Study on Wetting Salt and Sand Stockpiles with Liquid Calcium Chloride

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Highway and city maintenance departments began wetting rock salt and abrasives with liquid calcium chloride more than 20 years ago to enhance the deicing performance of these materials on highways and streets. The newest method for combining rock salt or abrasives with liquid calcium chloride is called stockpile wetting. Stockpile wetting of rock salt consists of the injection of solutions of calcium chloride into the upper sections of piles of rock salt stored for use in highway ice and snow control. In this study, stockpile wetting was simulated by injection of calcium chloride solutions into 6-in.-diameter by 9-ft-tall columns of salt at temperatures of 50°F, 45°F, 40°F, 35°F, and 30°F. Concentrations of calcium chloride in the injected solutions ranged from 32 to 42 percent. The following characteristics of stockpile wetting were determined: (a) the extent and rate of movement of liquid downward through the simulated stockpile; (b) the quantity of liquid exiting the bottom of the stockpile as a function of temperature, solution concentration, and time; (c) the distribution of calcium chloride within the stockpile and quantities of calcium chloride in leachates; and (d) the ice melting capacity of stockpile-wetted rock salt compared to that of unwetted rock salt. Test results at temperatures 50°F or lower indicate that the preferred wetting parameters consist of injecting 42 percent $CaCl_2$ at a rate of 8 gal per ton. At 50°F and lower, wetting with 32 percent, 35 percent, and 38 percent $CaCl_2$ yielded leachates. Quantity of leachates is primarily a function of $CaCl_2$ concentrations. Wetted salt that remains in storage during hot summer months may produce leachate based upon test temperature rise to 85°F. Stockpile wetted rock salt out-performed dry rock salt in total ice melt at all temperatures and almost all time intervals.

To enhance the deicing performance of rock salt and abrasives on streets and highways, road officials began wetting these materials with liquid calcium chloride more than 20 years ago. The newest method for combining rock salt or abrasives with liquid calcium chloride is called stockpile wetting. This involves the injection of a calcium chloride solution throughout a stockpile at various space intervals.

Because no guidelines had been established for wetting stockpiled salt or sand, a series of tests to determine the percent brine concentration, leachate, and solution distribution was undertaken. These tests revealed that a 42 percent calcium chloride concentration by weight solution would be best for this application because it (a) provides relatively uniform distribution of the calcium chloride solution from top to bottom in salt and sand stockpiles, and (b) generated no leachate at the test temperatures, which would occur during expected use conditions.

In an auxiliary test, however, it was determined that 42 percent liquid calcium chloride began to leach from the bottom of the four test salt stockpiles after 2 days when the temperature was raised to 85°F, simulating hot, summer weather. However, under normal field conditions it could be expected that only the surface of a stockpile would reach this high temperature as it equilibrates with the ambient temperature. Therefore, $CaCl_2$ leachate from the warm outer layer could be expected to recrystallize as the leachate contacts material that is at 69°F and below.

Over the past 20 years, road officials have been wetting rock salt and abrasives such as sand with liquid calcium chloride primarily by two means. The first involved the use of an overhead spraybar system whereby a loaded truck drove under the spraybar and the entire load was wetted with liquid calcium chloride. The other method involved mounting the spray equipment directly on spreader trucks. The salt or sand was then treated with liquid calcium chloride as it was dispensed from the truck's hopper.

In an effort to cut the capital equipment costs involved with those two methods, road officials began looking for different ways to apply liquid calcium chloride to salt and sand. During the mid-1980s, this led to the practice of wetting the materials while in stockpiles.

While many road officials were experienced in treating rock salt and sand with liquid calcium chloride using spraybar or truck-mounted systems, no guidelines had been established for treating stockpiled salt and sand. Therefore, 40 tests were conducted during an 8-month period starting in mid-1986 to provide potential users with guidelines for applying liquid calcium chloride to each stockpiled material and an indication of the results they could expect when treating icy streets and highways with this deicing combination.

Specifically, tests were conducted on 32, 35, 38, and 42 liquid calcium chloride weight percent solution concentrations at five different stockpile temperatures: 30°F, 35°F, 40°F, 45°F, and 50°F. These temperatures represent a typical range that could be found in the interiors of stockpiles during winter storage. The objective was to determine (a) the amount of liquid that leached out the bottom of the stockpiles over a specified period of time, and (b) the distribution of calcium chloride solutions on a 100 percent dry weight basis from top to bottom of the salt stockpiles.

