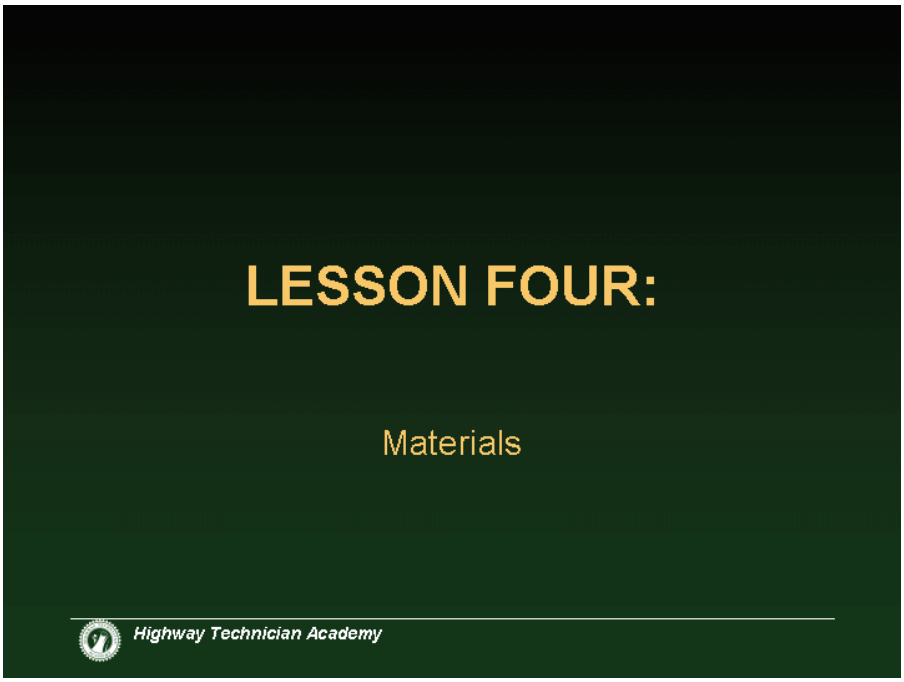
Lesson Four: Materials



A. Winter Maintenance Expenditures

1. **Annually, ODOT will make large expenditures for materials used in snow and ice control**
    a. During an average winter season, the Department spends approximately $30 million on rock salt and an additional $1 million on other materials
    b. When winters are harsh, such as that experienced during the 2007/2008 season, expenditures soar
        i. During the 2007/2008 season, approximately $78 million was spent for winter operations
2. **In addition to this direct cost, there are numerous indirect costs associated with the use of winter maintenance materials**
    a. Their use can:
        i. have an enormous impact on the environment and infrastructure (especially with corrosion on reinforcing steel and exposed bridge members)
        ii. result in extensive costs for repairs and damage
    b. Such impacts are minimized with proper application and storage techniques

B. Winter Maintenance Materials

1. Available Materials

a. Two types:

i. Chemicals

a) Used in snow and ice control to:

1) prevent bonding of the ice and snow to the road surface

2) prevent ice and frost from forming

3) prevent the buildup of snow pack

4) melt ice that has formed

b) Available in both solid and liquid forms

ii. Abrasives

a) Normally used for temporary traction and in conjunction with salt or other chemicals

b. The most commonly used winter maintenance materials and those typically used include:

i. Abrasives (sand, grits)

ii. Salt (Sodium Chloride) – rock salt

iii. Salt Brine - 23% brine solution

iv. Calcium Chloride (liquid or dry)

v. Magnesium Chloride (liquid or dry)

vi. Agricultural By-products

2. Material Selection

a. Numerous factors are considered within the selection process for determining which material(s) to use in snow and ice control. These factors include:

i. material performance

ii. use requirements

iii. infrastructure impact

iv. environmental impacts

v. availability

vi. cost

b. The variables within a storm event will dictate the material type and application rates best suited for the particular event

i. Through established guidelines and practices the selection process is narrowed to the best practice for the particular storm event

3. How Chemicals Work

a. Generally, all snow and ice removal chemicals work by depressing the freezing point of water and turning snow and ice into a liquid or semi-liquid slush

i. The function of lowering the freezing point of water is dependent upon the percent of chemical in solution

a) This means that dry chemicals do nothing until they take on moisture and go into solution or liquid form

ii. Some chemicals when dissolved into water will lower the freezing point of water below 32° F

a) We know that water will freeze at 32° F

b) If we mix certain chemicals in water (such as the anti-freeze normally used in our cars) the water will not freeze until it gets at a much lower temperature

c) This is how snow and ice chemicals work (just like anti-freeze)

b. Dilution of Solution

i. The effectiveness of the chemical depends upon the percent of chemical in the solution

a) It is well known that there is a proper mix of water and anti-freeze that will provide optimum protection to our cars from freezing in the wintertime

