Design and Installation of Hydronic Snow and Ice Melting (SIM) Systems to Optimize Performance and Efficiency
Introduction

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- Graduated UNB 1992
- Working in the hydronics industry since 1993
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Introduction to the Plastics Pipe Institute

PPI is a non-profit trade association representing the plastic pipe industry
- PPI’s five divisions focus on solutions for multiple applications:
  - Building & Construction Division (BCD)
  - Corrugated Plastic Pipe Association (CPPA)
  - Energy Piping Systems Division (EPSD)
  - Municipal & Industrial Division (MID)
  - Power & Communications Division (PCD)

PCD: HDPE Conduit for fiber optic
EPSD: Gas distribution piping
MID: HDPE water mains
Introduction to the Plastics Pipe Institute

PPI’s Building & Construction Division (BCD)
- BCD is focused on plastic pressure pipe and tubing systems used within buildings and on building premises for applications such as plumbing, water service, fire protection, hydronic heating and cooling, snow and ice melting and ground source geothermal piping systems: PEX, CPVC, PE-RT, PP-R
- BCD is involved with many industry groups:
What Is A Hydronic SIM System?

- **Snow and Ice Melting** (SIM) systems are hydronic systems designed to remove snow and ice by circulating a heat transfer fluid through tubing installed in an outdoor surface.

- SIM systems are used across North America in all climates.

- The piping material for SIM systems is typically:
  - PEX: Crosslinked Polyethylene (see CSA B137.5)
  - PE-RT: Polyethylene of Raised Temperature resistance (see CSA B137.18)
  - PP-R: Random Copolymerized Polypropylene (see CSA B137.11)
  - Type K soft copper tubing

- Learn more about these materials at [http://plasticpipe.org/building-construction/](http://plasticpipe.org/building-construction/)
Relevance of Hydronic SIM Systems

1. The safety, convenience and savings provided by a SIM system are more beneficial than ever, as changing weather patterns increase snowfall in many regions
2. Clearing slippery outdoor surfaces over a long winter is a high maintenance cost and involves the expense of harsh chemicals which can damage surfaces
3. Aging populations need access to services, yet may have limited mobility
4. Snow and ice melting systems can reduce liability while improving access
5. Operating costs for a hydronic SIM system are often much less than mechanical snow removal, saving facility owners money while reducing risks
Relevance of Hydronic SIM Systems

Annual snowfall data for **Toronto 1995-2016** shows blips, not trends
- Winters are unpredictable but reliable
- Data at [https://toronto.weatherstats.ca/metrics/snow.html](https://toronto.weatherstats.ca/metrics/snow.html)
Course Outline

This course will:

1. Indicate the typical benefits of SIM systems
2. Describe the three most common installation techniques
3. List a selection of typical applications
4. Introduce the five main design steps
5. Discuss the most common control strategies
6. Comment on operating costs
1. Benefits of Snow and Ice Melting Systems

This section will explain at least six benefits of SIM systems:

- Better safety
- Reduced liability
- Healthier convenience
- Lowered maintenance costs
- Minimized environmental impact
- Long-term reliability
Benefits of Snow and Ice Melting Systems

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

**Reduced Liability**
- Keeping residences and businesses free of snow and ice 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

*Bus station loading area.*

*Unfortunately, no tubing in the curb.*
Benefits of Snow and Ice Melting Systems

Healthier Convenience
- For 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 $10,000s 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 getting tracked inside
Benefits of Snow and Ice Melting Systems

Minimized Environmental Impact
- Hydronic SIM systems are powered by heat sources such as high-efficiency boilers, electricity, thermal solar, geothermal heat pumps or waste heat (commercial, industrial)
- They extend lives of surfaces by eliminating scraping, salting and sanding operations
- Run-off of 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**: Crosslinked Polyethylene (see CSA B137.5)
  - **PE-RT**: Polyethylene of Raised Temperature resistance (see CSA B137.18)
  - **PP-R**: Random Copolymerized Polypropylene (see CSA B137.11)
Benefits of Snow and Ice Melting Systems