A secondary test consisted of wetting sand stockpiles with each calcium chloride concentration at a stockpile temperature

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of 35°F. The purpose of this test was the same as described in (a) in the previous paragraph.

In one auxiliary test, the salt was injected with 42 percent liquid calcium chloride at a stockpile temperature of 35°F, held at this temperature for 6 days, then warmed to 85°F and held at that temperature for 12¹/₄ days. This test was to determine if leachate would be generated when stockpiles were wetted in cold weather then kept in storage until the summer-like temperatures occurred.

In another auxiliary test, the deicing performance of stockpiled rock salt wetted with 42 percent liquid calcium chloride was compared to untreated rock salt in terms of the total ice-melting rate and volume of each material.

BACKGROUND

Stockpile wetting is accomplished by injecting a calcium chloride solution at a specified rate into stockpiled salt to a depth of 2 to 3 ft and at 1- to 2-ft intervals throughout the surface of the stockpile. The solution then percolates downward and outward from the areas of injection. Ideally, wetting results in uniform distribution of the calcium chloride solution throughout the stockpile, with none of the solution leaching out the bottom.

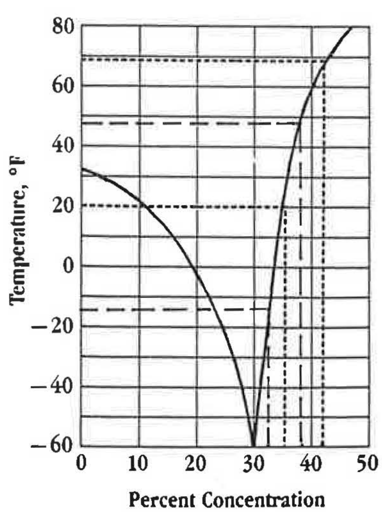

FIGURE 1 Crystallization points of solutions of liquid calcium chloride.

Liquid calcium chloride is available in concentrations of 32 percent, 35 percent, 38 percent, and 42 percent. Theoretically, 42 percent liquid calcium chloride heated to 80°F to 90°F would be expected to perform best for stockpile wetting applications. As shown in Figure 1, 42 percent liquid calcium chloride crystallizes at 69°F. Because application of the liquid calcium chloride to a stockpile would likely occur in late fall or early winter when stockpile temperatures are typically 30°F to 40°F, it would be necessary to heat a 42 percent solution to a temperature safely above its crystallization point to keep it in a free-flowing state.

When the 42 percent material is injected into the cooler salt stockpile, its temperature begins to drop rapidly. At 69°F, crystallization would begin to occur. Deeper into the pile, crystal growth continues. As long as the temperature remains below 69°F, runoff should not be expected.

Although application would normally take place in late fall when the stockpile's temperature has stabilized near 35°F, there may be instances with large stockpiles when the internal temperature is greater than 35°F. The higher brine concentration is then more important to prevent leaching.

Under those conditions, liquid calcium chloride concentrations of 32 percent, 35 percent, and 38 percent will leach out the bottom of the stockpile and possibly create environmental problems. This is because these brines crystallize at temperatures of −17°F for a 32 percent concentrate, 20°F for a 35 percent concentrate, and 48°F for a 38 percent concentrate as shown in Figure 1. For that reason, the 42 percent concentration of liquid calcium chloride theoretically should be used to produce the best results.

TESTING METHODOLOGY

The rock salt used in the tests met the Standard Specification for Sodium Chloride (ASTM D632), which specifies a sodium chloride product of 95 percent or higher purity and a distribution of particle sizes. As delivered, the salt contained about 0.1 percent moisture, according to supplier specifications and as verified by drying. The moisture content was increased to 0.5 percent prior to testing by adding the calculated quantity of water slowly to 150-lb batches of salt in a cement mixer and tumbling for at least 10 minutes. The purpose of increasing the moisture content of the rock salt to 0.5 percent was to simulate the conditions state and county highway departments experience when storing rock salt under cover.

