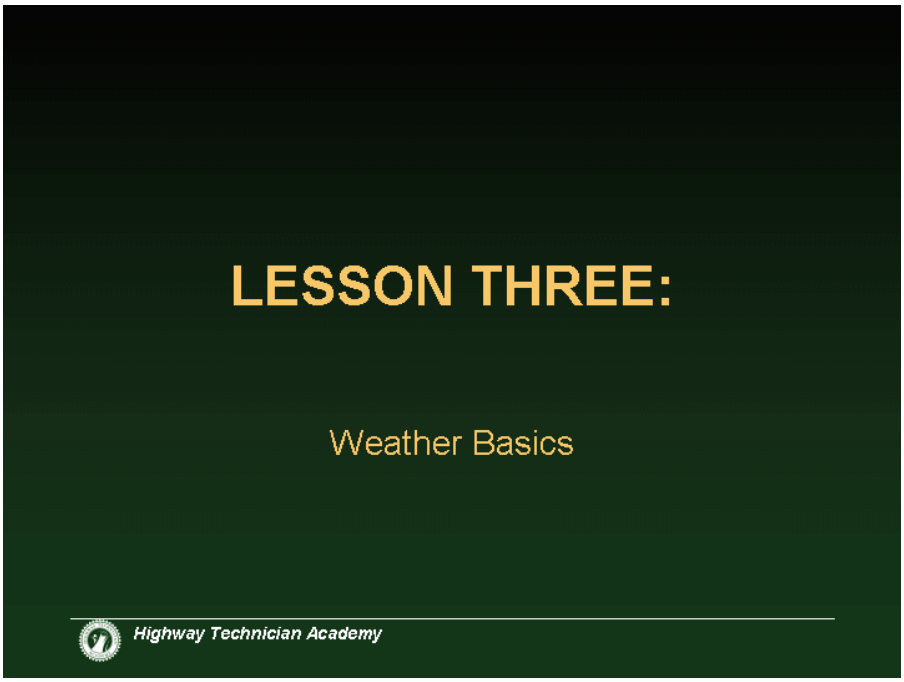
Lesson Three: Weather Basics



A. Understanding the Weather – Weather Forecasting and Pavement Temperatures

1. Basic forecasting issues

a. There are many kinds of weather science and weather forecasting approaches that are used for a variety of purposes

   i. For example, some forecasts for agricultural purposes may focus on long-term trends, such as over a season

b. In snow and ice control we concern ourselves with long term forecasting for general planning

c. When it comes to actual treatment our focus is the short-term forecast

   i. We need to know when an event is likely to occur and what types of changes it is likely to include

      a) For anti-icing or pre-treating the pavement ahead of the storm, we need to know about weather events a couple of days in advance

      b) For treatment during a winter storm we need hourly and minute-by-minute condition updates to stay ahead of the game

2. Forecasting Tools

a. The decision whether or not to initiate a treatment, when to start and what treatment to apply, can only be made if good weather information is available

i. This includes area forecasts such as those available through the National Weather Service and at various internet sites

ii. ODOT's intranet includes this service and provides a variety of weather and surface information

iii. Other forecasting tools frequently used are:

a) local forecasts made available through the local weather stations

b) location specific contract forecasting services

1) A number of the Districts have taken advantage of the contract forecasting services for their specific areas

3. Pavement Temperature

a. Real-time knowledge of the pavement surface is also necessary for making informed decisions on treatment

i. Knowing the pavement temperature and whether the surface is dry or wet are critical pieces of information used in the decision making process

b. Road Weather Information System (RWIS) sensors and frequently-used vehicle mounted temperature sensors accomplish this monitoring and warning function

i. In addition to the real-time monitoring function of RWIS, data obtained from these sensors can be used to generate a forecast of pavement temperature trends and warn when the pavement surface will, or is likely to, drop below freezing

ii. ODOT has employed an extensive RWIS for supplying such information on a statewide basis. Appendix B details ODOT's RWIS.

a) Users can view this data on the Buckeye Traffic web site which includes a variety of atmospheric and pavement related information

b) ODOT also has a number of snow plow units equipped with on board pavement temperature sensors

B. Weather Concepts

1. **Understanding what is occurring with the weather can provide needed insight to comprehending weather forecasts, when the forecast are both accurate and inaccurate**

2. **Winter Event Categories**

    a. The basic categories of winter events that relate to snow and ice control operations and winter road maintenance are:

        i. light snow

        ii. light snow with periods of moderate snow

        iii. moderate to heavy snow

        iv. black ice and frost

        v. freezing rain

        vi. sleet

3. **States of Water**

    a. These winter events, coupled with weather factors such as temperatures, wind and cloud cover can cause various types of road hazards to occur which require winter road maintenance operations

    b. Most types of winter hazards encountered are forms of water

        i. Water has three states:

            a) Gas (or vapor)

