Baystate Roads Program
Local Technical Assistance Program (LTAP)
Tech Notes
Tech Note #45

New Chemical Application Guidelines for Winter Operations

This tech sheet is based on the findings of National Cooperative Highway Reasearch Program (NCHRP) Project 6-13, Guidelines for Snow and Ice Control-Materials and Methods. This project developed a newly derived set of guidelines for selecting ice control chemical application rates for a wide range of weather, site, and traffic conditions found in North America. These guidelines apply to both state and local highway agencies. The guidelines were developed by adding appropriate existing documentation to new data collected from field testing of selected strategies and tactics over three winters. A total of 24 highway agencies (13 state, 1 provincial, 4 county, and 6 city or town) participated, testing at 51 site locations.

FACTORS THAT INFLUENCE THE CHOICE OF MATERIALS AND THEIR APPLICATION RATES

Operational changes need to be considered first. The most important operational consideration influencing the dilution rates is the potential treatment cycle times and traffic volume. Longer **treatment cycle times** allow more precipitation to accumulate on the roadway between treatments thus increasing the dilution rate. For equivalent effectiveness, more chemical must be applied for longer cycle times. The traffic volume and speed will also displace ice control chemicals from the roadway making them less effective.

When choosing materials for fighting snow and ice, you need to consider certain major factors, namely the dilution potential that the chemical treatments will face and the performance characteristics of the materials. For clarity, we need to define some terms.

Precipitation dilution potential is the potential form, type and rate of precipitation of a winter weather event in progress. The higher the moisture content of the event per unit or time, the higher the precipitation dilution potential.

Pavement conditions, particularly the pavement surface condition, refer to the aspects of the pavement itself that influence snow and ice control operations. The pavement surface temperature is a key component, as it has a major effect on how ice control chemicals perform and, ultimately on the treatment decision itself. As pavement temperatures decline below about 10 degrees Fahrenheit, most ice control chemicals become less effective in terms of the amount of ice melted per unit of chemical applied. Pavement temperature, therefore, drives the decision to plow only, plow and apply chemicals, or plow and apply abrasives depending also on level of service desired. Pavement surface conditions include any accumulations of snow and ice that may remain on the pavement at the time of treatment after plowing, such as loose snow, packed snow, and ice. *A significant pavement surface condition is whether the snow or ice is already bonded to the pavement surface.* Snow or ice remaining on the roadway surface after plowing will cause chemical treatments to dilute more quickly, in addition to the dilution caused by continuing precipitation. If the snow or ice is bonded to the pavement, considerably more chemical and mechanical effort will have to be applied to achieve a high level of service. This may take upwards of 30% or more chemical to unbond the snow and ice pack from the pavement.

Adjusted dilution potential is a term that characterizes the rate that a chemical's effectiveness is eroded under normal operating conditions. It takes into consideration precipitation rate, pavement conditions, and operational conditions. For simplicity, adjusted dilution potential is divided into three levels: low, medium and high.

SNOW AND ICE CONTROL CHEMICAL APPLICATION RATES

Winter maintenance field personnel should follow a step-by-step procedure to determine the most cost effective chemical application rate, as presented below. Appropriate application rates for solid, prewetted solid, and liquid salt (sodium chloride) (NaCl) are based on pavement temperature range, adjusted dilution potential level, and the presence or absence of ice/pavement bond. These recommended application rates depend on weather and pavement conditions at the times of treatment *and on how these conditions are expected to change before the next anticipated treatment.*

Plowing should be done before chemicals are applied to remove any excess snow, slush, or ice, leaving the pavement surface wet, slushy, or lightly covered with snow when treated.

Step 1. Determine the pavement temperature at the time of treatment with pavement temperature sensors or roadway weather information systems (RWIS) and project the temperature trend after treatment. You need to predict what the pavement temperature will be in the near term (1 to 2 hours after treatment). It generally does not change much in a couple of hours, unless influenced by sunshine.

Step 2. Establish the adjusted dilution potential for your intended chemical treatment by considering:

1. Type and rate of precipitation,
2. Pavement surface conditions in the wheel path area (snow covered or bare),
3. Operational conditions of cycle time and traffic speed and volume.

Use Table 1 to determine the adjusted dilution potential. The first part of the table establishes the precipitation dilution potential, and the second part of the table adjusts the precipitation dilution potential, as necessary, for various wheel path area conditions, cycle time, and traffic speed and volume.

