Design and Installation of Hydronic Snow & Ice Melting Systems to Optimize Performance and Efficiency

A presentation by the Plastics Pipe Institute

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The Plastics Pipe Institute

PPI Represents All Sectors of the Plastic Pipe Industry

- Formed in 1950 to research and develop test methods for plastic pressure pipes
- Today: Non-profit trade association serving North America based in Irving, TX
- Five Divisions, eleven employees

PPI Mission: Enable the highest quality of life and preserve our natural resources through the advancement, acceptance, and use of plastic pipe systems

PPI Activities: Research, education, technical expertise, and advocacy

Members: Over 170 member firms involved with the plastic pipe industry

PPI Website: www.plasticpipe.org

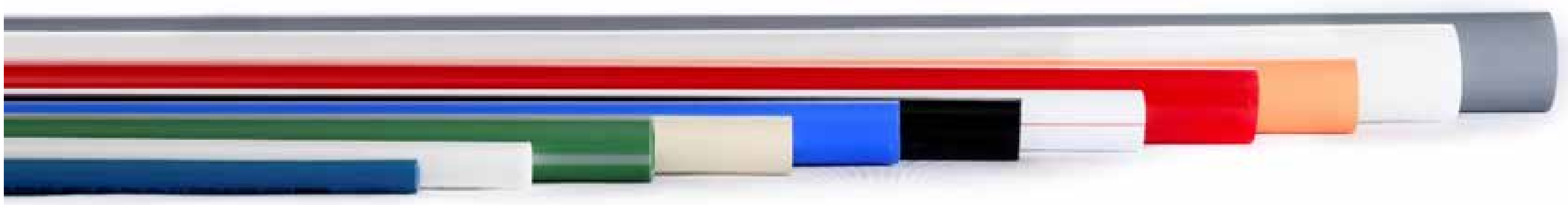
The Plastics Pipe Institute

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 (radiant) heating & cooling, snow & ice melting, district energy heating & cooling, and ground source geothermal piping systems.

BCD Materials: CPVC, HDPE (geo), PEX, PE-RT, PEX-AL-PEX, and PP (PP-R & PP-RCT)

BCD Homepage: https://plasticpipe.org/BuildingConstruction



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
  * *typically propylene glycol mixed with water at a ratio to prevent freezing*

- SIM systems are used across North America in all climates

- The piping material for SIM distribution systems is typically:
  - **PEX**: Crosslinked Polyethylene, or
  - **PE-RT**: Polyethylene of Raised Temperature Resistance

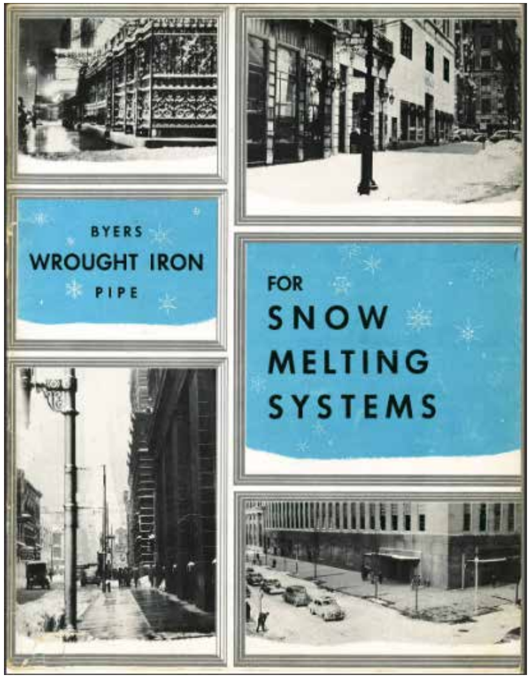
- PP (polypropylene) pressure pipe and CPVC may also be used for supply piping

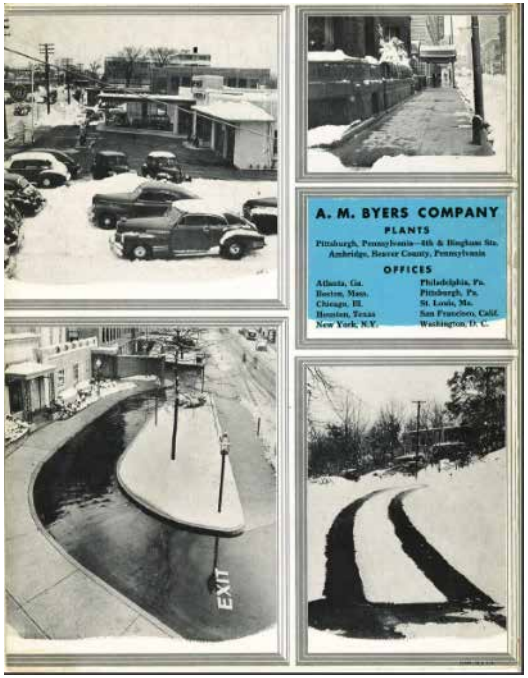
- Learn more about these materials at http://plasticpipe.org/building-construction/

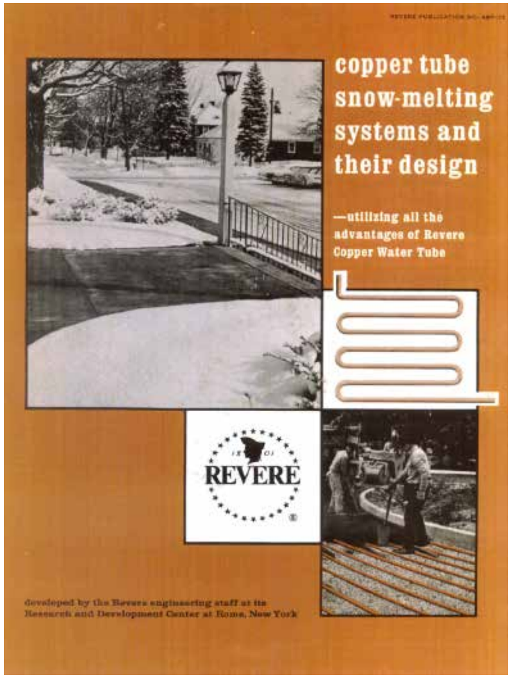
What Is A Hydronic SIM System?

SIM systems are not new! See iron and copper manuals from early 1950s

- A.M. Byers closed in 1969. Revere no longer produces tubing.







