UNH T² Center Technical Note

Salt Usage in Winter Operations

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"The NHDOT's winter maintenance goal is to obtain bare and dry pavements on most roads at the earliest practical time following cessation of a storm. Many municipal highway departments have similar goals" (*NHDES Fact Sheet WMB-4*).

Public safety is paramount. However, most public works budgets are currently reduced. Road Managers must balance public safety with the money allotted to complete winter road maintenance.

Many variables affect winter maintenance, such as the weather since we don't know when it will arrive or how long it will stay, environmental issues since the NH Department of Environmental Services (NHDES) and many communities have adopted policies that Road Managers must comply with, and personnel since many highway crews have been reduced to help balance the town budget in these difficult economic times.

Read this article to learn about options available to local road managers during winter maintenance while trying to reduce the harmful effects on the environment and still maintain a safe travel surface for the public.

Dry Salt

Salt lowers the melting temperature of snow and ice. This means that salt will allow ice and snow to melt even if the road and air temperatures are below the freezing point of water (32°F). However, a major problem with dry salting is it scatters when being spread and when vehicles travel over it. Also, salt is most effective at air temperatures above 20°F. Once the air temperature is below 10°F, salt can no longer dissolve to break the ice-pavement bond.

Salt and the Environment

Increased salt usage in winter operations has caused the chloride content in New Hampshire waters to increase by 1000% over the past 50 years (*NCHRP Report 577*). High salt content is dangerous in many ways. First, high salt content disrupts aquatic ecosystems causing harmful effects to aquatic life. In a worst case scenario, an entire ecosystem can be destroyed. Second, high salt content negatively affects vegetation by causing the vegetation to eventually die if it can not adapt. Also, if a plant's water source is contaminated, it is likely that the area groundwater that people use for drinking is contaminated as well. Third, high salt content in soil decreases the capacity to support natural and native life. A plant thrives in its natural environment. If the environment conditions change, then it is likely that the life supported by the soil will die. Fourth, salt dust can be thrown up into the air during street sweeping procedures if residue is left on the roads. This can irritate people's sinuses, especially if they have a pre-existing condition. Fifth, salt affects the taste of drinking water and taste is an important concern for most people in regard to drinking water.

Abrasives

Abrasives (the most common one is sand) are commonly used to increase the traction on roadways when slippery conditions are present. Abrasives can be used in several instances. First, use abrasives on paved roads with speed limits below 30 mph where there are hills or where braking, accelerating, or turning occurs. Second, use abrasives at low speed intersections if snowpack or ice will remain on the road for a long time. Third, use abrasives at intersections where each connecting road is paved.

However, abrasives are not effective in every instance. For example, when dry sand is spread, 30% of it immediately scatters and over time, traffic will displace most of the remaining sand. As few as eight vehicle passes can move most of the sand off of a snow covered highway surface. Also, do not sand a road with a speed limit above 30 mph. Instead, plow and apply chemicals. In addition, do not use sand on gravel roads at all. Instead, groom the gravel road to break up and remove the snowpack.

Sand and the Environment

Sand left behind from winter maintenance operations must be removed from the environment. This is time consuming and costly, but it is important for several reasons. First, sand will wash off the road and end up in catch basins. Excess sand in catch basins causes drainage problems due to clogging. Second, sand will travel from catch basins into drainage pipes. Excess sand in drainage pipes will become trapped in the pipes and decrease the flow capacity, also causing flooding. Third, sand will travel through the drainage pipes and pile up at drainage outfalls. Excess sand negatively affects the marine ecosystems that drainage systems empty into.

In the spring, remove sand from the road, ditches, catch basins and drainage pipes to prevent flooding and hazardous driving conditions. Sand and debris removed from catch basins must be tested and disposed of properly. Modern trucks use high-pressure water to loosen compacted material and vacuum hoses are used to remove solids. Since these trucks are expensive, many municipalities hire contractors. They charge per catch basin and their fees increase for large quantities or compact material. Inspectors should always accompany contractors. Road Agents should establish cleaning schedules to minimize contaminants reaching receiving waters.

Something else to consider is the dust created while sweeping heavily sanded roads. Sand, like salt, can cause allergic reactions or respiratory issues for people living in the surrounding area. Be mindful of the amount of sand being put down.

Calcium Magnesium Acetate

Calcium Magnesium Acetate (or CMA) is another alternative to salt as an ice-fighting chemical. It is made up of limestone and acetic acid (the principal ingredient in vinegar). It is more environmentally friendly because it is less damaging to soils, less corrosive to concrete and steel, and non-toxic to aquatic life. However, it is more expensive compared to salt and calcium chloride. It costs around $600 per ton, whereas salt costs around $60 per ton.

Pre-wetting liquids

Sodium Chloride (NaCl) (a.k.a. salt) is the primary chemical used in de-icing and anti-icing applications. The mixture is 23% NaCl by weight. It is cheap and effective. When salt mixes with water, the freezing temperature is lowered. If salt is dropped on ice, the ice will begin to melt unless the temperature is much lower than the freezing point of water.

Pre-wetting a chemical or abrasive usually entails applying a light covering of liquid over the material to be applied to the road. It helps keep the material from bouncing off the road and scattering while spread.

Calcium chloride ($CaCl_2$) is the second most

common chemical used to battle ice and snowpack, after sodium chloride. It is more expensive than sodium chloride but it is rising in popularity for a pre-wetting liquid.

The mixture is 32% $CaCl_2$ by weight. It is effective at much lower temperatures than salt. It releases heat when it is dissolved in water. It can be effective in melting ice as low as 0°F. It also draws moisture from the air, which allows it to melt ice better because it will already be in brine form. These properties make it especially valuable in severe conditions.

