

# Application Rate Guidance for Salt Brine Blends for Direct Liquid Application and Anti-Icing

Prepared as Task 5 of Clear Roads Project 19-01

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## 1. FIELD DATA COLLECTED

The objective of this research is to provide agencies with the information needed to apply various liquid deicers in a broader range of field conditions, particularly at lower pavement temperatures (below 20°F). Winter maintenance practices vary across regions with predominant winter conditions. Agencies from different geographical regions of the country were selected for participating in field data collection to provide a wide range of winter conditions, road types, and resources. This report provides a summary of the data collected, data processing, and development of application rate guidance.

Data collected consisted of route information and field data in terms of weather, roadway conditions, materials, application rates, and performance measures. Seventeen agencies representing nine states submitted data from 31 routes resulting in field data for 167 storms. Table 1 provides route and storm data submitted by state and agency.

*Table 1. Number of storms collected by state and agency*

State	Agency	Routes	Storms
Michigan	Farmington Hills	1	14
Idaho	DOT	4	0
Minnesota	DOT	7	9
Nebraska	DOT	1	1
Ohio	DOT	4	0
Oregon	DOT	2	5
Utah	DOT	1	4
West Virginia	DOT	1	0
Wisconsin	Brown County	1	10
	Jefferson County	1	20
	Marathon County	1	14
	Marquette County	1	13
	Outagamie County	1	16
	Price County	1	2
	Shawano County	1	15
	Washington County	1	18
	Wood County	2	26
<b>Total</b>		<b>31</b>	<b>167</b>

## 2. DEVELOPMENT OF GUIDANCE

Data was first reviewed for completeness and consistency. Unfortunately, some of the agencies submitted route information, but did not submit storm data (Idaho, Ohio, West Virginia). Also, materials or application rates information was not submitted for some of the storms (24 storms). Available storm field data was used for analysis.

### 2.1. Existing Guidance

The objective of this research was to expand liquid application rate guidance available in the Clear Roads Material Application Methodologies Guidebook prepared by Washington State University in 2019 (Shi et al. 2019). Application rates in the Clear Roads guidebook were derived from guidelines and experiences from state DOTs. Guidance is provided in four tables according to intensity of snowfall and freezing rain:

- Light Snow (< 1 in/hr., < 4” in 24 hrs.)
- Moderate Snow (1–2 in/hr., about 4–8” in 24 hrs.)
- Heavy Snow (> 2 in/hr. > 8” in 24 hrs.)
- Freezing Rain

## 2.2. Field Data Characteristics

Available field data collected as part of this study was classified by pavement temperature range and snowfall precipitation. Results are provided in Table 2.

Table 2. Number of storms by temperature range and snowfall

Pavement Temperature	Snowfall (in/hr)		
	0.0-0.5	0.5-1.0	2.5-3.0
> 32°F	21		
25-32°F	81	3	1
20-25°F	27		
15-20°F	12		
0-15°F	16		
< 0°F	6		
<b>All</b>	<b>163</b>	<b>3</b>	<b>1</b>

Distributions of field data based on pavement temperature and snowfall indicated that the majority of data available were for conditions with a snowfall rate of less than one inch per hour, which specifically covers existing guidance for light snow of the Clear Roads guidebook. Therefore, liquid application guidance was expanded for light snow conditions, especially for missing guidance below 20°F, which are highlighted in yellow in Table 3. (NR = not recommended)