Summary: Typical benefits include

- Better safety
- Reduced liability
- Healthier convenience
- Lowered maintenance costs
- Minimized environmental impact
- Long-term reliability
2. 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 in. (5 - 8 cm) below the surface for faster response time (this is not always practical)
- Tubing is often stapled directly onto the insulation board or tied to rebar or wire mesh within the poured structural concrete
- Some insulation board has the integrated “knobs” for holding the tubing
- This is a simple and affordable technique for installing SIM piping
SIM Installation Techniques

Tubing embedded within poured concrete

Poured concrete with tubing embedded 2 to 3 inch from top surface
SIM Installation Techniques

Tubing embedded within poured concrete

Poured concrete with tubing embedded 2 to 3 inch from top surface

Courtesy Ridgeway Home Services
SIM Installation Techniques

Tubing installed under interlocking pavers

- Plastic tubing is installed above insulation using plastic rails, staples or screw clips
- Tubing is encased within 1 1/2 in. (4 cm) of sand bed, compacted to 1 1/8 in. (3 cm)
- 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

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
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 in. (7.5 cm) of stone dust or sand media, compacted
- Asphalt is placed above the media 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:** Compact 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
SIM Installation Techniques

Importance of 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 (so double the size of heat source and circulators!)

= Tubing filled with warm glycol

Bottom Insulation
SIM Installation Techniques

Importance of Insulation
- Insulation may be extruded polystyrene (XPS), polyurethane (PU), or expanding foam that is sprayed onto existing concrete or the earth to follow contours
- CSA B214-16 requires 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 in., 1 ½ in. or 2 in. (25 mm, 38 mm, 50 mm)
- Be sure the insulation is rated for outdoor use and meets the expected compressive loading from vehicles, or settling can occur
SIM Installation Techniques

Importance of Insulation

Courtesy Viega LLC
SIM Installation Techniques

Summary: This section described three installation types for outdoor surfaces

1. Poured concrete
2. Interlocking concrete pavers
3. Asphalt

Images Courtesy REHAU
3. Typical applications of SIM systems

This section gives examples of application types

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

Sidewalks
- Private home
Typical applications of SIM systems

**Sidewalks**
- Commercial building

*Courtesy Zurn*
Typical applications of SIM systems

**Sidewalks**
- Municipal building
- University (handicapped parking)

*Courtesy Klimatrol*
Typical applications of SIM systems

Sidewalks
- Hotel
Typical applications of SIM systems

Steps
- Public and commercial spaces

Courtesy REHAU

Courtesy NIBCO
Typical applications of SIM systems

Steps
- Residential installations

Courtesy Klimatrol

Courtesy Ridgeway Home Services
Typical applications of SIM systems

Driveways
- Under stained concrete or pavers

[Images of driveways with text: Courtesy Klimatrol, Courtesy Ridgeway Home Services]
Typical applications of SIM systems

Driveways
- Under stained concrete or pavers

Courtesy Klimatrol
Typical applications of SIM systems

Driveways
- Under stained concrete or pavers

Courtesy Thornton Plumbing & Heating
Typical applications of SIM systems

Ramps
- Pedestrian and vehicle ramps
Typical applications of SIM systems

Ramps
- Pedestrian and vehicle ramps
Typical applications of SIM systems

Roadways
- SIM systems add safety with steep inclines

Courtesy REHAU
Typical applications of SIM systems

Parking garages
- SIM in the inclined ramps and in exposed levels of ramps
Typical applications of SIM systems

Hanger doors and aprons
- SIM prevents sliding doors from freezing

Courtesy VIEGA LLC
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

Train stations
- Add safety and convenience to outside train stations and platforms
Typical applications of SIM systems

Aviation
- Train tracks at airports
Typical applications of SIM systems

**Aviation**
- Medivac landing pads
Typical applications of SIM systems

Aviation
- Ramps, taxiways, runways

YYZ Pearson does not have a SIM system!
Fleet of scrapers, blowers, melters, and fuel trucks
Typical applications of SIM systems

Aviation
- Alternative…
Typical applications of SIM systems

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

- Critical in cities and commercial facilities
Typical applications of SIM systems

Summary: This section listed examples of applications

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

Melting snow is basically 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. **Evapourate** the water (or let it drain off)
SIM Design Steps