Some agencies have simplified the dilution potential guidance by considering only precipitation dilution potential and the presence or absence of a packed or bonded condition. They feel that their surface conditions, traffic volumes and cycle times are constant.

Anti-icing material from straight-stream nozzle.

Step 3. Finally, using field observation or sensor data, determine if an ice/pavement bond condition exists *(yes or no)*. Then, using the observations and calculations from Table 1 as inputs, go to Table 2 to determine the appropriate application rate for solid chemicals and prewetted solid.

Step 4. If you are using a chemical other than salt, use Table 3 to determine your application rate. The determination of equivalent application rates in Table 3 is based on the total amount of ice melted per unit of chemical for calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$). The application rate data for each of these chemicals, normalized with respect to NaCl, are provided for various pavement temperature ranges and application rates.

Table 1. Precipitation dilution potential and its adjustments

		Precipitation Rate		
Precipitation Type	**Light**	**Moderate**	**Heavy**	**Unknown**
1. Snow (powder)	Low	Low	Medium	Low
2. Snow (ordinary)	Low	Medium	High	Medium
3. Snow (wet/heavy)	Medium	High	High	High
4. Snow (unknown)	----------	Medium	----------	----------
5. Rain	Low	Medium	High	Medium
6. Freezing rain	Low	Medium	High	Medium
7. Sleet	Low	Medium	High	Medium
8. Blowing snow	----------	Medium	----------	----------
9. Snow with blowing snow	*SAME AS TYPE OF SNOW*			
10. Freezing rain with sleet	Low	Medium	High	Medium
11. None If wheel path area condition is:				
Dry or damp	Not Applicable			
Wet	Low			
Frost or black ice (thin ice)	Low			
Slush or loose snow	Medium			
Packed snow or thick ice	High			
Adjustments to precipitation dilution potential				
a) Wheel path area condition when precipitation is present	**Increase precipitation dilution potential above by number of levels ***			
Bare	0			
Frost or thin ice	0			
Slush, loose snow, packed snow, or thick ice	1			
b) Cycle Time				
0-1.5 hrs	0			
1.6-3.0 hrs	1			
Over 3.0 hrs	2			
c) Traffic volume at traffic speed > 35mph				
Less than 125 vehicles per hour	0			
More than 125 vehicles per hour	1			

*When you make adjustments to the precipitation dilution potential, an adjustment of "1" would change a low level to a medium level or a medium level to a high level. An adjustment of "2" would change a low level to a high level. The end result of adding various adjustments to the precipitation dilution potential is termed **adjusted dilution potential.** *The adjusted dilution potential level cannot exceed "high."*

Table 2. Application rates for solid, prewetted, and liquid sodium chloride

Pavement Temperature (°F)	Adjusted dilution potential	Ice/Pavement bond	Application Rate	
			Solid [a] lb/LM	Liquid [b] gal/LM
Over 32	Low	No	90 [c]	40 [c]
		Yes	200	NR [d]
	Medium	No	100 [c]	44 [c]
		Yes	225	NR [d]
	High	No	110 [c]	48 [c]
		Yes	250	NR [d]
30 to 32	Low	No	130	57
		Yes	275	NR [d]
	Medium	No	150	66
		Yes	300	NR [d]
	High	No	160	70
		Yes	325	NR [d]
25 to 30	Low	No	170	74
		Yes	350	NR [d]
	Medium	No	180	79
		Yes	375	NR [d]
	High	No	190	83
		Yes	400	NR [d]
20 to 25	Low	No	200	87
		Yes	425	NR [d]
	Medium	No	210	92
		Yes	450	NR [d]
	High	No	220	96
		Yes	475	NR
15 to 20	Low	No	230	Pre-wet only
		Yes	500	NR
	Medium	No	240	Pre-wet only
		Yes	525	NR
	High	No	250	Pre-wet only
		Yes	550	NR
10 to 15	Low	No	260	Pre-wet only
		Yes	575	NR
	Medium	No	270	Pre-wet only
		Yes	600	NR
	High	No	280	Pre-wet only
		Yes	625	NR
Below 10°F	A. If unbonded, try mechanical removal without chemical			
	B. If bonded, apply chemical at 700 lb/ LM. Plow when slushy. Repeat as necessary.			
	C. Apply abrasives as necessary.			

