Providing Safety, Efficiency, and Value with Hydronic Snow Melting
Course Agenda

1. Typical benefits of SIM systems
2. The three most common installation techniques
3. Selection of typical applications
4. The five main design steps
5. Most common control strategies
6. Operating costs

Don’t get stuck!

Lance MacNevin, PPI
Bo DeAngelo, Viega
What is a Hydronic SIM System?

Snow and Ice Melting = SIM

- Hydronic systems designed to melt snow and ice by circulating fluid through tubing embedded in an outdoor surface.
- SIM systems are used across North America in all climates.
- Typical Piping Materials:
  - PEX: Cross-linked Polyethylene
  - PE-RT: Polyethylene of Raised Temperature Resistance
  - PP (polypropylene) pressure pipe and CPVC are also used for supply piping
- Learn more about these materials:
  - http://plasticpipe.org/building-construction/
What Is A Hydronic SIM System?

- SIM systems are not new! See iron and copper manuals from early 1950’s.
Benefits of Hydronic SIM Systems

Why Hydronic SIM Systems?

- Safety, convenience, and savings
- Reduced liability while improving access
- No harsh chemicals
- Access for an aging population, and those with reduced mobility
- Low maintenance cost
- Hydronic SIM operating costs are often lower than mechanical or manual removal.

Courtesy VIEGA LLC
Relevance of Hydronic SIM Systems

- Winters are unpredictable but reliable!
  - Snow coverage across USA – Jan. 18, 2018
  - Image from http://www.intellicast.com/Travel/Weather/Snow/Cover.aspx
Benefits of Snow and Ice Melting Systems

- Better Safety
  - Snow and ice melting systems eliminate hazardous build-up, keeping surfaces clear during snowfall events and evaporating water to prevent freezing.
  - These systems provide better safety for walkers and drivers than mechanical snow removal.
Benefits of Snow and Ice Melting Systems

- Reduced Liability
  - Snow and ice free residences and businesses improves access and safety, while eliminating a source of liability risk in winter.
  - Snowbanks and trip hazards are practically eliminated.
  - Liability insurance premiums might even be reduced, reducing ownership costs.
Benefits of Snow and Ice Melting Systems

- Healthier Convenience
  - The ultimate in snow removal convenience!
    - SIM systems clear outdoor surfaces, leaving them dry.
  - No snow banks are left behind.
  - For residential customers, this eliminates potential health risks of aching backs and heart attacks.

Courtesy Ridgeway Home Services
Benefits of Snow and Ice Melting Systems

- **Lowered Maintenance Costs**
  - Traditional snow removal is very expensive and unpredictable.
  - Facility owners can pay $1,000s per year for labor, equipment, & supplies.
  - Hydronic SIM systems are usually less expensive to operate than mechanical removal.
  - Indoor maintenance costs are reduced by avoiding sand and salt being tracked indoors.

Left: Snow removal equipment and supplies at parking garage

Right: Salt at bank entrance
Benefits of Snow and Ice Melting Systems

Left: SIM system pre-pour

Right: SIM system in operation.
1. No snow storage.
2. Municipality prohibits moving snow into “public right of way”.
3. Environmental concerns over SIM chemicals.
Benefits of Snow and Ice Melting Systems

- Minimized Environmental Impact
  - Hydronic SIM systems are powered by heat sources such as high-efficiency boilers, electricity, solar thermal, geothermal heat pumps, or waste heat (commercial, industrial)
  - They extend lives of surfaces by eliminating scraping, salting, and sanding operations
  - Run-off from deicing chemicals (e.g. salt) onto lawns and drains is eliminated
  - Less fuel is used to power boilers than to power trucks (lower CO₂ emissions)
  - These factors can reduce environmental impacts
Benefits of Snow and Ice Melting Systems

- Long-term Reliability
  - Plastic tubing does not corrode on the inside or outside
  - Hydronic boilers, circulators and piping components are highly reliable
  - With proper design and installation, hydronic SIM systems provide decades of reliable operation with virtually no maintenance to piping systems
  - The piping material for SIM systems is typically PEX, Cross-linked Polyethylene
Benefits of Snow and Ice Melting Systems

Summary of benefits

- Better safety
- Reduced liability
- Healthier convenience
- Lower maintenance costs
- Minimized environmental impact
- Long-term reliability
SIM Installation Techniques