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


Courtesy VIEGA LLC

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

1. Better safety
2. Reduced liability
3. Healthier convenience
4. Lowered maintenance costs
5. Minimized environmental impact
6. Long-term reliability

Benefits of Snow and Ice Melting Systems

1. Better Safety

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

Benefits of Snow and Ice Melting Systems

2. Reduced Liability

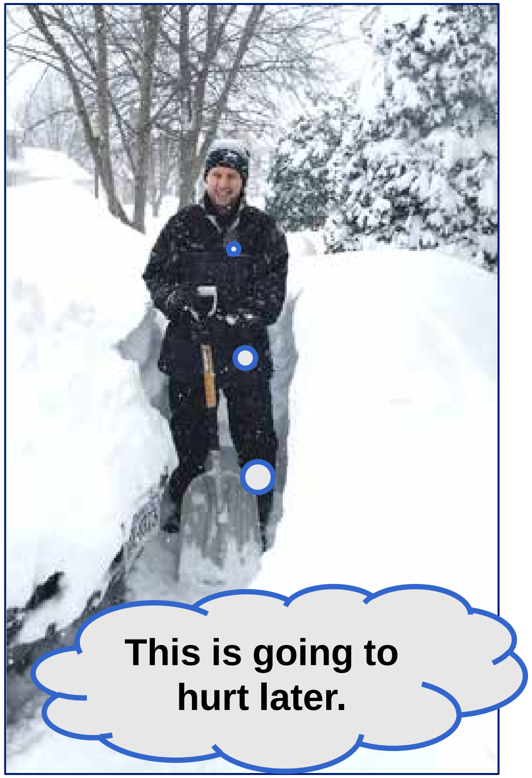
- Snowbanks and trip hazards are practically eliminated
- Keeping residences and businesses free of snow and ice improves access and safety, while eliminating a source of liability risk in winter
- Liability <u>insurance premiums might even be reduced</u>, reducing ownership costs

Benefits of Snow and Ice Melting Systems

3. Healthier Convenience

- For the ultimate in snow removal <u>convenience</u>, SIM systems clear outdoor surfaces, leaving them dry
- No snow banks are left behind
- For residential customers, this eliminates potential <u>health risks</u> of aching backs and heart attacks


Courtesy Ridgeway Home Services



Benefits of Snow and Ice Melting Systems

4. 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 getting tracked inside

Left: Snow removal equipment and supplies at parking garage

Right: Salt at bank entrance

Benefits of Snow and Ice Melting Systems

5. 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)
- Less fuel is used to power boilers than to power trucks (= lower CO_2 emissions)
- SIM systems extend lives of surfaces by eliminating scraping, salting, and sanding
- Run-off of deicing chemicals (e.g., salt) onto lawns and drains is eliminated
- These factors can reduce environmental impacts

Benefits of Snow and Ice Melting Systems

6. 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
  - **PE-RT**: Polyethylene of Raised Temperature resistance

Benefits of Snow and Ice Melting Systems

PEX and PE-RT Capabilities

- PEX and PE-RT tubing have long-term pressure ratings of:
    - 160 psi @ 73°F (1,110 kPa @ 23°C)
    - 100 psi @ 180°F (690 kPa @ 82°C)
- Actual burst pressure is well over 500 psi
- These are tough and durable, yet flexible, products

- PEX tubing is produced in accordance with international standards ASTM F876, F3253 and/or CSA B137.5

- PE-RT tubing is produced in accordance with international standards ASTM F2623, ASTM F2769 and/or CSA B137.18

Benefits of Snow and Ice Melting Systems

Long-term Reliability

- Piping in the mechanical room and to supply manifolds can be a variety of materials:
  - **PEX** or **PE-RT**
  - **CPVC**: Chlorinated Polyvinyl Chloride
  - **PP**: Polypropylene (PP-R or PP-RCT)
  - Supplies to remote manifolds are usually piped with **pre-insulated PEX** tubing




Benefits of Snow and Ice Melting Systems

Summary: Typical benefits include…

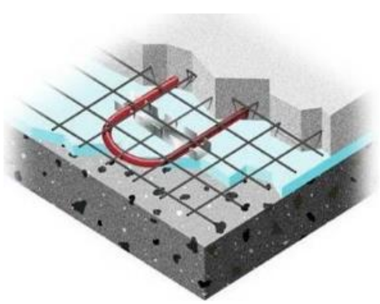
1. Better safety
2. Reduced liability
3. Healthier convenience
4. Lowered maintenance costs
5. Minimized environmental impact
6. Long-term reliability

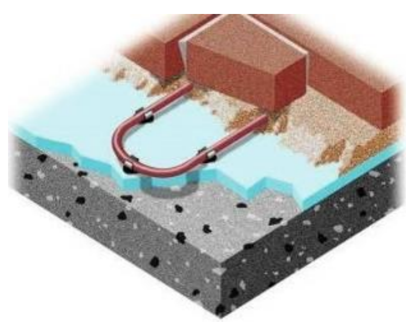
2. SIM Installation Techniques

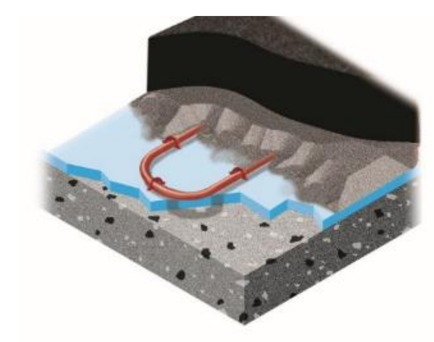
This section describes three typical installation types for outdoor surfaces