                1) Steam is a mixture of gas and liquid

            b) Liquid

                1) Rain drops are liquid

            c) Solid

                1) Ice and snow are both solid forms

    c. Water can change states from one form to the other

        i. Understanding these changes is important to understanding road hazards that occur during the winter

        ii. Under the right set of conditions and circumstances water can change between any of the three states

    d. Those most critical to winter operations include:

i. Melting/Thawing

a) The process of water changing from a solid state (ice or snow) to a liquid (water)

b) This occurs when pavements are de-iced or when the temperatures rise above freezing

ii. Freezing

a) The process of water changing from a liquid (water) to a solid (ice)

iii. Condensation

a) When water changes from a gas state (vapor) to a liquid – the opposite of evaporation

b) Water vapors can condense on the pavement surface; if the surface is below freezing, frost and/or ice will occur

iv. Evaporation

a) When water changes from a liquid to a gas

1) Heat can cause water to evaporate (like steam from a boiling pot)

2) Likewise, the pavement surface can warm up to a point where the water will evaporate

3) Evaporation can also occur on the roadway when traffic or wind causes the air current to swirl on the surface and have a "drying effect"

C. Pavement Temperature and Dew Point

1. The two most critical factors that can produce a winter hazard are pavement temperature and dew point

2. Pavement Temperature

a. Pavement temperature, not air temperature, is the deciding factor for treatment type and duration

i. It is important to know current pavement temperatures and the near-term pavement temperature forecasts to accurately treat snow and ice problems

b. Factors affecting the pavement temperature:

i. Air temperature trends

a) Rising or falling air temperature trends can indicate what the pavement temperatures are likely to do

ii. Subsurface temperatures

a) Warm subsurface temperatures, such as those during the fall, will help the pavement to hold heat and keep the pavement temperature from dropping

b) During the winter and spring the pavement temperatures will drop quicker because the ground is cold

c) In the spring the pavement temperatures can be considerably colder than the air temperature. This can create frost and ice on pavements and bridges.

d) Remember that subsurface factors do not apply to bridge decks – bridge decks will generally cool faster than the pavements because there is no insulation from the ground

iii. Time of day

a) Generally, once the sun goes down the pavement temperature is going to cool

b) Alternately, when the sun beats down on the pavement surface (especially black asphalt) the temperature will rise

iv. Cloud cover

a) This will impact pavement temperatures in ways you may not expect

1) During the daytime cloud cover will cause the pavement surface to be cooler (because the sun is not getting through and beating down on the surface)

2) During the night, the reverse occurs. Without clouds at night the heat escapes and cooling occurs.

v. Wind speed and direction

a) The wind can have a drying effect on a wet pavement and, depending upon its direction, can bring a warm or cold air with it.

1) This, in turn, will affect the air temperature and subsequent pavement temperatures.

Exercise: Pavement Temperature

1. During what season, Fall, Winter, or Spring, does the subsurface hold the most heat?

3. Dew Point

a. The saturation temperature of the air

   i. The dew point represents when the air is fully saturated with moisture; in other words the air is "holding" as much water vapor as it can

b. The dew point is a measure of the moisture in the air

   i. The higher the dew point, the greater the moisture in the air

   ii. The lower the dew point, the drier the air

c. The air temperature is always above or equal to the dew point

   i. When the air temperature is cooled to the dew point, water vapor in the air will condense into either:

      a) a liquid (as warm air that condenses on a cold glass)

      b) a solid (as frost that forms on a cold surface)

4. Effects of Pavement Temperature and Dew Point

a. If we have a very cold roadway surface or bridge deck surface along with air that has cooled to its dew point, black ice or frost can form on the surface

   i. Remember that bridge decks will generally freeze before pavement surfaces because they have no subsurface with retained heat to help keep the surface above freezing

b. Frost and black ice are less likely to occur when conditions are windy

   i. With windy conditions, a mixing of upper and lower air layers occurs. This reduces surface moisture and brings warm air down to the surface.

Exercise: Effects of Pavement Temperature and Dew Point

1. What condition is likely to occur when the dew point is at or above 32° F and the pavement surface is at or below 32° F?

