Chapter 2

ANTI-ICING

This chapter presents recommendations for successful anti-icing practices. It presents information that will assist in the development and the implementation of a systematic anti-icing program. The chapter is organized into six sections to give recommendations and procedures from the time an anti-icing program is initiated to a postseason analysis of the program.
The six sections in this chapter are:

1) Getting Started
2) Preseason
3) Prestorm
4) During the storm
5) Poststorm
6) Postseason

2.1 Getting Started

No short discussion or list of recommendations can completely cover the wide range of weather conditions facing agencies state-wide. Therefore agency managers should use these guidelines as a starting point for developing their own anti-icing program, to accommodate local experience, specific site concerns, and agency objectives.

2.1-A Equipment/Materials

Automated Systems

Automated anti-icing systems use sensors in the pavement to monitor conditions and activate a spray system for anti-icing liquids when the pavement approaches freezing.

Automated systems may be cost justified in areas where frosting or freezing may present the most hazards. Examples of places where a spray system may be justified are bridges, sharp curves, and steep hills.

Tankers

Highway agencies interested in beginning or experimenting with an anti-icing program might consider modifying some existing spreader equipment before investing in new equipment. When modifying dump trucks for a anti-icing program. It is recommend that a 1,250 gallon tank be used in single axle dump trucks and a 2,000 gallon tank in tandem axle trucks. Consideration should be made for baffling tanks over 1,000 gallons. Also asphalt distributor trucks, liquid fertilizer spreaders, and weed control spreaders have been successfully modified and used in

anti-icing programs. Trailer mounted tanks can also be used. Another option is to purchase a new or used semi-trailer for an anti-icing program

Figure 1: A semi-trailer equipped for anti-icing

Application Equipment

When applying liquids, streamer nozzles 1/4" or more in diameter should be used in order to prevent clogging due to suspended solids in the solution. Fan nozzles are not recommended as they spray the entire road surface with liquid, potentially making a slippery road. Streamer nozzles will apply the liquid in evenly spaced increments (see Figure 2). To allow for proper distribution of the anti-icing liquid on a roadway the streamer nozzles should be placed 10”-14” apart on the spray bar.

Adjustable height applicator bars will allow operators to minimize the effect of wind and air turbulence from the trucks. Placing rubber mats on either side of the spray bar will also minimize over-spray. Rubber hoses that are just long enough to touch the ground can be put over the spray nozzles to apply the liquid at the road surface.

Figure 2: Anti-ice rig equipped with rubber application hoses

Storage Tanks/Pumps

Tank walls should be rated 12 pounds per square inch or be capable of handling liquid with a specific gravity of up to 1.6. All tanks should be placed on a flat concrete surface and installed according to manufacturer's recommendations. Fill and discharge openings in the storage tank should be three inches (3") in diameter and accept cam lock fittings. The tank should be vented and labeled with the name of the liquid being stored inside. If the tank is to be filled from the top, an anti foam agent needs to be mixed in the liquid to prevent foaming while filling. It is not recommended that the tanks be made of any type of metal due to the corrosiveness of some anti-icers.

Pumps should be constructed out of corrosive resistant materials and be capable of pumping liquids with a specific gravity of 1.6 or greater.

Chemical Storage

All anti-icing and de-icing chemicals should be stored under cover or inside a building. It is important to utilize good housekeeping practices in and around all chemical storage facilities to ensure chemicals are not exposed to weather.

Chemical Containment

Consult your local regulatory agency, as to proper storage and containment of anti-icers and de-icers. Abide by all local, state, and federal laws and/or guidelines.

Choosing a liquid

Choosing a material for use in snow and ice control is not simple. Some agencies opt to use different materials for different conditions and many agencies are not able to use some materials due to environmental restrictions, cost, or availability of the products.

Deciding which material is best can only be done by proper evaluation, proper use, and input from the public. The exact liquid evaluation process should be determined by each individual agency. There are many resources that can be consulted before choosing a liquid. A selection of resources can be found in Appendix 1.

A policy outlining how the operations are to be done, modifying this document to meet your specific needs, a training program for the crews, informing the public, use and evaluation of new and innovative materials, and proper planning will help control costs, improve efficiency, and make your job easier.

2.1-B Chemicals/Materials

Five chemicals have been used for liquid anti-icing treatments nation wide: sodium chloride (NaCl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), potassium acetate (KA) and any of the chloride products combined with an Agricultural Bi-Products (ABPs). Some important properties of these chemicals are given in Table 1: Properties of anti-icing chemicals. Not all products/suppliers are listed in Table 1.

