

FINAL REPORT
A SURVEY OF ANTI-ICING PRACTICE IN VIRGINIA

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(The opinions, findings, and conclusions expressed in
this report are those of the author and not necessarily
those of the sponsoring agencies)

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ABSTRACT

This study documents the current Virginia Department of Transportation's anti-icing practice so that development of a coordinated statewide plan for implementing anti-icing technology can be considered. The researcher surveyed VDOT managers to determine who is using anti-icing technology. Based upon the results of the initial survey, the researcher conducted follow-up interviews. This report uses anecdotal survey information to assess the effectiveness of various anti-icing techniques used within VDOT. The report concludes that where anti-icing practice has been implemented on a widespread basis, the results validate the findings of the Federal Highway Administration (FHWA) Study TE 28 and the anti-icing experiences of other states.

The report recommends that anti-icing practices for snow removal and ice control be implemented statewide for roads with a bare pavement policy. Initial implementation should focus on pre-wetting technology and the timely distribution of weather information to the area headquarters level. Pilot testing of direct liquid application technology should continue. Anti-icing practices that reduce chemical usage and the cost of snow removal and ice control while maintaining or improving level of service should also be evaluated. Finally, an anti-icing training program should be developed and taught statewide at the area headquarters level to facilitate implementation, improve current application and to transfer this state-of-the-art technology to the private sector.

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INTRODUCTION

Anti-icing as a part of highway snow removal and ice control in the United States is relatively new. It dates from the Strategic Highway Research Program (SHRP) investigation of several snow and ice control innovations and products in the early 1990s.¹ The Federal Highway Administration used the SHRP study to structure Test and Evaluation Project No. 28 (TE 28), “Anti-icing Technology” in 1995. The FHWA examined and tested various anti-icing strategies such as Road Weather Information Systems (RWIS), innovative materials, materials application systems and plowing systems.²⁻³ These studies showed that when deployed correctly, anti-icing operations can be considerably more effective and efficient than conventional snow removal and ice control techniques (de-icing). The TE 28 study produced a manual of practice that describes five anti-icing chemicals and how best to apply them under various weather conditions. The manual also describes the benefits, drawbacks and costs of each, and offers the most complete guide to anti-icing available.

Anti-icing is primarily *preventive*, in that it uses the early application of freezing-point depressants to prevent snow from bonding to pavement. De-icing, in contrast, is a primarily *reactive* strategy, focusing on snow and ice removal after bonding has occurred.³ Because chemical freezing point depressants have to be applied very early in a storm event, anti-icing technology is limited to highways assigned a high level of service (LOS). In Virginia, these highways are classified as bare pavement routes. On other roads VDOT uses de-icing, waiting until snow has accumulated before beginning snow removal operations. Appendix A discusses anti-icing in detail.

The Virginia Department of Transportation (VDOT) is implementing an anti-icing program in a piecemeal fashion. VDOT is currently developing a statewide RWIS along the lines recommended by SHRP. Individual residencies and districts are also trying selected anti-icing products and practices. Some locations have installed pre-wetting devices and liquefied chemical spreading devices on VDOT snow and ice control equipment. Others have tried products other than sodium chloride (salt) and calcium chloride, the two predominant chemicals used for snow removal and ice control by VDOT.

PURPOSE AND SCOPE

To date, VDOT has not adopted a statewide, coordinated anti-icing program. Before such a program can be instituted, a survey of the status of implementation of anti-icing technology within VDOT is needed. This report documents the locations, types and extent of anti-icing practice within VDOT as of 1996-1997 winter season. Because Virginia's current approach to anti-icing has been informal rather than systematic, only anecdotal evidence regarding the results of this anti-icing practice exists. This report bases its conclusions on that evidence alone.

Real-time atmospheric and road weather information is a major tool in anti-icing because the timing of the technology's application is so critical to its success. This report documents the weather information available to operating units and the extent to which they use it while conducting anti-icing activities.

