed choice based on specified priorities. It is a choice that can, for example, be defended before City Council. Citizens value their hard-earned dollars and expect them to be spent wisely to keep roads open and safe, while safeguarding the environment. The City Council and the citizens determine the policy. This tool turns the policy into a practical and functional choice.

As another example, here is an extreme environment/infrastructure priority model. It disregards ice control material costs and weights performance low (25%, with the logic that a lower weighting would be irresponsible since the material must perform its life-saving deicing mission). Environment and Infrastructure together account for three-fourths of the total weighting, split evenly with 37.5% weight for each. Chart 3 shows how the various materials stack up with these changed priorities. So, the choice belongs to the agency that can now be assured that at the temperatures to be encountered they are choosing materials that comply with their community's particular priorities. ❄️

Chart 2

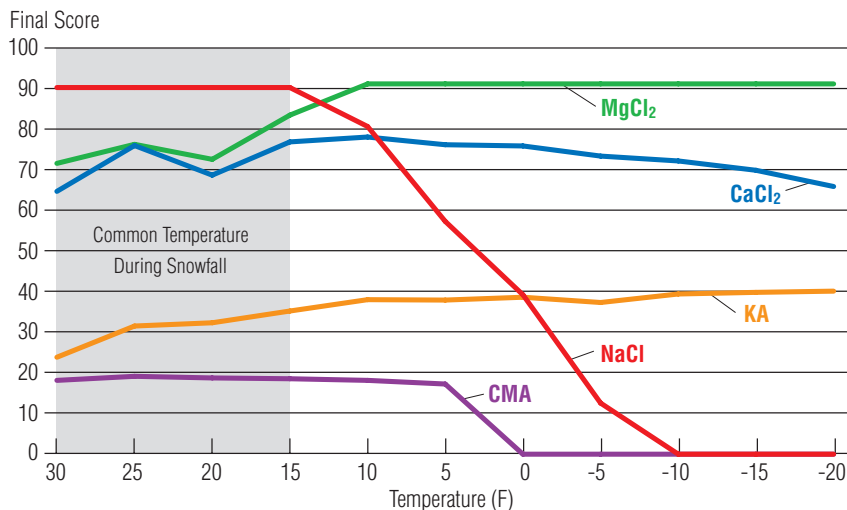
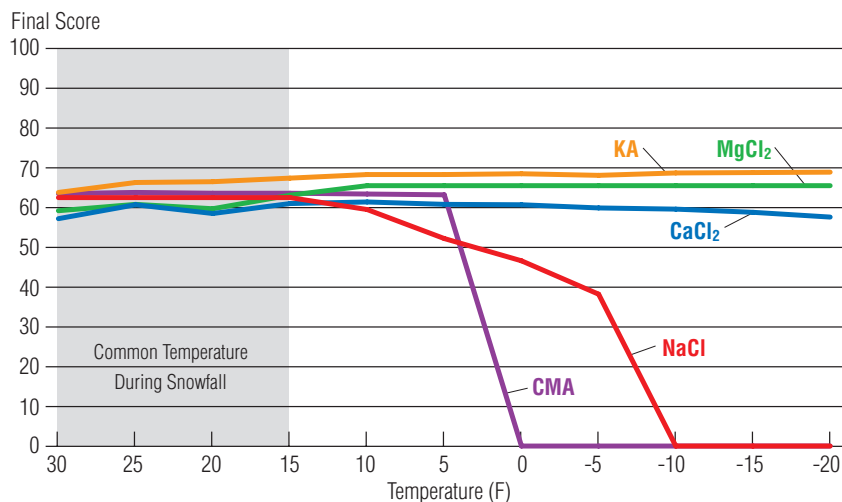


Chart 3





## 8 EQUIPMENT

**W**inter maintenance equipment typically has come in three varieties – a vehicle on which to put various pieces of equipment or stuff, stuff to remove snow and ice from the pavement (e.g. plows of one sort or another) and stuff to put snow and ice control material down onto the pavement (e.g. spreaders). To this, we can now add a fourth sort of equipment – information gathering equipment which can be stationary (e.g. an RWIS station) or mobile (e.g. a pavement temperature probe mounted on a truck).

