What are we going to talk about?

- Yeah its good enough!
- What is really going on?
- Do you like doing things the hard way?
When is it time to go to work?

- What do we use to determine when roads will become dangerous?
  - Our Eyes
  - A handheld temperature gun
  - A truck mounted sensor
  - A roadside weather station

Our Eyes

- For most of us they have never let us down
- Tells us what we need to know
- Help us make all sorts of decisions

- Can not tell differences in temperature
- Can not see how slippery something is
- Can be fooled by changes in light, especially at night
Handheld Infrared Gun

- Easy to use! Point and shoot!
- Cheap!
- No training!

- Sensor must be acclimated to environment
- Not originally designed for outdoor use
- Typical accuracy comments:
  - ± 4°F from 32°F to 55°F
  - Assumes ambient operations temperature of 73°F to 77°F
  - One model does not work below 32°F

A Weather Forecast

- All forecasts provide some good information
- Many sources can be compared to gain an understand of confidence
- Forecast needs to focus on impact to your operations
- A simple chance of snow is not as useful as timing and roadway impacts
The Science of Road weather

- Air Above the Pavement
- Sun or Solar Radiation
- Moisture
- Heat Beneath the Pavement

What is really going on?

Thermodynamics 101

- To understand how the air impacts our pavement we must understand how heat transfers from objects.
- Everything in nature is trying to reach a state of equilibrium, the universe loves a balance.
Example

The greater the exposed surface area the faster the change.
Another consideration is the material of the object. A bridge made of metal and concrete transfers heat very well, and therefore accelerates the temperature change.

Density and Composition Impact the Rate of Change.
Misconception of Wind Chill

- Wind Chill Factor was created by meteorologists to give people an idea of how cold it feels outside.
- The wind chill value itself has no meaning to object such as roads and bridges.
- For example, -10°F wind chill will not cool the bridge to -10.

When does the wind impact the pavement?

During times of air temperature change, the wind is blowing in colder temperatures, so the wind can help cool the pavement.
Why is one curve different than the other?

Solar Radiation
Pavement Temp vs. Air Temp

During a typical sunny day the temperature can be rising about 10º every hour, or 1.5 º every 10 min between 7am and Noon.
A brief cloud cover for 30 minutes before Noon could cause a forecast produced at Noon to be off by as much as 8-10º.

Sun in Winter

Even in the middle of January the sun has an affect on our pavement temperature.
Elevation and Pavement

- At higher elevations there is less atmosphere for the sun’s rays to penetrate, so solar heating is greater the higher the elevation.

Moisture

Two Forms are Important to the Pavement
- Water Vapor
- Precipitation
Dewpoint is one of the most important variables to monitor before and during a winter storm.

However, dewpoint is probably one of the least understood concepts in weather, so we will start with a little “Dewpoint 101”.

**Dewpoint**: The temperature to which air must be cooled for saturation to occur.

An Example

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Dewpoint</th>
<th>If you cooled the air</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>

Condensation Occurs!!!

When the temperature reaches the dew point, it causes water molecules in the air to form into water droplets.
The Soda Can Effect

On a hot day when you take a soda can outside the soda can sweats. Why?

Because the soda can is colder than the dewpoint outside.

Air Temperature 88°
Dewpoint 60°
Can temperature 35°

Air around the can is cooled causing water vapor in the air to condense on the can's surface, just like water vapor condensing on dust particles in the air to form clouds.

Why is Dewpoint important?

Dewpoint gives you a measure of how moist or dry an airmass is.

This is a dry airmass

Temp. 30
Dew point 15

This is a moist airmass

Temp. 30
Dewpoint 27

So, the larger the spread between the temperature and the dew point, the drier the air.

When temperature and dew point are the same, relative humidity= 100%, but this does not mean we have precipitation.
Remember that when the temperature and dewpoint are equal at the ground, we have condensation at the ground.