METHODS

The researcher conducted an initial survey of VDOT to determine the type and extent of anti-icing technology currently in use. Those surveyed included a total of 52 separate maintenance units. All 45 residency offices, the units that maintain the Northern Virginia Interstate highways, The Dulles Toll Road, the Powhite Parkway, and four toll facilities in the Suffolk District were surveyed. For purposes of this report, these units are designated as "organizational units." Sub-units of the organizational units are designated as "area headquarters." The survey and its results are provided in the next section (in Table 1).

Based upon the results of the initial survey, the researcher conducted follow-up telephone interviews with managers in each organizational unit that indicated they used anti-icing. In addition, the researcher contacted the managers of those organizational units not using anti-icing if an area headquarters in the organizational unit had direct access to a weather forecasting service. This survey documented the type and extent of anti-icing practice, and any experience with using weather information systems in the management of snow removal and ice control. Appendix B contains the telephone survey form.

RESULTS

Survey Findings

Fifty-two organizational units within VDOT were initially surveyed. Aggregate answers to the survey questions are presented in Table 1. Where feasible the answers are presented in the same format as the survey form. All answers are the number of organizational units, except those designated "number" in question 4. Those answers pertain to the number of chemical delivery units.

Table 1. VDOT Organizational Unit Anti-Icing Survey and Response

SURVEY OF ANTI-ICING ACTIVITY WITHIN VDOT			
1.	Are you using anti-icing technology?	<u>10</u> Yes	<u>37</u> No <u>5</u> Don't know
2.	Are you using any of the following anti-icing technology? (Yes answers)		
	<u>0</u> Pre-wetting of flake chemical - in the stockpile		
	<u>0</u> Pre-wetting of flake chemical - in the spreader		
	<u>9</u> Pre-wetting of flake chemical - at the point of discharge		
	<u>4</u> Liquid application directly on the pavement		
3.	What chemicals you are using? In what form?		
	Salt (NaCl):	<u>50</u> Flake	<u>0</u> Liquid
	Calcium (CaCl):	<u>25</u> Flake	<u>8</u> Liquid
	Magnesium Chloride (MgCl):	<u>0</u> Flake	<u>5</u> Liquid
	Calcium Magnesium Acetate (CMA):	<u>0</u> Flake	<u>0</u> Liquid
	Potassium Acetate (KAc):	<u>0</u> Flake	<u>0</u> Liquid
4.	Do you have any of the following types of equipment? (Yes answers) How many?		
	<u>10</u> Saddle tanks for liquid to apply to flake chemical	Number	<u>429</u>
	<u>1</u> Overhead spray bar for pre-wetting load	Number	<u>2</u>
	<u>8</u> Liquid storage tanks	Number	<u>31</u>
	<u>5</u> Liquid spreaders	Number	<u>7</u>
	<u>3</u> Unusual plowing equipment.		
5.	Do you have access to the following weather information systems. At what level?		
	Scancast	<u>31</u> At residency office	<u>4</u> At AHQ
	Weather Channel (Cable)	<u>22</u> At residency office	<u>4</u> At AHQ
	DTN	<u>26</u> At residency office	<u>3</u> At AHQ
	Other special weather information service:	<u>12</u> At residency office	
	None of the above:	<u>12</u> At residency office	<u>44</u> At AHQ
1.	Do you have an unusual technique, chemical, piece of equipment or other snow-related item that you feel could improve snow removal and ice control, and has not been covered above.	<u>5</u> Yes	<u>47</u> No
2.	Are you aware of the FHWA's "Manual of Practice for an Effective Anti-icing Program" published in June 1996?	<u>30</u> Yes	<u>22</u> No

A total of nine organizational units use anti-icing practices. Information concerning the organizational units, type and extent of practice is shown in Table 2.