The exact equipment types you need will be driven by decisions on level of service and by decisions about the materials you will use. So, obviously, if you are going to use an anti-icing strategy you will need equipment that can make direct liquid applications (DLA) to the pavement. Of course, this is not a one way decision – depending on the current equipment mix your agency has now, your level of service goals may have to be modified until your fleet can acquire the capabilities that will allow you reach the levels of service your community really wants – and that will take time, and money.

While you may not be able to have all the equipment you want right now, it is well worth knowing what you do want your equipment mix to look like eventually so you can develop a plan to get there. There are a few key factors to consider as you build the equipment mix that will allow you to achieve your desired service levels.

First, you need to have a calibration plan in place. We deal with this in more detail in the next two sections in the guide, but your equipment needs to be calibrated regularly and systematically. Why? Well, there is an old saying that you cannot manage it if you do not measure it. And you cannot measure what you are doing if you do not calibrate your equipment to measure properly.

Second, as you almost certainly already know, if you want a piece of equipment to break, put it on a plow truck. Being on a truck during a storm is one of the toughest environments for vehicle-borne equipment

around. And the last thing you want is for your equipment to break down during a storm event, because then instead of that truck being on the road achieving your level of service goals, it is in the shop achieving not very much at all. That means a pro-active maintenance system is a must. There are increasingly sophisticated systems for doing this becoming available, and an important decision is what level of sophistication is going to work best for your operations, but you need a system in place to catch problems before they become catastrophes.

Third, if at all possible you want flexibility in your equipment. That means that a given plow should be able to work on multiple trucks. Most agencies mate up a plow and a truck at the start of the season and they stay that way until spring. There is nothing necessarily wrong with that, but if the truck breaks down, you have lost the plow as well if it cannot be moved to a different vehicle (and vice-versa).

Fourth, in selecting your equipment you need to consider not just up-front cost, but a number of other factors as well. For example,

certain cutting edges reduce vibration substantially in comparison with “regular” cutting edges. That can provide savings in terms of reducing operator fatigue and reducing wear and tear on the plow and the vehicle to which it is mounted. You need a system that allows you to roll those savings into the final costs, along with some form of life-cycle costing. Those reduced vibration cutting edges might be a lot more expensive than a “regular” cutting edge, but if they last a lot longer, how will you fold that factor into your cost mix?

Fifth, and this ties back into the pro-active maintenance issue, you need to keep your equipment clean. Chlorides of any sort will cause corrosion in metals and the best way to avoid that is to clean your equipment. Waiting until the end of the season to wash your trucks and spreaders is a sure way to guarantee a short lifetime for your equipment. ❄️



# 9 CALIBRATION

As alluded to previously, calibration of equipment is critical to ensuring that an agency has the information it needs to operate in a safe and sustainable manner. While the primary concern is material delivery systems, other equipment (in particular, sensors such as pavement temperature measuring devices) also need to be calibrated regularly.

As a minimum, equipment needs to be calibrated at least once a year. However, equipment may need to be calibrated more frequently than this, and until a record of performance has been established for a spreader or liquid dispensing system, it should be calibrated monthly. Once a system has stayed within calibration for three straight calibration cycles, then the length of time between calibrations can be increased.

Different materials will spread at different rates even when equipment settings are exactly the same, so spreaders and liquid dispensing systems must be calibrated with the material that will be used. If more than one material will be used for a given system it needs to be calibrated for each material separately.

## Procedure

Calibration of spreaders is simply calculating the pounds per mile actually discharged at various spreader control settings and truck speeds. It is carried out by first counting the number of auger or conveyor shaft revolutions per minute, measuring the salt discharged in one revolution, then multiplying the two and finally multiplying the discharge rate by the minutes it takes to travel one mile. An excellent example of a calibration chart in spreadsheet format can be found on the Salt Institute website. Operational spreadsheets can be found on the same page. A sample calibration chart is shown on this page.

With hopper-type spreaders, specific gate openings must be calibrated. Measure from the floor of the conveyor to the bottom edge of the gate.

Each spreader must be calibrated individually; even the same models can vary widely at the same setting.