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*

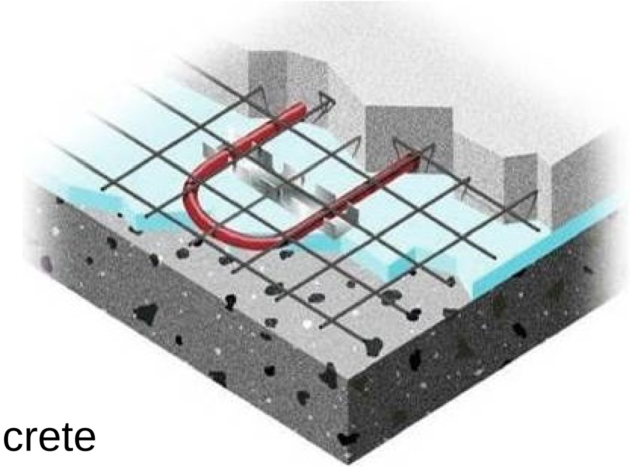






SIM Installation Techniques

1. Tubing embedded within poured concrete

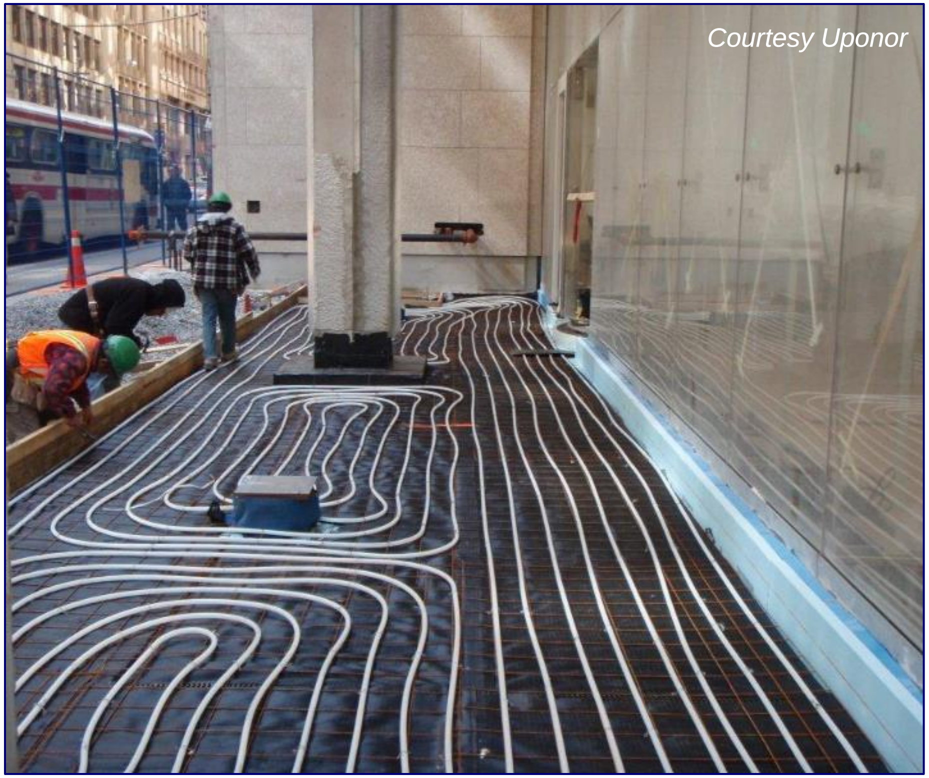


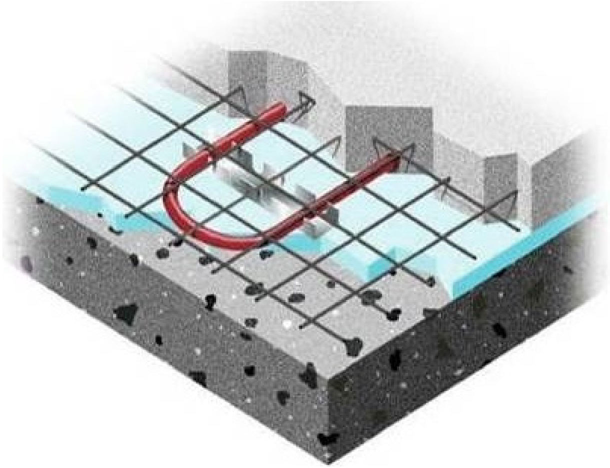
- In poured concrete, the plastic tubing is simply <u>embedded within the concrete</u>
    - Very popular for stained concrete
- Recommended to place the tubing 2 to 3 inches (5 - 8 cm) below the surface for faster response time (not always practical)
- Tubing is sometimes stapled directly onto the insulation board or tied to rebar or wire mesh within the poured 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

1. Tubing embedded within poured concrete

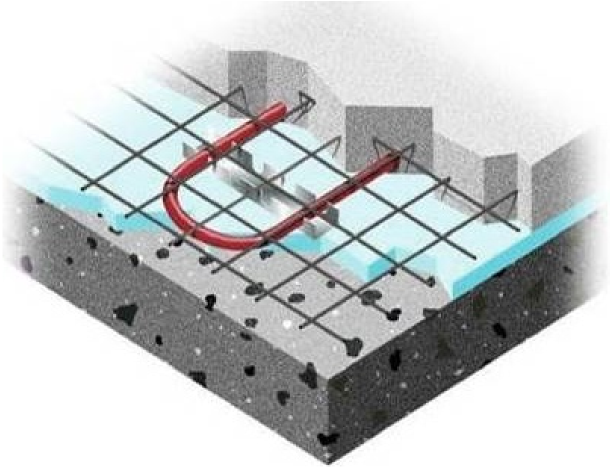




Poured concrete with tubing embedded 2 to 3 inch from top surface

SIM Installation Techniques

1. Tubing embedded within poured concrete

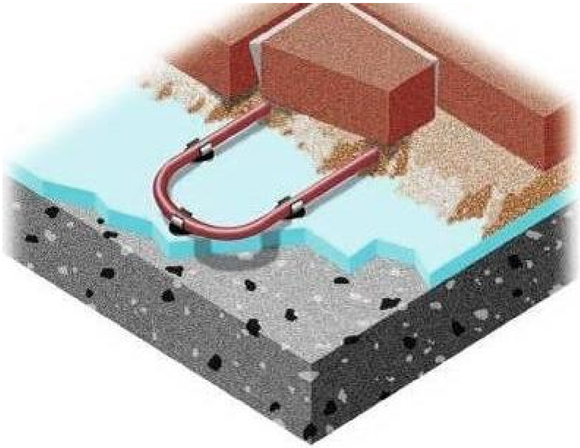


Poured concrete with tubing embedded 2 to 3 inch from top surface

SIM Installation Techniques

2. Tubing installed under interlocking pavers

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



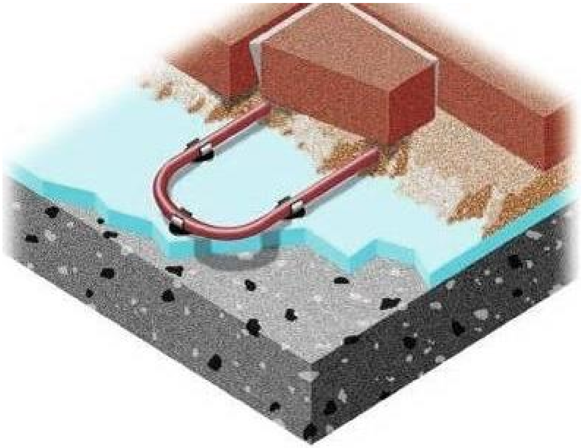
Pavers installed over sand bed with embedded heating tubing

Media

- Compacted sand bed is recommended
- Stone dust loses strength when wet, and can heave when frozen

SIM Installation Techniques

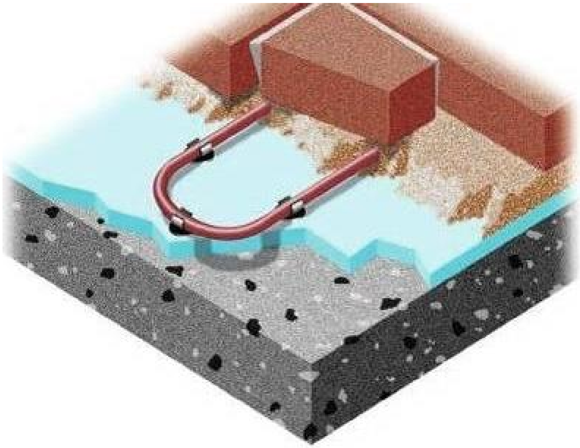
2. Tubing installed under interlocking pavers