Table 3. Clear Roads CR15.01. Guidebook Application Rate Guidelines for Light Snow (< 1 in/hr., < 4” in 24 hrs.) (Shi et al. 2019)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/ln-mi)			Solid (lb/ln-mi)	
			NaCl	MgCl <sub>2</sub>	CaCl <sub>2</sub>	Dry Salt	Pre-wet salt
32°F	Steady or rising	Dry	NR			NR	
		Icy patches	20-40	15-35	15-35	120-160	110-150
32°F	Below is imminent	Dry (snow forecast)	20-40	15-35	15-35	NR	75-125
		Slush or light snow	30-40	15-30	15-30	140-180	100-150
25-32°F	Remaining in range	Dry (snow forecast)	30-50	20-40	20-40	NR	100-125
		Light snow cover	40-60	20-40	20-40	160-200	125-175
20-25°F	Remaining in range	Dry (snow forecast)	40-60	30-50	30-50	NR	125-175
		Light snow cover	50-80	20-40	20-40	200-250	175-225
15-20°F	Remaining in range	Dry (snow forecast)	NR	40-60	45-65	NR	175-225
		Light snow cover	NR	45-65	45-65	250-300	200-250
0-15°F	Steady or falling	Dry (snow forecast)	NR			NR	200-250
		Light snow cover	NR			NR	200-250
Below 0°F	Steady or falling	Light snow cover	NR			NR	NR

## 2.3. Guidance Based on Field Data and Practitioner Feedback

Ranges of application rates were identified according to pavement temperature range, temperature trend, road surface condition, and materials used. Guidance is provided exclusively from field data and practitioner feedback. Therefore, application rates provided are supported by field evidence from agencies successfully implementing liquid material under conditions not previously documented. Guidance was

developed for liquid application only and “Shake and Bake.” Shake and Bake is a combination of liquid application directly followed by a solid application, which is being used by agencies under low temperatures (below 20-15°F).

Field based application rate guidance was shared with practitioners who have extensive experience using direct liquid applications. The intent of involving practitioners was to receive feedback, validate observed application rates, and raise awareness about specific conditions. Separate meetings were scheduled with different practitioners to discuss the results of the application rate guidance. The following practitioners participated in these discussions:

<b>Name</b>	<b>Position</b>	<b>Agency</b>
Bret Hodne	Public Services Director	West Des Moines, Iowa
Kevin Hensley	Director of Public Works	City of Grimes, Iowa
Larry Schneider	Streets Director	City of Fort Collins, Colorado
Scott Rattay	Winter Maintenance Program Coordinator	Oregon DOT
Beth Skowronski	Assistant Maintenance Superintendent	McHenry County, Illinois
Bill Kern	Highway Commissioner	Jefferson County, Wisconsin
Sean Heaslip	Superintendent	Jefferson County, Wisconsin
Michael Piacenti	Operations Manager	Brown County, Wisconsin
Jim Griesbach	Highway Commissioner	Marathon County, Wisconsin
Brandon Dammann	Patrol Superintendent	Wood County, Wisconsin
Brian Trebiatowski	Highway Commissioner	Marquette County, Wisconsin
Vance Pollitt	Patrol Superintendent	Price County, Wisconsin

Generally speaking, all practitioners were in concurrence with the guidance developed based on field data. Comments from practitioners are summarized by topic in section 4.

## **2.4. Application Rates**

Application rates are provided for liquid applications and Shake and Bake. Tables 4 to 9 provide the range of application rates and corresponding number of storms and agencies from which the data was available.

### **Liquid Applications without Blending**

#### *Salt Brine Applications*

*Table 4. Application Rates for Light Snow with Salt Brine (<1 in/hr., <4” in 24 hrs.)*

#### *Magnesium Chloride Applications*

*Table 5. Application Rates for Light Snow with Magnesium Chloride (<1 in/hr., <4” in 24 hrs.)*

### **Liquid Applications with Blending**

#### *Salt Brine and Calcium Chloride Applications*

*Table 6. Application Rates for Light Snow with Salt Brine and Calcium Chloride (< 1 in/hr., < 4” in 24 hrs.)*

#### *Salt Brine and Geomelt Applications*

*Table 7. Application Rates for Light Snow with Salt Brine and Geomelt (< 1 in/hr., < 4” in 24 hrs.)*