## Equipment needed:

1. Scale for weighing
2. Canvas or bucket/collection device
3. Chalk, crayon or other marker
4. Watch with second hand or stop-watch

## Calibration steps

1. Warm truck's hydraulic oil to normal operating temperature with spreader system running.
2. Put partial load of salt on truck.
3. Mark shaft end of auger or conveyor.
4. Dump salt on auger or conveyor.
5. Rev truck engine to operating RPM (at least 2,000 RPM).
6. Count number of shaft revolutions per minute at each spreader control setting, and record.
7. Collect salt for one revolution and weigh, deducting weight of container. For greater accuracy, collect salt for several revolutions and divide by the number of turns to get the weight for one revolution. This can be accomplished at idle or very low engine RPM. Multiply the shaft revolutions per minute (Column A) by the discharge per revolution (Column B) to get the discharge rate in pounds per minute for each control

setting (Column C), then multiply discharge rate by minutes to travel one mile at various truck speeds to get pounds discharged per mile.

8. So, for example, at 20 mph (or 3 minutes per mile) with 30 shaft revolutions per minute, and a 7 lb discharge per shaft revolution, we would get  $30 \times 7 \times 3 = 630$  lbs per mile.

## Calibrating Automatic Controls

Automatic controls come with factory calibration cards that indicate the proper rate of spread for each setting. However, when there is a need to calibrate, use the following steps:

1. Remove or turn off spinner.
2. Set auger on given number, such as No. 2.
3. Tie sack or heavy canvas under discharge chute.
4. Mark specific distance, such as 100 or 1,000 ft.
5. Drive that distance with spreader operating.
6. Weigh salt collected in sack or canvas.
7. Multiply weight of salt by 5.3 (in case of 1,000 ft) or 52.8 (in case of 100 ft).

This will be the amount of salt discharged per mile, which remains constant regardless of speed, but calibration must be done for each control setting. \*

## Calibration Chart

Agency: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Truck No.: \_\_\_\_\_ Spreader No.: \_\_\_\_\_  
 Date: \_\_\_\_\_ By: \_\_\_\_\_

Gate Opening (Hopper Type Spreaders)			Pounds Discharged Per Mile										
Control Setting	A Shaft RPM (Loaded)	B Discharge Per Revolution (Pounds)	C Discharge Rate (lb/min)	Minutes to Travel One Mile									
				5 mph x 12.00	10 mph x 6.00	15 mph x 4.00	20 mph x 3.00	25 mph x 2.40	30 mph x 2.00	35 mph x 1.71	40 mph x 1.50	45 mph x 1.33	
1		This weight remains constant											
2													
3													
4													
5													
6													
7													
8													
9													
10													

## 10 MEASURING PERFORMANCE

**A**n important part of sustainable practice is measuring what you are doing so that you can evaluate your practices and, if necessary, improve upon them. That means that a safe and sustainable Snowfighting agency will have a system in place to measure their performance, and to use those measurements in continuous improvement efforts.

The most central step in this action for an agency is to measure whether they have achieved their levels of safety and service. Currently, most levels of service are expressed in terms of road conditions (e.g. bare pavement, or bare wheel tracks) and these definitions are subject to some interpretation. For example, if there is a small amount of snow present along the mid-line of a road, the road is technically not in a bare pavement condition, but operationally, as long as that small amount of snow does not obscure pavement markings, it can be considered to be bare. Operators (or those charged with determining whether the level of service has been met) need to be trained in determining whether levels of service have been met.

One particularly helpful tool that agencies have used to keep track of their performance is a post-storm review. This will include a description of the storm itself, and possibly even some index value describing how severe the storm was, followed by an inventory of the resources applied to dealing with the storm. Ideally, all members of an agency's winter maintenance team should be involved in the post-storm review, so that successes can be identified, celebrated, and shared, and failures can be discussed and methods to avoid those same failures in the future can be identified and implemented.

Safe and sustainable winter maintenance requires that an agency commits to improvement in the long term, since such improvement implies an agency that is becoming both more efficient and more effective. Efficiency and effectiveness are clearly parts of a safe and sustainable program. \*

## 11 STRATEGIC (ANNUAL) OPERATIONS

**C**learly, a safe and sustainable Snowfighting operation requires long term thinking, and that means there are certain actions that need to be planned and executed on an annual basis. A key example of this is training which is discussed further below. But there are many other annual actions that can be taken to improve your agency's commitment to safe and sustainable Snowfighting.