1) A mix of half water and half anti-freeze, or 50% solution, will provide protection down to –34° F

2) A mix of 3 parts water and 1 part anti-freeze, or a 25 % solution, will protect only to 10° F

b) Snow and ice chemicals require the proper mix to work effectively. When a chemical is mixed with water, or goes into solution, and changes the freezing point of

water, the newly created lowest temperature at which the solution will now freeze is called the Eutectic Temperature.

1) As we see from the above example on anti-freeze, this freezing point is based on the percent of material in solution

(a) It is important to remember that as this concentration changes, or as the mixture dilutes, the melting temperature also changes. This is commonly referred to as the "dilution of solution".

(b) It is also important to know that the solubility of chemicals will vary with temperature. The lower the temperature, the less the solubility.

c. Solid Chemicals

i. Solid chemicals used for snow and ice control, such as rock salt, must first mix with moisture to create brine before it has any melting capabilities

a) That is, the chemical must be in solution

ii. Rock salt will bore through snow and ice, dissolving to form a strong brine solution that spreads under the ice or hard-packed snow, undercutting and breaking the bond to the road surface

a) Once the bond is broken, the ice and snow can be plowed off

iii. By applying chemical materials prior to a storm, we can prevent the bonding to the road surface and melt the snow and ice as it comes in contact with the brine

Exercise: How Chemicals Work

1. True or False? Snow and ice removal chemicals lower the freezing point of water.

4. Abrasives

a. What are abrasives?

i. Abrasives are solid particles of sand, cinders, ashes or crushed aggregate.

ii. Most of these materials vary in specifications and size.

a) Depending upon material type the size can range from fine sand to ½ inch diameter particles.

b) Specifications detail material size, type, shape, hardness and moisture content and environmental issues.

b. How do abrasives work?

i. Abrasives have the ability to give a rapid increase in traction on the surface of ice and snow pack or at very low temperatures when chemicals agents are not effective.

ii. Disadvantages

a) Abrasives have no melting action.

1) This relates directly to the need for mixing salt or other chemicals with abrasives.

b) Cleanup

1) Excess material must be removed to eliminate possible drainage problems, safety hazards and air pollution.

5. Salt (Sodium Chloride)

a. What is salt?

i. A natural material. It has been used for ice control since early in the nineteenth century.

ii. Rock salt is mined by conventional mining processes and is the most commonly used product for snow and ice control.

b. Why is salt used?

i. Salt is widely used because of its effectiveness at moderate subfreezing temperatures, relatively low-cost, availability and ease of application in the solid form with current spreader equipment.

ii. At pavement temperatures above 20° F, salt is effective for combating ice and light snow and greatly enhances the effectiveness of plowing under heavy snow conditions.

c. How does salt work?

i. In order for salt to act as a freezing point depressant, it must go into solution.

a) A dry particle of salt spread on a dry surface will just sit there until it can absorb enough energy from the environment to form a liquid film on the surface of the salt particle.

ii. This initial "brine" then triggers the solution of the rest of the salt.

iii. As salt dissolves it continually absorbs energy from its surroundings.

a) Requiring heat energy when going into solution is defined as endothermic.

iv. It is important to remember that salt requires energy to dissolve.

a) During lower temperatures (times of less available energy) more salt is required and it takes even a longer time to take effect. Depending upon conditions, this can be a long process.

1) This explains why placing dry salt on a dry road is not effective.

v. In addition, dry salt does not adhere very well to a dry surface; it is prone to blow or bounce off before it has the chance to go into solution.

vi. Here are some facts about rock salt:

a) At 30°, 1 pound of salt can dissolve 46.3 pounds of ice.

b) At 20°, 1 pound of salt can dissolve 8.6 pounds of ice.

c) At 15°, 1 pound of salt can dissolve 6.3 pounds of ice.

d) At 6°, 1 pound of salt can dissolve 3.2 pounds of ice.

Exercise: How Does Salt Work?

