

## Snow Fence

Snow fences are an economical approach to help control blowing snow, reduce snow removal costs and improve visibility for the traveling public. In 1965 the Department placed more than 6,000,000 feet of snow fence at the beginning of the season while in 2002 we placed only 636,000 feet of snow fence. Why the drastic reduction in snow fence installations?



One of the main reasons for the reduction is improved roadway design. The designs now used provide more snow storage areas along the right-of-way. Another reason is more powerful plows that make removal of blowing and drifted snow an easier task. Even with redesign of roadways and higher-powered equipment there are still many areas that would benefit from a well-designed snow fence. The following are basic guidelines for snow fence placement:

- The best fence porosity (open space in face of fence) is 40-50%
- One 6-foot fence holds as much as two 4-foot fences
- Fences should be set back from the edge of the roadway 35 times the height of the fence (A 4-foot fence should be 140 feet from the edge of the roadway)
- A gap of 5-10 inches at the bottom of the fence will make the fence more efficient in trapping snow
- Extend the fence beyond the area you are trying to protect to allow for any changes in wind directions.

## Controlling Material Applications

Salt can damage plant life, contaminate ground water, and rust out vehicles. Sand can contribute to air pollution and clog drains and waterways. Budgets become tighter, resources more limited, and salt and sand are more expensive every year.



*What can we do???*

One thing is to better control the application of these materials. Over the last few years, the department has made an investment in equipment to reduce waste, increase efficiency and help protect the environment. You can also do your part. Here's some facts --

### Prewet systems

A Michigan DOT study conducted in the mid-seventies showed that a typical application of dry material down the center one third of the roadway typically resulted in a 30 % loss of material. When the material was prewet with a liquid, the amount of material lost into the ditch was reduced to 8%. The Iowa DOT's average use of salt over the last 4 years was approximately 170,000 tons and the cost today for salt is approximately \$37 a ton. If material were to be spread without prewetting, we would lose approximately 51,000 tons into the ditches at a cost to taxpayers of nearly \$1.89 million. Even when materials are prewet, there is an estimated loss of 13,600 tons of salt into ditches at a cost of \$503,200. To put that into a better perspective, prewetting significantly reduces waste material, but even when prewet, in an average year 544 semi loads or 150 railcars of salt go into Iowa's roadsides.

### Ground Speed Controls

Many trucks are now equipped with ground speed oriented spreader controls (Ravens) to further help control the use of materials. The ground speed oriented systems are designed to automatically monitor and control the application rate of materials based on the speed of the truck. In theory, if the system is set to spread 200 pounds per lane mile the ground speed system should control applications at that rate whether the truck is moving at 5mph or 30 mph. If the spreader control is not calibrated properly or the auger is not receiving salt the application rates will be off.

### What can I do to control material applications?

Whether equipped with a ground speed control or not, it is important to make sure every spreader is calibrated according to the manufacturer's specifications at the beginning of each winter season and anytime work is done on the truck that might impact the spreader controls. If every truck in the fleet was calibrated to spread *only* 5% too much material throughout the season, that would result in an over application of 8500 tons of salt, totaling \$314,500 – that's 340 semi loads or 94 rail cars worth of salt.

The attachment contains a calibration guide and spreadsheet provided by the Salt Institute to help calculate and record calibration information on spreaders.

As you can see, anything we can do to help control the use of materials for maximum efficiency and minimum waste will help protect the roadside environment and also our budget.

## Radar and How it Works

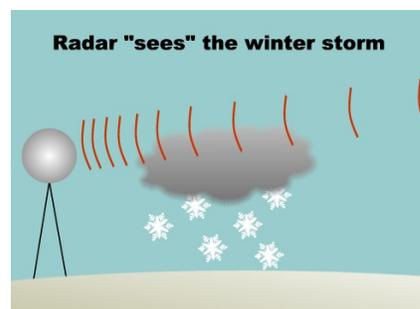
The National Weather Service uses Nexrad (**N**ext generation Weather **R**adar) radar sites around the United States to predict precipitation and winds. The basic principal for how radar works is that radio waves are transmitted into the atmosphere and if the waves strike an object, the radio wave bounces back to the antenna. Over the course of an hour approximately 7 seconds is spent sending radio waves from the antenna and the remaining 59 minutes and 53 seconds is spent “listening” for the waves to bounce back to the antenna. The objects that reflect the waves back to the antenna are typically raindrops, sleet, snow or hail but may also include bird migrations, insect swarms and dust storms.



The radio waves reflected back to the antenna are converted to pictures to show the location and intensity of precipitation. To determine the direction of the precipitation and winds, the radar measures the frequency change in the returning radio waves. Waves of something moving away have a lower frequency while those approaching a radar will have a higher frequency.

Radar sites can detect most precipitation types that occur within 90 miles of the site and intense rain and snow can be detected approximately 150 miles from the radar site. Radar does an excellent job with summer storms, since thunderheads can reach 50,000 feet or more into the sky. However, winter events tend to occur much lower in the atmosphere. To complicate matters even more, the radio waves are sent out at a slight upward angle so the radio waves are higher from the ground, the farther from the radar site. With a low-lying winter storm, the radar may completely “overshoot” the precipitation.

What’s this all mean?? Overall, radar is less effective in “seeing” winter precipitation than summer storms. Though snow may in fact be occurring, a low lying winter storm may not appear on the radar image until it is closer to the radar site. Radar sites that provide Iowa coverage are located in Des Moines, Omaha, Quad Cities, Sioux Falls, and LaCrosse. So, the farther you are located from one of these radar sites, the less positive you can be that winter precipitation events in your area will be accurately and completely shown on the radar image.



For more information:

<http://www.crh.noaa.gov/radar/radinfo/radinfo.html>

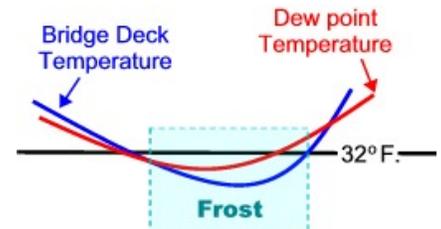
<http://www.accuweather.com/wx/school/dopplerfaq.htm>

## Bridge Frost – What it is and how it forms

What is bridge frost? Bridge frost is really pretty basic – it is a simple accumulation of ice crystals on the bridge deck's surface. But what causes it is a little more complicated --

Bridge frost occurs when two things happen:

- The bridge deck temperature is at or below the dew point temperature *and*
- The bridge deck temperature is below freezing



When both of these conditions are present, frost will occur. The longer the bridge deck temperature is below the dew point and the bigger the difference between the two, the heavier the frost accumulation will be. Most commonly, frost will occur on clear, cold nights with calm winds, but neither of these conditions is *required* for frost to form.

