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New Chemical Application Guidelines for Winter Operations

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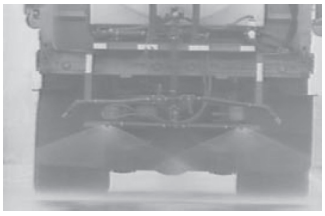
This tech sheet is based on the findings of National Cooperative Highway Research Program (NCHRP) Project 6-13, Guidelines for Snow and Ice Control – Materials and Methods, presented at the 6th International Symposium on Snow Removal and Ice Control Technology, June 7 to 9, 2004, Spokane, Washington (see credit at end). 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.

Anti-icing material from straight-stream nozzle.



Anti-icing material from fan-type nozzle.

FACTORS THAT INFLUENCE THE CHOICE OF MATERIALS AND THEIR APPLICATION RATES

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.

Adjusted dilution potential is a term that characterizes the rate that a chemical's effectiveness is eroded under operating conditions. It takes into consideration precipitation, pavement 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 from 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, particularly the pavement surface condition in the wheel path area, refer to the aspects of the pavement itself that influence snow and ice control operations. The pavement surface temperature has to be considered, 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 degrees Fahrenheit, 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 level of service goals. Pavement surface conditions in the wheel path area also 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 critical 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 will have to be applied to achieve an unbonded condition.

Operational conditions also need to be considered. 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** that influence dilution potential are traffic volume and traffic speed. Higher speeds and higher volume will displace ice control chemicals from the roadway.

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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 and on page 4. 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 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, leaving the pavement surface wet, slushy, or lightly snow covered when treated.

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, and operational conditions of cycle time and traffic speed and volume. Use Table 1 on the next page 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 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.

Step 3. Finally, using field observations 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 on the next page to determine the appropriate application rate for solid, prewetted solid, or liquid salt.

Step 4. If you are using a chemical other than salt, use Table 3 on page 6 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 (CaCl2), magnesium chloride (MgCl2), potassium acetate (KAc), and calcium magnesium acetate (CMA). The application rate data for each of these four chemicals, normalized with respect to NaCl, are provided for various pavement temperature ranges and application rates.

SUMMARY

This methodology can be very useful in developing and implementing salt management plans 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 NCHRP Project 613 through its newsletter. 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.

Material in this tech sheet was excerpted from Guidelines for Snow and Ice Control Materials and Methods, by Robert R. Blackburn, Duane E. (Dewey) Amsler, Sr., P.E., and Karin M. Bauer, prepared for the 6th International Symposium on Snow Removal and Ice Control Technology, Spokane, Washington, June 7-9, 2004.

Call 1-800-FOR-LTAP for more information about winter materials.

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 – Wet – Frost or black ice (thin ice) – Slush or loose snow – Packed snow or thick ice	Not applicable Low Low Medium 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 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 solid, 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	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/LM. Plow when slushy. Repeat as necessary. C. Apply abrasives as necessary.			

LM = lane-mile of road.
NR = not recommended.
Table notes:
a. Values for "solid" also apply to prewetted 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 applying 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.

Table 3. Equivalent application rates for five ice control chemicals.

Temperature range (°F)	NaCl		$CaCl_2$		$MgCl_2$		KAc		CMA	
	Solid	23% Liquid	Solid	32% Liquid	Solid	27% Liquid	Solid	50% Liquid	Solid	25% Liquid
	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM	lb/LM	gal/LM
30 - 32	50	22	56	16	47	17	79	15	82	35
	100	44	111	32	94	33	158	30	164	70
	150	66	167	47	141	50	237	44	246	105
	200	87	222	63	188	66	316	59	328	140
	250	109	278	79	235	83	395	74	410	174
28 - 30	50	22	53	15	45	16	75	14	85	36
	100	44	106	30	90	32	150	28	169	72
	150	66	159	45	135	48	225	42	254	108
	200	87	212	60	180	64	300	56	338	144
	250	109	265	75	225	80	375	70	423	180
26 - 28	50	22	51	14	43	15	71	13	87	37
	100	44	102	29	86	30	142	27	174	74
	150	66	153	43	129	46	213	40	261	110
	200	87	204	58	172	61	284	53	348	148
	250	109	255	72	215	76	355	66	435	185
24 - 26	50	22	49	14	41	14	67	13	90	38
	100	44	98	28	87	29	134	25	179	76
	150	66	147	42	123	43	201	38	269	114
	200	87	196	56	164	58	268	50	358	152
	250	109	245	70	205	72	335	63	448	191
22 - 24	50	22	47	13	39	14	63	12	92	39
	100	44	94	27	78	28	125	23	184	78
	150	66	141	40	117	41	188	35	276	117
	200	87	188	53	156	55	250	47	368	157
	250	109	235	67	195	69	313	59	460	196
20 - 22	50	22	45	13	37	13	59	11	95	40
	100	44	89	25	74	26	117	22	189	80
	150	66	134	38	111	39	176	33	284	121
	200	87	178	51	148	52	234	44	378	161
	250	109	223	63	185	65	293	55	473	201

LM: Lane mile of road
NaCl: Sodium chloride
$CaCl_2$: Calcium chloride
$MgCl_2$: Magnesium chloride
KAc: Potassium acetate
CMA: Calcium magnesium acetate