1. True or False? Salt absorbs energy to dissolve.

2. True or False? To melt snow and ice, rock salt must mix with moisture and create brine.

6. Salt Brine

a. What is salt brine?

i. Salt brine is commonly used in anti-icing operations and for pre-wetting solid rock salt.

a) Salt brine is made by mixing rock salt in water to approximately a 23% solution.

ii. The proportion of salt to water is critical to the effectiveness of the brine.

a) Too much or too little salt affects the freezing point depressing qualities of the brine.

b) The proper salt brine mixture is 23.3% (the optimum solution for salt brine) at which the freezing point is –6° F (the eutectic temperature).

iii. Most of the ODOT garages across the state are equipped with salt brine production equipment and storage tanks.


Spray Bar
Approx. 3000 GL per HR
Salt Hopper
3 to 4 Ton Capacity
Brine Collection Tank
Calcium Chloride Storage Tank
Capacity
6000 GL
Brine Storage Tank
Capacity
6000 GL
Automated Brine System

Exercise: Salt Brine

True or False? The proportion of salt to water is critical to brine effectiveness.

b. How is salt brine used in anti-icing?

   i. In anti-icing the application is made ahead of or before an event to:

      a) prevent frost,

      b) prevent black-ice,

      c) prevent freeze-bond to pavements and

      d) buy critical response time.

   ii. The brine is applied directly to the pavement surface in anticipation of an upcoming event.

      a) The material is applied with a liquid application unit in streams, at controlled amounts, in an application that leaves the surface merely damp.

      b) The brine streams are placed about 8” to 12” apart and will dry on the pavement surface.

   iii. Once frost forms or snow begins to fall, the moisture will activate the dried strips into brine that helps prevent frost from forming on the surface or snow/ice from bonding.

   iv. Anti-icing applications do not result in the flow of liquid on the pavement so the uniformity of spread must be achieved at the time of application.

      a) Anti-icing applicators use the typical series of stream nozzles to allow for uniform coverage without excessive mist and fanning of the liquid (early models of applicators used fan nozzles and created problems with premature freezing of the mist).

c. Brine used in pre-wetting solid material

   i. In the pre-wetting of solids, the brine is usually placed in a holding tank on the salt truck and sprayed on the salt at the time of spreading.

   ii. Pre-wetting the solid material improves its effectiveness in many ways:

      a) Accelerates the solution process

      b) The pre-wetted material adheres to the road surface better than a dry material and results in less loss through bounce and scatter.

      c) Provides faster effect of the chemical

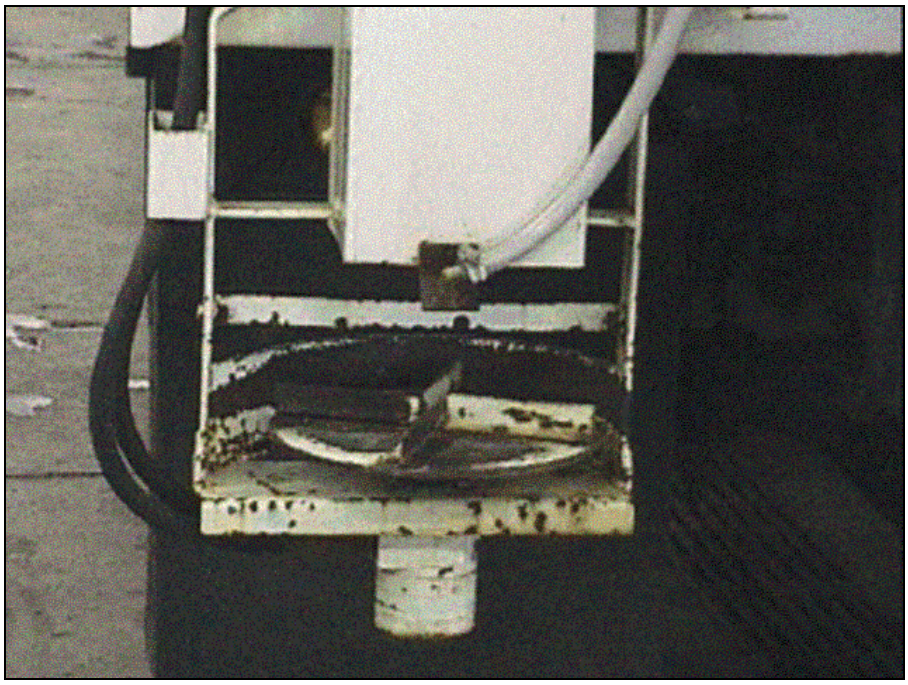
      d) Reduces material requirements because more stays on the road surface.

   iii. Salt brine is widely used because it is:

      a) Readily available (easy to produce)

      b) Very economical

      c) Effective for events occurring at moderate subfreezing temperatures



7. Other Chlorides (Calcium or Magnesium)

a. What are chlorides?