When conditions are right for frost, the moisture in the air turns directly into ice in a process known as deposition. The “liquid” stage in the more common transition of water from vapor to liquid to ice is skipped.

Conditions that are favorable for bridge frost are pretty common in Iowa since we are lucky (??) enough to have a climate with cold enough temperatures and plenty of moisture in the atmosphere. So.... if these conditions are fairly common, how come I seldom see frost?

The very beginning of a frost event is nearly invisible – there are just tiny, nearly microscopic crystals of ice within the pores of the roadbed. Sometimes a frost event may be present but never progress beyond that nearly invisible point. No one really knows how long and how far the deck temperature must be below the dew point to create a roadway hazard, so as an agency we must be alert to any frost potential.

In addition, the frost crystals that form with frost contain very little moisture. If roads have been pretreated for frost or there was a recent, past snow event, there may be enough deicing chemical present on the bridge to melt the ice crystals as quickly as they form. That is why on your way into work you may see bridge frost on county or city bridges that have had little or no recent use of deicers, while our bridges remain frost-free. That's not because frost didn't occur – it may have – but the deicers we use kept it at bay.

Road frost is a different critter entirely – it takes a different set of circumstances to make road frost happen and will be the subject of a future Snow and Ice Fact.

## Salt – Where does it come from and how is it produced?

Salt is the chemical compound sodium chloride or NaCl and occurs naturally throughout the world. Salt is obtained either from the sea, brine lakes, or under-ground deposits that were once the site of ancient seas or salty lakes millions of years ago.



Worldwide there are more than 100 nations with salt production facilities producing more than 200 million tons of salt each year. The United States is the largest supplier of salt in the world with annual production of 45 million tons. Half of the U.S. salt production is in the form of brines, which are used heavily in the chemical industry, while the remaining production is in various types of dry salt.

Dry salt can be produced in three ways

- Solar evaporation – A process where the sun and wind remove the water from seawater or natural brine lakes. Most solar salt production facilities are located in the Southwestern part of the U.S. where rainfall is low and sunshine is high.
- Solution mining - Water is injected into an underground salt deposit forming a cavern of brine. The brine is pumped out and either sold “as is” or the water is mechanically evaporated out. Most table salt is produced in this way.
- Deep-shaft mining - Shafts are drilled to an underground salt deposit and a combination of explosives and mechanical equipment break up the salt deposits. The salt is brought to the surface, crushed and an anti-caking agent added.

Deep shaft mining is the primary production method for rock salt, also called halite. Evaporated salts (either from solar or solution mining) are normally too fine a gradation to use as a deicer.

All of the rock salt we use for winter operations typically comes from the deep shaft mining process. About 16 million tons of rock salt is produced annually in the U.S. The salt we buy is either mined in Kansas or Louisiana and makes its way to our facilities via barge (in the case of Louisiana salt), rail and trucks. The salt we use is mined about 1000-1500 ft. below ground. Approximately one half of the price we pay for salt is for the transportation to get it to our facilities from the mines.

Two years ago we received a shipment of salt from the East coast that originated in Chile. In Chile, the geological formations have “pushed” the ancient salt deposits that are normally deep below ground close to the surface. In this particular location the salt can simply be quarried rather than mined. Because the climate is extremely dry, there is no problem quarrying the exposed salt. The salt from Chile had a distinct red or pink tint that is due to minute amounts of iron deposits that are not found in salt produced in North America.

For more information:

<http://www.saltinstitute.org/>

## Surface and Subsurface Temperatures

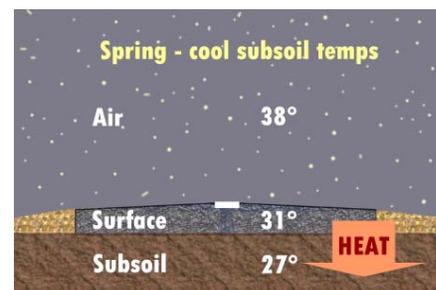
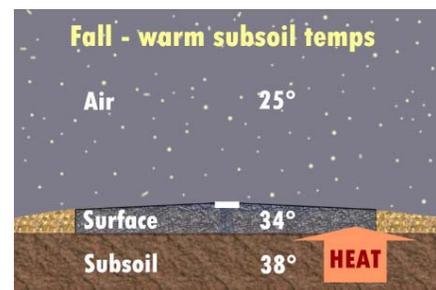
Years ago, when someone said the word “temperature”, you could pretty much be assured that they were talking about how cold the air is. Now, take a look at the RWIS information and you will find four different temperatures – air, surface, subsurface and dew point. Let’s take a quick look at the first two.

Surface temperature is the temperature of the roadway or bridge deck surface and is the “key” to what will happen to the roadway when there is precipitation. If rain or snow is falling, it matters little what the air temperature is (other than helping you decide whether a heavy coat or insulated boots are in order!) But if the surface temperature is at or below freezing, watch out! Precipitation can freeze on the roadway and create less than ideal road conditions. So, if precipitation is expected, a surface temperature approaching 32 degrees is the “trigger point” for many critical investigations and decisions – will the roads freeze or not, is the surface temperature expected to rise or fall, what are the other weather conditions, will crews need to go out or stay in, should deicing chemicals be used, should they be liquid or dry, and how much to apply.

Subsurface temperature is measured approximately 18” below the surface of the roadway and is the temperature of the earth at that level. Subsurface temperatures change *very* slowly due to the large mass of the earth. Throughout the summer, warm days and plentiful sunshine warm the earth. It takes a great deal of cold weather to slowly cool the earth’s mass, so in the fall, subsurface temperatures often remain far higher than you may expect. In the first week of Dec., 2002, about half the RWIS sites are still reporting subsoil temperatures above freezing, despite some quite cold weather.

Why is subsoil temperature important? The subsoil temperature has a big influence on the surface temperature. It can be a very cold day, but if the subsoil temps still retain summer heat, the surface temperature will be “pushed up” by the retained heat. This is why the first few snows of the year often require little action. In midwinter, once the subsurface temps fall below 32, they no longer help keep the surface temperature high. But then spring arrives, and yup, just the opposite happens – you can have rain on a warm spring day that immediately freezes on the pavement. Over the winter, the subsurface has cooled and retains that coolness for quite some time, so the subsurface temperature can “drive down” the surface temperature lower than you would expect.

