Cypress Mountain: A Case Study in Snow and Ice Control with Liquid Chemicals

Prepared **By:**

Ice and Snow Technologies, LLC.

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ACKNOWLEDGEMENTS

The Authors wishes to acknowledge the assistance of the staff and management of Cypress Bowl Ski area including owner John Kersher, General Manager Linda Swain, Assistant General Manager Bobby Swain, head of all Mountain Operations Scott Bowen, and, in particular, Local Equipment manager, in charge of equipment and maintenance John Imlah, whose detailed record keeping made this analysis possible. As with any analysis, the quality of the data is critical to the quality of the results.

The Cypress Mountain Ski Area (formerly Cypress Bowl Ski Area) is owned by Boyne USA Resorts which also owns Big Sky Resort in Montana, Boyne Highlands, Boyne Mountain and Boyne Harbor in Michigan, Brighton in Utah, and Crystal Mountain in Washington.

Road Guard Plus™ is a product of Tiger Calcium Services Inc. is a corrosion inhibited liquid form of calcium chloride and magnesium chloride brine developed especially for anti-icing and pre-wetting at extremely low temperatures down to -45°C. The active ingredients for de-icing are 26% calcium chloride, 3% magnesium chloride, 3% alkaline chlorides including sodium chloride and potassium chloride, 3% highly effective corrosion inhibitors.

DISCLAIMER

The assessments and conclusions presented in this report are solely those of the Author(s) and do not reflect the opinions of Cypress Mountain Ski Area. Brand names are used only to provide clarity and context. As such, their use does not constitute an endorsement by Ice and Snow Technologies, LLC, Boyne USA Resorts, or the Management of Cypress Mountain.

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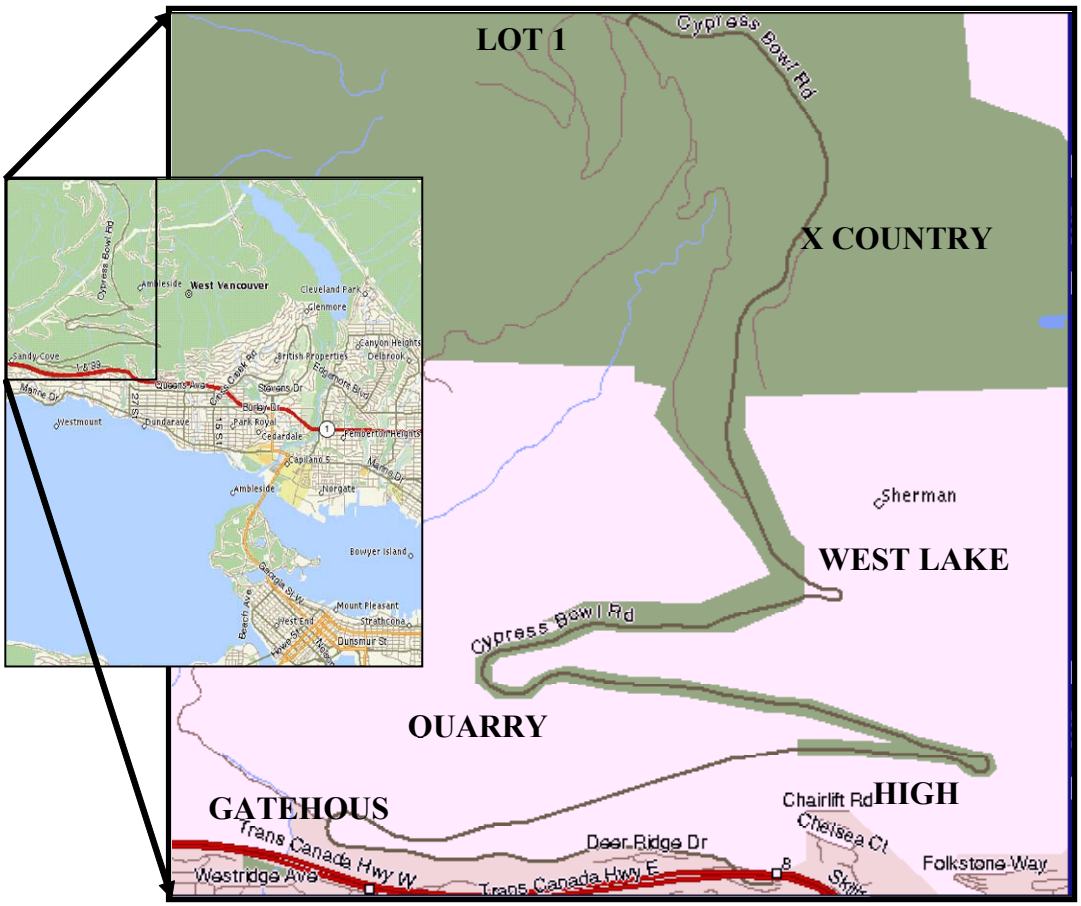
1.0 INTRODUCTION