Table 2. Organizational Units Using Anti-icing Technology

Organizational Unit*	Pre-wet At Spinner	Direct Liquid	Trucks with Saddle Tanks	Direct Liquid Spreaders	CaCl ₂	MgCl ₂	Other	Notes
Fairfax	X	X	237	1	X			
Leesburg	X		54			X		
Manassas	X	X	62	2	X	X		
NoVa Interstate	X	X	102	1	X	X		
Fredericksburg	X	X	38	1	X			
Warrenton	X		44		X			
Sandston	X		2		X		X	CG-90
Hillsville	X		1		X			
Salem	X		2		X			

* Amherst and Halifax have equipment on order for pre-wetting at the spreader discharge point, but the equipment has not yet been delivered. The Northern Virginia Interstate Unit maintains the Dulles Toll Road.

Anti-icing Practice

Organizational units engaged in some form of anti-icing practice or using an unusual chemical fall into one of two groups. Those in the first group, located in the Northern Virginia District, and the Warrenton and Fredericksburg Residencies, practice large-scale anti-icing. Those at the pilot testing level, the Sandston, Salem and Hillsville Residencies comprise the second group. Both groups' experiences are reported below. Information on the large-scale operations is divided into two categories: pre-wetting and direct liquid application.

Pre-wetting

Seventeen managers at the area headquarters level reported that they have used pre-wetted salt for the past 3-5 years to prevent ice formation on certain roads. They use either solid salt or a 2:1 mixture of salt and sand sprayed with a calcium chloride or magnesium chloride solution as it is discharged from a spreader. The application rate for salt alone usually is 127 kg/lane km (450 lb./lane mile). The application rate for the mix of salt and sand could range up to 190 kg/km (675 lb./lane mile). Managers were less certain about the application rate for the pre-wetting agent. They explained that most pre-wetting units are set prior to delivery and cannot be easily adjusted in the field. In almost all cases the application rate for the solid material is not adjusted when a pre-wetting agent was used.

All 17 started with a few pre-wetting units the first year, and dramatically increased the number used the following year. Most employ pre-wetting in snowstorms when the temperature is between -10°C and 0° C (15°F and 32°F). Some indicated they use pre-wetting only when the temperature is below -4°C (25°F) and one indicated that he uses it only on cold spots and at higher elevations. Pre-wetting is usually not used when a wet snow is falling and the temperatures are near 0°C (32°F).

The 17 managers generally found that pre-wetted salt goes into solution faster, the brine formed is more evenly distributed on the pavement, and the effect lasts longer than when untreated solid chemical is used under the same conditions. Most indicated that pre-wetted salt could be applied earlier in the storm than untreated salt. The addition of moisture to the solid salt also reduces the bounce of the material as it hits the pavement. They reported that pre-wetted salt could always be placed when a light skim of snow existed on the pavement without fear that it would be blown off by traffic. Pretreatment, the application of chemical to the pavement prior to the onset of precipitation, has been used in a few instances with good results. The product used in all cases was pre-wetted salt. The superintendents report that pretreatment creates a bond breaker that allows snow to be plowed off the road more easily later. In most cases the pretreatment occurred at locations where traffic was light at the time of application and the speed of traffic was 56 km/hr (35 mph) or less.

Many field managers reported that pre-wetting also has its drawbacks. The liquid pre-wetting agent accelerates corrosion of spreaders, engines and wiring. Saddle tank filters on the spreader units often clog and require cleaning. More intensive cleaning of the equipment after storms, including the lubrication of moving parts, is necessary to reduce the rate of corrosion. Managers in five organizational units reported that liquid magnesium chloride appears to be less corrosive than calcium chloride and produces the same benefits, although the cost per liter is higher. Small quantities of solid calcium chloride have been used in past years as an additive to abrasives to keep them from freezing. All the field managers indicated that liquid calcium chloride is easier to use and store than solid CaCl.

Most managers noted no accelerated deterioration to the roadway infrastructure due to the use of pre-wetted salt, with two exceptions. Two superintendents indicated that use of pre-wetted salt on surface-treated roads, such as those found in subdivisions, appeared to accelerate deterioration of the pavement. One superintendent noted an increase in pitting of concrete medians. In all three cases, the deterioration occurred on streets that had not been previously treated with pre-wetted salt, or where there was an increase in overall chemical use (since the rate of application of solid chemical was not reduced to offset the chloride ions added by the liquid spray).