LM= lane-mile road NR= not recommended

Table notes:

a. Values for "solid" also apply to pre-wetted solid and include the equivalent dry chemical weight in prewetting solutions.

b. Liquid values are shown for the 23-percent-concentration solution

c. In unbonded, try mechanical removal without chemicals. If pretreating, use this application rate.

d. If very thin ice, liquids may be applied at the unbonded rates.

General Notes:

1. These application rates are starting points. Local experience should refine these recommendations.

2. Prewetting chemicals should allow application rates to be reduced by up to about 20 percent, depending on such primary factors as spread pattern and spreading speed.

3. Application rates for chemicals other than sodium chloride will need to be adjusted using the guidance in Table 3.

4. Before applying any ice control chemical, the surface should be cleared of as much snow and ice as possible.

5. Pre-wetting at lower temperatures (10-15 degrees) should only be done with CaCl and MgCl. 10+/- gal per ton

NOT WITH SALT BRINE!

Table 3. Equivalent application rates for three most common ice control chemicals

Temperature Range (°F)	NaCl		$CaCl_2$		$MgCl_2$	
	Soild	23% Liquid	Soild	32% Liquid	Soild	27% Liquid
	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM
30-32	50	22	56	16	47	17
	100	44	111	32	94	33
	150	66	167	47	141	50
	200	87	222	63	188	66
	250	109	278	79	235	83
28-30	50	22	53	15	45	16
	100	44	106	30	90	32
	150	66	159	45	135	48
	200	87	212	60	180	64
	250	109	265	75	225	80
26-28	50	22	51	14	43	15
	100	44	102	29	86	30
	150	66	153	43	129	46
	200	87	204	58	172	61
	250	109	255	72	215	76
24-26	50	22	49	14	41	14
	100	44	98	28	87	29
	150	66	147	42	123	43
	200	87	196	56	164	58
	250	109	245	70	205	72
22-24	50	22	47	13	39	14
	100	44	94	27	78	28
	150	66	141	40	117	41
	200	87	188	53	156	55
	250	109	235	67	195	69
20-22	50	22	45	13	37	13
	100	44	89	25	74	26
	150	66	134	38	111	39
	200	87	178	51	148	52
	250	109	223	63	185	65

LM: Lane mile of road

NaCl: Sodium chloride

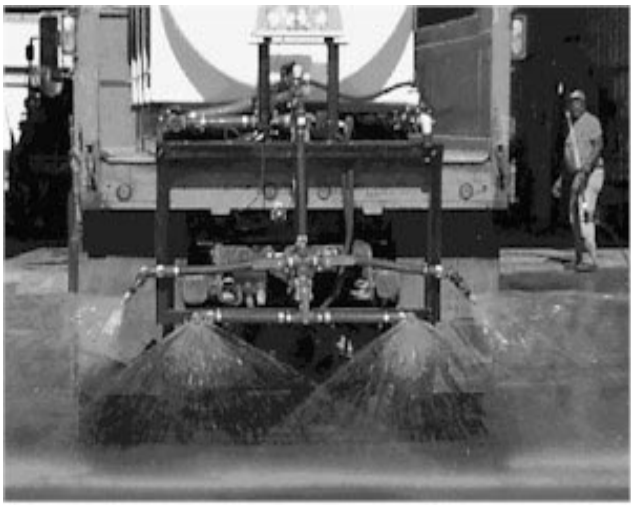
$CaCl_2$: Calcium chloride

$MgCl_2$: Magnesium chloride

SUMMARY

This methodology can be very useful in developing and implementing a salt management plan and providing for an effective and efficient snow and ice control strategy. The Salt Institute is now recommending these guidelines be put into practice for your snowfighting program and has already promoted the results of the NCHRP Project 6-13 through its newsletter. The practice of applying the "right" amount of chemical at the "right" time for weather and road conditions will result in long-term chemical savings. To effectively utilize these tools, agencies will have to modify their operations to include tools like RWIS, pre-wetting, direct chemical application; compared to using only a few application rates over the course of winter weather events just like we have for the last 30 years. The time to change is now! These strategies do work and should become part of an efficient, environmentally responsible highway operation.

Anti-icing combination multiple liquids at the same time -- can combine liquid CaCl with liquid NaCl.