#### *Salt Brine, Calcium Chloride, and Geomelt Applications*

*Table 8. Application Rates for Light Snow with Salt Brine, Calcium Chloride, and Geomelt (< 1 in/hr., < 4” in 24 hrs.)*

### **Shake and Bake**

#### *Salt Brine and Dry Salt*

*Table 9. Application Rates for Light Snow with Salt Brine and Dry Salt (< 1 in/hr., < 4” in 24 hrs.)*

Table 4. Application Rates for Light Snow with Salt Brine (<1 in/hr., <4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Field Data Details		
			NaCl	Storms	Locations	Agencies
32°F	Steady or rising	Icy patches	30-50	8	4	Outagamie (WI), Shawano (WI), Price (WI), and Marathon (WI)
32°F	Below is imminent	Slush or light snow	30-60	6	4	Utah (UT), Brown (WI), Outagamie (WI), and Washington (WI)
25-32°F	Remaining in range	Light snow cover	40-65	37	10	Nebraska (NE), Farmington Hills (MI), Outagamie (WI), Washington (WI), Wood (WI), Brown (WI), Marquette (WI), Shawano (WI), Jefferson (WI), and Marathon (WI)
20-25°F	Remaining in range	Light snow cover	50-90	7	3	Nebraska (NE), Shawano (WI), Wood (WI)

Table 5. Application Rates for Light Snow with Magnesium Chloride (<1 in/hr., <4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Field Data Details		
			MgCl <sub>2</sub>	Storms	Locations	Agencies
32°F	Below is imminent	Slush or light snow	30	2	1	Oregon (OR)
25-32°F	Remaining in range	Light snow cover	30	1	1	Oregon (OR)
20-25°F	Remaining in range	Light snow cover	30	1	1	Oregon (OR)

Table 6. Application Rates for Light Snow with Salt Brine and Calcium Chloride (< 1 in/hr., < 4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Field Data Details		
			NaCl and CaCl <sub>2</sub> 90/10 Blend	Storms	Locations	Agencies
20-25°F	Remaining in range	Light snow cover	20-45	4	3	Farmington Hills (MI), Minnesota (MN), and Shawano (WI)
15-20°F	Remaining in range	Light snow cover	40-60	4	3	Farmington Hills (MI), Outagamie (WI), and Shawano (WI)

Table 7. Application Rates for Light Snow with Salt Brine and Geomelt (< 1 in/hr., < 4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Field Data Details		
			NaCl and Geomelt 80/20 Blend	Storms	Locations	Agencies
32°F	Steady or rising	Icy patches	40	1	1	Farmington Hills (MI)
32°F	Below is imminent	Slush or light snow	40	1	1	Farmington Hills (MI)
15-32°F	Remaining in range	Light snow cover	40	3	1	Farmington Hills (MI)

Table 8. Application Rates for Light Snow with Salt Brine, Calcium Chloride, and Geomelt (< 1 in/hr., < 4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Field Data Details		
			NaCl, CaCl <sub>2</sub> , and Geomelt 80/10/10 Blend	Storms	Locations	Agencies
15-20°F	Remaining in range	Light snow cover	40	1	1	Farmington Hills (MI)
0-15°F	Steady or falling	Light snow cover	45	1	1	Farmington Hills (MI)

Table 9. Application Rates for Light Snow with Salt Brine and Dry Salt (< 1 in/hr., < 4” in 24 hrs.)