Pavers installed over sand bed with embedded heating tubing

SIM Installation Techniques

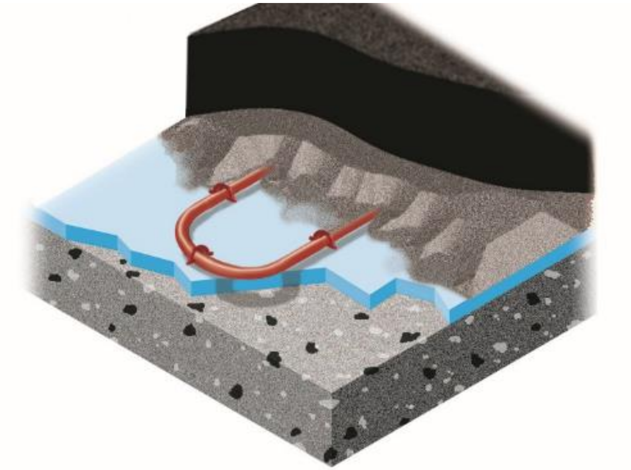
2. Tubing installed under interlocking pavers



Pavers installed over sand bed with embedded heating tubing

SIM Installation Techniques

3. Tubing installed under asphalt

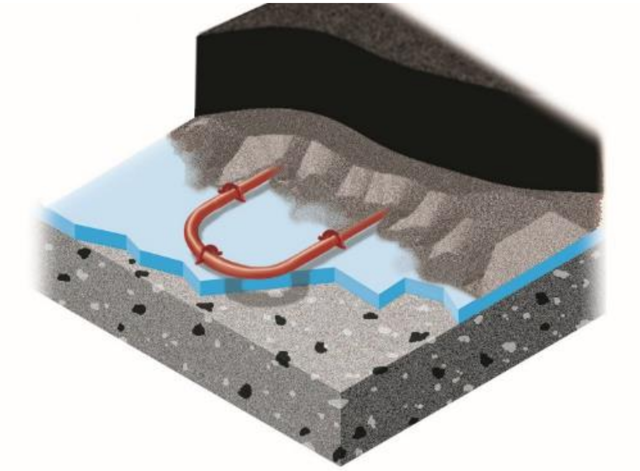


- Plastic tubing is installed above insulation using plastic rails, staples, screw clips, or wire mesh
- Tubing is encased within 3 inches (7.5 cm) of stone dust or sand media, compacted
- Asphalt is placed above the media (dust or sand) and compacted normally
- Cold water is flushed through pipes during 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 from overheating until the asphalt cools off

Media: Compacted stone dust works best. No pea stone or crushed gravel.

SIM Installation Techniques

3. Tubing installed under asphalt



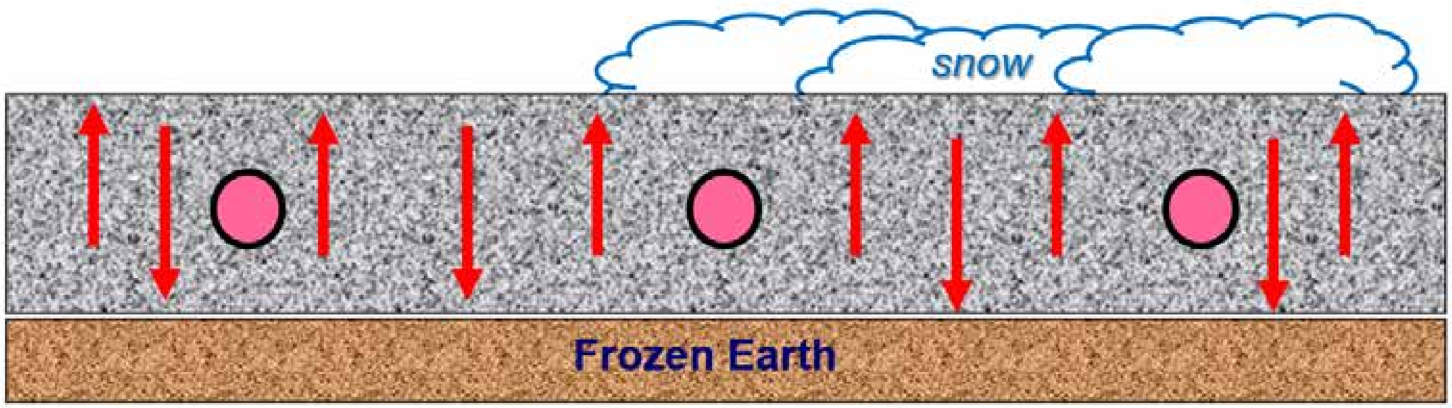
Tubing embedded within sand or stone dust below asphalt

SIM Installation Techniques

Importance of Appropriate 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, especially at cold start (you'd better double the size of heat source and circulators!)

● = Tubing filled with warm glycol

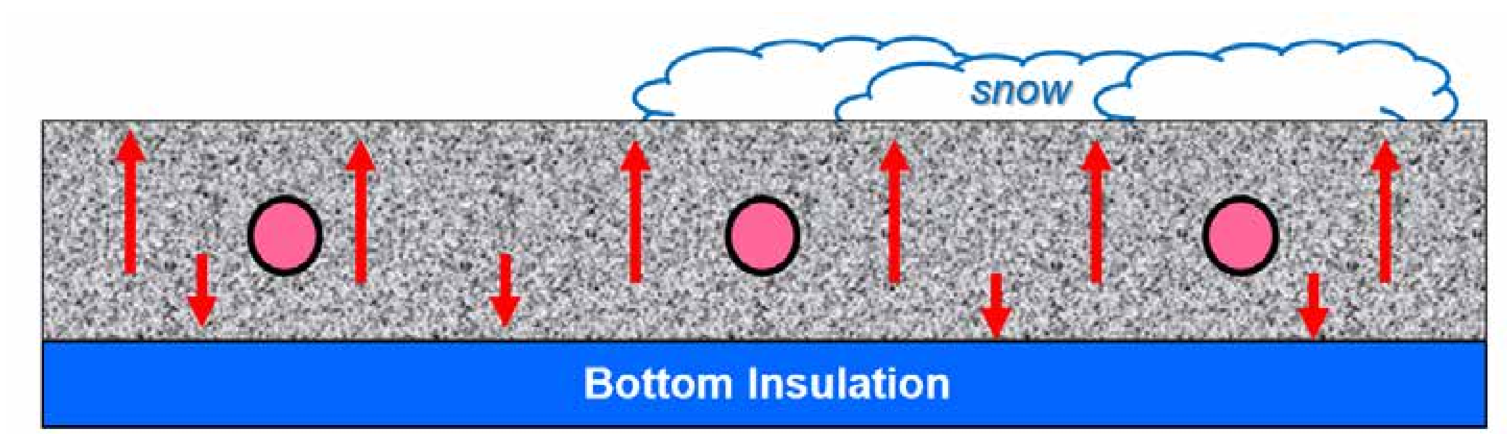


SIM Installation Techniques

Importance of Appropriate Insulation

- A significant amount of heat can be conducted to the frozen earth below the SIM surface, if appropriate insulation is not installed
- With insulation, downward losses are significantly reduced, much better response time
- Smaller heat source and circulators, better efficiency