Direct Application of Liquid

Direct application of liquid calcium chloride or magnesium chloride has been tried at five area headquarters. Experiences at three area headquarters are typical of the results achieved:

1. *Dumphries Headquarters (Manassas Residency)*. For the past three winters, the Dumphries headquarters (Manassas Residency) has used two 3785-liter (1000-gallon) slip-in liquid spreader units to spray liquid magnesium chloride directly onto Route 1 prior to the start of a storm. This pretreatment was followed by an application of pre-wetted salt as soon as was feasible after precipitation began to fall. The superintendent credited this procedure with keeping the pavement clear during the heavy snowstorms of the winter of 1995-96 while other high priority roads nearby were snow-covered for long periods. He cautioned that the quality and percentage mixture of the liquid magnesium chloride must be monitored carefully when used as a direct liquid application. Impure or improperly diluted liquid magnesium can quickly freeze on roadway surfaces.
2. *Chancellorsville AHQ (Fredericksburg Residency)*. The Chancellorsville AHQ (Fredericksburg Residency) has employed a 3785 liter (1000 gallon), slip-in liquid chemical spreader for approximately five years. Liquid calcium chloride is applied to the pavement on a three-lane section of road at a rate of approximately 47 to 59 liters/lane km (19.6 to 24.5 gallons/lane mile). The superintendent reported the crew typically applied chemicals at the first flake of snow and always earlier than straight solid chemical.
3. *Merrifield area headquarters (Fairfax Residency)*. The Merrifield area headquarters (Fairfax Residency) used one direct liquid spray unit this past winter. Problems calibrating the spray nozzles delayed use of the equipment. Use was limited to two situations where surfaces on steep grades were covered with ice and required emergency response. Temperatures were in the -2°C to -1°C (28°F to 30°F) range. The liquid was applied using gravity feed at a rate estimate to be 78 liters/lane km (33 gallons/lane mile), within in the range suggested by the TE 28 manual of practice.³ In both cases, the application of liquid calcium chloride rapidly cleared the ice after standard procedures had failed.

Pilot Testing

Sandston Residency had two spreaders equipped with pre-wetting units available during the past winter. However, since Sandston did not experience conditions severe enough to use them, the residency gained no experience with the technology.

Salem Residency had two spreaders available this past winter. They were used only once during a storm, at a point when the temperature had dropped to -4°C (25°F). No modification was made to the rate of application for the solid material. A noticeable

increase in the melting action of the salt occurred, and the section where it was used resisted snow accumulation for a longer period of time than adjacent roadways.

In the fall of 1996, Hillsville Residency purchased one pre-wetting unit for use on I-77. The pre-wetting spray unit was used this past winter during all chemical spreading activity, except when the temperature was below -12° C (10°F) or anticipated snowfall was very light. The Hillsville manager was concerned that at low temperatures, the brine formed by the pre-wetting spray would become diluted and freeze. Normal procedure is to spread between 85 to 200 kg/lane km (300 - 700 lb./lane mile) of solid salt. The salt was pre-wet with calcium chloride. The residency did not reduce the amount of salt spread per lane kilometer. The superintendent at Laurel AHQ indicated that they experienced no major problems as a result of using the pre-wetting unit. Performance on the section assigned the pre-wetting unit seemed no better or worse than adjacent maintenance sections.

Unusual Materials

The Sandston Residency has used CG-90, a product made by Cargill Salt, as a replacement for salt on the Varina-Elon Bridge since it opened in 1990. The bridge, a cable-stayed box girder design, crosses the James River on route I-295. The VDOT State Maintenance Engineer directed that CG-90 be used to reduce the rate of corrosion to the support cables and the concrete superstructure.

CG-90 contains 90 percent or more sodium chloride and a proprietary additive (4 - 5%). This additive reportedly reduces corrosion to 10 percent of that caused by untreated salt. CG-90 is applied in dry, granular form by a truck specifically assigned to the bridge. The truck is not equipped with any unusual equipment. The material is applied at a rate of approximately 85 kg/lane km (300 lb./lane mile). Salt is applied to the adjacent approach roadway surfaces at a rate of approximately 170 kg/lane km (600 lb./lane mile). Current costs for materials are \$44/metric ton (\$40/ton) for sodium chloride salt and \$198/metric ton (\$180/ton) for CG-90. CG-90 forms a brine very effectively.