There are many other things beside the subsoil temperature that affect the surface temperature - sunshine, air temperature, precipitation, chemical applications, and a clear night sky - but understanding the basic seasonal influences of the subsoil temperature is a good beginning to better understanding what is happening to the roadway surface.

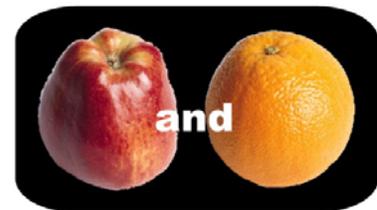


## Air Temperature, Dew Point Temperature & Relative Humidity

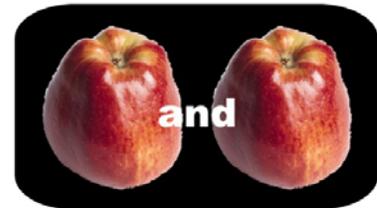
The air temperature is that “traditional” measure of just how cold the air surrounding us is. Air temperature is one of the many factors that affect the pavement temperature but is even more important in its affect on the temperature of bridge decks. Unless the sun is shining, bridge deck temperatures will more closely “follow” the air temperature. Pavement temperatures may not be as closely related to the air temperature, since the subsoil temperature plays its own part in influencing the pavement temperature.

The dew point temperature is just a little more complicated, but no less important. The dew point temperature is a way to measure the moisture in the air. Hey, you thought relative humidity was a measurement of the moisture in the air? Well, you’re right, they both are, so let’s compare the two.

Relative humidity tells how much moisture is in the air compared to how much moisture the air can hold at the current temperature. For example, if the relative humidity is 75%, this means that the air contains 75% of the maximum amount of moisture it can hold at any given temperature. The relative humidity can **never** exceed 100%. The problem with relative humidity is that the air can hold much more moisture when it is warm than when it is cold. So, 80% humidity when the temperature is 90 degrees (you know what that feels like!) is a lot different than 80% humidity when it is 20 degrees. Looking at relative humidity at different temperatures is kind of like comparing apples and oranges.



**OR**



The dew point temperature takes both the current temperature and the relative humidity into account to come up with a temperature measurement that represents the amount of moisture in the air. Just like relative humidity can never exceed 100%, the dew point can **never** be higher than the air temperature. The closer the dew point is to the air temperature, the more moisture there is in the air. Now, if it is 90 degrees or 20 degrees and there is a 5-degree *difference* between the dew point temperature and the air temperature, we are on common ground. Regardless of what the air temperature is, if the two temperatures are moving closer, moisture is accumulating in the air, and if moving farther apart, the air is becoming drier. *Now* we are comparing apples to apples.

Problems arise when the dew point temperature is warmer than the objects it comes in contact with. In the summer, if the dew point is higher than the temperature of the grass in your lawn, you will find dew in the morning. If the dew point and air temperature meet, watch out for fog. But most important to us, if a bridge deck or road surface is below freezing and the dew point is warmer than the surface temperature, frost or black ice can form.

## Eutectic Temperature

Recent facts have been looking at different types of temperatures, so let's continue the trend and take a look at another type of temperature, but one that's not related to weather – the eutectic temperature.

The eutectic temperature is very important whenever you are using deicing materials. That mess of vowels looks pretty intimidating and technical, but the word is pronounced “yoo’-tek-tic.” Now that you know how to pronounce it, what is it?

Very simply, the eutectic temperature is the point where a substance freezes or melts. Another way to refer to the eutectic temperature is freeze point.

Water, as we all know, will freeze at 32° F., so 32° F. is the eutectic temperature of water. When you mix salt and water so that salt is 23 percent of the solution - what you know as regular old salt brine - the eutectic temperature is reduced to -6° degrees F. (six degrees below zero.) However, the tricky thing is that if you mix **less** salt with the water, the temperature at which it freezes goes up. And surprisingly, if you add **more** salt to the solution, the eutectic temperature also rises.

Here's an example -

Salt Solution	Eutectic Temperature	
10%	20° F	Too little salt
15%	12°	
20%	0°	
23%	-6°	Most Effective Brine
25%	16°	Too much salt
30%	30° F	

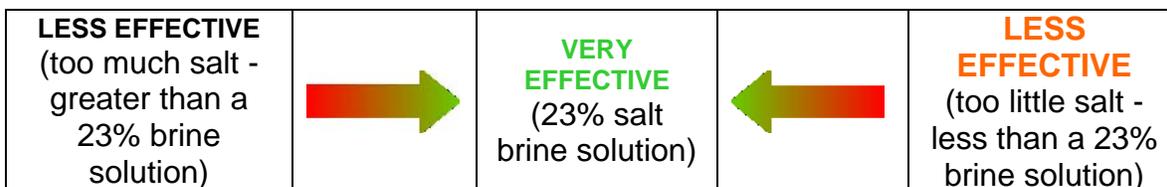
When you mix salt with water it works a lot like antifreeze - too little or too much is not a good thing.

So, when you are looking at solutions of various concentrations, there is always an ideal concentration that gives you the most bang for the buck – or the most water from the ice! In the case of salt brine, that ideal is a **23% solution** to give you the **lowest possible eutectic temperature**.

## Rock salt's action on the roadway

What really happens when you apply rock salt to a roadway? First, the salt must find a source of heat & moisture before it can begin to work. As we add salt to the ice or snow on the pavement, it begins to draw moisture and heat from the snow or ice creating a solution of salt and water. It is that solution of salt and water, or what is commonly referred to as a brine solution, which *really* acts to melt the ice. The grains of rock salt on the pavement have *no effect* until they become brine.

Immediately after a rock salt application, there is not enough moisture in the solution on the roadway. Remember what happens when there is too much salt and not enough water in a salt brine solution? You got it - the eutectic temperature or freeze point is high. As more ice melts, more water is added to the solution, and at some point in time, that rock salt you added to the road becomes a highly effective 23% brine solution with a eutectic or freeze point of -6°. But just a minute – if all the ice or snow is not melted or there is additional precipitation, even more water gets added to the salt, and you guessed it - the eutectic temperature starts to rise as the solution is diluted and the solution becomes less effective. So, just like brine has an “ideal” concentration of 23%, when you apply rock salt, the same basic action occurs and the melting action follows a predictable cycle:



This action explains why there is a lag time between a rock salt application and the beginning of melting. It also explains one of the primary benefits of prewetting – if you provide that initial moisture and the rock salt doesn't have to “find” the moisture it needs to begin working from the snow and ice, the melting action begins much sooner. Prewetting “jump starts” the melting action.