● = Tubing filled with warm glycol



SIM Installation Techniques

Importance of Appropriate Insulation

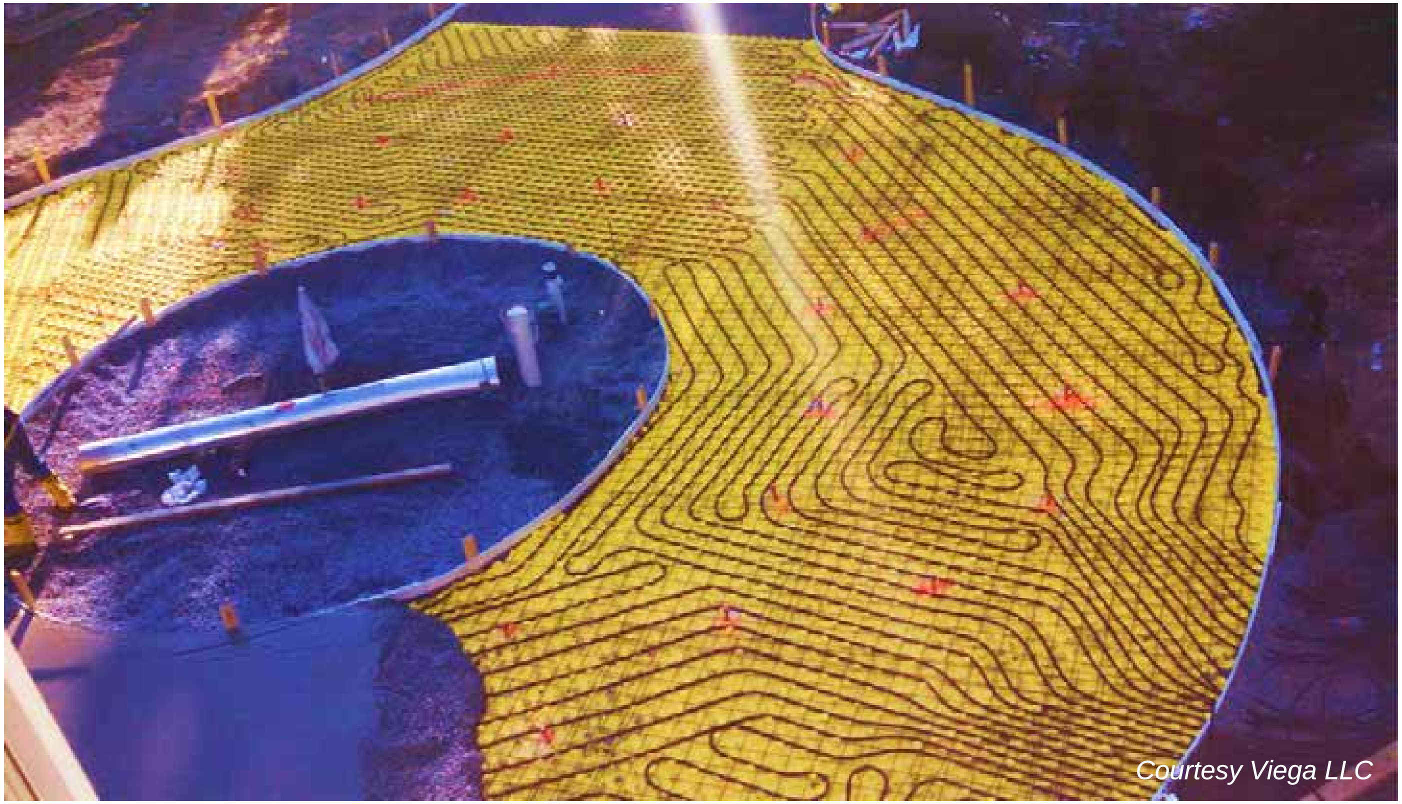
- Codes typically require **at least R-5** insulation below SIM areas, but many designers specify **R-10**, since insulation also improves response time
- Typical insulation thickness is 1 in., 1 ½ in. or 2 in. (25 mm, 38 mm, 50 mm)
- Insulation is typically extruded polystyrene (XPS), polyurethane (PU), or expanding foam that is sprayed onto existing concrete or the earth to follow contours
- Be sure the insulation is rated for outdoor use and meets the expected compressive loads from vehicles, or settling can occur

Spray-foam insulation on old stone steps (church)

Medivac landing pad on hospital rooftop

SIM Installation Techniques

Importance of Appropriate Insulation



SIM Installation Techniques

Importance of Drainage

- Just like rain, melted snow must have a good drainage path
- 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 drain box/es

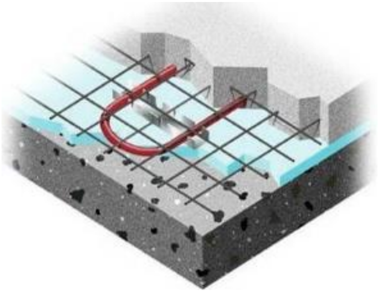
- Be sure that drains will not freeze (use pipes under or around drain (see image)

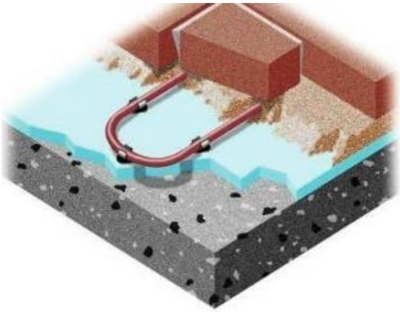
- Connect drain to available storm sewer system, within code requirements, or to a nearby pond

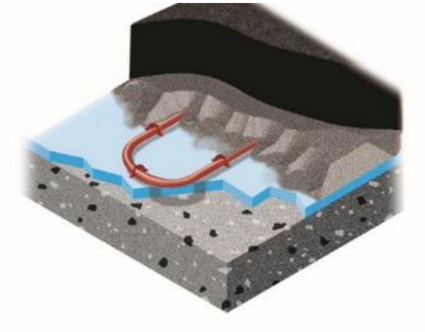
SIM Installation Techniques

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. Pool decks
4. Driveways
5. Ramps
6. Roads
7. Parking garages
8. Train stations
9. Hangers
10. Aviation facilities

Also, Melting “hot pads”