Test sand conformed to Kansas Department of Transportation (KDOT) ice-control specifictions for particle size as follows:

Size	*Percent Passing*
³/₈ in.	100
4 mesh	85–100
16 mesh	50–90
30 mesh	5–50
100 mesh	0–5
200 mesh	2 (max)

No moisture specification was reported by KDOT. When received, the sand contained 4 to 5 percent moisture and was dried to an average of 0.95 percent moisture. The calcium chloride used in the tests met ASTM D98 specifications. To conduct the tests, four Plexiglas™ columns were constructed, each measuring 9 ft 4 in. high, 6 in. I.D., and ¹/₈ in. thick. Four columns were built so that tests for each calcium chloride concentration could be carried out simultaneously at the various test temperatures.

Fastened to the bottom of each column was a sheet metal plate with a ¹/₄-in. hole drilled into its center. A tube was placed over the hole for draining, collecting leachate in plastic bottles.

All columns were placed in a refrigerated enclosure which consisted of an insulated double-walled plywood box, 10 ft high × 5 ft wide × 4 ft deep. The front of the box consisted of a double walled 4 ft × 8 ft Plexiglas™ door to provide insulation and permit observation and photography without entering the test chamber.

The columns were loaded with rock salt to within 4 in. of the top. As the columns were filled, they were vibrated slightly to allow settling of the salt.

The temperature within the salt stockpile columns was measured by insertion of a thermometer to a depth of approximately 10 in. All salt stockpiles in the refrigerated enclosure were cooled overnight (16 to 18 hours) until the temperature was within 0.5°F of the test temperature.

To assure visual observation of the calcium chloride solution as it penetrated through the stockpile columns, all solutions were treated with a blue dye, Bull's Eye (Milliken Chemical), at the rate of 1 part dye:500 parts calcium chloride solution.

Injection of the calcium chloride solutions was by a metal probe, consisting of 1/2-in. diameter copper tubing 30 in. long which contained four sets of 1/8-in. holes at 6-in. spacings and 90-degree intervals. The injection pressure apparatus consisted of a 2-gal Freon™ tank fitted on the bottom with a 1/2-in. pipe and a lever-type quick-open valve. The top was fitted with a pressure gauge, a quick-connect fitting for attachment of an air hose, and a screw cap which was removed to introduce the calcium chloride solutions to the tank.

The calcium chloride solutions were injected at 40 psig and at a depth of 2 ft. The quantity of 100 percent dry weight calcium chloride per ton of rock salt was 40.15 lb for all tests (1.91 percent) (Table 1). Therefore, the liquid volume injected into the piles was at the following application rates: 32 percent solution, 11.45 gal per ton of salt; 35 percent solution, 10.19 gal per ton of salt; 38 percent solution, 9.10 gal per ton of salt; and 42 percent solution, 8.0 gal per ton of salt.

TABLE 1 APPLICATION RATES

	Percent			
	42	38	35	32
100 percent dry $CaCl_2$/ column (g)	1.130	1,139	1,139	1,139
Solution/column (g)	2.814	2,998	3,255	3,560
Solution/column (ml)	1,892.5	2.157.5	3,410.3	2,710.8
100 percent dry $CaCl_2$/ ton (lb)	40.15	40.15	40.15	40.15
Solution/ton (gal)	8.0	9.1	10.19	11.45

To ensure that each calcium chloride solution was above its crystallization point at the time of injection, the temperature of each was as follows:

1. At 32 percent: 35°F (crystallization temp. −17°F),
2. At 35 percent: 35°F (crystallization temp. +20°F),
3. At 38 percent: 60°F (crystallization temp. +48°F),
4. At 42 percent: 80°F (crystallization temp. +69°F).

The Plexiglas™ columns were charged sequentially with 42, 38, 35, and 32 liquid calcium chloride weight percent solution concentrations over a 30 to 40 minute period. Total test time was 120 hours.

TEST RESULTS

In the primary tests, studies were conducted on 32, 35, 38, and 42 liquid calcium chloride weight percent solution concentrations at stockpile temperatures of 30°F, 35°F, 40°, 45°F, and 50°F. In the first part of these tests, the objective was to determine the amount of calcium chloride that leached out the bottom of these stockpiles over a 1-week period.