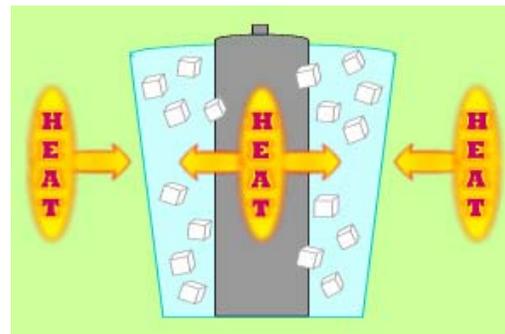
So what is the secret to an ideal rock salt application? The real trick is to get the right amount applied (but not too much) so that you reach a point where the salt can be the most effective, and time any reapplication to happen before the diluted solution becomes too ineffective.

## Ice Cream Freezer Effect

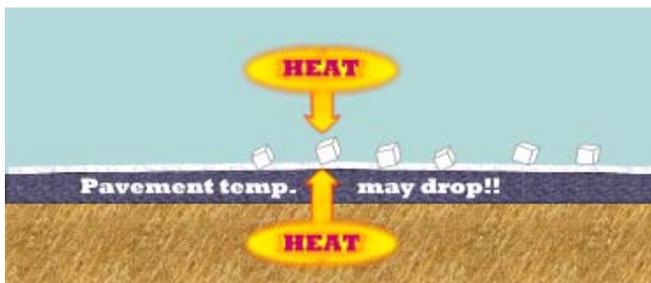
Have you ever wondered why rock salt is added to the ice when making homemade ice cream? The addition of the rock salt to the ice forms a brine (just like that used for prewetting and anti-icing). And just like on the roadway, the freezing point or eutectic temperature of the salt/water/ice solution is lowered below 32 degrees. But there is something else going on here that we need to examine.

Remember from last week's fact that both moisture and heat are required to form the brine that melts the snow and ice?

When you add the salt to the ice cream freezer, it's a no-brainer to figure out where the moisture comes from, but where does the heat come from? The heat for the changeover from ice to water is drawn from the ice cream container, the ice cream mixture, and the brine solution itself or the surrounding air. That transfer of heat from the surrounding surfaces is what drives down the freeze point of the brine solution and the ice cream mixture.



So how does that relate to the use of rock salt on the roads? When you apply rock salt, the heat required for the melting action must come from somewhere. And that heat will come from the surrounding surfaces – the air, brine solution, the roadway or the subsurface.



Surprisingly, pavement temperatures can drop a few degrees when rock salt is applied as a deicer. A study in New York conducted by Surface Systems, Inc. (SSI) has shown that when rock salt is applied to snow or ice pack, the pavement

temperatures can drop up to 6 degrees and can take up to an hour to fully recover to normal pavement temperatures. The pavement temperatures recover more rapidly when the moisture layer is thin, often within only 10-15 minutes. But, as the thickness of the snow or ice pack increases, the amount of time needed to recover to normal pavement temperatures takes much longer.

Heat and moisture are always needed to begin a melting process with salt. It is easy to understand where the moisture comes from, but now you know a little more about the heat. In an ice cream maker, the heat to melt the ice comes from the ice cream container or the surrounding air. On the road surface, the roadway, or more likely, the subsurface, is where it usually finds its source of heat and in the process cools everything between it and the heat source – the thing that is our primary concern – the pavement.

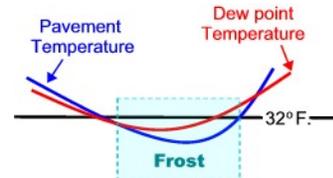
## Road Frost – What it is and how it forms

Bridge frost, road frost.... Frost is frost, right? Well, the answer to that is yes, or at least, well.... kind of yes. Let's take a look at the similarities and differences –

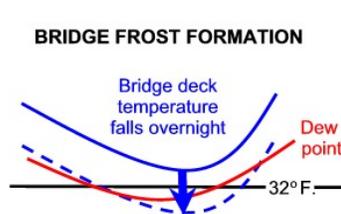
Both bridge and road frost are a simple accumulation of ice crystals on the roadway surface.

Both bridge and road frost occur when

- The surface temperature is at or below the dew point temperature *and*
- The surface temperature is below freezing



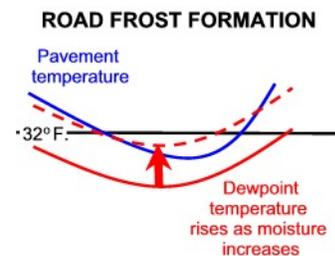
And for both types of frost, the longer the surface temperature is below the dew point and the bigger the difference between the two, the heavier the frost accumulation will be.



However, the conditions that normally lead to road frost are different from bridge frost. Bridge frost is most likely to happen on a clear, cold, calm night when the bridge deck cools to below the dew point as the air surrounding the bridge cools and heat from the bridge deck is lost.

Roads are a lot different than bridges because the massive amount of soil under the pavement warms and cools at a very slow rate – over days, not hours. The stored heat of the earth affects the pavement temperature, making it less dependent on the air temperature changes. That is why you often see much less change in the pavement temperatures in the overnight hours, and much wider swings in the bridge deck temperatures.

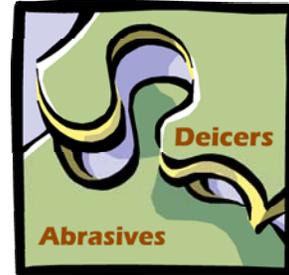
As winter progresses, and the subsoil temperatures fall below freezing, the subsurface will help keep the pavement temperatures low, even if the air temperatures are warmer. Now, if that warmer air has a lot of moisture in it, and the surface temperature remains below freezing, the dew point can rise above the colder pavement temperature forming road frost.



So, if exactly the same interaction of surface temperature and dew point cause both types of frost, then how come we have way more bridge frost events? In Iowa's cold, dry winter weather it is not very common to have an influx of humid air to *raise* the dew point. However, the wide fluctuations in the bridge deck temperatures make it far more likely that the deck temperature will *fall* below the dew point – thus more bridge frost events.