This case study is a continuation of a process begun the year 2000. The study documents the evolution of the use of liquid chemicals in the process of snow and ice control. Briefly, the crew of Cypress Mountain Ski Area has progressed from a sand/salt and plow strategy in the year 2000; through a prewet salt and liquid magnesium chloride with prewet sand and plow strategy in the year 2001; to the present strategy of using liquid Road Guard Plus™ (primarily a calcium chloride-based liquid) along with plowing and some prewet sand in the year 2004.

2.0 BACKGROUND

2.1. TOPOGRAPHY

Cypress Mountain is a ski area located in a Provincial park adjacent to metropolitan Vancouver British Columbia.



2.2. ROADWAY CHARACTERISTICS

The roadway is of asphalt construction with numerous parking lots. The agency jurisdiction includes the parking lots and spur roads to some of the facilities.

The grade is an average of 5.5% for the length of the road, which is roughly 14.3 kilometers long and consists of 48.2 lane kilometers of treated roadway.

2.3. CLIMATE

The general climate is Pacific Maritime Mountain, similar to the Oregon and Washington Cascade Mountains, with relatively moderate winter temperatures and, at times, fairly heavy snowfall. At LOT 1, with a base elevation 980m, the annual average snowfall is 622 cm (244 in.). The snow is generally heavy and relatively wet.

3.0 OPERATIONS

The winter season typically lasts from November 1 to April 1 and there are up to 5 supervisory / lead people providing 24 hour a day/ 7 days-a-week coverage. The target level of service for the section is "bare and wet" pavement conditions.

Pavement Temperatures are measured using a hand-held radiometer. This unit costs about $500 Canadian (Cdn). The particular unit is a Snap On Tool, Enhance® Model 30 PB. It measures temperature from –32 to + 545 degrees Celsius with +/- 1 degree accuracy and costs about $500 (Cdn).

The winter of 2000 – 2001 was the first season for the use of liquid chemicals. The transition to the present strategy took place in January of 2004.

3.1. PROCEDURES

The general procedure for a winter storm is:

a) The Environment Canada weather forecast is received and reviewed by the supervisor/lead person to determine if there is a threat.

b) If a storm or icing condition is expected, the workers are given an advanced warning.

c) The supervisor/lead person will call out the workers if the storm or icing conditions materialize.

3.1.1 Winter 1999 –2000

a) The workers will plow and apply a 50/50-sand/salt mix (by volume) until the "bare and wet" pavement condition is achieved. Roadway surface temperatures are measured and logged using the hand-held radiometer

b) On frost days, the crews patrol with 2 trucks loaded with a 50/50-sand/salt mix looking for ice until the end of the shift.

3.1.2 Winter 2000-2001

a) The workers will plow and apply prewetted salt until the "bare and wet" pavement condition is achieved. Sand is used only of needed. The sand is also prewetted.

b) On frost days, after an initial application of liquid magnesium chloride (Typical application was 110 liters per lane kilometer) with 1 truck, the crews will patrol for a short time and, if no further problems are noted, go home.