Some actions can be considered part of an annual review of operations. For example, taking a look at your snow plow routes on an annual basis means that you keep the lane miles properly balanced between routes and that you handle long term growth impacts in your community incrementally, rather than in sudden large changes in operations. Some agencies also like to conduct a post-winter review in the spring (once all the snow has stopped!) to see what worked well in the previous winter and what did not work so well. This also provides an opportunity to review any experimental changes that were made in the previous winter to see if the experiment should be continued, or if perhaps it is ready for full implementation.

Other coordination efforts with appropriate emergency service agencies are very helpful. This is especially important when issues such as disaster declarations are considered. When a disaster is declared, typically some sort of Emergency Management protocol is invoked and it is important that agencies understand their roles in such situations.

Other annual activities are more along the lines of tracking activities taken by the agency. This could include tracking total loading of materials on different road segments, developing pro-active frost treatment programs, having a snow drift prevention program in place, having a system to designate and track environmentally sensitive road segments, developing and deploying systems that provide real time information on road surface conditions to road users, and even surveying the public to ascertain how well they think your agency is performing. Not every agency needs to do all of these things, but considering which would be of special benefit to your own community has been found to be a very valuable activity. \*



# 12 TACTICAL (PER STORM) OPERATIONS

Once you are in the winter season, your activity is going to be much more focused on dealing with each storm as it comes along. One of the key concerns you will face in this context is getting a good forecast that will allow you to take pro-active measures.

In the ideal situation you want forecasts that are pavement focused – that is, they predict what the pavement temperature will be through the storm. This allows you to determine how much material you need to apply. Remember that the amount of material you apply will be a function of pavement temperature, cycle time, and precipitation type. The table nearby shows some typical application rates based on these factors. Your particular rates may vary a bit from these values, but if you do not have your own application table, this is a really good place to begin and make adjustments from.

In addition to having pavement temperature forecasts, you will also want site specific forecasts. We all know that there are parts of our road system that are “trickier” than others – perhaps they are always colder, or more prone to snow-drifting or whatever. Put another way, not all your roads are going to see the same weather so your forecast should account for that. Obviously, the larger the area for which you have responsibility, the more likely this is to be true.

To get these sorts of forecasts, you are going to need to get some sort of value-added meteorological service. The US National Weather Service does not provide pavement forecasts and is not intended to either – it was developed primarily as a tool for aviation, not highways.

Other things to think about in a tactical sense would include, especially for more urban areas, adjustments to your maintenance plan to account for varying traffic levels due to commute times. If you know certain roads get very busy during the commute, then you need to get them dealt with before the commute begins if a storm is happening, otherwise they are just going to jam up, and your trucks do not good at all stuck in a traffic jam.

Also, because Murphy will always strike when he can cause the most problems, it is good to have some contingency plans in place for when you have equipment failure or similar events during storms. Can you pull trucks off lower priority routes if a truck on a high priority route is disabled for some reason? Such flexibility of operations can be critical. \*

## Example Salt Application Rates

Prewetted salt @12' side lane (assume 2-hr route)							
Surface Temperature	(Fahrenheit)	32–30	29–27	26–24	23–21	20–18	17–15
lbs of salt to be applied per lane mile	Heavy Frost, Mist, Light Snow	50	75	95	120	140	170
	Drizzle, Medium Snow 1/2" per hour	75	100	120	145	165	200
	Light Rain, Heavy Snow 1" per hour	100	140	182	250	300	350
Prewetted salt @12' side lane (assume 3-hr route)							
Surface Temperature	(Fahrenheit)	32–30	29–27	26–24	23–21	20–18	17–15
lbs of salt to be applied per lane mile	Heavy Frost, Mist, Light Snow	75	115	145	180	210	255
	Drizzle, Medium Snow 1/2" per hour	115	150	180	220	250	300
	Light Rain, Heavy Snow 1" per hour	150	210	275	375	450	525

