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Are You Using The Right Amount Of Ice Control Chemical?

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The answer to this crucial question is based on the findings of NCHRP Project 6-13 (Guidelines for Snow and Ice Control – Materials and Methods), presented at the 6th International Symposium on Snow Removal and Ice Control Technology, June 7-9, 2004, Spokane, Washington. The study produced a methodology derived from field data, to prevent roadways from developing a bond between frozen precipitation and the road surface or improving pavement ice condition within a couple hours of applying chemicals.

This article presents a new, empirically 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 (with apologies, the tables use English, not metric, measures). These guidelines apply to both state/provincial and local highway agencies. The guidelines were developed under NCHRP Project 6-13 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. Three highway agencies were able to provide test data for the same location over all three winters.

Factors That Influence The Choice Of Materials And Their Application Rates

The major factors to consider when choosing a snow and ice control materials treatment are the dilution potential chemical treatments will face and the performance characteristics of the materials. For clarity, let's define some terms.

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

Precipitation dilution potential is the contribution to adjusted dilution potential caused by the 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 are the properties of the pavement itself that influence snow and ice control operations. The only pavement condition we will consider is pavement surface temperature 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 12°F, most ice control chemicals become very inefficient 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 LOS goals). Unpaved or gravel roads are not suitable for chemical treatment.

Pavement surface conditions (in the wheel path area) describe any accumulations of snow and ice that may remain on the pavement at the time of treatment (after plowing). These include loose snow, packed snow, and ice. **A critical 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 will need to be applied to achieve an unbonded condition.

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The most important **operational conditions** influencing dilution potential are **treatment cycle time** and traffic. Longer treatment cycle times allow more precipitation to accumulate on the roadway between treatments. For equivalent effectiveness, more chemical must be applied for longer cycle times.

The two **traffic characteristics** thought to influence dilution potential are traffic volume and traffic speed. Higher speeds and higher volume will displace ice control chemicals from the roadway.

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. Appropriate application rates for solid, prewetted solid, and liquid 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 time 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, hopefully, leaving the pavement surface wet, slushy, or lightly snow covered when treated.

Step by Step

Step 1. Determine the pavement temperature at the time of treatment and project the temperature trend after treatment. You need to estimate or predict using modeling techniques just 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 type and rate of precipitation, pavement surface conditions in the wheel path area, operational cycle time and traffic speed & volume. Use Table 1 to determine precipitation dilution potential. As necessary, adjust the precipitation dilution potential for various wheel path area conditions, cycle time and traffic speed & volume. Finally, using field observations or sensor data determine if an ice/pavement bond condition exists (yes or no).

Note: When making 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."**

NOTE: Some agencies have simplified this 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.

TABLE 1 - Precipitation Dilution Potential and Its Adjustments

Precipitation type	Precipitation rate			
	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 speeds >35 mph	
Less than 125 vph	0
More than 125 vph	1

Step 3. Using the calculations and observations from Table 1 as inputs, go to Table 2 to determine the appropriate application rate for solid, prewetted solid, or liquid NaCl.

Step 4. If you are using a chemical other than NaCl, 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 ($CaCl_2$), magnesium chloride ($MgCl_2$), potassium acetate (KAc), and calcium magnesium acetate (CMA). The

TABLE 2 - Application Rates for Solid, Prewetted Solid, and Liquid Sodium Chloride