- This section describes three common installation types for outdoor surfaces
  1. Poured concrete
  2. Interlocking pavers
  3. Asphalt

Hydronic snow and ice melting systems can be successfully installed in practically all types* of external surfaces *Permeable concrete is the most difficult surface
SIM Installation Techniques

- **Tubing embedded within poured concrete**
  - In poured concrete, the tubing is simply embedded within the concrete.
  - Very popular for stained concrete
  - Recommended to place the tubing 2 to 3 inches of the surface for faster response time
    (not always practical)
  - Tubing is often stapled directly to the insulation board, or tied to rebar or wire mesh within the concrete pour
  - Some insulation board have integrated “knobs” for holding the tubing,
  - This is a fast and affordable technique for installing SIM piping.
SIM Installation Techniques

- Tubing embedded in concrete

Poured concrete with tubing embedded 2 to 3 inch from top surface
CAD Section of SIM in Concrete

- Plastic Zip Ties
  Note: Place fasteners every 2’ on straight runs and 3 times at each u-turn to hold down any return bends or shapes created.

- Wire Mesh

- Compact Fill Material

- 1/2”, 5/8”, 3/4” ViegaPEX Barrier Tubing

- Tube Spacing (per design)

- 4” Concrete
  Note: Minimum 2” concrete above tubing.

- 1” (R-5) Minimum EPS rigid foam board insulation under slab and along edges recommended or per local code. (Ensure compression rating is suitable for application.)

SNOW MELTING INSTALLATION - CONCRETE
Plastic Zip Ties
SIM Installation Techniques

- **Tubing below interlocking pavers**
  - Plastic tubing is installed above insulation using plastic rails, staples or screw clips.
  - Tubing is encased within 1 1/2 inches of sand bed, compacted to 1 1/8 inches thick.
  - Pavers are placed above sand bed, and installed normally.
  - Technical specifications and drawings of SIM systems with pavers can be found at www.icpi.org

The Media
- Compacted sand bed is recommended.
- Stone dust loses strength when wet, and can heave when frozen.
SIM Installation Techniques

- Tubing installed under interlocking pavers

Pavers installed over sand bed with embedded heating tubing

Courtesy Ridgeway Home Services
CAD Section of SIM in Pavers

Plastic Zip Ties
Note: Place fasteners every 2’ on straight runs and 3 times at each u-turn to hold down any return bends or shapes created.

Compacted Sand or Crushed Stone
Note: Minimum 1 1/2” bed required above tubing.

Wire Mesh
Compact Fill Material
1/2”, 5/8”, 3/4” ViegaPEX Barrier Tubing
Tube Spacing (per design)

1” (R-5) Minimum EPS rigid foam board insulation under slab and along edges recommended or per local code. (Ensure compression rating is suitable for application.)

SNOW MELTING INSTALLATION - PAVERS
Plastic Zip Ties

Note: Crushed stone diameter not to exceed 0.38”
SIM Installation Techniques

- **Tubing installed under asphalt**
  - Plastic tubing is installed above insulation using plastic rails, staples or screw clips.
  - Tubing is encased within 3 inches (7.5 cm) of stone dust or sand media, compacted.
  - Asphalt is placed above the media (dust or sand) and compacted normally.
  - Cold water is flushed through pipes during placement of asphalt and until it cools.
  - Water flow is regulated to be less than 150 °F (65 °C) at the manifold outlet to keep the tubing “cool.”

*Media:* Compacted stone dust works best. No pea stone or crushed gravel.
SIM Installation Techniques

- Tubing installed under asphalt
- Tubing embedded within sand or stone dust below asphalt
CAD Section of SIM in Asphalt

Plastic Zip Ties
Note: Place fasteners every 2’ on straight runs and 3 times at each u-turn to hold down any return bends or shapes created.

Wire Mesh

Compact Fill Material

1/2", 5/8", 3/4" ViegaPEX Barrier Tubing

Tube Spacing (per design)

4” Asphalt

Compacted Sand or Crushed Stone
Note: Minimum 1 1/2” bed required above tubing.

1” (R-5) Minimum EPS rigid foam board insulation under slab and along edges recommended or per local code. (Ensure compression rating is suitable for application.)