# 13 EXPERIENCE BASED TIPS

**A**ny sort of operational activity benefits from the hard won lessons of experience and Snowfighting is no exception to this. The following suggestions are just some of the tips that may help you and your agency going forward:

- Salt bridges first. Bridges freeze long before road surfaces because they do not hold warmth as a roadbed does, since cold air reaches both the top and bottom surfaces of bridge decks. They should receive early attention and an application of salt. Bridge decks may ice over or frost may form on them, when there is no precipitation.
- Apply salt on the high side of elevated curves. Salt brine will flow down and across a banked curve. If salt is spread on the centerline, everything above it will remain icy. Spread salt on the high side of the curve and let gravity do the rest of the work.
- Leave no gaps. Operators must ensure that when they come to the end of their assigned route they go a bit beyond to plow and salt a potential gap in coverage. A short, neglected stretch of roadway can be very hazardous to an unsuspecting motorist.
- Watch for drifting. In continued high winds (above 15 mph) maintain a patrol to watch for drifting and slick spots, even after the pavement has been cleared. Treat icy buildups with a salt application. If there are spots where you have drifting often, consider using snow fences to stop the drifting.
- During some very low temperature storms with dry blowing snow, the use of salt may not be appropriate. The dry snow may blow off the pavement if no salt is used.
- Avoid slick conditions from buildup of ice or packed snow by applying a salt application heavy enough to prevent refreezing.
- Traffic icing can be very dangerous. Occasionally, under certain weather conditions, a paper-thin sheet of ice forms in wheel paths on a bare pavement even when pavement looks clear. This black ice formation can be deadly. Maintenance operators should be instructed to watch for this condition and to apply salt immediately when it is detected.
- Get equipment on the road. Once word of an impending storm has been received get vehicles out of the yard and onto their plowing and spreading routes as soon as possible. Delay in getting to critical areas may cause severe traffic tie-ups. Also, nothing is more reassuring to motorists than to see anti-icing sprayers or loaded spreaders and plows patrolling prior to storms.
- Make a list of trouble spots that operators should keep a close eye on during storms. Make sure all personnel understand that bridges, intersections, ramps, hills, and curves may all cause problems and so need full attention. A safe road or street is of little value without safe entrances and exits. Have operators out patrolling routes rather than waiting in the maintenance area for direction.
- Make use of new technology where it can help. Systems such as GPS/AVL, traffic light controls, variable message signs, various camera systems, and others all have the potential to improve the management of operations during a winter storm. Additionally, by using such systems to track your operations, you can better measure your performance over time and identify areas for possible improvement. ❄



## 14 A WORD ABOUT SAFETY

**T**he main purpose of snow and ice removal is, of course, to provide safe travel for motorists. In doing this, those in maintenance must not overlook their own safety; neither must they overlook the possibility that in trying to provide safe pavement, they may be creating another safety hazard.

Become familiar with a few “do’s and don’ts” that can make your work far safer:

- Do check all equipment before each use. Make sure lights, brakes, windshield wipers, exhaust systems, tires, chains, and steering are safe. Don’t leave the yard without having done those pre-trip inspections.
- Do promptly report all mechanical trouble. Don’t expect that a problem will magically disappear if you ignore it.
- Do remember that speed can kill, especially in a snowstorm and at night.
- Do resist the urge to get the job done in a hurry.
- Do respect the rights of others. Be considerate of motorists who have trouble driving in snow; report stranded motorists when possible.
- Do keep first aid kits completely stocked. Check fire extinguishers and flares often.
- Do observe traffic laws.
- Don’t drive distracted.
- Do watch for signs of fatigue in equipment operators. ❄️

## 15 BUILDING THE TEAM

**M**aintenance people typically feel a keen obligation to the traveling public. They have the kind of *esprit de corps* that comes only with training and experience.

Proper training for maintenance personnel is vital. It provides the know-how to get the job done and encouragement to perform in a way that brings praise rather than discredit to your organization. They are also crucial to ensuring efficient and effective operations. If an operator does not understand how the tools at their disposal work – how can they be effective?