3.1.3 Winter Early 2004

a) The workers will plow and apply liquid Road Guard Plus™ until the "bare and wet" pavement condition is achieved. Sand is used only if needed. The sand is also prewetted.

b) On frost days, after an initial application of liquid Road Guard Plus™ (Typical application was 75 liters per lane kilometer) with 1 truck, the crews will patrol for a short time and, if no further problems are noted, go home.

3.2. EQUIPMENT

The equipment used in snow and ice operations consists of:

a) A grader with a 3, or 4-m. moldboard and a 3-m. wing plow is used about 20% of the time on the roadways.

b) A large loader with a snow bucket is used about 10% of the time on the roadways.

c) A Case #480 loader is used to load sand and salt,

d) 2 Sicard 5150 snow blowers are used about 10% of the time on the roadways,

e) 2 International and 1 Freightliner trucks with snowplow, 5 cu m. dump box, and spreader were used in the winter of 1999-2000. For the winter of 2000 – 2001, one of the Internationals and Freightliner were fitted with prewet systems. The other International was fitted with a liquid application system, but retaining the plow. These units spend 95% of their time on the roadways.

f) A 2003 Volvo, tandem axle with liquid applicator was added for the winter of 2003 – 2004.

4.0 WEATHER - MARCH 2000, MARCH 2001, and March 2004

For the purposes of this study, the month of March in the years 2000, 2001, and 2004 was selected for comparison as it provided the most complete data and the most comparable weather conditions. This data is recorded at the Lot 1 site.

4.1. WEATHER STATISTICS

The following table shows that the month of March 2001 was only slightly milder from a conventional standpoint.

WEATHER SUMMARY – MARCH 2000, MARCH 2001, & MARCH 2004

WEATHER ELEMENT	UNIT	MAR 2000	MAR 2001	MAR 2004	CRITERIA
SNOW	**DAYS**	**18**	**14**	**8**	Trace or more of SNOW
RAIN	**DAYS**	2	5	2	Trace or more of RAIN
NO PRECIP.	**DAYS**	11	12	19	No Measurable Precipitation
FREEZING	**DAYS**	28	24	22	The low temperature is below freezing
FROST	**DAYS**	10	10	4	The low Temperature is below freezing and there is no precipitation
TOTAL SNOW	**CM**	122.04	115.53	99	Total snow fall
MAXIMUM SNOW	**CM**	30	25	25	Maximum Daily snow fall
AVERAGE SNOW	**CM**	3.94	3.73	3.2	Average daily snow fall
WEATHER INDEX		-12.30	-11.26	-9.52	WSDOT Weather Index Calculation

WEATHER INDEX - WSDOT weather index is derived from the original SHRP weather index. It should be noted that the winter index values are not linear in nature and one can not draw any inferences except that the two months were relatively equal in regards to weather severity. The range is from -50 (severe) to 50 (mild).

4.2. DISCUSSION OF WEATHER

The most significant difference in the Marches of 2000 an 2001 is the rainfall, one day of which was freezing rain. The study area received almost as much snow in 2001 as it did in 2000 and,

while the maximum daily snow was slightly lower, the average daily snowfall was about the same.

March of 2004 while having a slightly milder Winter Index of 9.52 showed almost as many freezing days but fewer snow days and a lesser total snowfall than 2001.

It should also be noted that the total number of freezing days was almost equal and the number of frost days was the same.

5.0 MATERIALS - March 1999-2000 vs. March 2000-2001

Materials used at Cypress Mountain include sand, salt, 30% magnesium chloride liquid in the winter of 2000-2001, and Road Guard Plus™ in starting in January of 2004.

5.1. COSTS.

The costs, in Canadian Dollars, reflect all fixed charges and taxes, for materials delivered to the maintenance yard. It should be noted that there is a $0.25 environmental tax per metric tonne of sanding material (Abrasives). Note, also, that there was a $5.00 increase in the purchase price of salt in the winter of 2000 –2001.