During the heavy snows encountered in 1993 and 1996, the chemical kept the snow accumulating on the bridge in a slushy state. No bond formed between the snow and the bridge surface. On each occasion, a bond formed between the snow and the adjacent approach roadway pavement. Because a truck was specifically assigned to the bridge, it usually received an application of CG-90 earlier in the snow removal operation than did the road, which could account for the better performance. It also appears that the goal of reduced corrosion is being met. Metal joints in the deck and metal doors on the bridge show no signs of corrosion after six years of service.

CG-90 is user-friendly. It has been stored under conditions similar to those used for salt and is still useable after two years in a stockpile, as it does not cake together.

Road Weather Information System Findings

Of the 52 organizational units surveyed, 40 indicated they had access to a professional weather forecasting service at their main office, including all nine of the organizational units involved in anti-icing activity. The researcher interviewed managers at eight of these nine units in order to determine how they used these services. One unit does not use the system.

Seven managers use only the real-time information; none use the forecast feature, SCANCAST™, or the historic records kept by the system. Most organizational units rely on the Weather Channel or the Data Transmission Network (DTN) instead of the RWIS. Those surveyed generally characterized the SSI system as difficult to access. Also, they observed that the forecasts are not updated often enough to be useful.

The DTN system and the Weather Channel were both highly rated. DTN was praised as simple to use and accessible on demand. The forecast and real-time information were described as accurate and clearly stated. The Weather Channel was described in similar terms although information is not as available “on demand.” Neither DTN nor Weather Channel allow managers to talk to a forecaster. DTN has a National Weather Service forecast available, but it is not revised often. The Weather Channel does broadcast a localized forecast every 20 minutes, giving the viewer the impression that it is current. Managers indicated that this access to a localized, professional forecast every 20 minutes on the Weather Channel was an advantage over DTN. DTN, a satellite transmission system, is easily accessible at any location in the state. The Weather Channel is broadcast over cable and requires access to a cable network.

Eight organizational units indicated that access to professional forecasting services was available at some or all of the area headquarters within the organizational unit. Those organizational units with forecasting services available at the area headquarters level are shown in Table 3.

Table 3. Organizational Units with Weather Forecasting Services at the Area Headquarters Level

Organizational Unit	Weather Information System		
	Scancast	DTN	Weather Channel
Fairfax Residency	X		X
Manassas Residency	X		X
NoVa Interstate Area	X	X	
Elizabeth R. Tunnel	X		
Abingdon Residency			X
Salem Residency			X
Warrenton Residency		X	
Verona		X	

The area superintendents all felt that access to DTN or the Weather Channel assisted them in planning and scheduling snow removal operations and tracking the progress of storms. A number indicated that they use the information at other times to plan weather-sensitive operations, and to track severe weather events that may affect work in progress. The following incident illustrates the value of area level access to professional weather information:

A superintendent tracking a snowstorm on DTN noted the forecast and radar transmissions both indicated a six- to eight-hour break in the storm. Temperatures were to be in the mid-30s with no precipitation expected. Based on his access to this information, the superintendent released the hired trucks assigned to his area with instructions to return in six hours. At the time of the decision, the snow removal operation had been under way for 12 hours, the ground and roads were wet, the sky was overcast and humidity was high. Without direct access to the information, the superintendent said he would have retained the hired trucks for the full period. The decision resulted in an \$1,800 savings in hired equipment costs, which more than covered the DTN installation and first year's rental cost.⁴

DISCUSSION

The comments of those within VDOT using anti-icing practices on a widespread basis support Field Evaluation Report TE 28's conclusions, although in the case of conclusion 1, below, the support is implied rather than direct.² Among its findings, TE 28 lists the following:

1. A change to an anti-icing practice from a practice that relies on applications of salt/abrasives mixes for chemical treatments will generally result in both far less chemical use and improved conditions, when the anti-icing techniques have only to support the same level of service.
2. Well-timed initial chemical applications can prevent or mitigate reductions in friction, as well as support the anti-icing objective of preventing a strong bond.
3. Rock salt can be successfully used as the primary chemical treatment in anti-icing operations. Pre-wetting of rock salt can result in improved effectiveness of anti-icing operations.