SIM heat loads are 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

This section will introduce the five main design steps

1. Select the appropriate performance level for the customer
2. Determine the required heat output/heat flux
3. Select and size heat source to meet the peak load
4. Design the piping distribution system in terms of size, spacing, circuit lengths
5. Size hydronic equipment such as circulator pumps, expansion tanks, etc.
SIM Design Steps

1. Select 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
- The designer and customer agree to the most appropriate Snow-Free Area Ratio and Frequency Distribution
- Then, the specific heat loads can be selected from the published data, weather research or case studies
SIM Design Steps

1. Select 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)
- Designers can pick a similar Canadian city and use the Table
- Historical Weather Data found at http://climate.weather.gc.ca/index_e.html

Courtesy Thornton Plumbing &
1. Select the Appropriate Performance Level

- **ASHRAE HVAC Applications** “Ch. 51 Snow Melting and Freeze Protection”
- See excerpt below for Madison, WI:

<table>
<thead>
<tr>
<th>Location</th>
<th>Snowfall Hours per Year</th>
<th>Snow-Free Area Ratio, ( A_r )</th>
<th>75%</th>
<th>90%</th>
<th>95%</th>
<th>98%</th>
<th>99%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexington, KY</td>
<td>50</td>
<td>1</td>
<td>81</td>
<td>108</td>
<td>123</td>
<td>150</td>
<td>170</td>
<td>233</td>
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<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>49</td>
<td>65</td>
<td>74</td>
<td>85</td>
<td>95</td>
<td>197</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>16</td>
<td>30</td>
<td>39</td>
<td>46</td>
<td>55</td>
<td>162</td>
</tr>
<tr>
<td>Madison, WI</td>
<td>161</td>
<td>0.5</td>
<td>99</td>
<td>138</td>
<td>164</td>
<td>206</td>
<td>241</td>
<td>449</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>0</td>
<td>61</td>
<td>82</td>
<td>98</td>
<td>129</td>
<td>163</td>
<td>245</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>39</td>
<td>60</td>
<td>91</td>
<td>113</td>
<td>194</td>
</tr>
</tbody>
</table>

- **Frequency Distribution** makes sense, but what about **Snow-Free Area Ratio**?
SIM Design Steps

1. 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

1. 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>
</tr>
</thead>
<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>
</tr>
<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>
<tr>
<td>School Sidewalk, Steps, Ramp</td>
<td>1.0</td>
<td>90</td>
</tr>
<tr>
<td>School Parking Lot</td>
<td>0.5</td>
<td>90</td>
</tr>
<tr>
<td>Fire/Rescue Station Vehicle Ramp</td>
<td>1.0</td>
<td>98 to 99</td>
</tr>
<tr>
<td>Hospital Sidewalk, Steps, Ramp</td>
<td>1.0</td>
<td>98 to 99</td>
</tr>
<tr>
<td>MediVac Landing Pad</td>
<td>1.0</td>
<td>99</td>
</tr>
</tbody>
</table>

Note: These are friendly suggestions to help manage expectations.

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

1. 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>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Sidewalk, Steps</td>
<td>0.5 or 1.0</td>
<td>75 or 90</td>
<td>65 to 125</td>
</tr>
<tr>
<td>Residential Driveway</td>
<td>0.0 or 0.5</td>
<td>75 or 90</td>
<td>40 to 100</td>
</tr>
<tr>
<td>Commercial Sidewalk, Steps</td>
<td>1.0</td>
<td>90 to 95</td>
<td>125 to 175</td>
</tr>
<tr>
<td>Commercial Parking Lot</td>
<td>0.5</td>
<td>75 or 90</td>
<td>65 to 100</td>
</tr>
<tr>
<td>Commercial Parking Ramp</td>
<td>0.5 to 1.0</td>
<td>90 to 95</td>
<td>100 to 175</td>
</tr>
<tr>
<td>School Sidewalk, Steps, Ramp</td>
<td>1.0</td>
<td>90</td>
<td>125</td>
</tr>
<tr>
<td>School Parking Lot</td>
<td>0.5</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Fire/Rescue Station Vehicle Ramp</td>
<td>1.0</td>
<td>98 to 99</td>
<td>200 to 225</td>
</tr>
<tr>
<td>Hospital Sidewalk, Steps, Ramp</td>
<td>1.0</td>
<td>98 to 99</td>
<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