MATERIALS UNIT COST

TYPE	UNIT	PURCHASE	SHIPPING	PST TAXES	GST TAXES	ENV TAXES	TOTAL UNIT COST
SAND	Metric Tonne	$ 5.650	$ 9.60	$1.070	$0.400	$ 0.25	$ 16.97
SALT (99-00)	Metric Tonne	$ 50.000	$ 8.00	$4.060	$3.500	*	$ 65.56
SALT (00-01)	Metric Tonne	$ 55.000	$ 8.00	$4.410	$3.850	*	$ 71.26
MgCl	Liter	$ 0.179	*	$0.013	$0.013	*	$ 0.205
CaCl	Liter						$ 0.22

5.2. SUMMARY OF MATERIALS USED.

The following materials use and costs are for the month of March for each winter.

MATERIALS SUMMARY

MATERIAL	UNIT	AMOUNT			COST		
		March 2000	March 2001	March 2004	March 2000	March 2001	March 2004
SAND	**Tonne**	254.01	92.06	70.0	$ 4,311	$ 1,562	$1260
SALT	**Tonne**	452.69	89.54	-	$ 29,678	$ 6,381	-
MgCl	**Liter**		61,800	-	-	$ 12,669	-
Road Guard Plus™	**Liter**		-	30,000	-		$6,600
TOTAL MATERIALS COST ==========➔					**$ 33,988**	**$ 20,612**	**$ 7,860**

5.3. DISCUSSION OF MATERIALS COSTS

The reduction in materials cost use can be attributed to a more efficient operation with less wastage due to the use of liquid chemicals, directly applied, or as a prewet for sand and salt. The reduction in the use of sand is due to the prewetting process. The reduction in the use of salt is partly due to its replacement with magnesium chloride as well as the prewetting process and subsequent non-use in 2004.

6.0 CONCLUSIONS

This case study illustrates that, even in the initial stages, the use of liquid chemicals can yield significant savings for the winter maintenance community. The results can be shown as follows:

6.1. MONTHLY OPERATIONAL SAVINGS

Given the relatively equal weather conditions between March of 2000 and March of 2001, the following table illustrates the advantages of a liquid chemical based operation.

OPERATIONAL COST SUMMARY
MARCH 2000 vs. MARCH 2001

ITEM	COST		%
	MARCH 2000	MARCH 2001	CHANGE
LABOR & EQUIPMENT	$ 26,325.05	$ 19,045.40	-28%
MATERIALS	$ 33,988.91	$ 20,611.88	-39%
TOTAL COST =	**$ 60,313.95**	**$ 39,657.28**	**-34%**

OPERATIONAL COST SUMMARY
MARCH 2001 vs. MARCH 2004

ITEM	COST		%
	MARCH 2001	MARCH 2004	CHANGE
LABOR & EQUIPMENT	$ 19,045.40	$15,543.68	-18%
MATERIALS	$ 20,611.88	$ 7,860.00	-62%
TOTAL COST =	**$ 39,657.28**	**$ 23,403.68**	**-41%**

OPERATIONAL COST SUMMARY
MARCH 2000 vs. MARCH 2004

ITEM	COST		%
	MARCH 2000	MARCH 2004	CHANGE
LABOR & EQUIPMENT	$ 26,325.05	$15,543.68	-41%
MATERIALS	$ 33,988.91	$ 7,860.00	-77%
TOTAL COST =	**$ 60,313.95**	**$ 23,403.68**	**-61%**

6.2. MONTHLY REDUCTION IN CHLORIDE RELEASE

6.2.1 Calculating Chloride Content

The chloride content of any chloride-bearing chemical can be calculated as follows:

MOLECULAR WEIGHT CALCULATION

ELEMENT	ATOMIC WEIGHT	COMPOUND	MOLECULAR WEIGHT	% Chloride
CHLORINE	35.4527			
SODIUM	22.98977	ROAD SALT (Na Cl)	58.44247	60.66 %
MAGNESIUM	24.3050	MAG CHLORIDE ($Mg Cl_2$)	95.2104	74.47 %
CALCIUM	40.078	CALCIUM CHLORIDE ($CaCl_2$)	110.983	63.89%
POTASSIUM	39.0983	POTASSIUM CHLORIDE (KCl)	74.551	52.45%