## Roadway Treatments

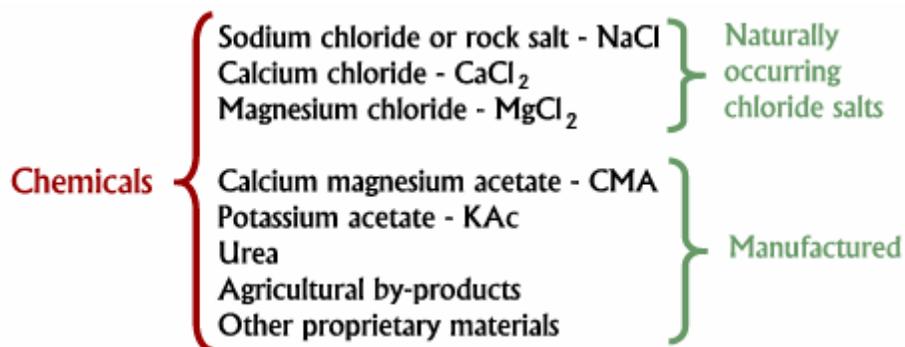
Ever put together a jigsaw puzzle? Well, winter maintenance can be a lot like that puzzle. It takes a lot of different pieces to put it all together - skilled personnel, a lot of different types of equipment, materials, forecasts, knowledge of pavement temperatures, etc. And just like when you put together a puzzle, you have to look carefully at all the pieces and see how they all fit together. And... every storm is a new puzzle!



In the next few facts we will look in detail at a couple of the pieces related to roadway treatments – deicers and abrasives. Though roadway treatments are just one of the puzzle pieces, consider how you would complete the picture without them...

First off, let's deal with deicers. What is a deicer? A deicer is any material that lowers the eutectic or freeze point of water. Deicers all play some role in preventing the snow and ice bond to the pavement when used as an anti-icer or, when used as a traditional deicer, melts enough of the accumulated snow or ice so that it can be plowed off the road.

Deicers are all technically a chemical of some sort. But some are naturally occurring chloride salts and others are manufactured.



Abrasives, on the other hand, have nothing to do with melting snow and ice and do not lower the freeze point. Abrasives can be sand, cinders, ashes or crushed rock. Abrasive's primary role is to provide traction.

## Chemical Concentration

When we talk about salt brine's ideal chemical concentration being 23%, just what does that *really* mean?

Very simply, chemical concentration is how much chemical is contained in a liquid. And, a liquid containing a chemical is referred to as a solution. The *concentration of a solution* is expressed as a percentage. That percentage is the percent **by weight** of the chemical in the solution. Without getting too technical, let's look at the numbers for salt brine:

One gallon of water weighs about 8.3 pounds

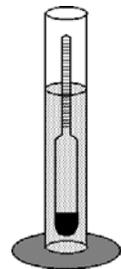
A gallon of properly made salt brine weighs a little over 10 ½ pounds

The difference in weight (the amount of salt in the brine solution) is about 2.2 pounds

Now for the math: 2+ lbs divided by about 10 ½ lbs = approx. .23 or 23%

If you are mixing brine and "shooting" for the most effective 23% concentration, there are a lot of variables. It's not like baking a cake - there is no exact recipe to follow. Rock salt may contain up to 5% impurities (that gunk in the bottom of the brine maker), which will not dissolve into the solution. The temperature of the water can make a difference, as well as some other weird, technical things that affect the mix.

That is why a hydrometer is used to measure the concentration of each batch of brine. A hydrometer is an instrument that is calibrated to measure the weight of a volume of solution **as compared to** the weight of the same volume of water – called the specific gravity. Water has a specific gravity of 1.0. A 23% solution of salt brine has a specific gravity of 1.176. So that tells you that the same volume of salt brine has that something extra in it – the dissolved salt. If you know that water weighs about 8.3 pounds, you can multiply that by the hydrometer reading (1.176 for salt brine) for a ballpark estimate of the weight of a gallon of solution.



The hydrometers that we use are specialized for use with chloride solutions, so rather than shooting for a 1.176 specific gravity, you will want each batch of salt brine to match a 23% solution reading on the hydrometer, or if using a type of hydrometer called a salimeter, a reading of 85. They all mean the same thing – that you are right on at mixing a 23% solution when you are at a reading of 1.176, 23% or 85, depending on the type of hydrometer.

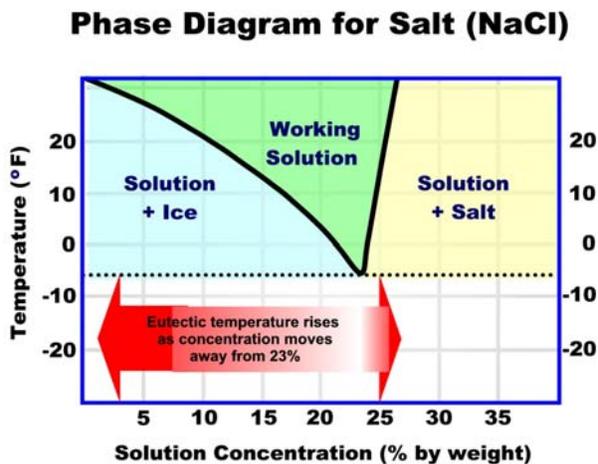
So, why is concentration so important? Each particular deicing chemical has a specific concentration at which the eutectic temperature (freeze point) is the lowest. When salt brine is at a 23% solution, the eutectic temperature is the *absolute lowest* it can be at – 6 ° F. If there is either more or less salt in the solution, the freeze point rises. Each deicer has a *different* ideal concentration that corresponds to its lowest eutectic point. Here's a rundown on the stats for some of the common deicers used throughout the country.

Deicer	Ideal Concentration	Eutectic Temperature
Sodium Chloride	23%	- 6 ° F
Calcium Chloride	30%	- 60 ° F
Magnesium Chloride	22%	- 28 ° F
Potassium Acetate	49%	- 76 ° F
Calcium Magnesium Acetate	32%	- 17 ° F
Urea	33%	+ 10 ° F

## Partners – Temperatures & Chemical Concentration

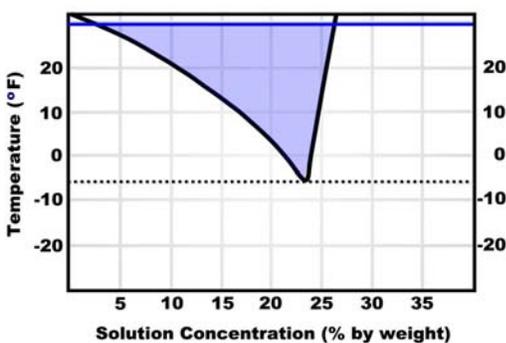
Some things just naturally go together - things like chips and dip or pretzels and beer. When it comes to deicing chemicals, the two things that naturally go together are chemical concentration and temperatures. You can't understand one without the other.