Results from TE 28 indicate pre-wetting and direct liquid application of chemicals can be used under most conditions where untreated solid salt is now used. This practice can lead to a reduction in the rate of chemical application without degradation in the level of service. In Virginia, the time and conditions under which pre-wetting and direct liquid application, when available, were used varied. In contrast to the TE 28 recommendations, very few locations surveyed indicated they had reduced their solid chemical usage when

pre-wetting was practiced. Where it did occur, there was no indication that it was due to a conscious management-level policy decision. Most managers described *improved* levels of service when pre-wetting was used without changing the amount of solid salt used. This result implies that the *previous* level of service could be achieved, and costs reduced, if the rate of solid chemical application were reduced when pre-wetting is practiced.

Since anti-icing is primarily preventive, it should begin prior to or very early in a storm event. Anti-icing options are dependent on existing and anticipated weather conditions. Decisions on whether or not to initiate a treatment, when to start and what treatment to apply, can be significantly enhanced if accurate and timely weather information is available.³ Survey responses indicate that organizations with direct access to specialized weather information consider it a valuable tool in the decision process, and practice anti-icing with greater confidence.

Improvement in the operational effectiveness of snow removal and ice control can be obtained relatively simply by adding bits and pieces of the anti-icing technology to VDOT's current practice. Among field operations people who have used anti-icing technology extensively, the perception is widespread that it is effective. Obtaining improvements in efficiency and cost-effectiveness is more difficult. The current widespread variation in practice and lack of attention to details emphasize this difficulty. As noted above, the researcher also found that little attention was paid to keeping track of the application rate of liquid to solid chemical in the pre-wetting operation, or to monitoring liquid chemical usage. To achieve the cost and environmental benefits of anti-icing practice, the TE 28 field evaluation report suggests that state agencies adopt guidelines for practice and systematically implement the technology. Additional information from the TE 28 report is contained in Appendix A of this report.

CONCLUSIONS

1. Adoption of anti-icing practice within VDOT has been slow and has been accomplished primarily by word of mouth. There has been very little transfer between organizational units of experiences and knowledge gained.
2. Where anti-icing practice has been implemented within VDOT, the results generally have supported the findings of FHWA Study TE 28 and the anti-icing experiences of other states.
3. Those areas that have invested heavily in anti-icing technology have not yet adopted the full range of anti-icing practice. Information concerning the full range of anti-icing practices has not been distributed to the area headquarters level and knowledge concerning its most effective and efficient use is not widespread.

4. Availability of weather information at the area headquarters level can improve area managers' decision-making when planning for snow removal operations, tracking storms and choosing options (both anti-icing and de-icing) for action.

RECOMMENDATIONS

1. Anti-icing practice for snow removal and ice control should be implemented statewide for roads with a bare pavement policy.
2. Initial implementation should focus on pre-wetting technology and distribution of weather information to the area headquarters level. Procurement of equipment and materials, application methods, and the development of operations guidelines should be emphasized.
3. Pilot testing of the technology of direct liquid application should continue.
4. Pilot testing of anti-icing practices that may reduce chemical usage and the cost of snow removal and ice control while maintaining or improving level of service should be undertaken.
4. A program of training in anti-icing technology and practice should be developed and taught statewide at the area headquarters level, using the information contained in the FHWA Manual of Practice for an Effective Anti-Icing Program.

ACKNOWLEDGMENTS

The researcher thanks the many residency and area headquarters level managers who provided information for this report. Their agreement, to a person, to be candid and forthcoming is much appreciated. Those who step forward to try new technology in the face of the status quo should always be praised and encouraged, and I do so here.