SNOW MELTING INSTALLATION - ASPHALT
Plastic Zip Ties

Note: Crushed stone diameter not to exceed 0.38”
**SIM Installation Techniques**

- **Importance of Good Insulation**
  - A significant amount of heat can be conducted to the frozen earth below the SIM surface if appropriate insulation is not installed
  - Without insulation, downward losses can exceed 50% of all the energy supplied to the area (you’d better double the size of heat source and circulators!)
SIM Installation Techniques

- **Importance of Good Insulation**
  - Insulation is typically extruded polystyrene (XPS) or expanded polystyrene (EPS) sheets, or polyurethane (PU) expanding foam sprayed onto existing concrete or the earth.
  - Codes typically require at least R-5 insulation below SIM areas, but many designers specify R-10, since insulation also improves response time.
  - Typical insulation thickness is 1”, 1 ½” or 2”.
  - Be sure insulation is rated for outdoor use and meets compressive loading requirements.
SIM Installation Techniques

Rapid Grid
- EPS Foam
- Attachment system
- Vapor barrier
- Tubing protection
SIM Installation Techniques

- **Importance of Drainage**
  - Slope surfaces for natural drainage
  - Drain to lowest points of the property
  - Control run-off so as not to create hazards
  - Plan locations of trench drains
  - Be sure that drains will not freeze
  - Connect drain to available drain piping system, within code requirements
SIM Distribution Piping

- Distribution piping must be insulated
- Pre-insulated PEX is the preferred method
- Waterproofing must be taken into consideration
- Manifold boxes must be insulated
SIM Distribution Piping

- Distribution piping must be insulated
- Pre-insulated PEX is the preferred method
SIM Distribution Piping

- Waterproofing must be considered
SIM Distribution Piping

- Manifold Boxes must be insulated!
SIM Pitfalls - Don’t do this!
Summary: This section described common installation types for outdoor surfaces.
1. Poured concrete
2. Interlocking concrete pavers
3. Asphalt
4. Distribution Piping & Manifold Boxes
Typical Applications of SIM systems

- This section gives examples of application types

1. Sidewalks
2. Steps
3. Pool decks
4. Driveways
5. Ramps
6. Roads
7. Parking garages
8. Train stations
9. Hangers
10. Aviation
11. Melting “hot pads”
Typical Applications of SIM systems

- Sidewalks
  - Private home
Typical Applications of SIM systems

- Sidewalks
  - Commercial building
Typical Applications of SIM systems

- Sidewalks
  - Hotel
  - Municipal Buildings
Typical Applications of SIM systems

- Sidewalks
  - Hotel – Bus station loading area

Unfortunately, no tubing in the curb.
Typical Applications of SIM systems

Steps
- Public and commercial spaces
Typical Applications of SIM systems

- **Steps**
  - Residential installations

[Images: Courtesy Klimatrol and Courtesy Ridgeway Home Services]
Typical Applications of SIM systems

- Pool decks
  - Facilitates winter access
  - Tubing can also be used to extract heat from surface in summer, to cool the deck
  - Same heat can be “pumped” back into the pool
Typical Applications of SIM systems

- Driveways
  - Under stained concrete or pavers

Courtesy Klimatrol

Courtesy Ridgeway Home Services
Typical Applications of SIM systems

- Driveways
  - Under asphalt
Typical Applications of SIM systems

- Driveways
  - Complicated shapes and patterns
Typical Applications of SIM systems

- Ramps
  - Pedestrian and vehicle ramps
Typical Applications of SIM systems

- Hanger doors and aprons
  - Prevent sliding doors from freezing

Courtesy VIEGA LLC
Typical Applications of SIM systems

- Melting Hot Pads
  - What to do with all that snow?
  - Build a hydronic SIM system with drainage.
  - Push snow onto the “hot pad” or “melting pad”, and melt away
  - Just like a Zamboni melting pit!

- Drainage is essential
- May need to “mix” the pile

- Critical in congested cities and most commercial facilities
Typical Applications of SIM systems

Summary: typical applications for SIM systems

1. Sidewalks
2. Steps
3. Pool decks
4. Driveways
5. Ramps
6. Roads
7. Parking garages
8. Train stations
9. Hangers / Aviation
10. “hot pads” = OUTSIDE THE BOX!
SIM Design Steps

Melting snow and ice is essentially a three-step process:
1. Warm the snow or ice to the melting temperature by applying 0.51 Btu/lb
2. Melt the snow into cold water; the latent heat of fusion for melting is 144 Btu/lb
3. Evaporate the water (or let it drain – uses less energy)
SIM Design Steps