Anti-icing material from fan-type nozzle.

Material in this tech sheet was excerpted **and adapted** by Alan Gesford, Technology Transfer Specialist at Penn State, from *Guidelines for Snow and Ice Control Materials and Methods*, by Robert R. Blackburn, Duane E. Amsler, Sr., P.E., and Karin M. Bauer, prepared for the 6th International Symposium on Snow Removal and Ice Control Technology, Spokane, WA, June 7-9, 2004. **It is reprinted with permission from Mr. Gesford.**

Paul Brown, Director of Snow and Ice Operations at MassHighway, has adapted the tech note to standard practices in Massachusetts with attached tables illustrating salt application rates (per lane mile) and lane mile applicaton rates.

The NCHRP Project 6-13 Report is available online at: http://www.nas.edu/trb/index.html or from:

Transportation Research Board
National Research Council
2101 Constitution Ave., N.W.
Washington, DC 20418

SALT APPLICATION RATES (PER LANE MILE)

*****Double these rates for centerline applications*****

Current Pavement Temperature Range (°F)	Anticipated Pavement Temp. Change (Higher or Lower)	Severity/ Precipitation Type	Application rate 240lb Per Ln/mile	Recommended Treatment	Comments
Above 32	Higher▲	Light -Rain, Sleet or Wet Snow	240	Initial application, reapply as needed	Pre-wet salt application Do not Pre-treat roadway
	Lower▼	Moderate to Heavy -Rain, Sleet or Wet Snow	240		Pre-Wet initial Salt application Pre-treat roadway with Calcium Chloride @ 20-30 gals per lane mile
25 to 32	Higher▲	Light Freezing -Rain, Sleet, Dry Snow or Wet Snow	240	Initial application plow and reapply as needed	Pre-wet Salt with Calcium Chloride @ 8-10 gals per ton Pre-treat roadway with Calcium Chloride @ 20-30 gals per lane mile or Pre-Wet Salt with Calcium Chloride @ 8-10 gal per ton.
		Moderate to Heavy -Freezing Rain, Sleet, Dry Snow or Wet Snow	240		
	Lower▼	Light -Freezing Rain, Sleet, Dry Snow or Wet Snow	240		
		Moderate to Heavy -Freezing Rain, Sleet, Dry Snow or Wet Snow	240		
20 to 25	Higher▲	Light -Sleet, Dry Snow or Wet Snow	240	Initial application, plow/reapply as needed	Pre-treat roadway with Calcium Chloride @ 20-30 gals per ton ➢ Pre-wet Salt with Calcium Chloride @ 8-10 gal per ton
		Moderate to Heavy -Sleet, Dry Snow or Wet Snow	240		
	Lower▼	Light - Sleet, Dry Snow or Wet Snow	240	Initial application, plow/reapply as needed	
		Moderate to Heavy -Sleet, Dry Snow or Wet Snow	240		
15 to 20	Higher▲	Light –Sleet or Dry Snow	240	Initial application, plow/reapply as needed	Pre-treat roadway with Calcium Chloride @ 20-30 gals per lane mile Pre-wet Salt with Calcium Chloride @ 8-10 gals per ton
		Moderate to Heavy –Sleet or Dry Snow	240		
	Lower*▼	Light – Sleet or Dry Snow	240	Initial application, plow/reapply as needed	
		Moderate to Heavy –Sleet or Dry Snow	240		
15 or Below				Apply sand if necessary, plow as needed	Monitor pavement temperature. Switch to wetted salt if rising above 15° F

- If snow is blowing off roadway and no hard pack exists, do not apply materials.
- DO NOT APPLY ON PACK unless applied with Salt

Lane Mile Application Rates and Corresponding Miles Treated

	Application Rate/Lane Mile											
			120		240		480		720			
# of Yards	LANE MILES YOU CAN TREAT											
1			16.6		8.3		4.3		2.7			
2			33.3		16.6		8.6		5.4			
3			49.9		24.9		12.9		8.1			
4			66.5		33.2		17.2		10.8			
5			83.1		41.5		21.5		13.5			
6			99.7		49.8		25.8		16.2			
7			116.3		58.1		30.1		18.9			
8			132.9		66.4		34.4		21.6			
9			149.5		74.7		38.7		24.3			
10			166.0		83.0		43.0		27.0			