“It is not the critic who counts, not the one who points out how the strong man stumbled or how the doer of deeds might have done them better. The credit belongs to the man who is actually in the arena, whose face is marred with sweat and dust and blood; who strives valiantly; who errs and comes short again and again; who knows the great enthusiasms, the great devotions, and spends himself in a worthy cause; who, if he wins, knows the triumphs of high achievement, and who, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who know neither victory or defeat.”

- Theodore Roosevelt

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APPENDIX A

Anti-icing and Deicing

Definitions

Anti-icing and deicing are terms used in the field of highway snow removal and ice control. They have been used at various times to describe a practice, strategy, technology or program. They are defined as follows:

Anti-icing is the *prevention* of snow and ice bonds to pavement through the timely application of a chemical freezing-point depressant.

De-icing is the *removal* of snow and/or ice after it has bonded to the pavement.

A distinction between a primarily-*preventive* and a primarily-*reactive* strategy is intended when referring to anti-icing and deicing respectively.³ Because it is primarily preventive and dependent upon chemical freezing point depressants, use of anti-icing technology is generally limited to highways assigned a high level of service (LOS). In Virginia, these highways are classified as bare pavement routes.

Current VDOT Practice

Current practice at most locations within Virginia is to wait for the snow to start covering the pavement or the ice to form before applying a dry solid salt, abrasive or combination thereof. This activity usually starts before a bond has occurred between the snow or ice and the pavement. While this activity appears similar to that defined as anti-icing, it is actually de-icing. VDOT's standard strategy is as follows

- Operators are called out, or held at the headquarters based on a weather forecast.
- They load up with salt, or abrasives and then, if they are early, they wait for the snow to start.
- Once it starts, they wait for enough accumulation to hold the dry salt pellets on the pavement as it falls from the spreader.
- When that point is reached, the operator starts to spread chemicals to get them down on the road surface before the snow becomes too deep and traffic packs it to the surface.
- After that, operators plow when it is deep enough, periodically reapplying chemicals as needed.

Under the current strategy:

- Operations people may spend a lot of time waiting for snow to reach a depth where they can spread chemicals or plow.

- They often have a limited window of opportunity to apply chemicals to the pavement.
- They often end up with snow and ice bonded to the pavement on part of the system because the route cannot be covered before snow depth and traffic conspire to create a snow pack.
- Even if the chemical is placed on the pavement prior to a bond occurring, the time it takes for the solid salt to form a brine often creates intermittent bonding of snow and ice to the pavement.

What may look like an anti-icing operation in the beginning, ends up as a de-icing operation.

TE 28 Manual of Practice Guidelines for Anti-icing

Anti-icing is a sophisticated program of chemical choices and delivery methods supported by accurate, up-to-the-minute weather information. The manual of practice³ produced by the TE 28 study is considered the state-of-the-art for anti-icing practice. The manual discusses five chemical types: sodium chloride (salt), calcium chloride, magnesium chloride, calcium magnesium acetate (CMA), and potassium acetate. Each has advantages and disadvantages when one considers cost per ton, temperature limitations, environmental concerns and public relations. The manual also discusses placing chemicals on the roadway in three different forms: 1) the traditional dry solid flake, 2) flake, pre-wetted with a liquid, and 3) liquid. Pre-wetting is defined as spraying a liquid on the flake chemical prior to placing it on the road. This is better done once the material is loaded on the truck, instead of in the stockpile, and is best done at the instant the material leaves the truck to be spread on the road. Again, each option offers advantages and disadvantages from a cost, temperature, environmental and public relations standpoint.

The manual of practice offers guidelines on the numerous combinations of chemical type and delivery system for applying chemicals to the road. The guidelines include suggested rates and timing of application for each combination. The guidelines for type of chemical, delivery system, rate and timing are provided for six different types of weather event. The reader should refer to the manual of practice for more detailed information.