Pavement Temperature (°F)	Adjusted dilution potential	Ice pavement bond	Application rate	
			Solid (1) lb/L-M	Liquid (2) gal/L-M
Over 32	Low	No	90 (3)	40 (3)
		Yes	200	NR (4)
	Medium	No	100 (3)	44 (3)
		Yes	225	NR (4)
	High	No	110 (3)	48 (3)
		Yes	250	NR (4)
30 to 32	Low	No	130	57
		Yes	275	NR (4)
	Medium	No	150	66
		Yes	300	NR (4)
	High	No	160	70
		Yes	325	NR (4)
25 to 30	Low	No	170	74
		Yes	350	NR (4)
	Medium	No	180	79
		Yes	375	NR (4)
	High	No	190	83
		Yes	400	NR (4)
20 to 25	Low	No	200	87
		Yes	425	NR (4)
	Medium	No	210	92
		Yes	450	NR (4)
	High	No	220	96
		Yes	475	NR
15 to 20	Low	No	230	NR
		Yes	500	NR
	Medium	No	240	NR
		Yes	525	NR
	High	No	250	NR
		Yes	550	NR
10 to 15	Low	No	260	NR
		Yes	575	NR
	Medium	No	270	NR
		Yes	600	NR
	High	No	280	NR
		Yes	625	NR
Below 10°F	A.If unbonded, try mechanical removal without chemical. B.If bonded, apply chemical at 700 lb/L-M. Plow when slushy. Repeat as necessary. C.Apply abrasives as necessary.			

NR = Not recommended.

Specific Notes:
1. Values for “solid” also apply to prewet solid and include the equivalent dry chemical weight in prewetting solutions.
2. Liquid values are shown for the 23-percent concentration solution.
3. In unbonded, try mechanical removal without applying chemicals. If pretreating, use this application rate.
4. If very thin ice, liquids may be applied at the unbonded rates.

General Notes:
5. These application rates are starting points. Local experience should refine these recommendations.
6. Prewetting chemicals should allow application rates to be reduced by up to about 20% depending on such primary factors as spread pattern and spreading speed.
7. Application rates for chemicals other than sodium chloride will need to be adjusted using the guidance in Table 3.
8. Before applying any ice control chemical, the surface should be cleared of as much snow and ice as possible.

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application rate data for each of the five chemicals, normalized with respect to NaCl, are provided for various pavement temperature ranges and application rates.

In summary, this methodology can be very useful in developing and implementing salt management plans. The practice of applying the "right" amount of chemical for weather and road conditions will most likely result in long term chemical savings when compared with using only a few application rates over the full spectrum of winter weather events.

TABLE 3 - Equivalent Application Rates for Five Ice Control Chemicals

Temperature (⁰F)	NaCl		$CaCl_2$		$MgCl_2$		KAc		CMA	
	100%* Solid	23%* Liquid	90-92%* Solid	32%* Liquid	50%* Solid	27%* Liquid	100%* Solid	50%* Liquid	100%* Solid	25%* Liquid
	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM
31.5	100	45	109	32	90	31	159	30	159	69
31	100	46	111	32	91	32	161	31	161	72
30.5	100	47	111	33	91	32	155	30	155	71
30	100	48	107	33	94	33	158	31	158	74
29	100	49	109	34	91	33	155	31	155	79
28	100	52	109	34	91	33	152	31	152	81
27	100	54	109	35	90	34	153	31	153	86
26	100	56	104	34	96	36	161	33	161	95
25	100	57	102	34	99	35	167	35	167	108
24	100	61	108	38	102	41	167	35	167	114
23	100	62	112	41	102	41	164	35	164	117
22	100	65	110	41	102	42	160	35	160	121
21	100	68	107	40	101	42	155	35	155	125
20	100	70	108	42	98	42	150	34	150	129
15	100	90	103	44	96	44	142	34	142	170
10	100	120	101	49	95	47	138	35	138	265
5	100	165	104	57	96	51	139	37	139	630

NaCl: Sodium chloride.
$CaCl_2$: Calcium chloride.
$MgCl_2$: Magnesium chloride.
KAc: Potassium acetate.
CMA: Calcium magnesium acetate.

* Typical percent concentrations of the solid and liquid forms with the balance being largely water.

General Note:
The above application rates are normalized to 100 lb/LM of dry solid NaCl. The application rates corresponding to a dry solid NaCl rate other than 100 lb/LM are determined by multiplying the equivalent chemical application rates for a given temperature by the ratio of the desired dry solid NaCl rate to 100 lb/LM. For example, if a 200 lb/LM of dry solid NaCl application rate were recommended at a temperature of 20°F, then switching to a 90 to 92 percent concentration of solid $CaCl_2$ would require a slightly higher application rate of 216 lb/LM.

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