Each deicing chemical has an ideal concentration where the eutectic temperature is the lowest it can be. But what happens when the concentration is less than ideal? Or, the pavement temperature is higher or lower? A tool that shows any deicing chemical's effectiveness at differing concentrations and temperatures is called a phase diagram. A phase diagram (shown below) tells you the eutectic temperature (black line) at various chemical concentrations (shown on the horizontal) and various temperatures (shown on the vertical). Let's take a closer look at the phase diagram for salt (NaCl).

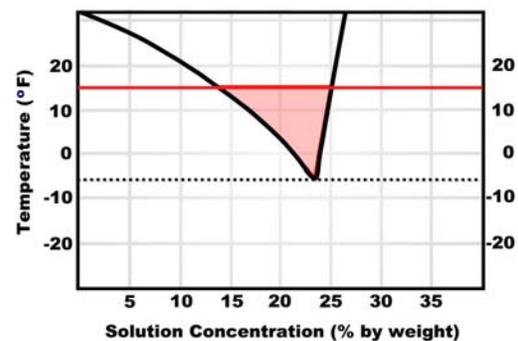


Salt will **only** work as a deicer when the pavement temperature and chemical concentration fall within the green zone on the phase diagram. Follow the line for a chemical concentration of 20% up to the 20 degree line. The intersection of those two values falls in the middle of the green zone, so you know that at those values, salt works to melt ice or snow. As the chemical dilutes and the concentration falls, the temperature at which it will melt snow or ice goes up. Surprisingly, if the concentration is too high, the temperatures rise even faster.

What does this really mean in the real world? Let's look at some examples.



**Pavement temperature is 30 degrees -**  
Salt will work to melt snow or ice when the concentration is as low as about 3% and as high as 27% (the shaded blue zone). At this temperature, the salt can be diluted a lot by melting or additional precipitation and **still** continue to work.



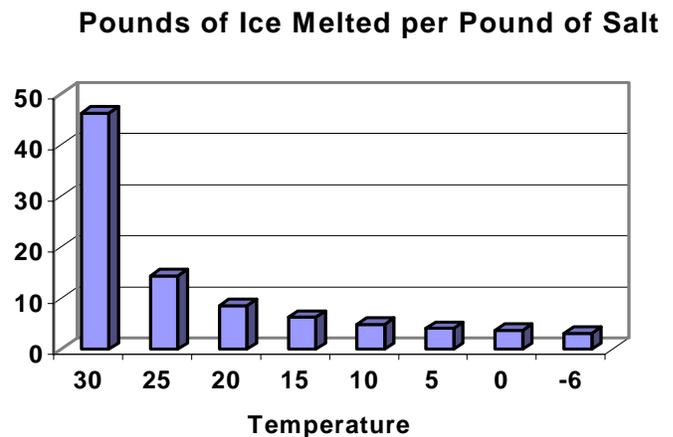
**Pavement temperature is 15 degrees -**  
At lower temperatures, a much narrower range of concentrations will work to melt snow or ice. The concentration needs to stay between about 13% and 23% (the red shaded zone). Additional precipitation or melting will dilute the chemicals to a point where they are no longer effective more rapidly than at higher temperatures.

Let's say you and your family are going to the local steak house tonight for the "works." When the bill arrives, you haul out a huge sack of coins, and count them out. Is that a very effective way to pay the bill? However, if you stop for a quick burger at the fast food joint, it would be practical to use the quarters in your pocket to pay for your food.

Where is this leading? In both cases above, you *were* able to pay for your food, but one made sense and the other didn't. The same can be said for the use of deicers at different temperatures. In this fact we will discuss at what temperature different chemicals may or may not make sense to use - the **effective** temperature.

When pavement temperatures are very low, the amount of deicer used must be so high to work that its use may not be very practical or effective. It's like paying for that steak dinner with coins – you can do it, but is it the best thing to do? For deicing chemicals, there is a point where the amount of the chemical that you would need to melt the snow and ice is so excessive that it may be unreasonable. The cost would be extremely high when compared to the result, and it may be impossible to physically make enough runs at a high enough application rate to do much good.

Let's take a closer look at salt. This diagram shows the melting capacity (in a laboratory setting) of a *single* pound of salt at different temperatures. Note that you can melt about **5 times** more salt at 30 degrees than you can at 20 degrees. And, below 15 degrees, the amount of ice melted by the pound of salt is very small and falls even further at lower temperatures.



For each deicing chemical, there is a temperature above which the chemicals can be expected to be effective *in a practical sense* – the effective temperature. Yes, salt will melt ice all the way down to its eutectic point of -6, but in the real world, when the pavement temperature hits about 15 degrees, some consideration needs to be given to the payoff of using salt. That doesn't mean that you *can't* use salt below the effective temperature, and at times it may be the smart thing to do (such as when pavement temps are expected to rise), but you do need to be aware of the reduced effectiveness.

The chart below lists both the eutectic temperature and the effective temperature of various deicing chemicals

	Eutectic	Effective		Eutectic	Effective
NaCl (salt) - sodium chloride	- 6	+15	KAc - potassium acetate	- 76	- 15
CaCl - calcium chloride	- 60	- 20	CMA - calcium magnesium acetate	- 17	+ 21
MgCl - magnesium chloride	- 28	+5	Urea	+10	+25

### Endothermic and Exothermic

Sounds like some type of weird medical procedure that you want to stay *far* away from, doesn't it?? But you can relax - these scientific terms refer to the absorption or generation of heat by a deicing chemical.

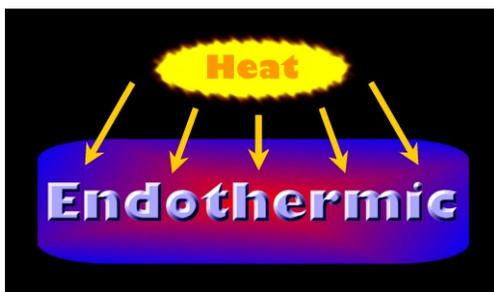
Water (or H<sub>2</sub>O) can be found in any one of three states – a solid (ice), a liquid (regular water), or gas (steam). When H<sub>2</sub>O changes from one state to another, a chemical process occurs that requires some type of energy; and that energy is in the form of heat.



When you apply a deicer, the heat has to come from somewhere to begin the chemical process of melting. If a deicer has endothermic properties it must absorb heat from its surroundings - the air and pavement\*.