TE 28 Field Evaluation Report Conclusions

The field evaluation report² for TE 28 lists several conclusions concerning the advantages and dangers inherent in anti-icing practice. Among these are:

- Anti-icing operations can lead to a considerably higher degree of operational success throughout a storm relative to conventional practices. When dangerous packed snow conditions develop, anti-icing operations can lead to a weaker bond

between the pavement and snowpack and an earlier breakup of the pack (bonded snow).

- Initial chemical solution applications should be made either as a pretreatment in advance of a storm or as an early-storm treatment. In the case of a chemical solution pretreatment, the practice is not always as straightforward as applying the solution onto dry pavement before the time at which precipitation starts. In particular, in storms that begin with rain or snow falling on a pavement with above-freezing temperatures, pretreatment long before pavement temperatures drop to freezing should be avoided because of the excessive dilution of the chemical that will occur. In storms that begin with freezing precipitation falling onto a pavement with below-freezing temperatures, however, pretreatment is indeed appropriate.
- Initial rock salt or pre-wetted rock salt applications in advance of precipitation are not always necessary for preventing bonded snowpack, but early applications when the pavement condition is no worse than wet, slushy, or lightly snow covered are clearly necessary for successful anti-icing practice.
- Relative to conventional practices in which surfaces are not treated until later in a storm, benefits from sodium chloride solution pretreatment can include higher friction and better pavement conditions early in a storm. These benefits have been observed to be short-lived, however, and should not be expected to endure over a long period. Subsequent chemical applications should be made as soon as conditions begin to deteriorate. In essence, pretreatment should be thought of as buying time in the earliest stages of a storm until subsequent operations become effective.
- Abrasives are not a freezing point depressant and therefore cannot be an active material of an anti-icing operation that is conducted to prevent bond formation between packed snow or ice and pavement. Use of salt/abrasives mixes at moderately or much higher application rates than straight chemical does not lead to corresponding improvements in friction or pavement conditions. The implication of these results is that the presence of abrasives is detrimental to the effectiveness of chemicals in the mix. Abrasives in the chemical mix may serve other purposes. They add color to the mix, which helps the motorist identify locations that have been treated. They also improve traction in those situations where snow has accumulated on the surface. However, during storm periods when anti-icing operations are successful in either preventing or mitigating snowpack hazards, abrasives applications provide no consistent or apparent benefit in braking friction, traction, or pavement condition.²

These conclusions indicate the potential benefits of having numerous options available from which to choose. They add emphasis to the TE 28 study conclusion that access to localized weather information, especially just prior to the start of a winter storm is

important. Knowing when snow or freezing rain will begin allows the snowfighter the option of using liquid or pre-wetted flake chemicals *prior* to the start of the storm. The results can be better initial application of chemical, longer effect from the application and less use of chemical per lane mile.

APPENDIX B

Telephone Survey Anti-icing Interview Questions

Location _____ Date _____ Name _____

1. You use ___ **saddle tanks** for pre-wetting. Is that number of vehicles or number of tanks?
2. What are the AHQ locations where you practice **pre-wetting**? Contact there?
3. What experience have you had with **pre-wetting**?
 - How long?
 - How often?
4. What are the #/LM of flake you use, **normally**?
5. Have you adjusted your #/LM usage with **pre-wetting**? What has been the result?
6. How many gallons /mile of liquid do you use in **pre-wetting**?
7. What is the AHQ location of your **direct liquid** application? Contact there?
8. What experience have you had with **direct liquid** application?
 - Where used?
 - How long?
 - How often?
9. How many gallons/LM did you use for **direct liquid** application?
10. How are you using **RWIS** information?
 - Forecast (SCANCAST)?
 - Real-time information?
 - History?
 - Other?
11. Has **RWIS** changed your way of dealing with storms? How?
12. Has **DTN** changed your way of dealing with storms? How?
13. Has the **Weather Channel** changed your way of dealing with storms? How?
14. What AHQ has **RWIS, DTN, Weather Channel**? Contact there?
15. On the survey, you indicate you use some **unusual plowing equipment**. Tell me about it?
16. On the survey, you indicate you use some **unusual technique, chemical, piece of equipment or other snow related item**. What is it? Tell me about it
