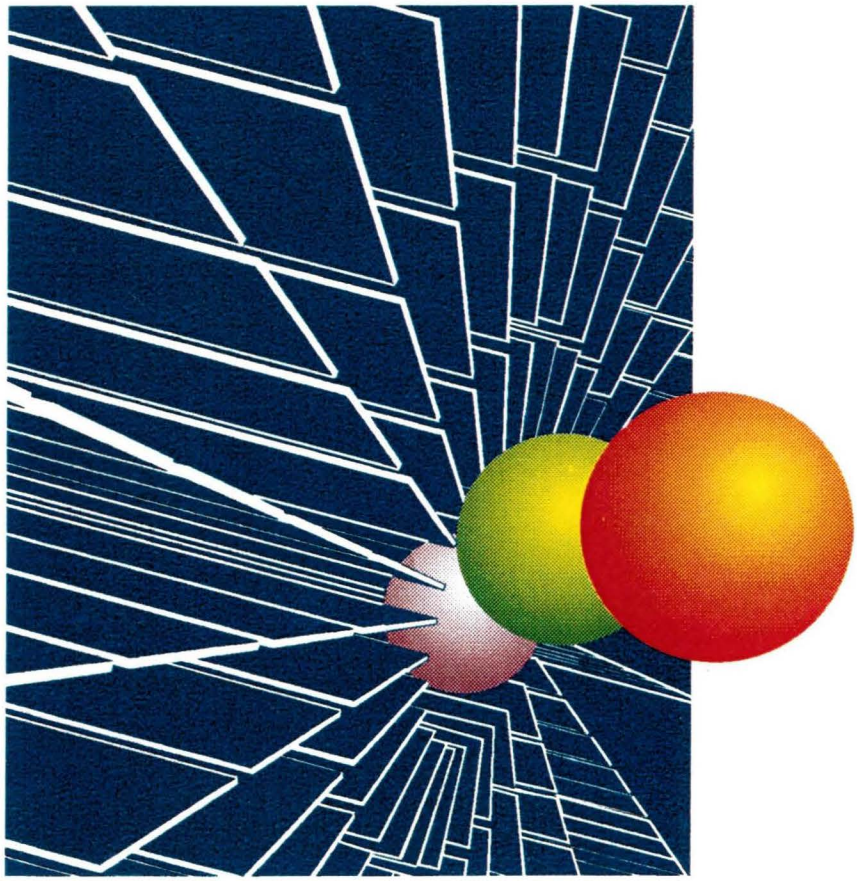
96-008

MoDOT

Research, Development and Technology Division

Salt Brine De-icing Procedures Documentation



October 1996

Overview

Sodium chloride (NaCl) solution, also referred to as salt brine, has been used as a de-icing solution for quite some time, but has only recently started to be utilized in Missouri. First adapted by the Scandinavian countries of Denmark, Sweden, and Norway, this technology drew the attention of the Strategic Highway Research Program (SHRP).

In order to test new technology, the department chose to participate in an anti-icing program initiated by SHRP. District 4 (Kansas City maintenance area) was selected to particiapte in the program which consisted of utilizing salt brine as both a prewetting agent for sodium chloride and as a pretreatment agent to minimize the amount of snow and ice that accumulates on the road surface. Urich, in Henry County, was the first maintenance building in District 4 to produce any salt brine in November 1994. As of the end of the 1995-1996 snow season, 26 of the 34 maintenance buildings in District 4 were using salt brine in place of the calcium chloride that had been used previously. So far, salt brine has proven itself to be both more effective and much cheaper to produce.