Typical Applications of SIM systems

1. Sidewalks

- Private home

Typical Applications of SIM systems

1. Sidewalks

- Commercial buildings

Typical Applications of SIM systems

1. Sidewalks

- Downtown Anchorage – public sidewalks

Typical Applications of SIM systems

1. Sidewalks

- Municipal building

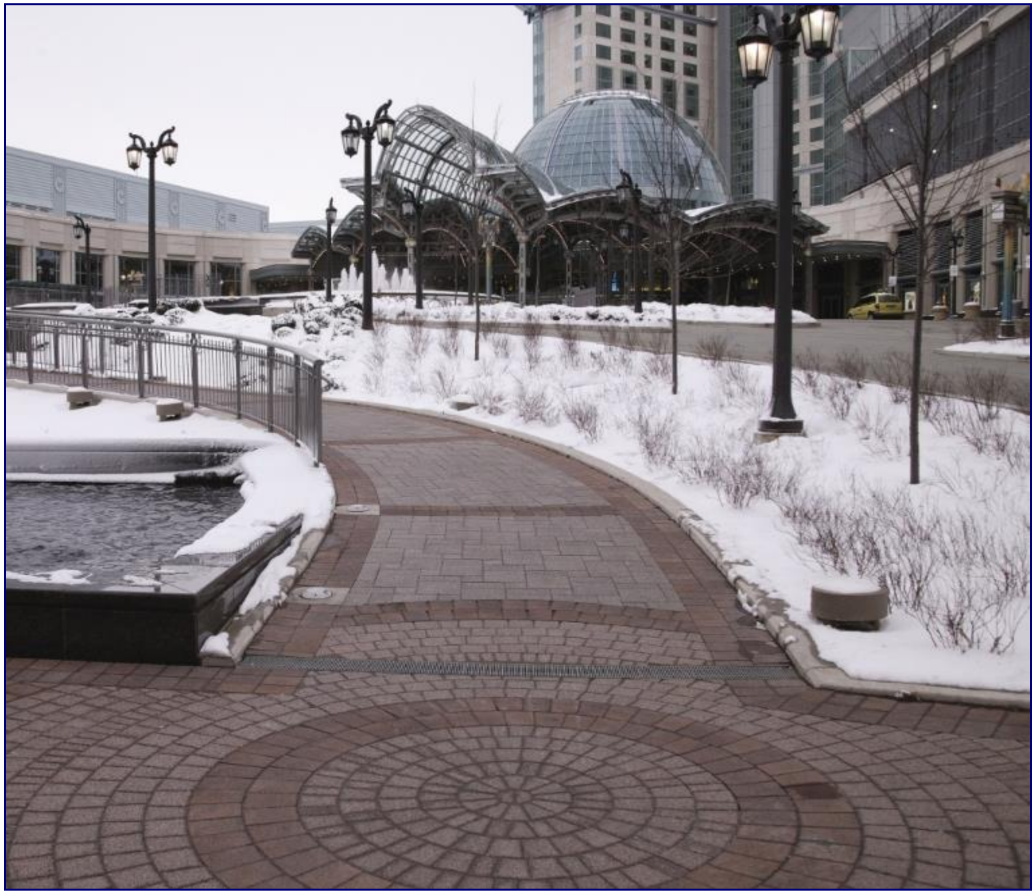
Courtesy Klimatrol

- University (handicapped parking)

Typical Applications of SIM systems

1. Sidewalks

- Hotel



Typical Applications of SIM systems

1. Sidewalks

- Hotel, Bus station loading area

Unfortunately, no tubing in the curb.

