Abridgment

Portable Hydrodynamic Brine Roadway Deicer System

MARK A. PICKETT AND JOHN F. CARNEY III

The portable roadway deicing system presented in this paper sprays a saturated liquid brine solution under high pressure onto the roadway. Because the sodium chloride is already in solution, it begins to melt the ice as soon as it contacts the roadway. Since the solution has a larger surface area in contact with the ice than the sodium chloride grain, the melting action is quicker and more uniform. The solution is applied at a constant flow rate, and the precise amount of sodium chloride applied per lane-mile of roadway can be determined and controlled. The Connecticut Department of Transportation uses 50-80 percent less sodium chloride per lane-mile with this system as compared with conventional methods. The hydrodynamic system presented here is designed so that it can be removed easily from the truck, which allows the vehicle to be used for other duties.

In the early 1970s the Connecticut Department of Transportation became aware of the need for an alternative method for deicing the state's roadways. The conventional deicing method consisted of spreading solid sodium chloride on the road by means of a spreader located on top of a dump truck. This system had several drawbacks. Large amounts of solid sodium chloride were being applied--approximately 700 lb/2 lane-miles. In the solid state, sodium chloride has no direct melting action and, if the moisture content of the air is low (below 70 percent), the sodium chloride remains inert. The melting action of sodium chloride only occurs after the solid grains have formed a solution by taking moisture from the air or from the road (1-3). In addition, in the solid state, sodium chloride often cakes up in the spreader. This either disrupts or entirely stops the flow of sodium chloride onto the roadway. Thus, it is difficult to determine or control precisely how much sodium chloride is spread per lane-mile.

These drawbacks prompted the Connecticut Department of Transportation to investigate the possibility of spreading sodium chloride on the roadway as a liquid brine solution rather than as a solid. Because the brine solution is an active deicer, it would eliminate the possibility that the melting process would require a long time to initiate because of insufficient moisture in the air or on the road. The brine solution would also cause a more even melting of the ice. Also, because the brine solution would have a large surface area in contact with the ice, the melting action would occur faster than with the use of solid sodium chloride.

In the liquid state, sodium chloride forms a fully saturated solution when mixed in the ratio of 2.60-2.64 lb sodium chloride/gal water. When this brine solution is sprayed on the roadway, the precise amount of sodium chloride applied per lane-mile can be determined and controlled. Another advantage of spraying a brine solution rather than spreading solid sodium chloride is that the force of the spray striking the ice pack will erode away some of the ice pack.

PROTOTYPE SYSTEM

In the summer of 1976, a brine deicer system was built by the Connecticut Department of Transportation that had a three-way brine-control valve located in the truck cab and nozzles located on a spray bar between the front and rear truck tires (4). The nozzles were positioned at an angle of about 5° (0.10 rad) from the horizontal so that the velocity of the truck as it moved forward could combine with the velocity of the pressurized brine solution (300 lb•f/in²) to cause significant erosion of the ice pack.

In this system, the precise amount of sodium chloride applied per lane-mile was easily controlled. It was found to work effectively when applying only 400 lb of sodium chloride/2 lane-miles. The system included a 1500-gal fiberglass tank; however, because the unit was permanently mounted to the chassis of the truck, it was out of commission when the truck had any mechanical problems, and the truck could not be employed for other maintenance operations in three out of four seasons of the year.

PORTABLE SYSTEM

During 1978-1980, under a contract with the Connecticut Department of Transportation, the civil engineering department of the University of Connecticut designed and constructed six portable systems. The system can be placed in the bed of a dump truck and can be removed from one truck and placed on another truck in about 10 min by one person. This can be done anywhere, even along the side of the road; no special tools are required. Only one temporary and two permanent modifications to the dump truck are necessary. Two quick disconnects are installed--one for the electrical line that allows a switch in the cab to operate the brine three-way control valve and another for the pressure line that operates the pressure gage located in the cab. As a temporary modification, the tailgate is removed.

Four of these portable systems are being employed by the Connecticut Department of Transportation and individual units were delivered to the Utah and the Minnesota Departments of Transportation. The portable deicer system is shown in Figures 1 and 2.