Table 1: Properties of anti-icing chemicals

Liquid Category	Minimum freeze point, °F (for storage characteristics)	Concentration (Percent)	Ice Melt Capacity at 15 °F (grams ice melted per gram deicer)	Performance Ratio (24% salt brine = 1.0)
Magnesium Chloride Based Liquids				
Magnesium Chloride Brine	-27	22 %	0.58	2.1
	-6	26 %	0.72	2.6
Caliber M-1000	-79	30 %	0.60	2.2
Calcium Chloride Based Liquids				
Calcium Chloride Brine	-60	30 %	0.35	1.3
	+30	36 % (dust palliative)	---	Don't Use !!
LiquiDow Armor	-40*	30 %	n/a	n/a
Ice Ban CM-80	-67*	28 %	n/a	n/a
Sodium Chloride (Rock Salt) Based Liquids				
Salt Brine	-6	24 %	0.28	1.0
Other				
Potassium Acetate (KAc)	-70	50 %	0.9	3.2
CMA	-10	30 %	0.0	0.0

* Agitation is required!

2.1-C Source of Weather and Forecasting Information

Having and using weather and forecast information is one of the keys to successful and effective anti-icing. Reliable weather and forecasting information can help make the decisions of when to anti-ice and what treatment to apply much easier. Forecasting information should include; when the precipitation is expected to start, its form, the probable air temperature, the temperature trend during and after the storm, and the wind direction and speed. Current weather information should include the air and pavement temperatures, dew point, wind speed and direction, and precipitation form. A few sources of weather and forecasting information are described below.

National Weather Service

The National Weather Service is the easiest and cheapest way to access weather information. This information is readily available for any geographic area, and can be accessed by internet, radio, and cable television.

Nowcasting

Nowcasting refers to the use of real-time data for short-term forecasting. It relies on rapid transmittal of pavement and weather data from RWIS installations, radar, field observations and any other information source for making a judgment of the probable weather and pavement condition/temperature over the next hour or two. Nowcasting brings all available information together for proper decision making.

Road Weather Information System

RWIS is an integrated wide-spread network of weather data gathering and pavement condition monitoring systems built to provide information winter operations managers can use to make operational decisions. The most visible components of the RWIS are the roadside installations of the system. A single site, which includes several pavement and subsurface sensors, is referred to as a Remote Processing Unit (RPU) or an Environmental Sensing Station (ESS). The RPU consists of atmospheric sensors mounted on a 30-foot tall metal tower, pavement sensors embedded in the pavement surface and beneath the surface, an enclosure containing the computer processor and the required communications components.

Data from the pavement and weather sensors are formatted at the RPU, transmitted to the central processing unit (CPU). Each CPU has a separate computer directly attached to it and a modem through which information is provided to remote users.

Satellite Transmitted Weather Information

Weather can also be transmitted to each garage via satellite. This system usually requires an upfront set up fee and a monthly charge for the weather information.

2.2 Preseason

2.2-A Order Materials

Anti-ice liquids need to be ordered and delivered before the season begins. In Michigan, direct maintenance facilities, as well as counties and cities that have maintenance contracts with the state can purchase from the DMB contract. Generally the prices from this contract are cheaper than what would be paid if the counties or cities purchased these items on their own.

2.2-B Calibrate Equipment

In order to work efficiently all liquid distribution systems need to be calibrated on at least an annual basis. Calibration should be done to the manufacturer's recommendations.

2.2-C Training

It is essential to have trained personnel before starting an anti-icing program. The crews performing anti-icing operations should receive training pertaining to: when and when not to apply chemical, proper application rates for different conditions, how to operate the new equipment, and how to track their results using a TAPER log. It is also important to have a yearly refresher training.

Everyone resists change, but change, in most cases is required for an anti-icing program to be successful. Training of operators and managers is very important when moving into this area of technology. An anti-icing program will require more information for making earlier informed decisions and may involve different methods and materials than do conventional methods. This will require an emphasis on training.

2.2-D Acceptance Testing/Quality Control

Each garage or agency needs to develop a way of testing anti-icing liquid before it is delivered to the storage site. The tests need to be simple enough that they can be carried out at a garage when a load of chemical is delivered. Of the available tests, viscosity and specific gravity are the simplest and easiest to perform. Significant deviation in test results from expected values will signal a problem with the product. Since theses tests can be conducted upon delivery, suspect loads do not have to be accepted and thus will not contaminate an otherwise "healthy" supply.