Typical Applications of SIM systems

2. Steps

- Public and commercial spaces

Typical Applications of SIM systems

2. Steps

- Residential installations

Typical Applications of SIM systems

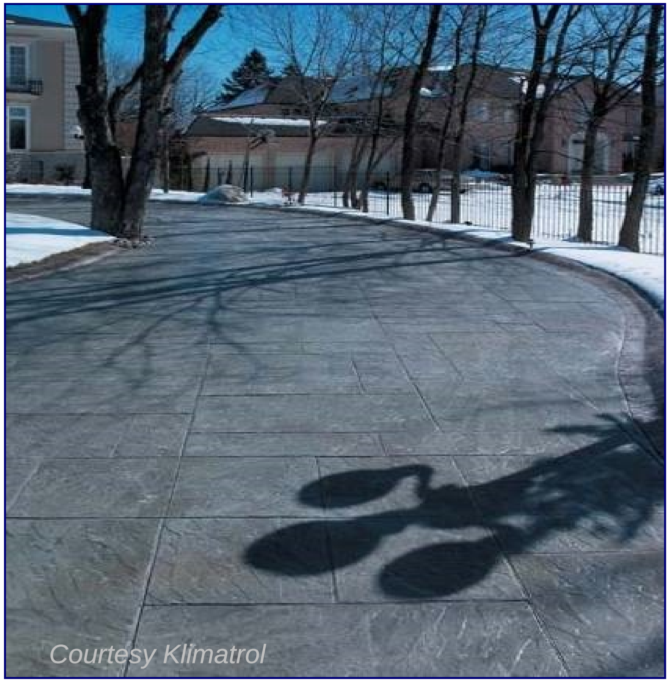
3. Pool decks

- 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 water

Typical Applications of SIM systems

4. Driveways

- Under stained concrete or pavers



Typical Applications of SIM systems

4. Driveways

- Under stained concrete or pavers

Courtesy Klimatrol

Typical Applications of SIM systems

4. Driveways

- Under stained concrete or pavers

Courtesy Thornton Plumbing & Heating

Typical Applications of SIM systems

4. Driveways

- Complicated shapes and patterns are possible

Typical Applications of SIM systems

4. Driveways

- Commercial applications

Typical Applications of SIM systems

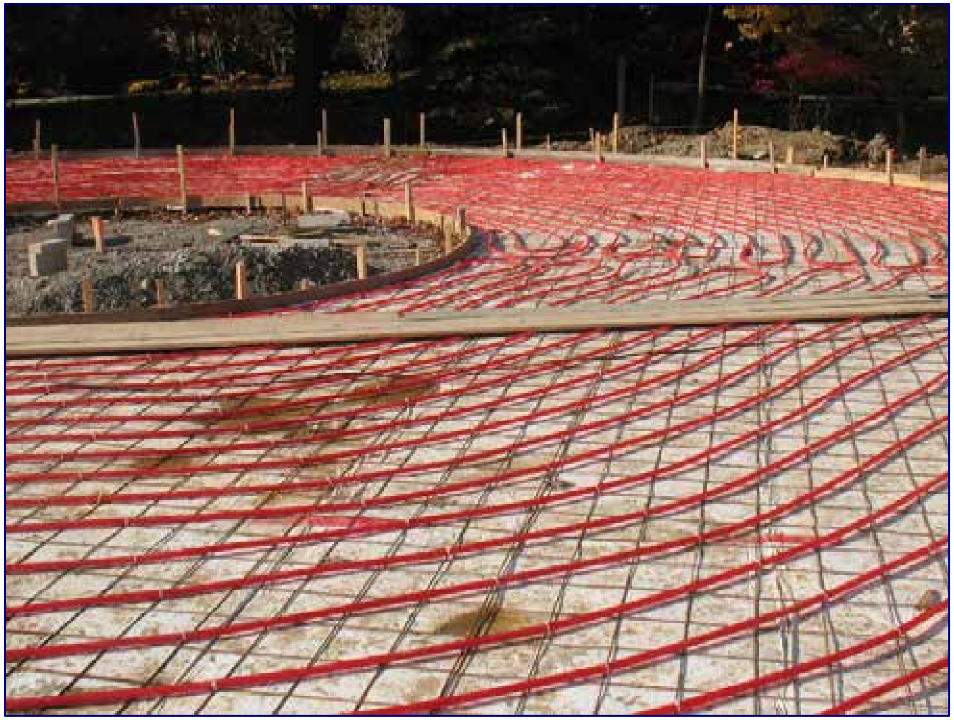
5. Ramps

- Pedestrian ramps

Typical Applications of SIM systems

5. Ramps

- Pedestrian and vehicle ramps



Courtesy REHAU

Typical Applications of SIM systems

5. Ramps

- Vehicle ramps

Typical Applications of SIM systems

5. Ramps

- Vehicle ramps

Typical Applications of SIM systems

6. Roadways

- SIM systems add safety with steep inclines

Typical Applications of SIM systems

7. Parking garages

- SIM in the inclined ramps and in exposed levels of ramps


Courtesy REHAU

Typical Applications of SIM systems

8. Train stations

- Add safety and convenience to outdoor train stations and platforms


Courtesy REHAU


Courtesy Uponor

Typical Applications of SIM systems

9. Aircraft hanger doors and aprons

- Prevent sliding doors from freezing

Courtesy Viega, LLC

Typical Applications of SIM systems

10. Aviation

- Train tracks at airports

Typical Applications of SIM systems

10. Aviation

- Medivac landing pads

Courtesy REHAU

Typical Applications of SIM systems

10. Aviation

- Ramps, taxiways, runways

Most airports do not have a SIM system!

Fleets of scrapers, blowers, melters, and fuel trucks move and melt the snow

Typical Applications of SIM systems

10. 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!

- Drainage is essential
- May need to "mix" the pile

- Helpful in congested cities and many commercial facilities

Typical Applications of SIM systems

Summary: This section listed examples of applications

1. Sidewalks
2. Steps
3. Pool decks
4. Driveways
5. Ramps
6. Roads
7. Parking garages
8. Train stations
9. Aircraft hangers
10. Aviation facilities

Also, Melting “hot pads”

Courtesy Arndt & Son

4. 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 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

Courtesy Thornton Plumbing & Heating

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.

Courtesy Arndt & Son

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
- 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

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)

- For other cities, designers can select a similar city from the Table or do detailed calculations

Courtesy Thornton Plumbing & Heating

SIM Design Steps

1. Select the Appropriate Performance Level

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

Table 1 Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions[a] (*Continued*)

Location	Snowfall Hours per Year	Snow-Free Area Ratio, A_r	Heat Fluxes Not Exceeded During Indicated Percentage of Snowfall Hours from 1982 Through 1993, Btu/h·ft² [b] 75%	90%	95%	98%	99%	100%
		1	81	108	123	150	170	233
Lexington, KY	50	0.5	49	65	74	85	95	197
		0	16	30	39	46	55	162
		1	99	138	164	206	241	449
Madison, WI	161	0.5	61	82	98	129	163	245
		0	23	39	60	91	113	194

- **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


Courtesy Thornton Plumbing & Heating

*E.g., **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:

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

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

1. Select the Appropriate Performance Level

- Sample heat flux values (for a climate similar to Boston, MA):

SIM Application Type	Free Area Ratio (Ar)	Frequency Distribution (%)	Required Heat Flux (Btu/hr-ft^2)
Residential Sidewalk, Steps	0.5 or 1.0	75 or 90	65 to 125
Residential Driveway	0.0 or 0.5	75 or 90	40 to 100
Commercial Sidewalk, Steps	1.0	90 to 95	125 to 175
Commercial Parking Lot	0.5	75 or 90	65 to 100
Commercial Parking Ramp	0.5 to 1.0	90 to 95	100 to 175
School Sidewalk, Steps, Ramp	1.0	90	125
School Parking Lot	0.5	90	100
Fire/Rescue Station Vehicle Ramp	1.0	98 to 99	200 to 225
Hospital Sidewalk, Steps, Ramp	1.0	98 to 99	200 to 225
MediVac Landing Pad	1.0	99	225

SIM Design Steps

1. Select the Appropriate Performance Level

Design Example: Parking Ramp in Albany, NY

- Melting area: **1,000 ft^2** Garage ramp
- Construction: **6 inch** poured concrete over insulation
- Owner requests system 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**