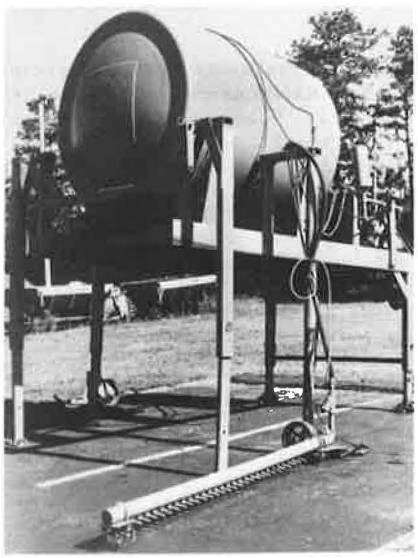
Attachment and Removal of Portable System

The driver attaches the systems as follows:

1. The truck bed is partly raised and the truck is backed under the free-standing system.
2. When the truck is completely under the system, the bed is raised higher, which lifts the front supports off the ground. The telescoping front supports are then retracted and pinned.
3. The bed is completely lowered; this raises the rear support feet off the ground. The telescoping rear supports are then retracted and pinned.
4. The spray bar is then swung underneath the truck and pinned on the right side.
5. The dump system hydraulic line is disconnected and the quick disconnect for the brine system is connected in its place. Now the lever in the cab for raising and lowering the dump body will control the spray bar. The spray bar will lower under its own weight.
6. The electrical quick disconnect for the brine three-way control valve is then connected.
7. The quick disconnect for the cab brine system pressure gage is then connected.
8. The entire system is then fastened to the truck by means of pins and padeyes.

Figure 1. Portable system in operation.

Figure 2. Free-standing, left-side front view of portable system.



The procedure for removing the system is similar.

Brine-Making Facilities

Connecticut is divided into four districts, and each district is equipped with a facility for making and storing brine. The stationary brine-making facilities consist of a 5000-gal brine storage tank and a 375-gal dissolver tank. The dissolver tank is first filled with solid sodium chloride. Then fresh water enters the dissolver tank via a circular diffuser bar located at the bottom of the tank. The fresh water is supplied from the town water system at water-main pressure. As the water rises through the solid sodium chloride in the dissolver tank, the concentration of sodium chloride in solution increases. When the solution level reaches the top of the dissolver tank, the concentration is 100 percent. The solution then enters an effluent pipe via holes in the pipe. The solution then flows by gravity to the storage tank. A sampling valve in the effluent line allows the monitoring of solution concentration. The dissolver tank needs to be filled with solid sodium chloride about every four or five hours. Brine solution is produced at the rate of 10 gal/min.

Field Experience With the Deicer System

Tables 1 and 2 summarize the results for the winters of 1976-1977 and 1977-1978 (3). No data were taken for the winter of 1978-1979, and the winter of 1979-1980 was too mild in Connecticut to generate meaningful data. All of the data presented in Tables 1 and 2 were obtained from a section of roadway located on I-84 from CT-229 in Southington to CT-70 in Cheshire. Brine solution was applied to the westbound lanes, which included a long continuous grade that rises 320 ft over a distance of 1.8 miles. The entire test section encompassed approximately 15.9 lane-miles, including the lane for truck climbing. Solid sodium chloride was applied to the eastbound (downhill) lanes.

In storm no. 11A of 1977-1978, two applications of brine solution were made on dry, dense, thin pack. After each application, the pack was converted to a light slush. A 96.5 percent saturated solution was used. Ambient temperature at the time of brine application was 22°F.

Storm no. 18 was a lengthy blizzard that occurred on February 6 and 7. On February 8, after approximately 48 h of snowplowing, an extremely tight, dense 0.25-in-thick pack remained on the roadway. This was removed with one brine application. Ambient temperature was 21°F. Maintenance personnel at the test site stated that immediately after application of the brine, either bare pavement resulted or the pack was loosened sufficiently to permit removal by plowing.

On two occasions during storm no. 21 the test section was covered with a thin, extremely slippery

Table 1. Summary of test results for two winters.

Winter	Storm No.	Precipitation Total (in)	Precipitation Type	Roadway Cover	Brine Applied (gal)	Results
1976-1977	10	3	Snow	Mealy snow, thin pack	2250	Pavement wet, pack broken
	11	1	Snow	Thin pack	1350	Pavement wet with slush
	14	8.8	Snow	Mealy snow	2250[a]	Pavement wet and clean
	23	0	Snow	Ice	750[b]	Ice removed on contact
1977-1978	11A	0.4	Snow	Thin pack	2250	Pavement wet with slush
	18	18	Snow	0.25-in pack	3700[c]	Pack loosened
	21	6	Snow	Thin pack	800[d]	Wet

[a]85 percent brine solution.
[b]65 percent brine solution.
[c]Deicers used only for clean-up operations.
[d]90 percent brine solution.