SIM heat loss is based on several factors:

- Slab temperature at start of snowfall
- Air temperature when snowing/melting
- Rate of snow fall
- Snow density
- Wind velocity
- Apparent sky temperature
- Humidity level of the atmosphere

These issues must be taken into account when predicting SIM loads
SIM Design Steps

- Set appropriate performance
- Determine required heat output
- Size (and select) heat source
- Plan, layout, and draw piping design
- Size and select hydronics
- 1-5 to make customer happy
SIM Design Steps

- Set the Appropriate Performance Level
  - ASHRAE HVAC Applications “Ch. 51 Snow Melting and Freeze Protection” includes tables showing Frequencies of snow-melting surface heat fluxes at steady state conditions for major US cities
    - For cities not found in that table, a series of 14 calculations can be used to estimate the loads based on historical weather data for that location
  - In principle, the designer and customer agree to the most appropriate Snow-Free Area Ratio and Frequency Distribution for the system
  - Then, the specific heat loads can be selected from the published data, weather research or case studies
  - Essentially, **the customer gets to select how capable the system shall be!**
SIM Design Steps

- Set the Appropriate Performance Level
  - ASHRAE HVAC Applications “Ch. 51 Snow Melting and Freeze Protection” provides relevant information for US cities for these calculations
  - (with some assumptions)
    - For other cities, designers can select a similar city from the Table or do detailed calculations

Courtesy Thornton Plumbing & Heating
### SIM Design Steps

- Select the Appropriate Performance Level
  - ASHRAE HVAC Applications “Ch. 51 Snow Melting and Freeze Protection”
  - See excerpt below for Colorado Springs, CO:

<table>
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<th>Location</th>
<th>Snowfall Hours per Year</th>
<th>Snow-Free Area Ratio $A_f$</th>
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<th>$90%$</th>
<th>$95%$</th>
<th>$98%$</th>
<th>$99%$</th>
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<td>112</td>
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</table>
SIM Design Steps

- Select the Appropriate Performance Level

Snow-Free Area Ratios:

- Ar = 1.0  Snow-Free Area of 100%
  No accumulation during snowfall

- Ar = 0.5  Snow-Free Area of 50%
  Some accumulation during snowfall

- Ar = 0.0  Snow-Free Area of 0%
  Surface may be covered with snow during heavy snowfall, melting snow from the bottom of the layer

Ex: Ar = 0.5 is 50% snow-free during snow fall
Snow will be completely melted, evaporated and dried before system turns off
SIM Design Steps

- Set the appropriate Confidence Level
- A 95% system in Colorado, with a Snow Free Area Ratio of 1 will perform as follows:
- 100% of area will be snow free 95% of the time
  - For 151 hours the area is snow free (95% of 159 hours)
  - Of that remaining 5%, or approximately 8 hours:
    - Some build up for approximately 5 hours (159 * 3%) (98%)
    - For approximately 1.5 hours snow will accumulate on the slab to a thickness at which the snow blanket insulates the slab, but the thickness will not increase beyond that level. Snow melts on the underside of the blanket at the same rate at which the snow is falling (159 * 1%) (99%)
    - For approximately 1.5 hours the system cannot keep up with the snowfall, build up may occur (159 * 1%) (100%)

AHR 2019_RPA Educational Session
SIM Design Steps

- Select the Appropriate Performance Level
  - Suggested Performance Levels:

<table>
<thead>
<tr>
<th>SIM Application Type</th>
<th>Free Area Ratio (Ar)</th>
<th>Frequency Distribution (%)</th>
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<tbody>
<tr>
<td>Residential Sidewalk, Steps</td>
<td>0.5 or 1.0</td>
<td>75 or 90</td>
</tr>
<tr>
<td>Residential Driveway</td>
<td>0.0 or 0.5</td>
<td>75 or 90</td>
</tr>
<tr>
<td>Commercial Sidewalk, Steps</td>
<td>1.0</td>
<td>90 to 95</td>
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<tr>
<td>Commercial Parking Lot</td>
<td>0.5</td>
<td>75 or 90</td>
</tr>
<tr>
<td>Commercial Parking Ramp</td>
<td>0.5 to 1.0</td>
<td>90 to 95</td>
</tr>
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<td>School Sidewalk, Steps, Ramp</td>
<td>1.0</td>
<td>90</td>
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<td>School Parking Lot</td>
<td>0.5</td>
<td>90</td>
</tr>
<tr>
<td>Fire/Rescue Station Vehicle Ramp</td>
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<td>98 to 99</td>
</tr>
<tr>
<td>Hospital Sidewalk, Steps, Ramp</td>
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<td>98 to 99</td>
</tr>
<tr>
<td>MediVac Landing Pad</td>
<td>1.0</td>
<td>99</td>
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</table>

Note:
These are courtesy suggestions to help gauge and manage customer expectations.