2.3 Prestorm

Deployment of personnel

Use of modern weather forecasting information will provide more time in advance of a storm to plan operations. With better information, maintenance teams can more efficiently determine standby status and inform personnel with more lead time. Timely weather information is essential when making effective crew call out decisions. This is especially important for anti-icing operations as the timing of the initial treatment is critical. By minimizing the mobilization time, managers can reduce the call in time of the entire crew and extend crew availability.

Information assembly

The initial anti-icing operation is most often the application of liquid to the pavement in advance of the storm. However, before this action is taken, information about the nature and the characteristics of the anticipated storm should be assembled and a decision made concerning the action. Several pieces of information need to be assembled upon first notice of a winter storm. The information includes weather forecasts, color weather radar data from the weather centers or through modem access, and where available, RWIS data. Special attention should be paid to the areas in your vicinity that may have already been affected by the approaching storm. The

information can be used to estimate locally when and where the event will begin, its extent, severity, and impact.

The timing of the initial anti-icing application should be made in anticipation of worsening pavement conditions. The effectiveness of anti-icing is dependent on the amount of liquid placed, the amount of moisture received prior to the storm, and displacement of the liquid by traffic. Residual salt from previous operations has a short-lived effect on highway conditions at the beginning of storms and should not be relied upon as an initial anti-icing operation.

Decision point

After reviewing the information, managers must decide when to initiate treatment and what type of treatment to apply. They make their decision based on a combination of many factors:

- When precipitation is expected to start
- Form of precipitation
- The probable air and pavement temperatures
- The anticipated trend of the temperatures
- The expected sky conditions
- The wind speed and direction
- The intended timing of the treatment
- Traffic considerations and timing

Traffic

Although traffic density has an effect on friction, it is not as direct or consistent as the effects of precipitation type, precipitation rate and pavement temperature. In fact, anti-icing operations have been shown to be successful in high volume rush hour traffic, as well as low volume, middle-of-the-night traffic. The routine use of traffic information should be mostly to ensure that anti-icing operations are completed ahead of rush periods in order to avoid delays which can lead to bonded snow pack or ice. Local experience or LOS may warrant incorporation of traffic information within an individual agency's anti-icing operational guide.

Wind

Experience has shown crosswind speeds in excess of 12 to 15 MPH may cause drifting across a pavement and retention of snow if the pavement is wet. The threshold wind speed at which this becomes a problem will vary widely with the road site and other conditions. Highway maintenance personnel should be alert to the conditions that may cause interception of snow and incorporate the information in their operations.

When a decision is made to apply liquids during windy conditions, experience has shown adjusting the sprayer closer to the pavement can be successful in avoiding loss and more closely achieving the desired application.

Safety and handling of liquid anti-icers

Liquid anti-icers stored in unheated tanks will reach temperatures much less than freezing. Therefore, skin contact with the liquid chemicals at these temperatures can result in "instant" frostbite.

Goggles or face shield protection and rubber gloves with long gauntlets should be worn, consult the product's Material Safety Data Sheet (MSDS) for exact handling instructions. All storage and dispensing tanks should be labeled "Liquid anti-icer," as well as using the name of the specific anti-icer. All loading and off-loading should be performed in a safe manner, as close to ground level as possible. Liquid anti-icers are especially harsh on leather articles of clothing.

2.3-C Recommended Practices

Application

Operators can spread liquid chemical uniformly over the pavement at relatively fast speeds as a pre-storm treatment. To minimize the amount of bonded snow or ice, the chemical must be applied before enough snow has accumulated to keep the chemical from reaching the pavement or being excessively diluted.

A factor of great importance is pavement temperature. Pavement temperature directly influences the formation, development, and breaking of a bond between fallen or compacted precipitation and the road surface. Also when high humidity levels are accompanied by low dew point temperatures, there will be a potential for formation of frost.

Unless some external source of heat is provided, the pavement temperature will generally track air temperature with a time delay. For road sections without obstructions to the sky, solar radiation during the day and exposure to the clear night sky will affect the road surface temperature more than on sections influenced by air contact only.

Type and rate of precipitation and pavement temperature are the most important variables to consider when performing anti-icing operations.