Percentage NaCl by Weight	Hydrometer Specific Gravity at 59 F	Freezing Point Fahrenheit
0	1	32
1	1.007	31
2	1.014	30
3	1.021	28.9
4	1.028	27.8
5	1.036	26.7
6	1.043	25.5
7	1.051	24.2
8	1.059	22.9
9	1.067	21.6
10	1.074	20.2
11	1.082	18.8
12	1.089	17.3
13	1.097	15.7
14	1.104	14.1
15	1.112	12.4
16	1.119	10.6
17	1.127	12.93
18	1.135	6.7
19	1.143	4.6
20	1.152	2.4
21	1.159	0
22	1.168	-2.5
23	1.176	-5.2
23.3	1.179	-6
24	1.184	1.4
25	1.193	13.3
26	1.201	27.9
26.3	1.203	32

This table shows the percentage of NaCl by weight compared to the freezing point.

The Recipe

The following items are needed to start production of salt brine.

1) 1, 10' long, 386 gallon cattle tank (preferably plastic, but galvanized is acceptable)
2) 1, 8' long, 252 gallon cattle tank
3) 1, 1800 gallon/hour plastic sump pump
4) rubber hose for sump pump
5) hydrometer with beaker for testing
6) a garden hose for feeding fresh water
7) a five-gallon bucket
8) regular nylon door screen

Key Steps in Making Salt Brine

1) Place the 8' tank over the 10' tank and fill with road salt.
2) Run water into the top tank (this water can also be recycled water, such as stockpile runoff, truck wash water, or storm water from holding ponds).
3) Open top drain and let brine run into bottom tank. Brine will be at its full strength of 26 percent. Continue to add salt into the top tank without letting the tank get less than half full of salt. It will take less than half the salt in the top tank to fill the bottom tank. Both the tank and the concentration should be watched carefully if the brine is immediately pumped from the lower tank into storage tanks since it will be at its full strength and may condense at the bottom.
4) If running only one load, shut off the water and plug the exit drain on the top tank when the bottom tank becomes full. Floats have been added by some maintenance buildings to the bottom tank to shut off the water and close the drains.
5) The concentration of the salt brine should be tested periodically with the hydrometer. If the concentration is more than the optimum 23 percent, add water until the concentration reaches 23 percent. A table showing the percentage of NaCl by weight compared to the freezing point is shown on the left.

Advantages of Salt Brine

The following case example, from the spring 1996 edition of the Missouri Transportation Bulletin, gives a clear picture of the advantages of salt brine.

"Two maintenance sub-areas, Warrensburg and Knob Noster, in Johnson County maintain 271 miles of roadway. On Jan. 18 freezing rain began at 1 a.m. The rain turned to sleet about 4 a.m., and turned to snow about 7 a.m. and continued throughout the day. The wind ranged from 30 mph with gusts up to 50 mph. Plowing continued throughout the day.

"By 7:30 a.m. on Jan. 19, there was approximately 1 1/2 to 2 inches of packed snow and ice on all the roadways. The air temperature was four degrees Fahrenheit and the pavement temperature was six degrees. The sun was shining and the wind calm.