Because of the significant amount of data that was generated by these tests, it is impractical to reproduce all results in this paper and allow for comparisons between the different concentrations of liquid calcium chloride. Therefore, Tables 2–4 summarize the relevant results of this test. These are the results of two tests for each concentration. It is interesting to note that leachate quantities exhibited no significant trend with temperature. Also, on average, leachate breakthrough times decreased as the calcium chloride concentration used increased. For example, the average breakthrough time on all tests for the 32-percent solution was 0.9 hours; the 35-percent solution was 3.4 hours; and the 38-percent solution was 6.0 hours (Table 5).

TABLE 2 LEACHATE QUANTITY (GALLONS PER TON ROCK SALT)

Percent $CaCl_2$ Solution	Temperature (°F)					
	50	45	40	35	30	Avg
32	4.55	4.94	4.60	4.45	4.77	4.7
35	2.32	4.00	2.83	2.88	2.97	3.0
38	1.86	1.70	1.76	1.82	1.66	1.8
42	0	0	0	0	0	0

TABLE 3 LEACHATE QUANTITY (PERCENT OF INJECTED VOLUME)

Percent $CaCl_2$ Solution	Temperature (°F)					
	50	45	40	35	30	Avg
32	40	43	40	38	42	41
35	23	39	28	29	29	30
38	20	19	19	20	18	19
42	0	0	0	0	0	0

TABLE 4 CONCENTRATION OF $CaCl_2$, IN LEACHATE, WEIGHT PERCENT

Temperature (Replicate) (°F)	Percent $CaCl_2$ Solution		
	32	35	38
50 (1)	28.5	28.4	32.0
50 (2)	25.9	29.4	32.1
Avg	27.2	28.9	32.15
45 (1)	27.2	31.8	34.2
45 (2)	27.9	31.9	29.4
Avg	27.6	31.85	31.8
40 (1)	27.5	31.5	27.8
40 (2)	29.7	33.5	32.6
Avg	28.6	32.5	30.2
35 (1)	29.1	31.0	32.6
35 (2)	27.6	29.7	32.3
Avg	28.4	30.4	32.5
30 (1)	28.0	31.4	33.3
30 (2)	25.1	30.2	31.9
Avg	25.6	30.8	32.6
Composite Avg	27.7	30.9	31.9

NOTE: No leachate was observed from any test for the 42 percent solution.

TABLE 5 LEACHATE BREAKTHROUGH TIMES OF STOCKPILE ROCK SALT WETTING

Temperature (°F)	Percent $CaCl_2$ Solution 32 No. 1	32 No. 2	32 Avg	35 No. 1	35 No. 2	35 Avg	38 No. 1	38 No. 2	38 Avg	42 No. 1[b]	42 No. 2[b]
50	0.5	0.5	0.5	4	2	3	1.0	1.0	1.0		
45	0.5	0.5	0.5	0.2	0.2	0.2	5.0	10[a]	7.5		
40	0.2	4	2.1	0.2	4	2.0	15[a]	2	8.5		
35	0.5	0.7	0.6	7.5	15[a]	11	20[a]	2	11		
30	1.0	0.8	0.9	1.5	0.4	1.0	3	1.3	2.1		
Avg			0.9			3.4			6.0		

[a]Extrapolated breakthrough times.
[b]No leachate breakthrough.

The second part of the primary testing was to determine the distribution of calcium chloride solutions on a 100 percent dry weight basis from top to bottom of the stockpiles over a specified period of time.

This was achieved by removing the salt from the columns in four equal sections from bottom to top; each column was marked by quarters 27 in. long. Each column was then placed over a 5-gal pail and the bottom sheet metal plate was removed and replaced with a metal shim. Each quarter of salt was then evenly discharged by gravity into separate pails. Salt from each pail was mixed for 3 to 4 minutes in a cement mixer to promote even liquid distribution. Samples of 1 to 2 lb were removed from the overall mixture and placed in glass jars for testing. These were analyzed for calcium chloride according to procedures specified in ASTM E449.