D. Precipitation Types

1. **Precipitation affecting winter road maintenance falls into four main categories:**
    a. Rain
        i. Liquid water drops
    b. Freezing rain
        i. Liquid falling through relatively warm air that freezes on contact with a cold surface
    c. Sleet
        i. Precipitation starting out as rain in warm air that, as it falls, encounters cold air below freezing. Sleet is liquid precipitation that freezes as it falls through the colder air.
    d. Snow
        i. A solid precipitation formed in super-cooled clouds. Very cold clouds or those that are well below 32 degrees form "dry snow" while clouds that are closer to 32 degrees from "wet snow".
2. **A storm can contain a variety of precipitation types.**
    a. The first snow observed in an approaching storm will usually be dry
    b. As the storm nears, the moisture content of the air and clouds increases and the snow becomes wetter
    c. If conditions are warm enough the wet snow may change over to sleet, freezing rain or just rain

E. Winter Weather Road Hazards

1. **Not all winter road hazards are a direct result of occurring precipitation. For example, non-precipitation events include:**

    a. Frost

        i. Occurs when the pavement temperature is below freezing and less than the dew point temperature of the air just above the pavement

        ii. Frost is a light, feathery deposit and is more likely to occur when the following three factors are present:

            a) the wind is calm,

            b) the sky is clear (few, if any clouds)

            c) the pavement temperature is at or below freezing and dips below the dew point

    b. Black ice

        i. Occurs when water droplets (those larger than frost) are deposited on the pavement and have time to spread out in to a thin layer before freezing

        ii. Black ice can also occur with freezing rain or frozen pooled water

    c. Freezing fog

        i. Will greatly reduce visibility and immediately freeze upon contact to any surface that is below freezing

    d. Blowing snow

        i. When strong winds blow snow across the roadway

    e. Storm runoff

        i. Will freeze and refreeze throughout the winter season

    f. Compacted snow

        i. May bond tightly to the road if simply crushed under auto tires (very difficult to melt or plow off)

    g. Slush

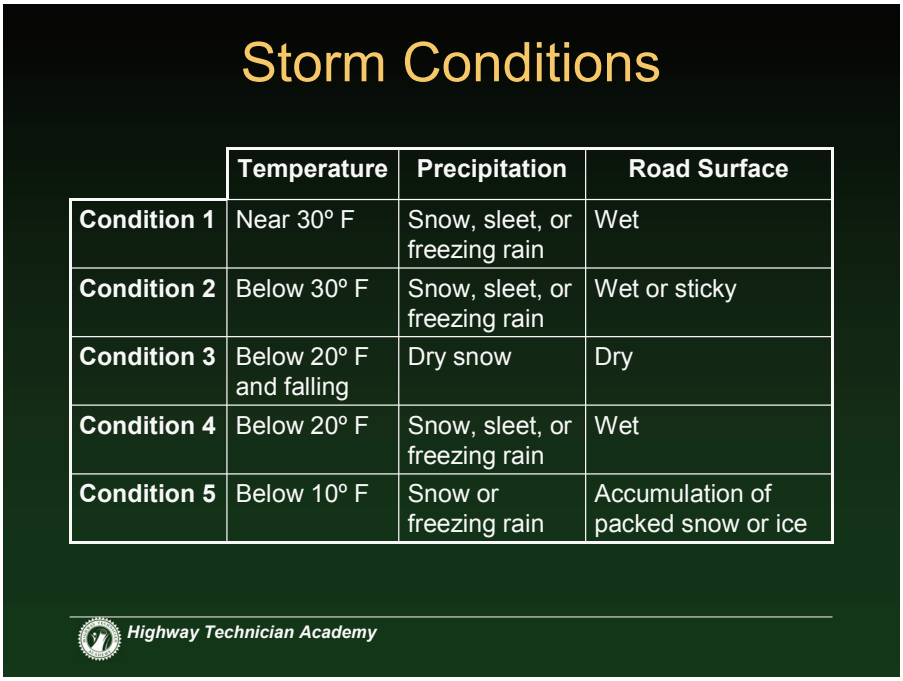
        i. A mixture of water and snow that can be easily plowed off

        ii. Can pose significant driving hazard if not removed

iii. Because slush is very heavy, exercise care when plowing to not damage property and equipment

Exercise: Winter Weather Road Hazards

1. True or False? All winter road hazards require the occurrence of rain or snow.



B. Storm Conditions

1. **According to the National Weather Service** there are 5 basic conditions of winter storms.

    a. Even through they have narrowed it down to 5 storm conditions, the variables in each can have drastic effects on the storm.

    b. Most storms occur under conditions 1, 2, or 3 but 4 and 5 are not that uncommon.

2. **The five categories of basic storm conditions include:**

	Temperature	Precipitation	Road Surface
Condition 1	Near 30° F	Snow, sleet or freezing rain	Wet
Condition 2	Below 30° F	Snow, sleet or freezing rain	Wet or sticky
Condition 3	Below 20° F and falling	Dry snow	Dry
Condition 4	Below 20° F	Snow, sleet or freezing rain	Wet
Condition 5	Below 10° F	Snow or freezing rain	Accumulation of packed snow or ice

3. Changing Conditions

a. The storm can and will change during its course

b. Temperatures may rise overnight instead of falling

c. The type of snow can change from heavy and wet with big flakes to dry and blowing