MOISTURE ADJUSTMENT & CHLORIDE CONTENT

COMPOUND	UNIT	% Water	Sp. Gr.	Kg Cl per Unit
ROAD SALT (Na Cl 95%)	Tonne	5%		576.27
30% MAG CHLORIDE ($Mg Cl_2$)	Liter	70 %	1.285	0.28708185

MOISTURE ADJUSTMENT & CHLORIDE CONTENT

Road Guard Plus™ (Tiger Calcium) Specific Gravity = 1.320

COMPOUND	% in Mix	Grams/liter	% Cl	Grams Cl per Liter
CALCIUM CHLORIDE ($CaCl_2$)	26%	343.2	63.89%	219.27048
MAG CHLORIDE ($Mg Cl_2$)	3.1%	40.92	74.47 %	30.473124
SODIUM CHLORIDE (NaCl)	2.3%	30.36	60.66 %	18.416376
POTASSIUM CHLORIDE (KCl)	0.7%	9.24	52.45%	4.84638
INHIBITOR	3%	39.6	00	00
TOTAL SOLIDS	32%	------	------	------
TOTAL S	-----	463.32	20.47%	273.00636

6.2.2 Total Combined Release of Chlorides

Given the reduced amounts and types of chemicals used, the monthly reduction in the release of chlorides into the environment can be calculated as shown below.

COMBINED RELEASE CALCULATION March 2000 vs. March 2001

COMPOUND	FACTOR	MARCH 2000		MARCH 2001	
		Quantity	Kg Cl	Quantity	Kg Cl
ROAD SALT (Na Cl)		452.69	260,872	89.54	51,599
30% MAG CHLORIDE ($Mg Cl_2$)	0.28708185 kg/L	00	00	61,800	17,742
TOTAL CHLORIDE RELEASE ==========➔			**260,872 Kg**	**----------**	**69,341 Kg**

This chart shows a reduction of 73 % in total chloride loadings from March 2000 to March 2001.

COMBINED RELEASE CALCULATION March 2001 vs. March 2004

COMPOUND	FACTOR	MARCH 2001		MARCH 2004	
		Quantity	Kg Cl	Quantity	Kg Cl
ROAD SALT (Na Cl 95%)	576.27 Kg/tonne	89.54	51,599	00	00
30% MAG CHLORIDE ($Mg Cl_2$)	0.28708185 Kg/L	61,800	17,742	00	00
ROAD GUARD PLUS™	0.273006 Kg/L	00		30,000	8,190
TOTAL CHLORIDE RELEASE ==========➔			**69,341 Kg**	**----------**	**8,190 Kg**

This shows a reduction of 91 % in total chloride loadings from March 2001 to March 2004.

COMBINED RELEASE CALCULATION March 2000 vs. March 2004

COMPOUND	FACTOR	MARCH 2000		MARCH 2004	
		Quantity	Kg Cl	Quantity	Kg Cl
ROAD SALT (Na Cl 95%)	576.27 Kg/tonne	452.69	260,872	00	00
30% MAG CHLORIDE ($Mg Cl_2$)	0.28708185 Kg/L	00	00	00	00
ROAD GUARD PLUS™	0.273006 Kg/L	00		30,000	8,190
TOTAL CHLORIDE RELEASE ==========➔			**260,872 Kg**	**----------**	**8,190 Kg**

This amounts to a reduction of 97 % in total chloride loadings from March 2000 to March 2004

6.3. MONTHLY REDUCTION IN SAND RELEASE

The 64% reduction of sand or abrasive consumption (254.01 tonnes in March of 2000 to 92.06 tonnes in March of 2001 and 70 tonnes in March of 2005) was also very significant. . While Cypress Mountain has no roadway-sweeping program, others who are required to sweep would realize additional saving.