Interpretations of analytical data on calcium chloride contents of each of the four sections of the salt columns were slightly hindered by the presence of calcium sulfate in the rock salt in variable concentrations (from 0.5 percent $CaSO_4$ to 3 percent $CaSO_4$). Reported data contain obvious anomalies attributable to this problem. The data generally indicate, however, reasonably uniform distribution of calcium chloride in rock salt stockpiles wetted with 32 percent, 35 percent, and 38 percent calcium chloride concentrations. With the 42 percent solution, $CaCl_2$ concentrations in upper sections tend to be higher than the average concentration, and in the lower sections lower than the average concentrations, especially at lower temperatures. Table 6 provides data on calcium chloride retained in each of the forty test stockpiles.

In the secondary testing, sand stockpiles at 35°F were wetted with the calcium chloride concentrations. The purpose of this test was the same as Part a of the primary test, that is, to determine the amount of calcium chloride leachate out the bottom of each stockpile over a specified time period. The calcium chloride application rate for sand stockpiles was the same as it was for rock salt: 40.15 lb (100 percent dry weight basis) per ton of sand for each concentration.

Tables 7 and 8 summarizes the relevant results of this test regarding leachate produced. In general, permeation of sand breakthrough occurred much more slowly than with rock salt, as follows:

Percent $CaCl_2$ Solution	*Breakthrough Time*
32	Approximately 30 hr
35	Approximately 50 hr
38	Approximately 72 hr
42	None

The average percent $CaCl_2$ (dry weight basis) in wetted sand compared with that in wetted rock salt is as follows:

Percent $CaCl_2$ Solution	*Percent in Rock Salt*	*Percent in Sand*
32	1.27	1.44
35	1.47	1.50
38	1.67	1.80
42	1.91	1.91

In the first auxiliary test (the dual-temperature test) a rock salt stockpile was injected with 42 percent liquid calcium chloride after the stockpile stabilized at a temperature of 35°F. This temperature was maintained for a 6-day time period. The temperature was then increased to 85°F and held there for a period of 12¼ days. The purpose of this test was to simulate wetting salt stockpiles in cold weather and allowing the material to remain in storage into the summer season.

Leachate breakthroughs occured at times ranging from about 45 to 100 hours after warmup. The end-of-test (12¼ days) leachates averaged 2.03 gal of the 8 gal of 42 percent liquid calcium chloride concentration per ton injected into the rock salt, or 25 percent of the injected quantity.

In the other auxiliary test, the deicing performance of stockpile rock salt wetted with liquid calcium chloride was compared to untreated rock salt by measuring the volumes of ice melted as a function of time and temperature. Rock salt containing 0.5 percent moisture was stored in stockpiles at 40°F. Portions of this salt were wetted with 38 percent and 42 percent liquid calcium chloride solutions. These materials were tested at temperatures of 5°F, 15°F, and 25°F, and at time intervals of 10, 20, 30, 45, and 60 min. The equipment needed was as follows.

Ice-Melting Test

The apparatus used in the ice-melting test consisted of two pieces of Plexiglas TM, one ¼ in. thick, one ½ in. thick, and both 11 in. square. A hole 9 in. in diameter was cut through the ½-in.-thick piece. The two pieces were then glued together under pressure, thereby producing a hole 9 in. in diameter and ½ in. deep. (See another paper by McElroy et al. in this Record, Figure 4.) Ten dishes were constructed in this manner in order to carry out simultaneous testing.

For each test, the dishes were charged with 130 ml of deionized water and placed in a level freezer compartment of a refrigerator overnight. This volume of water corresponded to an ice thickness of ⅛ in. Before each test, it was necessary to