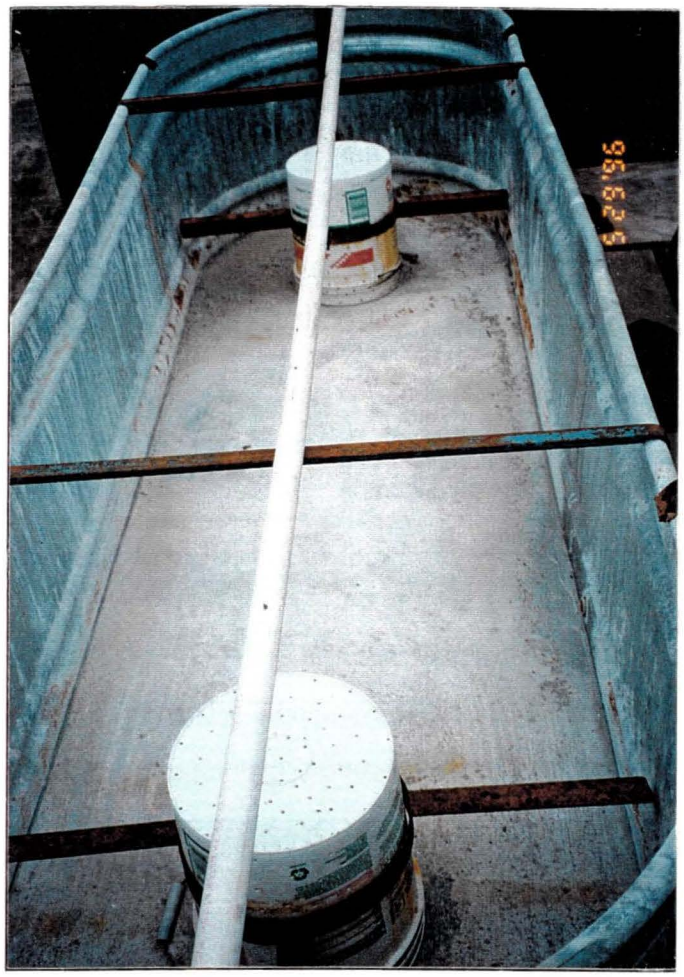
"At 9 a.m., the crews began applying 400 pounds of sand/salt mixture (1:1 ratio) per lane mile with eight gallons of salt brine per cubic yard as a prewetting agent. At 11 a.m., an application of 200 pounds per lane mile with eight gallons of salt brine was made. At 1 p.m., another application was made identical to 11 a.m. Immediately after this application, salt brine was applied from a gravity feed tank at 25 gallons per lane mile.

"The packed snow began turning gray and at 3 p.m. operators were able to plow the roadway 95 percent clean. Subsequently, the night crews were not required to report, while surrounding maintenance areas worked through the night and into the next day. The sub-areas used a total of 100 tons of chemicals for the storm."

Using the salt brine in this instance saved a considerable amount of money in labor and material costs.

What's Being Done in District 4

District 4 uses salt brine extensively in its snow removal process in all of its maintenance buildings including Odessa, Stadium, Holmes Park, and Warrensburg. According to former maintenance engineer Ivan Corp, although there was some initial reluctance and skepticism among maintenance personnel about using salt brine instead of the calcium chloride solution used in the past, the people who felt this way are now some of the most ardent proponents of using salt brine.



This is a view of the top tank used at the District 4 Odessa maintenance building in Lafayette County. The buckets are fixed in place and the PVC pipe is attached to the garden hose to allow even distribution of spraying water.

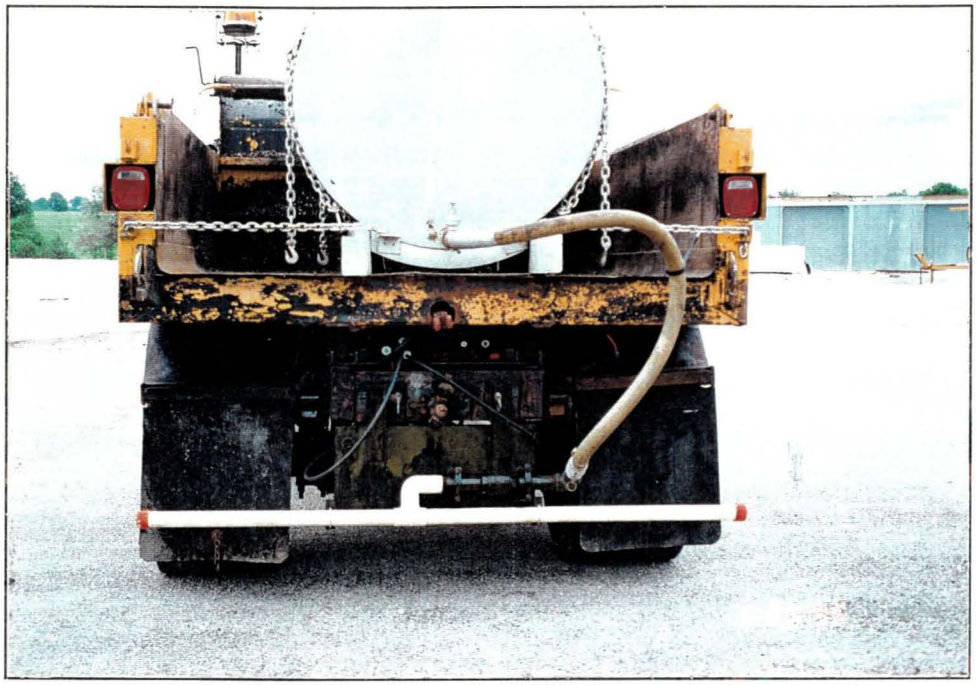
The maintenance building in Odessa has closely followed the outline for salt brine production, but has made a refinement to the process to better suit their needs. In an effort to keep large salt particles out of the final product, holes were drilled in a five-gallon bucket and placed over the drain, insuring a higher quality product.