Field Observations

There is no substitute for visual observation of weather conditions and conditions of the pavement surface. Observations remain an important tool for making operational decisions even when there is access to new technology such as RWIS. Although law enforcement personnel can help fulfill this role, trained highway maintenance field personnel are better prepared to judge the severity of conditions and to make or recommend corrective action

Once the storm begins, anti-icing is finished.

2.4 During Storm

Operations

An initial application of an anti-icing liquid may suffice for some conditions and short duration events, but it is far more likely that other treatments will be required during a storm. When the effects of initial anti-icing efforts begin to fade, operations should switch to standard winter operations.

2.4-A Development of Snowpack and bond

Even when anti-icing operations are performed successfully, a snow or ice pack may still develop a bond to the pavement. This generally implies de-icing is necessary. However, it is often observed in practice the previous anti-icing treatments have slowed the development of a bond, resulting in a weaker bond that is more easily broken. This leads to a quicker return to acceptable pavement conditions. Those developing anti-icing programs should recognize bonded snow and ice pack can occur even when anti-icing is "successful", but it will not usually have the strength of bonded pack observed during traditional de-icing operations.

Monitoring of conditions

It is important for pavement and weather conditions, weather forecast updates, and where available RWIS data continue to be closely monitored after the initial anti-icing operation has taken place. Special attention should be paid to pavement temperature, trend, and to changes in precipitation type and intensity. This information, plus observations of precipitation and pavement conditions, as well as evaluations of treatment effectiveness are needed to determine when standard winter operations should begin.

2.5 After Storm

Careful recording of conditions and the steps taken in response will provide the basis for fine-tuning the program for specific service levels and conditions.

2.5-A Assess effectiveness

To improve both the effectiveness and efficiency of an anti-icing program, each agency should evaluate the performance of its crews and equipment as well as the chemicals. All levels of the agency should be involved in this assessment. Many times, what a supervisor observes during a storm is not readily seen by an operator, and vice versa. Managers should also track the cost and effectiveness of the anti-icing program, and, where possible, compare the results to conventional operations.

To develop valid results, cost data of a storm or weather event must include all costs for materials (chemicals and abrasives), labor, and equipment employed in operations. For chemicals, this includes the purchase price, transportation to storage site, storage, truck loading, handling and mixing of solid chemicals, and solution preparation. For equipment costs the agency must develop hourly rates and multiply them by the hours used. Other costs should be considered, such as the cost of dispatchers, costs of specialized equipment, and cost of patrols, to name a few.

Agencies should measure the costs and effectiveness of the anti-icing and conventional operations separately for specific highway sections or routes. Analysts can then calculate the cost per lane mile for each type of operation, and accurately evaluate their relative success. Most importantly, anti-icing techniques provide the potential for maintaining roads in the best conditions possible during winter storms. Systematic anti-icing practices might or might not reduce overall costs. Cost savings will depend on the current practice: for example, what LOS

governs what materials it uses, whether it is more deicing than anti-icing, and the agency's information sources. Examples of success include providing the same level of maintenance effectiveness at less cost, or providing a higher level of maintenance effectiveness at the same cost. To evaluate the costs or success of anti-icing operations, an agency should examine both costs *and* LOS provided to the traveling public.

2.5-B TAPER Logs

There is no cure-all application rate for any chemical or any weather event. With every liquid the effectiveness and efficiency of use comes from experience and learning from what you did in the past. The TAPER log is an easy method to track you experiences, and establish application guidelines to meet your needs. A sample TAPER log is included in Appendix 2.
Taper stands for:

- **T** Temperature of pavement
- **A** Application rate
- **P** Product (chemical) applied
- **E** Event (storm) amount and type of precipitation
- **R** Result of snow and ice control activities

2.6 Post Season

2.6-A Evaluate and improve program for next season

Lessons can be learned from both the successes and failures of snow and ice control operations. Anti-icing is no exception. Improvements in operations and equipment can be identified and implemented through post-season assessment of practices and treatments. Therefore, report anti-icing/ deicing using liquid chemicals for snow and ice control in the daily TAPER log.

Anti-icing with liquid chemicals is expected to result in improved service to motorists and may translate into a financial savings with regard to materials and time necessary to return the pavement to before-storm conditions.

Clean-up

Since most anti-icing chemicals are corrosive all equipment should be washed or flushed after the winter season. Also, the liquid tanks should be circulated according to the suppliers recommendations.