TABLE 6 CALCIUM CHLORIDE RETAINED IN WETTED ROCK SALT: PERCENT OF 100-PERCENT-DRY-WEIGHT-BASIS $CaCl_2$

Percent $CaCl_2$ Solution	Quadrant (4 = top quadrant)	Temperature (°F) 50			45			40			35			30		
		No. 1	No. 2	Avg	No. 1	No. 2	Avg	No. 1	No. 2	Avg	No. 1	No. 2[a]	Avg	No. 1	No. 2[a]	Avg
42	1	1.41	2.19	1.8	1.66	1.69	1.67	0.84	1.35	1.10	0.73		–	1.36		–
	2	2.42	1.65	2.04	1.97	1.81	1.89	1.73	1.90	1.82	1.78		–	1.75		–
	3	1.63	2.02	1.82	1.95	2.26	2.10	1.87	1.85	1.86	1.80		–	1.68		–
	4	2.17	1.77	1.97	2.06	1.87	1.97	3.20	2.52	2.86	3.33		–	2.85		–
	1–4 composite	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
38	1	1.87	1.91	1.89	–[a]	1.87	–	1.62	1.20	1.45	1.32		–	2.49		–
	2	1.94	1.71	1.83	–[a]	1.56	–	1.55	1.80	1.68	1.40		–	1.27		–
	3	1.40	1.36	1.38	–[a]	1.66	–	1.85	1.62	1.73	1.07		–	1.50		–
	4	1.28	1.11	1.20	–[a]	1.57	–	1.60	1.78	1.69	2.68		–	1.34		–
	1–4 composite	1.62	1.53	1.58	1.62	1.66	1.64	1.66	1.62	1.64	1.62	1.61	1.61	1.65	1.63	1.64
35	1	1.18	1.43	1.31	1.08	1.18	1.13	1.29	1.71	1.50	1.33		–	1.87		–
	2	1.82	1.27	1.55	1.08	1.38	1.23	1.30	1.50	1.40	1.56		–	1.17		–
	3	2.54	1.94	2.24	0.92	1.14	1.03	1.26	1.54	1.40	1.03		–	1.42		–
	4	0.86	1.44	1.15	2.24	1.25	1.74	1.35	1.15	1.25	1.67		–	1.49		–
	1–4 composite	1.60	1.52	1.54	1.33	1.24	1.28	1.30	1.47	1.39	1.40	1.55	1.47	1.49	1.43	1.46
32	1	1.28	1.11	1.20	1.15	1.42	1.29	1.35	1.46	1.40	1.23		–	0.61		–
	2	1.39	0.95	1.17	1.42	1.05	1.24	1.46	0.98	1.22	1.40		–	0.99		–
	3	1.05	1.06	1.05	1.14	1.16	1.15	1.19	1.24	1.21	0.89		–	1.49		–
	4	1.20	2.04	1.62	1.26	1.19	1.22	1.20	0.94	1.07	1.16		–	1.57		–
	1–4 composite	1.23	1.29	1.26	1.24	1.20	1.22	1.30	1.16	1.23	1.17	1.37	1.27	1.17	1.31	1.24

[a]Not analyzed.

TABLE 7 LEACHATE VOLUMES IN WETTED SAND AT 35°F

Hours	Percent $CaCl_2$ Solution 32	35	38	42
21	0	0	0	0
44	1.75	0	0	0
68	2.71	1.25	0	0
75	2.89	1.50	0.016	0
92	3.25	1.92	0.033	0
99	3.39	2.11	0.18	0
116	3.65	2.44	0.53	0
121	3.73	2.56	0.64	0

NOTE: Volumes represent gal per ton.

TABLE 8 $CaCl_2$ DISTRIBUTION IN WETTED SAND AT 35°F

	Percent $CaCl_2$ Solution 32	35	38	42
$CaCl_2$ charged, 100 percent dry weight basis, per ton sand (lb)	40.15	40.15	40.15	40.15
Leachate				
Gal per ton	3.73	2.56	0.64	0
Percent $CaCl_2$	25.86	32.33	33.53	–
lb dry weight $CaCl_2$ per ton	10.0	8.82	2.13	–
$CaCl_2$ retained by sand				
lb dry weight per ton	30.15	31.33	38.02	40.15
Percent by weight, dry weight basis	1.44	1.50	1.81	1.91

smooth the ice surface. Therefore, a thick aluminum plate was placed on the ice surface and rotated by hand for several seconds until the surface ice was melted. The dishes were then placed on a level surface inside the testing cold room until melted water was refrozen. The deicers to be used for the day's operation were also placed inside the temperature control box bedore testing and allowed to equilibrate in order to simulate actual winter conditions.

To ensure accurate and consistent test results, a minimum of three runs was recorded for each time period and temperature level, and the average of those results was taken. Test equipment was thoroughly flushed and rinsed with distilled water after each test to avoid contamination.

Melting application rate was 3 oz/yd^2 for dry rock salt and 3.14 oz/yd^2 for stockpile wetted salt. The addition of 0.14 oz/yd^2 represents the amount of calcium chloride associated with the salt. These deicer rates created amounts of brine for each test series that were both measurable and manageable at all test temperatures and within the test time limitations.