1. Select the Appropriate Performance Level

Example: Parking Ramp in Hamilton, Ontario

- Owner requests system to be 100% snow-free during 95% of snowfall events
- Owner agrees that even in more severe weather, this system will be adequate
- This means $Ar = 1.0 \times 95\%$ frequency distribution
- Melting area: $1,000 \text{ ft}^2 (92 \text{ m}^2)$
SIM Design Steps

2. Determine Required Heat Output: Melting Operation

- Designer determines that for this project and location, with $Ar = 1.0 \, @ \, 95\%$ frequency distribution, system must supply $150 \, 	ext{Btuh/ft}^2$ output (based on weather research)
- Must also expect 20% downward loss: $150 \, 	ext{Btuh/ft}^2 \times 1.2 = 180 \, 	ext{Btuh/ft}^2$
- Required output is $180 \, 	ext{Btuh/ft}^2$
SIM Design Steps

3. Select and Size Heat Source

- Total load: 1,000 ft² x 180 Btuh/ft² = 180,000 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 combi-heater 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

4. Design the Piping Distribution System

The designer selects:

a. Tube size (**3/4 NTS tubing is typical**; 1/2 in. and 5/8 in. tubing is sometimes used)
b. Tube spacing (6 to 9 inch tube spacing is typical, based on width of area)
c. Tube circuit lengths (100 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

4. Design the Piping Distribution System

The designer selects:

a. **3/4 Tube size** (¾ NTS tubing is typical; 1/2 and 5/8 tubing sometimes used)
b. **8 in. Tube spacing** (6 to 9 inch tube spacing is typical, based on width of area)
c. **250 ft. Circuit lengths** (100 ft. to 300 ft. circuit length is typical, based on heat 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

4. Design the Piping Distribution System

- Reference, CSA B214-16 ([www.shopcsa.ca](http://www.shopcsa.ca))

<table>
<thead>
<tr>
<th>Nominal size</th>
<th>Maximum active loop length, m (ft)</th>
<th>Total loop length, m (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEX or PE-RT tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>40 (130)</td>
<td>45 (150)</td>
</tr>
<tr>
<td>5/8</td>
<td>70 (225)</td>
<td>75 (250)</td>
</tr>
<tr>
<td>3/4</td>
<td>90 (300)</td>
<td>100 (325)</td>
</tr>
<tr>
<td>1</td>
<td>135 (450)</td>
<td>145 (475)</td>
</tr>
<tr>
<td>Copper tube*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>—</td>
<td>43 (140)</td>
</tr>
<tr>
<td>3/4</td>
<td>—</td>
<td>85 (280)</td>
</tr>
</tbody>
</table>
SIM Design Steps

4. Design the Piping Distribution System

- Chosen design uses 3/4 in. tubing @ 8 in. spacing
  - This spacing requires 1.5 ft. tubing per ft$^2$, based on simple math $12''/8'' = 1.5$

- 1,000 ft$^2$ x 1.5 ft. tubing per ft$^2$ = **1,500 ft.** of tubing total requirement

- Divide the 1,500 ft. total length into 6 equal circuits:

- 1,500 ft. $\div$ 6 Circuits = **250 ft/circuit** (each circuit covers 167 ft$^2$)

- Heat load per circuit: **180,000 Btuh $\div$ 6 = 30,000 Btuh per circuit**
SIM Design Steps

4. Design the Piping Distribution System

- Tubing layout will have 6 equal circuits, each delivering up to 30,000 Btuh, through a nearby manifold

- Using 50% Glycol and a 25°F ΔT:

  - $\frac{180,000 \text{ Btuh}}{11,030 \text{ Btu/GPM}} = 16.3 \text{ GPM}$ flow rate (2.7 GPM/circuit)

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

4. Design the Piping Distribution System

- Evaluate head loss with 2.7 GPM in ¾ PEX or PE-RT:
- PPI Plastic Pressure Pipe Design Calculator www.plasticpipecalculator.com
- Head loss is 17.0 feet (velocity is 2.4 ft/s) in the distribution pipes