Table 2. Comparison of crystalline salt used for two winters.

Winter	Storm No.	Salt Applied as a Solid (ton/lane-mile)	Salt Used to Make Brine (ton/lane-mile)
1976-1977	10	0.89	0.19
	11	0.73	0.11
	14	0.89	0.16
	23		0.12
1977-1978	11A	0.61	0.21
	18	1.19	0.35
	21	0.98	0.17

ice pack. The brine solution completely removed the pack. Ambient temperature was 24°F.

During the winter of 1977-1978, a severe icing condition occurred on a steel open-grid-deck bridge. Maintenance personnel spent two hours in an attempt to remove the ice with conventional methods. But, after one application of a 90 percent saturated brine solution, the bridge was bare of ice, except for a few isolated spots. This remaining ice had been weakened sufficiently to allow removal by traffic.

Field experience has demonstrated that compacted snow and ice covers of 0.25 in or less in thickness are broken up by the pressurized brine solution and are easily removed by plowing. The mechanical action of the brine under pressure is insufficient to loosen the entire snow and ice pack if its thickness exceeds 0.25 in, but the brine solution will penetrate into the pack and will chemically destroy the bond between the pack and the pavement. The mechanical action of passing car tires will then break up the pack.

CONCLUSIONS

The brine roadway deicer system has operated satisfactorily in Connecticut for three winters. The high-pressure spray combined with the brine's deicing characteristics is capable of destroying packed snow and ice. During most storms, sufficient melting action occurred to cause splash up by the traffic within minutes of application of the solution. The portability of the system has proven itself during the limited operations of the winters of 1979-1980 and 1980-1981. The lowest ambient temperature at which the brine solution was used successfully in Connecticut was 20°F, although it is believed that the sodium chloride solution can be used successfully at 15°F.

ACKNOWLEDGMENT

This work was accomplished in cooperation with the Connecticut Department of Transportation and the Federal Highway Administration. The contents of this report reflect our views, and we are responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the official views or policies of the state or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

REFERENCES

1. G.E. Scotto. Liquid Treatments of Commercial $CaCl_2$ in Winter Road Maintenance. In Snow Removal and Ice Control Research, HRB, Special Rept. 115, 1970, pp. 156-171.
2. J.O. Kyser. Brine Solution Removes Stubborn Ice. Public Works, Jan. 1971.
3. M.M. Kasinskas. Evaluation of the Use of Salt Brine for Deicing Purposes; Report 3. Connecticut Department of Transportation, Wethersfield, April 1978.
4. M.M. Kasinskas. Evaluation of the Use of Salt Brine for Deicing Purposes. In Snow Removal and Ice Control Research, TRB, Special Rept. 185, 1979, pp. 275-281.

Publication of this paper sponsored by Committee on Winter Maintenance.

Crash Testing of A Portable Energy-Absorbing System for Highway Service Vehicles

JOHN F. CARNEY III

This paper is concerned with the testing of a new portable energy-absorbing system to be attached to the rear of a highway service vehicle. The research objective was to design a system to provide protection for both the motoring public and the service personnel engaged in maintenance operations on our highways. Its implementation during highway line-striping operations, which are conducted on almost a daily basis, would be of particular value. The energy-absorbing components of the system are four steel pipes connected in a series and cantilevered from the rear of the service vehicle. Full-scale crash tests were conducted to evaluate the performance of the system with respect to (a) structural adequacy, (b) impact severity, and (c) vehicle trajectory. The results of this testing program demonstrate that this energy-absorbing system provides protection during a collision for both the errant motorist and the state personnel working in the service vehicle. The unit is relatively light, inexpensive to construct and repair, and is compactly designed for use on curved and hilly roads.

In many highway-maintenance operations, personnel and equipment are inadequately protected from collision by an errant vehicle. To provide this needed protection, several portable energy-absorbing systems have been designed. One such unit employs hidro cell components (1,2) attached to the rear of a follower truck in maintenance operations. Another system employs modular crash cushion elements (3), which are 208-2 L (55-gal) drums. This system has been used in the states of Washington and Texas and consists of a trailer that carries 30 crushable barrels (10 rows of 3 barrels).

A modified version of this modular crash cushion has been developed by the highway wayside equipment