Each customer should decide and confirm what is expected for their project.
SIM Design Steps

- Select the Appropriate Performance Level
- Sample heat flux values (for a climate similar to Boston, MA):

<table>
<thead>
<tr>
<th>SIM Application Type</th>
<th>Free Area Ratio (Ar)</th>
<th>Frequency Distribution (%)</th>
<th>Required Heat Flux (Btu/hr-ft²)</th>
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<td>75 or 90</td>
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<td>Residential Driveway</td>
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<td>40 to 100</td>
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<td>Commercial Sidewalk, Steps</td>
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<td>Commercial Parking Lot</td>
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<td>65 to 100</td>
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<td>Commercial Parking Ramp</td>
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<td>School Sidewalk, Steps, Ramp</td>
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<td>90</td>
<td>125</td>
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<tr>
<td>School Parking Lot</td>
<td>0.5</td>
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<td>100</td>
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<tr>
<td>Fire/Rescue Station Vehicle Ramp</td>
<td>1.0</td>
<td>98 to 99</td>
<td>200 to 225</td>
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<tr>
<td>Hospital Sidewalk, Steps, Ramp</td>
<td>1.0</td>
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<td>200 to 225</td>
</tr>
<tr>
<td>MediVac Landing Pad</td>
<td>1.0</td>
<td>99</td>
<td>225</td>
</tr>
</tbody>
</table>
SIM Design Steps

- Select the Appropriate Performance Level
  Design Example: Parking Ramp in Albany, NY
  - Melting area: 1,000 ft² Garage ramp
  - Construction: 6 in. poured concrete over insulation
  - Owner requests panel to be:
    - 100% snow-free during 90% of snowfall events
      - Owner agrees that in more severe weather, performance will be adequate
        - $A_r = 1.0$ @ 90% frequency distribution
  - This system will be 100% snow-free during 90% of expected snowfalls
  - Various levels of accumulation in heavier snowfalls
SIM Design Steps

Design Example: Albany, NY (a wintery place)
SIM Design Steps

- Determine Required Heat Output: Melting Operation
  - Use ASHRAE Table 1 to find the “heat flux” (load) based on Ar = 1.0 and 90%
  - Table 1 shows 125 Btuh/ft² as the required output
SIM Design Steps

- Determine Required Heat Output: Melting Operation
  - Must also anticipate 20% downward loss: 125 x 1.2 = 150 Btuh/ft²
  - Required output is 150 Btuh/ft²
SIM Design Steps

- Determine Required Heat Output: Pick-up Energy
  - Each time the SIM system starts, the ramp temperature must be “picked-up” from cold start (or idle start) to the melting temperature, typically 38 °F*
  - Weather data provides “cold start” temperature for the location
    - For Albany it’s 18 °F on average
  - Consider the pick-up load when sizing the heat source

- Example:
  - Albany ramp is 6 in. thick concrete and requires 15 Btu per ft² per °F based on the “specific heat” of concrete of 0.23 Btu/lb-°F
  - *38 °F is the average temperature of the concrete slab during melting allow for losses due to wind, to avoid striping, etc.
SIM Design Steps

- Determine Required Heat Output: Pick-up

  - Albany ramp is 6 in. thick concrete and requires 15 Btu per ft² per °F based on the “specific heat” of concrete of 0.23 Btu/lb-°F

  - Pick-up Delta T is Melting Temperature - Cold Start Temperature (18 °F for Albany)
  
  Pick-up Delta T is 38 °F - 18 °F = 20 °F (based on averages)

Example:

- 1,000 ft² x 20 °F x 15 Btu per ft² per °F x 1.15 = 345,000 Btu (the pick-up load)
  - 1.15 is included to add 15% energy for downward and edge losses during the warming period (ASHRAE recommendation)

- This value - 345,000 Btu - will be used when estimating operating costs (later)
SIM Design Steps