The Stadium maintenance building in eastern Kansas City has adapted a herbicide sprayer for applying the salt brine as a pre-treatment agent. In doing so, it has made use of existing equipment and has reduced the number of times the sprayer needs to be removed from the truck.

The Holmes Park maintenance building has been able to prove that using salt brine also saves on material costs. This building ordered and applied over a thousand tons of salt for each of the two snow seasons from July 1, 1993 to June 30, 1995. However, for the 1995-1996 snow season, which was heavier than the previous season, even though a little more than a thousand tons were ordered, 650 tons to 700 tons of this material remains.

According to Corp, the maintenance building at Warrensburg is the leader in District 4 in terms

of amount of equipment and production capability. One of their trucks contains a 560 gallon tank with a gravity feed sprayer for applying the salt brine to the road to prevent snow and ice from freezing. The spray bar is a 2 inch diameter PVC pipe with 1/4 inch holes on 12 inch centers. This set-up is attached to a steel plate connected to the trailer hitch of the truck, so removal is relatively easy. The current 560-gallon tank is good for application on 20 miles of road. This truck will be upgraded to have a 1,000-gallon tank this winter. This building's salt brine production apparatus is portable—a hot-mix roller, minus its drum, was salvaged for this purpose. The original intent was to share production capabilities with surrounding buildings, but the demand experienced did not allow for doing so. The production capability of this set-up is 700 to 800 gallons per hour.



Pictured above is the pre-treatment sprayer located at the Warrensburg maintenance building in Johnson County in District 4. The sprayer has been attached to the trailor hitch for easy removal.

This is the portable salt brine production system at Warrensburg. It was a hot-mix roller salvaged for salt brine production. The demand Warrensburg experienced didn't allow them to share production capabilities with surrounding buildings as planned.

Other Districts, States and Studies

District 4 is not the only district using salt brine. Districts 2, 5, and 8 have used it, but not to the same extent. District 6 is also starting to convert to salt brine. Wayne Russell, a maintenance area supervisor based in the Festus maintenance building, says he is quite satisfied with salt brine. He has four buildings in his jurisdiction, two of which used sodium chloride exclusively this past winter with the other two continuing to utilize calcium chloride. Russell says the roads maintained with salt brine dried completely, while the roads using calcium chloride remained wet. Also, as an experiment, Russell prewetted a dead-end road along I-55 with salt brine. He did this at 11 a.m. with an air temperature of zero degrees Fahrenheit. By 4:30 p.m. that day, he says that the road was completely clear. Russell says he has realized a lot of savings on labor costs using salt brine.

Joe Kussman, currently the maintenance area supervisor at St. Clair in District 6, also used salt brine while working in the Eureka sub-area last season. He feels that the effectiveness of sodium chloride is comparable to that of calcium chloride, however the savings realized using liquid sodium chloride was significant. Typically, he uses approximately 20,000 gallons (ordering two 10,000-gallon tanks filled) of calcium chloride per snow season. For this past season, however, he used only a portion of one tank. Mr. Kussman said he also realized a slight savings in labor from having to cover some routes only once.