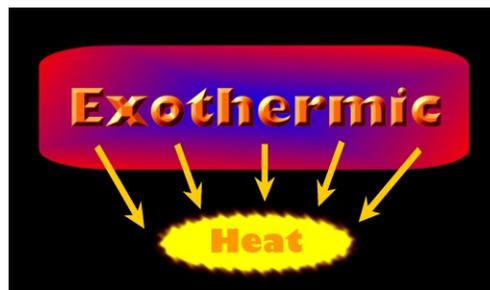
The common deicing chemicals that are endothermic are:

- NaCl (salt)
- CMA (calcium magnesium acetate)
- KAc (potassium acetate)
- Urea



There are other deicers that do not require heat from the surrounding air or pavement. Surprisingly, these deicers *produce* heat when the melting action takes place or are exothermic. The common deicing chemicals that are exothermic are:

- CaCl<sub>2</sub> (calcium chloride)
- MgCl<sub>2</sub> (magnesium chloride)



How can these possibly produce heat during the melting? In the case of calcium chloride, this chemical is found in nature as a liquid. Heat is then used to evaporate away the liquid to form either pellets or flake that are bagged for our use. That heat is "stored" in the dry chemical and is released when it returns to a liquid state during the melting process.

The heat produced by a deicer with exothermic properties is very short lived and is most significant in the very beginning of the melting action. A deicer with endothermic properties must capture heat from its surroundings before melting can begin, whereas a deicer with exothermic properties has its own "built in" heat source and can begin melting immediately.

\* See Fact 15 for an explanation of how the heat needed for melting can affect the pavement temperatures.

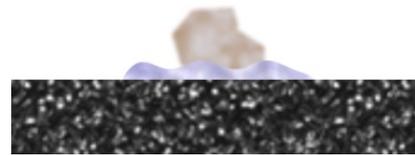
### Hygroscopic Chemicals

If you leave a bowl of sugar outside on a hot, sticky summer day, it doesn't take long for it to get lumpy. But, if you set out another bowl of sugar inside the air-conditioned house, after the same amount of time, it will probably be just fine. What's the difference?? Inside the air-conditioned house, the humidity is low. But outside the humidity is high and the sugar absorbs moisture directly from the humid air. Sugar is hygroscopic.

A chemical is said to be hygroscopic when it has a tendency to attract moisture. But two hygroscopic chemicals can vary in the power of that tendency to attract moisture. In some chemicals the tendency to attract water is so great that they very readily can "pull" the moisture right out of the air, even at relatively low humidity levels.

Why do you care? Both rock salt and calcium chloride are hygroscopic. This ability of the deicers to absorb moisture from the air is something you should be aware of. When conditions are right (or I should say very wrong) it can cause you some real problems. Let's take a closer look at the two chemicals.

### Humidity



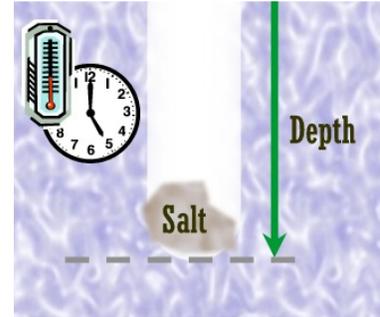
Calcium chloride begins to absorb moisture from the air when the relative humidity is relatively low - about 32%. A roadway previously treated with calcium chloride will stay completely dry, even for many days as long as the humidity remains low. But, if the humidity rises above 32%, the chemical residue on the roadway will begin to absorb moisture. The residue will dissolve into brine and the road will become increasingly damp as more and more moisture is absorbed from the air. Initially, the road may just become a little damp, but if pavement temperatures are below freezing, the calcium chloride may continue to absorb moisture until it is too dilute to keep the pavement wet. Then you have a potential problem – a sheet of ice. This can take you (and motorists) by surprise since this hazard can appear far after a precipitation event.

Exactly the same thing can happen with sodium chloride or salt. It also will absorb moisture, has the same potential to dilute enough to no longer stay wet and freeze on the roadway. However, with rock salt, the humidity has to be much higher before it can begin absorbing moisture from the air. The relative humidity has to exceed 75% before salt will begin to attract moisture. Because Iowa winters tend to be cold and dry, the relative humidity doesn't as often reach 75%, so you see this happening less often with salt. But still a hazard to watch for!!

## Ice Penetration and Undercutting

How well does a deicing chemical perform? That is far from an easy answer. Each chemical has a different “set” of performance characteristics and properties. So far, these facts have discussed a number of those characteristics and properties. But we aren’t done yet. This fact will discuss ice penetration and undercutting.

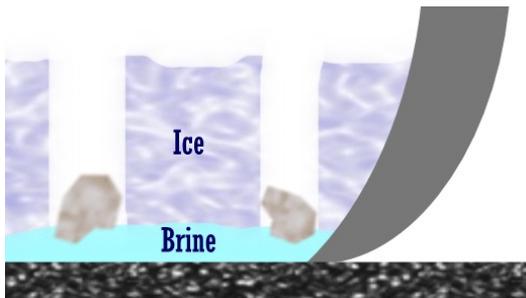
When snow or ice pack forms, the ability of a deicer to cut through the icy layer is important. Ice penetration is a laboratory measurement of that ability. The ice penetration for any solid chemical is a measure of the depth that a chemical will penetrate ice *in a given amount of time at a specific temperature*. In the real world, the numbers from the lab tests may not mean a whole lot, but you *can* look at how the same chemical performs at different temperatures and varying time periods, or compare the numbers for different chemicals.



The table below has some values for the ice penetration of salt and calcium chloride. Note that in the same amount of time, the penetration is deeper as the temperature rises for both deicers.

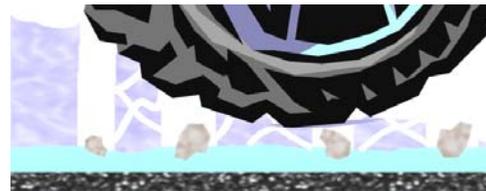
Ice Penetration (in 1/10 inches)						
	At 5 Degrees F.		At 15 Degree F.		At 20 Degree F.	
	After 10 min.	After 30 min.	After 10 min.	After 30 min.	After 10 min.	After 30 min.
NaCl (Salt)	0.7	1.2	0.9	2.5	0.9	3.1
CaCl <sub>2</sub> Pellets	0.7	2.5	1.3	3.6	2.1	5.5

Source: Manual of Good Practice for Snow and Ice Control with Dow Calcium Chloride Products



So, why is this so important? If a chemical penetrates to the *bottom* of the snow or ice pack, the brine will begin to undercut or spread out beneath the ice pack. When undercutting occurs, the bond of ice to the pavement begins to break so that you can more easily plow the ice off the roadway. The sooner undercutting occurs, the sooner an ice or snow-covered road can be returned to a safer driving condition.