- Select and Size Heat Source
  - Total load: 1,000 ft$^2$ x 150 Btuh/ft$^2$ = 150,000 Btuh required output
  - This is the total heat load for sizing the source, circulator, and piping network

- Heat source options:
  - **Dedicated** boiler sized for this load
  - **Shared** boiler sized for the SIM load plus heating loads or swimming pool or radiant heating
    - Be sure the SIM portion contains glycol antifreeze
  - Approved combiheater unit
  - **Geothermal** water-to-water heat pump
  - Waste heat from industrial processes
  - Rejected heat from commercial cooling system

This system will use a dedicated boiler
SIM Design Steps

Design the Piping Distribution System

The designer has several options:

a. Tube size (3/4 NTS tubing is typical; 1/2 and 5/8 tubing is sometimes used)
b. Tube spacing (6 to 9 inch tube spacing is typical, based on width of area)
c. Tube circuit lengths (150 ft. to 300 ft. circuit length is typical, but this is based on load, tubing size, heated area and the selected circulator)

Poured concrete with tubing embedded 2 in. to 3 in. from top surface is ideal for faster response time.
SIM Design Steps

Design the Piping Distribution System

The designer selects:

a. \( \frac{3}{4} \) Tube size
b. 9 inch o/c spacing (works well with 6x6 mesh)
c. 250 ft. circuit lengths (to keep head loss low)

Poured concrete with tubing embedded 2 in. to 3 in. from top surface is ideal for faster response time.
SIM Design Steps

- Design the Piping Distribution System
  - Chosen design uses ¾ tubing @ 9 in. spacing
  - Viega recommends a multiplier of 1.5 for 9” spacing to allow for return bends
    - 1,000 ft² x 1.5 ft. tubing per ft² = 1,500 ft. of tubing total requirement
    - Divide the 1,500 ft. total length into 6 equal circuits:
      - 1,500 ft. ÷ 6 Circuits = 250 ft/circuit (each circuit covers 167 ft²)
    - Heat load per circuit: 150,000 Btuh ÷ 6 = 25,000 Btuh per circuit (peak load)
SIM Design Steps

- Design the Piping Distribution System

- Tubing layout will have 6 equal circuits, each delivering up to 25,000 Btuh, through a nearby manifold

- Using 50% PP Glycol and a 25°F ΔT:

  - \[ 150,000 \text{ Btuh} = 13.6 \text{ GPM flow rate (2.2 GPM/circuit)} \]

  - \[ \frac{11,030^* \text{ Btu/GPM}}{} \]

  *Capacity of 50% pp glycol; work not shown

- This info can be used to determine head loss through the piping network using the PPI Plastic Pressure Pipe Design Calculator
SIM Design Steps

- Design the Piping Distribution System
  - Evaluate head loss with 2.2 GPM in ¾ PEX or PE-RT, 250 ft. circuits
  - PPI Plastic Pressure Pipe Design Calculator [www.plasticpipecalculator.com](http://www.plasticpipecalculator.com)
  - Head loss @ 60 °F is 18 feet (velocity is 2.0 ft/s) in the distribution pipes
SIM Design Steps

- Perform Hydronic Calculations
  - Size heat source piping, circulator, valves, etc. around this flow requirement
  - Size expansion tank considering large range of temperatures
  - Size the piping to the manifold to minimize head loss (probably 1 ¼ inch size)
  - Calculate head loss through each component that is in series to determine the total head loss value for selecting circulator

Example data for sizing circulator:
13.6 GPM flow rate (from previous)
@ 25 ft head loss (this math not shown)
SIM Design Steps

Summary: This Learning Objective introduced the five main design steps

1. Select the appropriate performance requirement
2. Determine the required heat output
3. Select and size heat source to meet the load
4. Design the distribution system in terms of size, spacing and layout
5. Perform hydronic calculations for sizing equipment such as circulator pumps, expansion tanks, etc.