States

The **Minnesota Department of Transportation** has been using salt brine for prewetting on a widespread basis since the 1993-94 snow season. Their position is to use salt brine as the most common prewetting agent, however, due to colder temperatures there that render salt brine ineffective, they will continue the use of magnesium chloride and calcium chloride as needed. MinnDot has leaned toward the use of electrical systems for application, due primarily to the lower costs, as well as its promoting a higher quality product by having consistent flow of the prewetting agent, better mixing capabilities, and allowing of other attachments. The goal with application equipment is to have simple systems that can withstand harsh on-the-road conditions.

The **Oregon Department of Transportation** has been using salt brine for quite some time. An article in the March 1996 issue of the newsletter published by the FHWA, called *Focus*, discusses the equipment that Oregon uses. Oregon DOT has tried to avoid having bronze valves and nozzles in the herbicide sprayers it utilizes for salt brine application, as the salt reacts with the bronze to create premature corrosion. Plastic has been found to work better. The article in *Focus* also points out that salt brine can weigh as much as 11 pounds per gallon, whereas regular water weighs slightly over 8 pounds per gallon. This should be kept in mind when filling the tanks on trucks in an effort to prevent overloading.

Studies

In an article presented at the 1996 Semisesquicentennial Transportation Conference Proceedings titled "Prewetting with Salt Brine", authors Thomas J. Donahey and Dennis Burkheimer give Iowa DOT's position on the use of salt brine. After having used salt brine for several seasons, they say that Iowa is "willing to bet on prewetting with salt brine as the method of our future." In comparing sodium chloride with calcium chloride, which is what Missouri has traditionally used, they state that calcium chloride "is capable of melting snow and ice at a faster rate than dry sodium chloride (but) because of the higher cost of calcium chloride and the residue that is left on the pavement, it has not been considered for mass use in Iowa for several years."

This same article highlights studies conducted in Germany and Finland in the late 1960's and early 1970's where salt brine was used to prewet the salt and cinders. In the study conducted in Germany, the amount of material left on the road after the passage of one hundred vehicles was measured. For the test site in which the material had been prewetted with salt brine, nearly 30 percent of the material stayed in place whereas only 5 percent of the dry material stayed in place.

Conclusions

Currently, 26 of the 34 maintenance buildings in District 4 have salt brine making capabilities. For the 1996-1997 snow season, all of the buildings in District 4 will have this ability. District 4 will be using salt brine exclusively for the coming snow season. Some of the other districts have used salt brine on occasion or are just getting started, but due to the success of District 4, it is the desire of the department that every district convert to using salt brine within the next two years. This will allow time for any stored supply of calcium chloride to be depleted, and for all necessary equipment to be purchased.

There are many advantages of using salt brine. One overpowering advantage that salt brine has over the previously used calcium chloride is cost. The department cost to buy calcium chloride is between 30 to 40 cents per gallon, whereas it is costing approximately 3 to 4 cents per gallon to make the salt brine. Salt brine is also much less corrosive to concrete than calcium chloride, according to an article titled "Concrete Deterioration by De-icing Salts: An Experimental Study" by Robert D. Cody, that was presented at the 1996 Semisesquicentennial Transportation Conference Proceedings. This is a savings realized by the public in roads and bridges that do not deteriorate as fast and vehicles that do not begin to rust as quickly.

By recommending implementation of salt brine usage, the department is not advocating that it be used exclusively in de-icing activities. There has been positive success using salt brine down to zero degrees Fahrenheit, but for temperatures below 15 degrees Fahrenheit, sodium chloride is not recommended for use. The SHRP anti-icing study recommends the suspension of sodium chloride, which includes salt brine, when the pavement temperature falls below 15 degrees Fahrenheit because its effectiveness diminishes substantially. The department wants to emphasize the need to be proactive instead of reactive during the winter season.

As salt brine usage increases throughout the state, expectations, successful experiences, and any additional improvements concerning production and delivery are eagerly anticipated. The Research Development and Technology Division will continue to document the history and the accompanying new procedures developed and implemented. This is just the tip of the iceberg.