To produce precipitation, we need condensation to occur well above the ground. That is where we need temperature to equal the dewpoint, or where the relative humidity is 100%.

RWIS can be used to show the formation of frost.

Criteria for Frost:

• Recent rain or melting snow
• Clear skies overnight
• Light winds (helps to have southerly direction)

Must haves:

• Pavement temperature must drop below freezing
• Pavement temperature must be equal to or less than dew point.
Black Ice or road frost example from Sioux City
Iowa Spring of 2000.

Why does radar sometimes show snow everywhere but it is not snowing out the window?

One common weather feature that can be misleading to view on Radar is Virga.

What is Virga?

As the snow falls from the clouds it falls into the drier air near the surface which causes the snowflakes to evaporate before they reach the ground.
How does this look on radar?

On Radar, it will appear there is snow nearby, and sometimes it will even look like snow is all around the radar but not at the radar site.

Remember that radar sees moisture. It cannot tell whether it is reaching the ground.
Affects of Precipitation

The harder the rain or snow is falling, the more it increases cooling.
Dew Point and Falling Temps.

- As soon as it begins to rain or snow some of the moisture begins to evaporate.
- Evaporation is a cooling process.
- If the air is dry the evaporation rate is high causing a lot of cooling. (Common in the winter)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Dew point</td>
<td>25</td>
<td>Dew point</td>
<td>29</td>
</tr>
</tbody>
</table>

Pavements will cool faster!

Subsurface Temperature
Uses for Sub-surface Sensor:

The main use for the sub-surface probe is input to the pavement temperature forecast model.

A proper pavement model takes into account the flow of heat both into and out of the pavement, and from both top and bottom.

Sub-surface is key when pavement temperatures are near freezing, especially during late fall and spring snow storms.

With a warm sub-surface, pavement temps may drop at first, but heat under the road will help melt any snow or ice that accumulates.
Do you like doing things the hard way?

Complicated?

- As you can see there are a lot of factors that are trying to influence the pavement temperature and condition.
- Your decision time can be broken into very simple pieces.

Now…and…and Later

- Next few hours
- Beyond that…
Measuring Current Pavement Temperature

Vehicle Mounted Pavement Sensor

Road Weather Information Systems (RWIS)

Road Weather Data

Fixed Road Weather Station

Mobile Weather Sensors
Mobile Weather Sensors

- Extremely popular because of cost and ease of use.
- Allows user to see entire road not just one spot.
  - Basic System is air and pavement temperature
  - Advanced System adds dew point, friction, and road condition.
- Not as accurate as fixed.

Embedded Pavement Sensors

- Placed directly in the road to measure pavement temperature.
- Detects road chemicals and freezing point of solution
- System archives data for later analysis.
Non-Intrusive Sensors

- Non-Intrusive is a very popular method for all road devices.
- In science we call measuring something from a distance remote sensing.
- Benefits of sensors:
  - Lower installation costs/cost to maintain
  - Safer for service and install
  - Accuracy similar to in-road sensors
  - Provides a new value – road friction

Why is friction so important

Friction coefficient

- $\mu = 0.8$ (good condition)
- $\mu = 0.2$ (0.15 mm ice)
What about Later?

Next few hours  Beyond that…

With pavement forecasts we can’t do regional forecasts!
Creating a Pavement Forecast

1. Make a forecast for atmosphere above a road.
2. Input into a pavement model along with:
   - Current pavement trend
   - Subsurface temperature
3. Model then can create a 24-48 hour pavement temperature forecast, knowing everything we just discussed.
Summary

- Develop a plan to make decision making easier.
- Don’t necessarily throughout what you do now!
  - Keep the gun!
  - Keep watching TV forecasts
- Take a look and see where improved weather information can provide you that quick win.
- Train the staff and make sure they have buy in.
- Keep track of your new successes to show higher level or political people in the agency.

- Most of all remember dew point and pavement temperature!

Questions?
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