De-icing

De-icing is a reactive process. De-icing is the process of breaking the bond between ice/snowpack and the pavement after the snow has fallen. Calcium chloride is the most common chemical used in de-icing roadways. The goal of de-icing is to achieve bare pavement as soon as possible. Plowing is also an integral part in de-icing roadways.

Anti-icing

Anti-icing is a preventative process. Anti-icing is to prevent ice and snowpack from bonding with the pavement before the snow has fallen. This is becoming a more popular method to improve driving conditions during winter. It can be more beneficial than de-icing, if done properly, because it does not allow the bond to form with the pavement at all. This improves road conditions immediately after a storm. Liquid chemical applications are the most successful way to prevent ice formation. Pre-wetting dry chemicals is another method, though less effective.

By using an anti-icing approach, material costs decrease due to more effective roadway treatment. Anti-icing can become ineffective if severe weather conditions persist. If heavy precipitation occurs before the onset of a winter storm but after the application of anti-icing chemicals, the effort made is rendered completely useless.

Spreader Calibration

Calibrating the spreader is the key to proper chemical application. Inspect and clean spreaders frequently since they are exposed to corrosive materials and extreme weather conditions. Each material that is used during de-icing and anti-icing will spread at different rates. Calibrate each spreader individually so that each spreader will disperse the material that it is spreading at the appropriate concentration.

Equip spreaders with automatic ground speed controls whenever possible. These automatically adjust the application rate as the truck changes speed. They allow for the truck driver to focus on the task of driving, instead of adjusting the spreader controls. This provides a safer driving environment, as well as cuts down on material waste.

Application Rate factors

No storm will be exactly like another. However, application rates must be determined before the start of each storm. Many things affect application rates. First, the ground temperature is one of the most important factors in application rate. For example, salt is five times more effective at 30°F than it is at 20°F. Second, the material being spread affects the application rate. Salt will not be spread in the same concentrations as calcium chloride or sand. Third, the nature of the storm affects application rates. A heavier or longer storm will require more material than a lighter or shorter storm. Fourth, pre-existing road conditions affect application rates. A road that is already heavily iced-over will require far more material than a clear road. Fifth, traffic conditions affect the application rate. Traffic on high volume or high speed roads will displace more material than traffic on low volume or low speed roads.

Material Storage and Handling

Follow these guidelines for a good chemical storage location:

- Locate a facility on a flat site away from surface waters and on an impervious surface that is easily protected from overland runoff.
- Chemicals should be stored under a cover to prevent material loss due to runoff.

Follow these guidelines for a good snow disposal location:

- Near flowing surface waters (but at least 25 ft. from high water line).
- Silt fence between disposed snow & high water line.
- At least 75 ft. from any private water wells. At least 200 ft. from community water wells. At least 400 ft. from municipal water wells.
- All debris in the snow storage area must be removed and properly disposed of by May 15 every year that the area is used.

To summarize, pre-wet road salt and other ice-fighting chemicals with a salt brine to jump-start the melting process and to improve material retention on the roadway. Calibrate your spreaders before every use to ensure the correct application rate. Only apply abrasives on roads with speed limits less than 30 mph and only when ice/snowpack is not melting. Dispose of plowed snow and debris properly to minimize environmental impacts. Store chemicals in a proper facility to protect them from the elements, and to protect the environment from the chemicals. Employ proper anti-icing techniques and plow frequently to efficiently combat snow and ice build-up on roadways.

References

- *NHDES. Road Salt and Water Quality. Environmental Fact Sheet WMB-4. Concord, NH: 1996.*
- *NHDES. Snow Disposal Guidelines. Environmental Fact Sheet WMB-3. Concord, NH: 2007.*
- *Nixon, Wilfrid & Anissa D. Williams. A Guide for Selecting Anti-icing Chemicals. Technical Report 420. Iowa City, IA: The University of Iowa, 2001.*
- *Salt Institute. 2009. <http://www.saltinstitute.org/Uses-benefits/Winter-road-safety>.*
- *Transportation Research Board. NCHRP Report 577. Washington, D.C.: 2007.*
- *Transportation Research Board. NCHRP Research Results Digest 335. Washington, D.C.: 2009.*
- *UNH Technology Transfer Center. Anti-icing of Local Roads. A Manual of Practice. Durham NH: 2004.*
- *Wisconsin Transportation Info. Ctr. Pre-wetting and Anti-icing Techniques for Winter Road Maintenance. Wisconsin Transportation Bulletin 22. Madison, WI: 2005.*

Table 2-1. Policy objectives.

Decision Category	Decision Weighting (%)
Purchase Price[1]	Sum = 100 %
Performance as Melting Potential (MP)[2]	
Natural Environment	
Infrastructure	

[1] The Decision Tool uses purchase price per dry unit of active ingredient, including shipping as a cost benchmark. This is a practical approach and yields a consistent and unbiased assessment of the dominant cost element (refer to Section 2.5 for further discussion).
[2] Given that the primary objective of winter maintenance is controlling snow and ice, it is recommended that performance weighting not be assigned a value below 25%.

Table 2-2. Operational objectives.

Decision Category (Policy Objectives)	Decision Subcategory (Operational Objectives)	Decision Weighting (%)
Natural Environment	Aquatic Life[1]	Sum = 100 %
	Drinking Water	
	Air Quality	
	Vegetation	
	Soil	
	Animals	
Infrastructure	Vehicles	Sum = 100 %
	Metal Infrastructure	
	Concrete Corrosion	
	Concrete Degradation	

[1] It is recommended that aquatic life weighting not be assigned a value below 25%

NCHRP Report 577 (page G-5) – Guidelines for the Selection of Snow and Ice Control Materials to Mitigate Environmental Impacts