To measure the amount of melt after a specified time period, each dish was tipped so that the brine flowed to the perimeter of the dish. Using a syringe and needle, the brine was quickly withdrawn and measured; the amount was recorded and then replaced in the deicer bore holes using the same syringe and needle.

As no $CaCl_2$ leachate was collected in a winter simulation, the 42 percent appears to be the ideal material for wetting stockpile rock salt, based on the test results. Tables 9 and 10 summarize the melting results of tests with plain rock salt androck salt treated with 42 percent liquid calcium chloride at 8.0 gal per ton.

In addition to greater melt volume when dry rock salt is wetted with calcium chloride, the liquid itself assists the salt to remain upon the pavement surface. This retention was demonstrated in a study by the Michigan Department of State Highways and Transportation (*1*) which showed that only 46 percent of dry salt remained in the center third of a 24-ft pavement (location where it was placed) to 73 percent for the wetted material. Total percent lost from this pavement (not retrieved) was 30 percent for dry salt to 4 percent for wetted salt.

A third consideration to evaluate, in addition to retention and melt, is the strong possibility of dry rock salt being blown away with traffic. This consideration has yet to be scientifically measured.

TABLE 9 MELTING RESULTS OF TESTS WITH PLAIN ROCK SALT

		Melt Volume (ml)	
Temperature (°F)	Time (min)	Three-Test Avg	Standard Error
25	10	5.50	0.794
	20	11.53	0.897
	30	16.57	0.940
	45	21.80	0.586
	60	25.77	0.536
15	10	2.13	0.088
	20	5.20	0.058
	30	7.97	0.088
	45	10.37	0.167
	60	12.53	0.088
5	10	0.45	0.050
	20	1.40	0.082
	30	2.45	0.155
	45	3.65	0.296
	60	4.93	0.217

NOTE: Application rate is 3 oz/yd^2.

TABLE 10 MELTING RESULTS OF TESTS WITH STOCKPILE WETTED ROCK SALT

		Melt Volume (ml)	
Temperature (°F)	Time (min)	Three-Test Avg	Standard Error
25	10	6.50	0.361
	20	12.90	0.153
	30	18.30	0.058
	45	22.87	0.348
	60	27.87	0.581
15	10	1.97	0.145
	20	5.90	0.058
	30	8.87	0.088
	45	11.10	0.115
	60	13.67	0.240
5	10	0.48	0.085
	20	1.78	0.075
	30	3.15	0.144
	45	4.63	0.193
	60	5.98	0.165

NOTE: Application rate is 3.14 oz/yd^2.

CONCLUSIONS

Test results of stockpile wetting on rock salt at temperatures 50°F or lower indicate that the preferred wetting parameters consist of injection of 42 percent $CaCl_2$ at a rate of 8 gal per ton. These conditions result in relatively uniform distribution of calcium chloride throughout the stockpile, without generation of leachate from the bottom of stockpiles. At 50°F and lower, wetting with 32 percent, 35 percent, and 38 percent $CaCl_2$ yielded leachates ranging from 7 to 41 percent of the material injected. The quantity of leachates is primarily a function of calcium chloride concentrations.

In actual field conditions, these leachates could present a hazard to the environment. All salt stockpiles, dry or wetted with calcium chloride, should be stored under cover on impervious floors with proper drainage and diking for environmental reasons.

Since about 25 percent of the 42 percent liquid calcium chloride leached out of the test stockpiles when these piles achieved 85°F, environmental precautions should be taken when stockpile wetted salt remains in storage during hot summer months. However, under normal field conditions only the surface material in the rock salt stockpiles would be expected to remain at 85°F. Therefore, the $CaCl_2$ leachate from the warm, outer stockpile layer could be expected to recrystallize as it penetrates the pile.

Results of these deicing performance tests indicated that stockpile wetted rock salt outperformed dry rock salt. In total ice melt, stockpile wetted rock salt significantly outperformed plain salt at all temperatures and almost all time intervals.

REFERENCE

1. *Prewetted Salt Report.* Michigan Department of State Highways and Transportation, June 1, 1975.