All equipment can be accurately sized based on these steps
Control Strategies

This section discusses three types of control strategies:

**On/Off** – System turns on with moisture + cold, turns off when dry
- The most economical in terms of annual operating costs
- May be fully automatic, timed, or use outdoor moisture sensor

**Idle/Melt** – Idles when dry + cold, heats up with moisture + cold
- Reduces response time to start melting
- Consumes much more energy to stay warm in between events

**Always On** – Constantly keeps outdoor surface warm, always ready to melt
- Electronic control will monitor supply/return fluid temperatures to modulate the fluid temperature and the heat output, as needed
Control Strategies

- **On/Off** – System turns on with moisture + cold, turns off when dry
  - Cold start each time there is snow or ice
  - A “semi-automatic” control provides electronic slab temperature control with fluid temperature modulation, starting with human initiation

- **Pros**
  - “Semi-automatic” controls lower capital cost, good for residential systems
  - A “fully automatic” control with moisture and temperature detection operates autonomously, provides lots of tuning possibilities

- **Cons**
  - With “semi-automatic”, a human needs to turn it on and set the timer
  - Can underperform if not operated correctly, can waste energy if overused
Control Strategies

- **Idle/Melt** – Idles when dry + cold, heats up with moisture + cold
  - Reduces response time to start melting operation
  - Typical idle temperature is 28°F (-2°C); adjustable
  - Typical melting temperature is 38°F (4°C); adjustable
  - Can program “cold weather cut-off” to prevent heating when it’s too cold.

- **Pros**
  - Reduces response time to start melting
  - Avoids heat/cool cycles for delicate outdoor surfaces

- **Cons**
  - Idling consumes much more energy to stay warm in between snow events
  - May increase annual energy consumption by 4 to 8 times when Idling
Control Strategies

- **Always On** – Constantly keeps outdoor surface warm, always ready to melt
  - Electronic control can monitor outdoor surface temperature and modulate the fluid temperature and the heat output, as needed, to keep surface warm
  - May be suitable when the SIM load is a fraction of the total building heat load
    Ex: Entrance to a hospital, sidewalk in a university campus

- **Pros**
  - Always ready, ultimate safety
  - Avoids complexity of controls
  - Great way to reject process heat or excess building heat in winter
  - Warm sidewalks feel good in winter!

- **Cons**
  - Always using energy
Control Strategies

- “Smart” controls with weather anticipation, high-end residential & commercial
  - PC-based systems tie into National Weather Service or Environment Canada to predict incoming snow and activate before the first snow falls (if programmed)
  - Computer uses outdoor moisture sensors or optical sensors
  - May be programmed to start warming SIM area before forecasted snowfall
  - Several manufacturers offer these controls
Control Strategies

- Moisture and temperature sensors are installed in ramps, sidewalks, driveways

Sensor socket before concrete

Sensor within a ramp

Sensor close-up
Control Strategies

- Moisture and temperature sensor placement recommendations:
  - Install in the first area to be hit with blowing or falling snow
  - The last place to be warmed by the sun
  - Last place to be dried due to drainage
  - Align sensor surface parallel to the slope of the surface
  - Brush off sand and dirt regularly

- Avoid placing sensors:
  - Under parked cars
  - In vehicle tire tracks
  - In protected areas

Sensor height aligned with finished grade
Control Strategies

- This section discussed three types of control strategies
  - Plus smart web-based controls, or “apps”
  - There are many specific options available from experienced firms
Comments on Operating Costs

This section discusses methods to estimate SIM operating costs.

The math is simple if you can predict or estimate:
- Location
- Melting area (of the surface)
- Annual hours of operation (melting)
- Number of events (for pick-up loads)
- Annual hours of idling (not operating)
- Heat flux/load during operation
- Heat flux/load during idling
- Fuel type
- Fuel cost
- Efficiency of heat source
Comments on Operating Costs

Example: 1,000 ft$^2$ ramp in Albany, NY. On/off operation (no idling)

- Location: Albany, NY
- Melting area: 1,000 ft$^2$ (92 m$^2$)
- Annual hours of operation: 156 hours of snowfall
- Number of events: 20 times (assumption)
- Annual hours of idling: no idle
- Heat flux/load during operation: 150 Btu/hr-ft$^2$ (max.)
- Heat flux/load during idling: no idle
- Fuel type: Natural gas
- Fuel cost: Approximately $0.50/Therm (see next slide)
- Efficiency of heat source: 95% AFUE boiler
Comments on Operating Costs

- Example: 1,000 ft² ramp in Albany, NY. On/off operation (no idling)

Energy Cost
- 1 Therm = 100,000 Btu by definition
- Cost per Therm varies by utility, customer and month
- Cost per Therm does not include all connection/distribution fees
- $0.50/Therm is an estimate based on several sources – use local pricing!
Comments on Operating Costs