Pavement Temperature	Trend	Road Surface Condition	Liquid (gal/l <sub>n</sub> -mi)	Solid (lb/l <sub>n</sub> -mi)	Field Data Details		
			NaCl	Dry Salt	Storms	Locations	Agencies
32°F	Steady or rising	Dry	20-40	100-200	8	5	Minnesota (MN), Jefferson (WI), Marathon (WI), Brown (WI), and Washington (WI)
32°F	Below is imminent	Dry (snow forecast)	25-45	100-200	8	4	Utah (UT), Jefferson (WI), Brown (WI), and Washington (WI)
25-32°F	Remaining in range	Dry (snow forecast)	30-50	150-250	18	7	Utah (UT), Jefferson (WI), Outagamie (WI), Wood (WI), Brown (WI), Price (WI), and Washington (WI)
20-25°F	Remaining in range	Dry (snow forecast)	40-50	150-250	2	2	Jefferson (WI) and Outagamie (WI)
15-20°F	Remaining in range	Dry (snow forecast)	40-50	200-300	4	2	Jefferson (WI) and Outagamie (WI)
0-15°F	Steady or falling	Dry (snow forecast)	50-90	200-300	2	2	Brown (WI) and Outagamie (WI)

## 2.5. Practitioner Feedback

### 2.5.1. Practices Below 20°F

**Practitioner 1:** Don't go above 55 gal/ln-mi and change the mixture. Add 10% Geomelt and still apply 50 gal/ln-mi. If pavement temperatures get to 0-5°F, CaCl<sub>2</sub> is added. In the 20-15°F, couple of hours in the middle of night, straight salt brine is used. If temperatures keep dropping, mixture is changed.

**Practitioner 2:** Really watch trending temperatures. If pavement temperatures are 15°F and up, stick with brine. If 15°F and going down, Beet Heat or AMP is added. May look to CaCl<sub>2</sub> once they get a tank.

**Practitioner 3:** Generally, put down around 40 gal/ln-mi between 25-32°F, and up it to around 50-60 gal/ln-mi from 15-25°F. CaCl<sub>2</sub> is added below 15°F.

**Practitioner 4:** Main source of deicers are MgCl<sub>2</sub> and solid salt. For pre-wet, usually use 10-20 gal/ton of MgCl<sub>2</sub>, sometimes 25 gal/ton based on conditions. When doing liquid only, application rates of MgCl<sub>2</sub> are 25-35 gal/ln-mi since the spreader controllers have only two settings (two valves). Below 20°F, plow and apply pre-wetted abrasives as needed. Follow Oregon Deicer Application Guidelines (Table 10).

Table 10. Oregon Department of Transportation MgCl<sub>2</sub> Deicer Application Guidelines.

Deicing (During the Storm)				
Pavement Temperature at the time of application	Light Snow (1" per hour or less)	Moderate - Heavy Snow (More than 1" per hour)	Freezing Fog/Black Ice	Freezing Rain/Sleet
Over 30	15-30 (L) or 100-200 (S)	200-300 (S)	15-30 (L) or 100-200 (S)	200-300 (S)
26 to 30	20-40 (L) or 100-200 (S)	200-300 (S)	20-40 (L) or 100-200 (S)	200-300 (S)
21 to 25	20-40 (L) or 100-200 (S)	200-400 (S)	30-50 (L) or 100-200 (S)	200-400 (S)
15 to 20	40-60 (L) or 200-300 (S)	200-500 (S)	40-60 (L) or 200-300 (S)	200-500 (S)
Below 15	PA	PA	AA	AA

Note: (L) = Liquid Mag (MgCl<sub>2</sub>) gallons per lane mile, (S) = Solid Salt (NaCl) pounds per lane mile, PA = Plow and apply pre-wetted abrasives as needed, AA = Apply pre-wetted abrasives as needed.

**Practitioner 5:** Below 20°F start using MgCl<sub>2</sub> based products such as GHCO Torch and Envirotech Apex at a rate of 30-60 gal/ln-mi in combination with 150-300 lb/ln-mi of dry salt (Shake and Bake). Does not use MgCl<sub>2</sub> at 25-32°F since it becomes supper slippery and has had bad experiences with car pile ups. It may be more expensive to implement proprietary products, but results outperform other surrounding jurisdictions or treatments using just salt brine or solid salt.