i. These materials are also naturally occurring and are liquids in their natural state and maintain an affinity for returning to a liquid.

ii. Both materials are commercially manufactured by either an extraction or chemical process.

iii. Both are produced and sold as a liquid solution and as a solid flake form.

a) ODOT typically uses calcium chloride as it is more readily available and slightly less expensive than magnesium.

b. How calcium and magnesium chlorides work

i. Unlike salt (sodium chloride), these chemicals do not require heat energy to go into a solution; instead they give off heat when they go from a solid into solution.

a) Releasing heat when going into a solution is referred to as exothermic.

ii. Calcium and magnesium chloride also attract moisture from their surroundings.

a) This improves their effectiveness in dry, cold conditions.

iii. These materials have low eutectic temperatures so they provide more melting action at lower temperatures.

iv. Both materials are also very corrosive by nature and are frequently purchased with added corrosion inhibitors.

Exercise: Other Chlorides

True or False? Calcium chloride releases heat as it goes into solution which improves effectiveness in cold weather.

c. How calcium chloride is used

i. The liquid calcium chloride and the corrosion-inhibited versions as purchased by ODOT are within a 30-33% solution.

a) This is the concentration that relates back to the eutectic temperature (-60° F).

ii. These products are typically used for pre-wetting salt and can be used to pre-wet abrasives.

iii. It is also common to purchase calcium chloride in a dry flake form and mix it with salt or abrasives for effective melting at low temperatures.

iv. The higher cost of calcium products frequently prohibits use for routine purposes.

a) These products can also be used in anti-icing; however, at the higher cost they quickly become uneconomical.

v. As detailed on ODOT's Route Application Guidelines and Goals document, the use of calcium chloride (or a corrosion-inhibited version) is recommended for use at temperature ranges below 25° F.

8. Agricultural By-products

a. Agricultural by-products work basically the same way as other snow and ice control chemicals although they do not form a brine.

i. They are soluble in water and the resulting solution acts by depressing the freezing point of water.

b. In addition to the melting characteristics, the agricultural by-products are environmentally friendly and less corrosive than many conventional materials.

c. These products are the concentrated liquid residues from the processing of grains and other agricultural products.

i. They are derived from the processing of agricultural raw materials and are often used in combination with other materials (for example, mixed with magnesium chloride).

ii. Like the chloride materials, their higher cost frequently prohibits use for routine purposes.

C. Material Handling and Storage

1. Material Handling

a. Handling abrasives, salt and other chemicals need not be hazardous, if you know what you are handling, and follow common sense requirements for personal protection.

2. MSDS Sheets

a. All chemical manufacturers are required to have a Materials Safety Data Sheet (MSDS) for each of their products.

i. These sheets are required by law to be available to the user, and the safe user will be familiar with all the information on these sheets.

b. Everything you need to know about the chemical is included in the MSDS.

i. The manufacturer's name, address, and telephone number

ii. Identification numbers for the chemical

iii. A list of the major components of the chemical

iv. Its characteristics and reactivity with other materials

v. Requirements for personal protective clothing and equipment needed in handing the chemical

vi. Emergency procedures in case of exposure or a spill

c. All materials are to be handled in accordance with their respective MSDS.

3. Material Storage

a. Improper stockpiling of salt and other materials can be responsible for the major portion of environmental problems associated with salt use.

i. Rain and melting snow can carry salt from uncovered piles into the ground and nearby bodies of water and possibly cause chloride build-up.

ii. Clean up of such contamination, should it occur, can cost millions of dollars. Salt piles must be covered.

b. Storage Requirements

i. Section 900, Snow and Ice Control of the Maintenance Administration Manual details specifics of storing various winter maintenance materials.

ii. Basic storage requirements provide for:

a) salt to be stored on an impermeable pad and to be covered,

b) abrasives to be stored in an accessible area and protected from freezing,

c) liquid chemicals are to be stored in a non-corrosive vessel,

d) no wall containment for salt brine, but protection from freezing is needed.

Exercise: Lesson Four Review

1. True or False? Generally, all snow and ice chemicals work the same by depressing the freezing point of water.

2. The effectiveness of a chemical to depress the freezing point of water depends upon the percent of chemical in_____.

3. True or False? Solid chemicals, such as rock salt, must mix with moisture to create brine before it has any melting capabilities.

4. "Dilution of _____" means that as a liquid mixture dilutes that its melting temperature changes.

5. Information on safe material handling is found on the _____ for each chemical used in snow and ice control.