Many maintenance organizations conduct training courses in the early fall months to assure that:

- Equipment operators fully understand how to operate and maintain plows, spreaders, loaders, and other equipment used for winter maintenance.
- All employees are thoroughly familiar with their responsibilities.
- All employees receive a full review of snow removal schedules, snow routes, and personnel and equipment assignments.
- Dry-runs are made over areas to be covered during actual Snowfighting operations.
- All employees understand how salt works in snow and ice, so they know how, when, and in what amounts it should be applied.

The underlying theme of all training sessions should be the Sustainable Snowfighting concept, which includes:

- Concern for public safety
- Concern for mobility and commerce
- Concern for the environment
- Proper covered storage
- Good maintenance of storage areas
- Good equipment maintenance and knowledge of equipment
- Proper spreader calibration
- Proper salt application

Every agency should have a fall meeting.

A session on snow and ice removal well ahead of winter gives a chance to discuss your plans with the people expected to carry them out. This meeting is a refresher course on Snowfighting tactics for experienced employees and an introduction to winter maintenance for new personnel.

This meeting gives management a chance for a formal review of the previous winter’s operations with operators and supervising personnel. Use it to determine what may have gone wrong last winter, and then make corrections for the coming season.

Promote a free exchange of ideas at the fall meeting. Encourage all personnel to speak up. New ideas and better tactics can come out of this session. ❄️

# 16 KEEPING THE PUBLIC IN THE LOOP

It is very important for an agency to engage with the public that they serve, and to this end media relations need to be considered as part of an agency's annual strategies. Some agencies hold annual open days (typically in the fall) to inform the public about their winter activities and to engage the local media. Others have a media interaction meeting in the fall to prepare local media for the coming winter activities. Along with this, some form of system to allow media contact during storms can be very helpful (some would say critically so) while activities that encourage media engagement (such as reporter ride-alongs) can provide substantial benefits to an agency.

Publicize snow emergency procedures and regulations. Keep broadcasters and newspapers periodically informed of snow clearing progress and specific problem areas. This way, motorists will know on which routes they will be able to travel with the least difficulty. Advance publicity on snow clearing priorities will reduce time-consuming calls from people demanding to know when their streets or roads will be cleared.

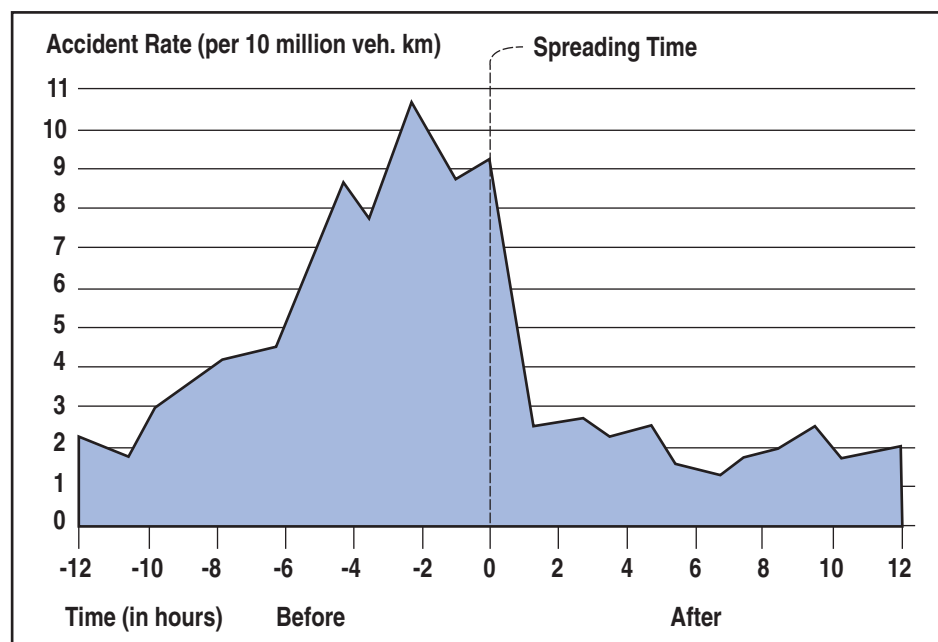
Before storms arrive, pass on information about approaching snow in time for schools, industry, and government agencies to decide whether or not to remain open or to close early.