7.0 LONG RANGE IMPACT

There are a number of long-range impacts that can be estimated from the monthly results. This is because the analysis of six months of weather over the three years shows the months of March in both 2000, 2001, and 2004 appear to be relatively close to "average" or "typical" (Appendix A).

7.1. ESTIMATED ANNUAL SAVINGS

One can estimate the annual savings by the following:

MONTHLY SAVINGS (Based on the Winter 1999-2000)	$36,910.27
# of winter months	X 5
TOTAL ANNUAL SAVINGS	**$184,551.35**

Depending on the fleet maintenance requirements, another $6030 (Cdn) could be added to this figure representing the savings in corrosion and sand-related damage to the fleet.

7.2. ESTIMATED ANNUAL REDUCTION IN CHLORIDE RELEASE

One can estimate the annual reduction in chloride release by the following:

MONTHLY REDUCTION (Based on the Winter 1999-2000)	**252,682Kg**
# of winter months	X 5
TOTAL ANNUAL REDUCTION	**1,263,410 Kilograms**

7.3. ESTIMATED ANNUAL REDUCTION IN SAND USAGE

One can also estimate the annual reduction in sand use.

MONTHLY REDUCTION (Based on the Winter 1999-2000)	**184 Tonnes**
# of winter months	X 5
TOTAL ANNUAL REDUCTION	**920 Tonnes**

The annual savings for sand purchase amounts to $ 15,255. Using the figure of $12 per tonne for urban pickup (City of Kamloops 1996) further savings of up to $ 11,040 would be realized by those agencies required to sweep.

8.0 CONCLUSIONS

The information presented above shows how a small maintenance crew can use state of the art technologies and methods to significantly reduce their overall maintenance costs along with reducing the environmental impact.

John Imlah, the Local Equipment manager, in charge of equipment and maintenance, attributes the improvements to the following:

- Changing to a superior product
- Better equipment
- Experience and training of crews
- Keeping good records
- Learning from our experience

It should be noted that calcium chloride-based deicers do have an exothermic characteristic when undergoing the dilution process. While the exothermic properties are not easily quantifiable, they do accelerate the melting process but do not change the overall melting capability on an equal weight to weight of active ingredient basis.

APPENDIX A – WEATHER COMPARISON

WEATHER ELEMENT	DECEMBER 1999	JANUARY 2000	MARCH 2000	DECEMBER 2001	JANUARY 2001	MARCH 2001	AVERAGE
SNOW DAYS	7.00	21.00	18.00	8.00	9.00	14.00	**12.83**
RAIN DAYS	4.00	1.00	2.00	3.00	4.00	5.00	**3.17**
NONE	18.00	9.00	11.00	18.00	18.00	12.00	**14.33**
FREEZING DAY	22.00	30.00	28.00	23.00	26.00	24.00	**25.5**
FROST ONLY	12.00	9.00	10.00	16.00	14.00	10.00	**11.83**
CM Snow	67.21	188.02	122.04	54.12	52.10	115.53	**99.84**
MAX SNOW	24.00	22.00	30.00	25.00	16.00	25.00	**23.67**
MEAN SNOW	2.32	6.07	3.94	1.87	1.68	3.73	**3.27**
WINTER INDEX	**-7.2**	**-27.3**	**-12.30**	**-4.1**	**-4.4**	**-11.26**	**-11.09**

WEATHER INDEX - WSDOT weather index is derived from the original SHRP weather index. It should be noted that the winter index values are not linear in nature and one can not draw any inferences except that there can be similarities and differences between any two months. The range is from -50 (severe) to 50 (mild).

APPENDIX B – Road Guard Plus Information

Road
Guard Plus

TIGER
CALCIUM SERVICES INC.