**Practitioner 6:** Implements 50-60 gal/ln-mi in the 15-20°F range. May add another 20 gal/ln-mi if temperatures drop further. Salt brine much more resilient than was previously thought. Application rates of 100 gal/ln-mi of salt brine with 150 lb/ln-mi of solid salt when doing Shake and Bake. Has used straight salt brine in steady temperatures all the way down to 8°F. May use straight salt brine in the range of 10-20°F in steady conditions.

### 2.5.2. Blending Applications

**Practitioner 1:** Geomelt works great for bridge decks. To do anti-frost, 5% in blend with brine and stays for a long time. It helps material stick and lasts for up to four days as long as there is no heavy precipitation. Usually implement it during Thanksgiving since people are not around.

**Practitioner 5:** Has experience using organic based products in the past. Although believes it does not have deicing properties and it was used to keep material on the road for a prolonged time.

**Practitioner 6:** Has been blending for a long time and has conducted several independent laboratory and field tests. Has not seen significant improvement with melting properties when blending alternative products with salt brine. For instance, a blend of salt brine, Geomelt, and CaCl<sub>2</sub> of 80/10/10 compared with 85/10/5 did not show much difference from the 5% increase in CaCl<sub>2</sub>, a minimal 0.2-degree eutectic temperature difference.

Geomelt softens material for plowing. Does not see large benefit for lower temperatures with non-chloride-based additives such as sugar-based products. Cost is an important factor when blending. Produces salt brine at \$0.10/gal and blending with more expensive additives will increase cost. Use non-chloride

additives primarily to keep material on the road, not for melting. Dilution of solution occurs with blending. Blending is more for residual value than melting value. High focus should be on salt brine rather than additives. How to keep the active ingredient on the pavement? That is where the non-chloride additives come in.

**Practitioner 7:** 5% sugar additives gave the desired results from a sticking perspective. At lower than 5% may get into a functional issue of how to blend.

**Practitioner 8:** All liquid routes have a blend of salt brine, Calcium Chloride, and organic. Ratios are 80% brine, 10% Chloride and 10% organic. Ratios can be adjusted for colder road temperatures. Blend at temps from 32 degrees down to 5-10 degrees above zero. Granular application rates vary from 100 lbs to 250-300 lbs a lane mile.

### 2.5.3. Shake and Bake Applications

**Practitioner 1:** Liquid never goes over 35 gal/l<sub>n</sub>-mi when pre-wetting solid salt. Between 200-250 lb/l<sub>n</sub>-mi of solid salt. May apply 300 lb/l<sub>n</sub>-mi of solid salt when the temperatures go to 0°F. Start mixing Geomelt to work at lower temperatures. May implement Shake and Bake using CaCl<sub>2</sub> if it gets really cold. Practitioner never used straight CaCl<sub>2</sub>, only when blending. It is lot more expensive. Learnt to lower expectations on non-busy roads. Go out late morning, put down salt and liquid. Let it sit, let the sun beat on it. At the end of the day clear it and put some material out.

**Practitioner 5:** Has been implementing Shake and Bake since the mid-80s. Uses a larger size of salt grains, does not use fine salt for Shake and Bake.

**Practitioner 6:** Believes that a heavier liquid application with less solid salt is more effective. A little concerned with the amount of solid salt observed in the field data with Shake and Bake which is up to 500 lb/l<sub>n</sub>-mi for cold temperatures. Believes that the spreader settings may be set on high speed which really covers multiple lanes, and the actual material per lane used is less than specified. Between 10-20°F uses 100 gal/l<sub>n</sub>-mi with 200-250 lb/l<sub>n</sub>-mi of solid salt at most. Interested to see more MgCl<sub>2</sub> and CaCl<sub>2</sub> used in Shake and Bake at lower temperatures.

### References

Shi, X., Xu, G., Du, S., Akin, M., Bergner, D., and Brown, P. (2019). *Material Application Methodologies Guidebook*. Report No.15-01. Clear Roads, Minnesota Department of Transportation.