Make contact with other agencies. Long before winter, meet with representatives of other public agencies to discuss means of cooperating in snow and ice removal. Take the initiative to let others know of your plans and to enlist their cooperation. Consider inviting these people to the pre-winter session: a representative of the top elected public official in your area, the local civil defense director, those in charge of bus transportation for school systems, police and fire officials, emergency road service managers of nearby clubs of the American Automobile Association (AAA), officers from local military units, and news media representatives.

Snowfighters are not miracle workers. They are dedicated, hardworking human beings who pit their will against the forces of nature – and usually win! The real record of their accomplishment is not the tons of snow removed or the miles of pavement kept clear or number of streets plowed. The achievement of open highways that allows business, industry, and government to function and people to travel safely and without undue delay is the testament of good Snowfighting.

According to a Marquette University study, road salting and plowing can reduce crash frequency by 88%. A one-day major snowstorm can cost a state \$300-700 million in both direct and indirect costs. \*

## Accident Rate Before and After Salt Spreading



# STORM RECORD



<b>Storm No:</b>			<b>Sec:</b>			<b>Div:</b>			<b>Date:</b>		
<b>1. Time</b>		<b>AM</b>	<b>PM</b>	<b>Day of Week</b>			<b>2. Location</b>			<b>Miles</b>	
Storm Started							From:				
Storm Ended							To:				
Road Cleared											

<b>3. Description</b>											
Dry Snow		Temp			Wind						
Wet Snow		Max:		Min:		Direction:		Velocity		MPH	
Sleet		Depth of Snow				Visibility					
Freezing Rain		Avg (in)		Drifts (ft)		Good:		Fair:		Poor:	

<b>4. Procedures</b>						<b>5. Results</b>							
		No of Apps		Time				Excellent		Good		Poor	
Salt				From: To:		Salt							
Plowing				From: To:		Plowing							
Abrasives				From: To:		Abrasives							

<b>6. Labor, Equipment &amp; Materials</b>											
Personnel		Reg Hrs.	O.T. Hrs.	Total	Equip. No.	Type	Hours	Material (TONS)			
								Salt			
Total											

**Comments:**

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Completed by: \_\_\_\_\_  
 Name, Title



# SAFE AND SUSTAINABLE SNOWFIGHTING AWARD APPLICATION

The Salt Institute began promoting safe and sustainable snowfighting in 1972, when it began its Sensible Salting Program. Decades later, SI is still leading the way in advancing effective in snowfighting to ensure winter safety, mobility, and protection of the environment.

Partnering with leaders in winter maintenance, SI has expanded its long-standing “Excellence in Storage Award” to include safe and sustainable operations. In 2012, we presented the Salt Institute’s “Safe and Sustainable Snowfighting Award,” a program that recognizes agencies that demonstrate best practices in salt storage and snowfighting.

Clear winter roads protect lives and commerce. Road salting and effective plowing can reduce injury crashes by up to 88%. And a one-day major snowstorm that shuts down roads can cost a state between \$300 and \$700 million in direct and indirect costs. Snowfighting is often an underappreciated vocation, but at the Salt Institute we recognize snowfighters as heroes who protect lives and enable our winter economy.

To apply for the “Safe and Sustainable Snowfighting Award” the facility manager should complete the application form and checklist (found as an insert to this handbook, on [saltinstitute.org](http://saltinstitute.org), or on [safewinterroads.org](http://safewinterroads.org)), have it signed by an immediate supervisor and returned with all supporting documentation to the Salt Institute by June 1. Please answer all questions.

Applications will be judged by our evaluation committee and in some cases a Salt Institute representative will make an on-site facility visit.

Award recipients will receive a “Safe and Sustainable Snowfighting Award” certificate and will be recognized in a Salt Institute press release.

# Publications Available *from the* Salt Institute



*Refer to [saltinstitute.org](http://saltinstitute.org) for further details and other literature*

## *Salt Storage Handbook*

A guide for environmentally sensitive handling and storing deicing salt.

**ABOUT THE SALT INSTITUTE:** The Salt Institute is a North American based non-profit trade association dedicated to advancing the many benefits of salt, particularly to ensure winter roadway safety, quality water and healthy nutrition. See [saltinstitute.org](http://saltinstitute.org) or call 239.231.3305.

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