Liquid De-icer for De-Icing, Anti-icing and Prewetting at Extremely Low Temperatures

Road Guard Plus is a corrosion inhibited liquid form of calcium chloride and magnesium chloride brine developed especially for anti-icing and pre-wetting at extremely low temperatures down to -45°C. The active ingredients for de-icing are 26% calcium chloride, 3% magnesium chloride, 3% alkaline chlorides including sodium chloride and potassium chloride, 3% highly effective corrosion inhibitors.

Quick Facts on Road Guard Plus

- A concentrated calcium chloride brine with 3% corrosion inhibitor added.
- Ability to cut through snow and ice more quickly than salt or magnesium chloride.
- Ability to melt snow and ice below -45°C (-49°F).
- Requres a minimum amount of agitation or recirculation while in storage.
- Less corrosive than rock salt, or sodium chloride.
- Can be mixed with sodium chloride brines in customer's storage tanks.
- Available in bulk tank truck or rail car.

Recommended Application Rates

As an anti-icer / de-icer, Road Guard Plus is typically applied at rates of 35 - 70 liters per lane kilometer. The end user is recommended to adjust application rates based on weather conditions, level of service goals and experience. As a prewetting agent, Road Guard Plus is typically used at rates of 30 - 50 liters per tonne of salt or sand.

www.tigercalcium.com 1-800-661-4298

Road Guard Plus

Percent $CaCl_2$+$MgCl_2$	Specific Gravity at 15°C	Freeze Point °C	Freeze Point °F
0	1.000	0.0	32
2	1.016	-1.3	29.7
5	1.042	-3.1	26.5
6	1.051	-3.8	25.2
7	1.060	-4.6	23.7
8	1.070	-5.5	22.1
9	1.079	-6.5	20.2
10	1.089	-7.7	18.2
11	1.099	-8.9	15.9
12	1.109	-10.3	13.5
13	1.119	-11.8	10.8
14	1.129	-13.3	8.0
15	1.140	-15.0	5.1
16	1.150	-16.7	2.0
17	1.161	-18.4	- 1.2
18	1.172	-20.3	- 4.5
19	1.184	-22.1	- 7.9
20	1.195	-24.1	-11.4
21	1.207	-26.1	-15.0
22	1.219	-28.2	-18.8
23	1.232	-30.4	-22.8
24	1.244	-32.8	-27.0
25	1.257	-35.3	-31.5
26	1.270	-38.0	-36.5
27	1.283	-41.1	-41.9
28	1.297	-44.5	-48.0
29	1.311	-48.3	-54.9
29.6	1.320	-51.8	-61.2

Composition

Calcium Chloride, $CaCl_2$	26.0 %
Magnesium Chloride, $MgCl_2$	3.1 %
Sodium Chloride, NaCl	2.3 %
Potassium Chloride, KCl	0.7 %

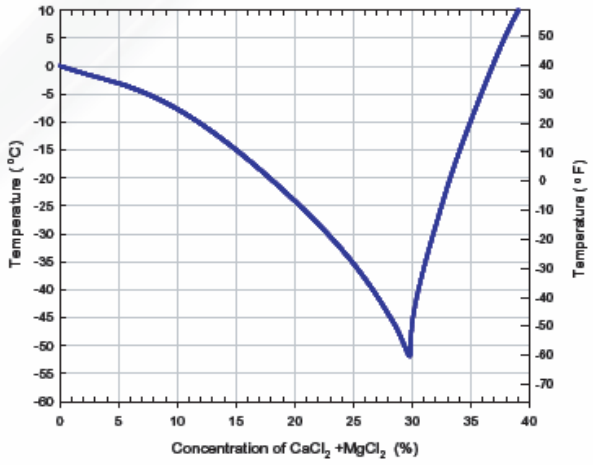
Calcium and Magnesium

Chlorides as Calcium Chloride	29.6%
Corrosion Inhibitors	3.0%
Total Chlorides for De-icing/Anti-icing	32%

Physical Properties

Appearance	Brown Liquid
Odor	Slight
Specific Gravity	1.320 kg/litre
Freezing Point	Free of solid down to -45°C
PH	6-10
Miscibility with water	Complete

Phase Diagram of Road Guard Plus



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