**Pressure Drop / Head Loss**

<table>
<thead>
<tr>
<th>Input</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Selection:</td>
<td>PEX (ASTM F876/CSA B137.5)</td>
</tr>
<tr>
<td></td>
<td>SDR 9</td>
</tr>
<tr>
<td>Flow Rate:</td>
<td>2.7 USGPM</td>
</tr>
<tr>
<td>Length of Pipe:</td>
<td>250 ft</td>
</tr>
<tr>
<td>Fluid Type (Water or % Glycol):</td>
<td>50% Propylene Glycol</td>
</tr>
<tr>
<td>Average Fluid Temperature*:</td>
<td>60 °F</td>
</tr>
</tbody>
</table>
SIM Design Steps

5. 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 1¼” PEX)
- Calculate head loss through each component which is in series to determine the total head loss value for selecting circulator

Courtesy Arndt & Son
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.
5. Control Strategies

This section discusses three control strategies

a. 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, or use outdoor moisture sensor (options)

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

c. 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

a. 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” control lowers capital cost, good for many 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

b. Idle/Melt – Idles when dry, 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 to snow

Pros
- Reduces response time to start melting
- Avoids heat/cool cycles for delicate outdoor surfaces
- Automatic controls can improve safety and save energy

Cons
- Idling consumes much energy, to stay warm in between events
- May increase annual energy consumption by 4 to 8 times due to Idling
Control Strategies

c. Always On – Constantly keeps outdoor surface warm, always ready to melt
- Electronic control will 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
- Warm sidewalks feel good in winter!

**Cons**
- Always using energy
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, like beside bushes or under the roof

*Sensor height being aligned with future top surface*

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Control Strategies

This section discusses three control strategies

- We didn’t even mention smart web-based controls, or “apps”
- There are many specific options available from experienced firms
6. 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 ft² ramp in Hamilton, Ontario. No idling

- Location: Hamilton, ON
- Melting area: 1,000 ft² (92 m²)
- Annual hours of operation: 120 hours
- Number of events: 10 times (12 hours/event)
- Annual hours of idling: no idle
- Heat flux/load during operation: 180 Btu/hr-ft² (max.)
- Heat flux/load during idling: no idle
- Fuel type: Natural gas
- Fuel cost: Approximately $0.30/m³ (see next slide)
- Efficiency of heat source: 95% AFUE boiler
Comments on Operating Costs

Example: 1,000 ft\(^2\) ramp in Hamilton, Ontario. No idling

- Location: Hamilton, ON
- Fuel type: Natural gas
- Fuel cost: see *Rate M1 South* Union Gas
- Summary: Approximately $0.30/m\(^3\)

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Comments on Operating Costs

Example: 1,000 ft² ramp in Hamilton, Ontario. No idling

Part 1: Energy Demand
- Operation: 120 hours x 180 Btu/hr-ft² x 1,000 ft² = 21,600,000 Btu/year
- Pick-up: 10 events x 350,000 Btu/event = 3,500,000 Btu/year
- Total Annual Load: 21.6 + 3.5 = 25.1 million Btu/year

Part 2: Cost of Energy Produced
- Fuel cost: Approximately $0.30/m³
- Efficiency of heat source: 95% AFUE boiler
- Energy Content of gas: 36,000 Btu/m³ (published)
- Cost per 1 million Btu = $0.30/m³ ÷ 36,000 Btu/m³ ÷ 95% x 1 million
  = $8.7 per million Btu produced
Comments on Operating Costs

Example: 1,000 ft² ramp in Hamilton, Ontario. No idling

Part 3: Annual Cost Estimate
- 25.1 million Btu/year x $8.7 per million Btu produced = $220/year
- Plus incremental electrical costs for circulator/s
- Compare with typical contracting costs for mechanical snow removal, plus sanding and salting (and the inconvenience and cost of snow banks left behind)
  - Savings could be 75% or more compared with mechanical snow removal costs
Comments on Operating Costs

Summary: This section discussed methods to estimate SIM operating costs

Hydronic SIM systems are efficient, reliable and can reduce operating costs
Course Summary

This course did:

1. Indicate the typical benefits of SIM systems
2. Describe the three most common installation techniques
3. List a selection of typical applications
4. Introduce the five main design steps
5. Discuss the most common control strategies
6. Comment on operating costs

Winter’s coming!
Design and Installation of Hydronic Snow and Ice Melting (SIM) Systems to Optimize Performance and Efficiency

Thank you!