Example: 1,000 ft² ramp in Albany, NY. On/off operation (no idling)

Part 1: Energy Demand
- Operation: 156 hours x 150 Btu/hr-ft² x 1,000 ft² = 23,400,000 Btu/year
- Pick-up: 20 events x 345,000 Btu/event = 6,900,000 Btu/year
- Total Annual Load: 23.4 + 6.9 = 30.3 million Btu/year

Part 2: Cost of Energy Produced
- Fuel cost: $0.50/Therm
- Efficiency of heat source: 95% AFUE boiler
- Energy Content of gas: 100,000 Btu
- Cost per 1 million Btu = $0.50/Therm \times \frac{100,000 \text{ Btu}}{\text{Therm}} \times 95\% \times 1 \text{ million } = \$5.20 \text{ per million Btu produced}
Comments on Operating Costs

- Part 3: Annual Cost Estimate
  - 30.3 million Btu/year x $5.20 per million Btu produced = $160/year in fuel costs

Based on stated assumptions and estimates

Other control strategies can affect cost
Ex: Idling the ramp between snowfalls

Electrical costs for heat source and circulator not shown, but these are minor in comparison

Disclaimer: Predicting the weather a week in advance is difficult, so predicting an entire season with high accuracy is impossible. Therefore, every effort is made to explain assumptions based on known or assumed data, using historical averages.
Comments on Operating Costs

- Part 3: Annual Cost Estimate
  - 30.3 million Btu/year x $5.2 per million Btu = $160/year in fuel costs
  - Compare with typical contracting costs for mechanical snow removal plus frequent sanding and salting (and the inconvenience and cost of snow banks left behind)
    - Estimates are $2,000 for annual snow removal costs via plowing
    - $160 vs. $2,000 = 90% cost savings
  - Plus, the SIM system is automatic and is always on time!
Comments on Operating Costs

- Summary: This section explained methods to estimate operating costs
  - $160 vs. $2,000 (quoted snow removal cost) is a 90% reduction on annual costs
  - All the benefits and safety, plus saving costs for the owners

Courtesy Thornton Plumbing & Heating
Course Summary

This course covered:

1. Typical benefits of SIM systems
2. The three most common installation techniques
3. Selection of typical applications
4. The five main design steps
5. Most common control strategies
6. Operating costs
Operating Costs

2 CASE STUDIES
Residential
Snow melt comparison

Residential
- Gas price: $0.52/therm
- Output [Btu/sqft/year]
  - Operation: 7,089*
  - Idle: 96,847*
  - Startup: 330
- 9,000 SqFt
- 1,200,000 Btu
- 167 Btu/sqft (including back-loss)
- $213,000 install cost
- $23.70/SqFt
- Ar = .5, Confidence 95%

Commercial
- Gas price: $0.50/therm
- Output [Btu/sqft/year]
  - Operation: 11,137*
  - Idle: 97,060*
  - Startup: 64
- 1,800 SqFt
- 300,000 Btu
- 202 Btu/sqft (including back-loss)
- $26,000 install cost
- $14.44/SqFt
- Ar = 1, Confidence 98%

*From ASHRAE 50.9, T3
Residential In Denver

9000 SqFt

- $386 manual removal per snow event
- with deicer
- $520/year + $16.50 per snow event
- $4045/year to idle SIM
Light Commercial In Denver

1800 SqFt

- $87 manual removal per snow event
- with deicer
- $101/year + $3.21 per snow event
- $889/year to idle SIM
Residential In Aspen

9000 SqFt

- $386 manual removal per snow event
- with deicer
- $520/year + $16.05 per snow event
- $4566/year to idle SIM
Light Commercial In Aspen

1800 SqFt

- $87 manual removal per snow event
- with deicer
- $101/year + $3.21 per snow event
- $889/year to idle SIM
Return on Investment - Summary of system comparisons

Residential SIM in Aspen, CO
- System Investment: $213,000
- 30yr Manual Cost: $356,864
- Gross “Profit”: $11,862/yr
- ROI (30 years): 67%
- ROI (annual rate of return) 5.6%

Commercial SIM in Denver, CO
- System Investment: $26,000
- 30yr Manual Cost: $37,177
- Gross “Profit”: $1,240/yr
- ROI (30 years): 43%
- ROI (annual rate of return) 4.3%
Questions?