When the ice is well penetrated by a deicer (think Swiss cheese) and undercutting the ice, the structure of the ice or snow pack is far more fragile. At this point, the weight of vehicles may begin to crush and break up the ice.



The shape and form of a deicer can also affect how well it penetrates and undercuts. Pellets of calcium chloride penetrate better than the flake form. The flakes tend to melt in a more horizontal manner so that the penetration is shallow and undercutting does not occur or is delayed. And, fine salt may not be as effective as coarse salt. Small grains of salt may completely dissolve before they reach the bottom of the ice pack. In this case, the penetration stops short of the bottom of the ice pack and undercutting is again less evident or delayed.

## Ice Melting Capacity

It's over 50 today and starting to feel like spring, so let's finish up with a few more chemical properties before it is time to wrap up this year's Snow and Ice Facts.

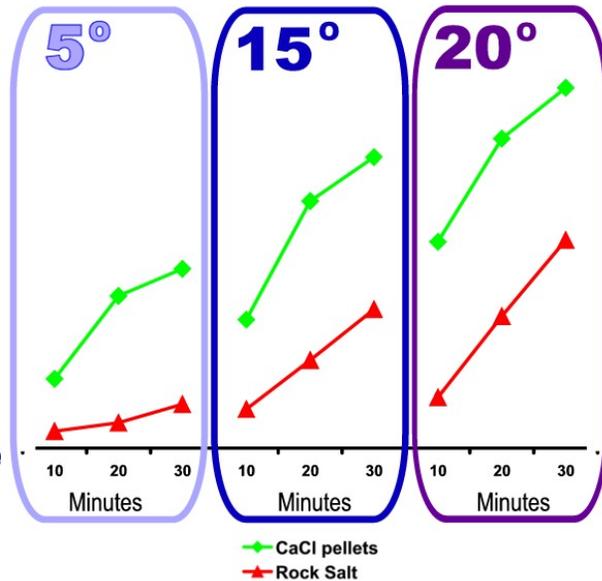
In Fact 20, "Effective Temperatures", the concept of melting capacity was mentioned. But let's look at this feature of deicers in a little more detail.

Different chemicals have a different ability to melt ice, but it is not quite as simple as saying that chemical X has a melting capacity of Z, and chemical M has a melting capacity of N. There are three **different** things that affect the melting capacity:

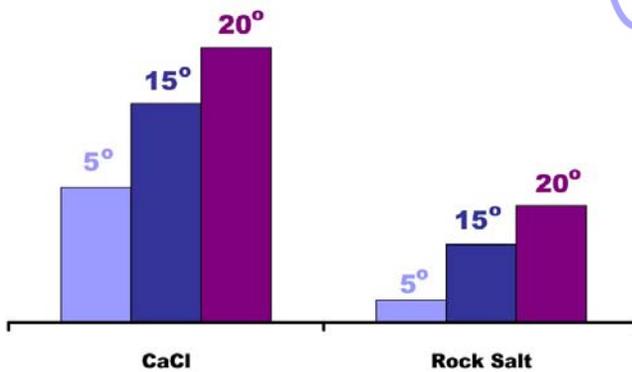
- Type of chemical
- Temperature
- Time

Let's take a look at the melting capacities of calcium chloride and rock salt. Each of three different temperatures is shown. The red line is for rock salt, and the green line for calcium chloride. At each temperature, the amount of ice melted in 10, 20 and 30 minutes is shown. This chart can tell you a lot. For example, salt melts about the same amount of ice in 30 minutes at 5 degrees as it does in only 10 minutes at 15 degrees. Study this chart so that you better understand the affect of time and temperature on the capacity of the chemicals to melt ice.

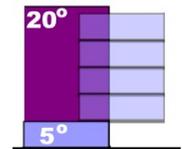
### Ice Melting Comparison (at various temperatures)



### Ice Melted after twenty (20) minute



Now, let's look at the same information in a different way. When you look at the amount of ice that can be melted in 20 minutes, you can clearly see the difference in the amount of chemical it may take at different temperatures to get a similar result. Compare the values for salt at 5 and 20 degrees. It would



take over **five times** more salt at 5 degrees than at 20 degrees to melt the same amount of ice.

## Iowa's Winter Climate

As the seasons begin to change, this last Snow and Ice fact of the winter will focus on a weather related issue – climate information.

Meteorologists talk a lot about both weather and climate, but they really are two quite different things. Weather is a short-term event - what is happening right now, tomorrow, or within the near future. On the other hand, climate looks at a *far* bigger picture. The dictionary says it pretty well:

***Climate:** the average course or condition of the weather at a place over a period of years...*

**The key to that climate definition is “over a period of years.” In many parts of the world, including the Midwest, there is a very wide variability in weather patterns and conditions. For that reason, meteorologists look at many years of data (often 30 years or more) before making any generalizations about the climate of a region. Where do they get all that data to study climate?**

Every single day, all year round, the National Climatic Data Center (NCDC) collects weather information from thousands of locations in the US. and around the world. In the U.S., weather data is obtained from the National Weather Service, Military Services, Federal Aviation Administration, Coast Guard, other agencies and from over 8,000 private citizens who are voluntary cooperative weather observers for the National Weather Service.

The Office of Maintenance has compiled Iowa's winter climate information from the NCDC and Iowa's State Climatologist for a 19-year period - the winter of 1983-4 to the winter of 2001-2002. The climate data is now available on DOTNET at

<http://dotnet/mntprog/weather/climatebinder/index.htm>

At this site you will find very detailed information for each of 24 selected Iowa locations, as well as many averages, rankings, maps & charts.

Here's an interesting tidbit from the climate data about the highest and the lowest ranked winters in the 19-year period.

	Ranked #1		Ranked #19	
<b>Snowfall</b>	2000-2001	45.5 inches	2001-2002	18.3 inches
<b>Precip. Days*</b>	1983-1984	60.4 days	1999-2000	35.8 days
<b>Temperature</b>	2000-2001	31.6° F.	1999-2000	38.6° F.

\*Precip. Day – a day when 0.01” or more precipitation occurs (rain and/or the liquid equivalent of frozen precipitation)

The weather information from this past winter will not be available until later this summer or fall. But when it is, the climate data will be updated to include the most current year's data. Want to guess where this past winter will be ranked.