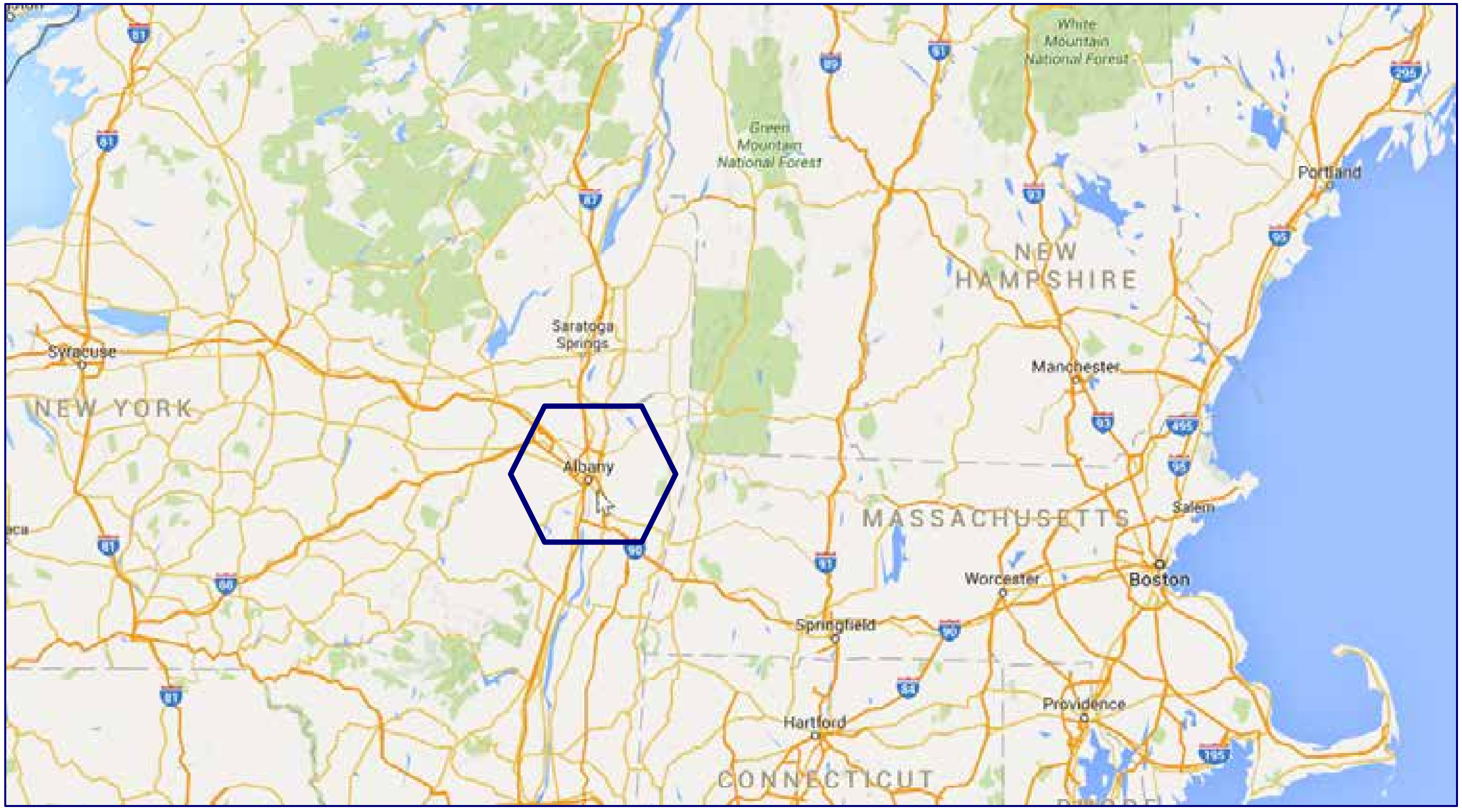
- This system will be 100% snow-free during 90% of expected snowfalls
- Various levels of accumulation in heavier snowfalls

50 ft. long

20 ft. wide

SIM Design Steps

Design Example: Albany, NY (a wintry place)



SIM Design Steps

2. 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 Btu/h-ft²** as the required output in Albany

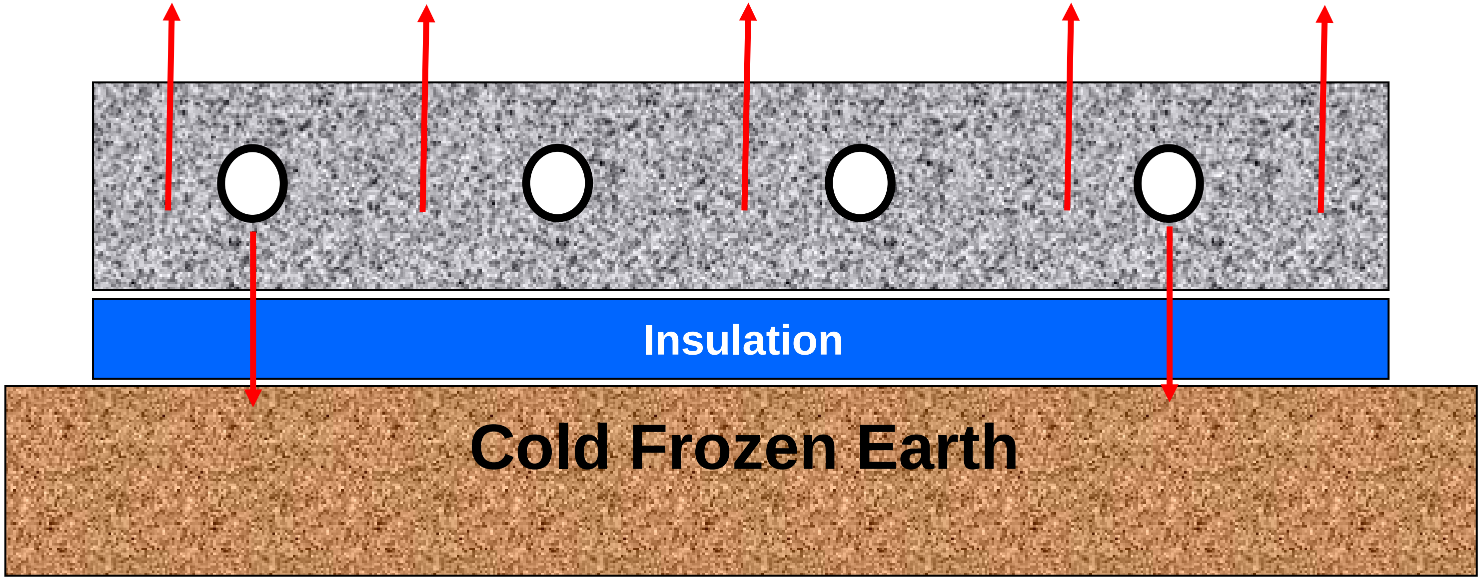
Table 1 Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions[a]

Location	Snowfall Hours per Year	Snow-Free Area Ratio, A_r	Heat Fluxes Not Exceeded During Indicated Percentage of Snowfall Hours from 1982 Through 1993, Btu/h·ft²[b]					
			75%	90%	95%	98%	99%	100%
Albany, NY	156	1	89	125	149	187	212	321
		0.5	60	86	110	138	170	276
		0	37	62	83	119	146	276
Albuquerque, NM	44	1	70	118	168	191	242	393
		0.5	51	81	96	117	156	229
		0	30	46	61	89	92	194

SIM Design Steps

2. Determine Required Heat Output: Melting Operation

- Must also anticipate 20% downward loss: **125 Btu/h-ft^2 x 1.2 = 150 Btu/h-ft^2**
- Required output is **150 Btu/h-ft^2**



SIM Design Steps

2. 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 (+5°C)*
- 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 ft^2 per °F** based on the “specific heat” of concrete of 0.23 Btu/lb-

SIM Design Steps

2. Determine Required Heat Output: Pick-up

- Albany ramp is 6 in. thick concrete and requires **15 Btu per ft^2 per °F** based on the "specific heat" of concrete of 0.23 Btu/lb-

- 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 ft^2 x 20°F x 15 Btu per ft^2 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

3. Select and Size Heat Source

- Total load: 1,000 ft^2 x 150 Btu/h-ft^2 = **150,000 Btu/h** 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
- Geothermal water-to-water heat pump
- Biomass or outdoor wood boiler
- Waste heat from industrial processes
- Rejected heat from commercial cooling system

This system will use a dedicated boiler

SIM Design Steps

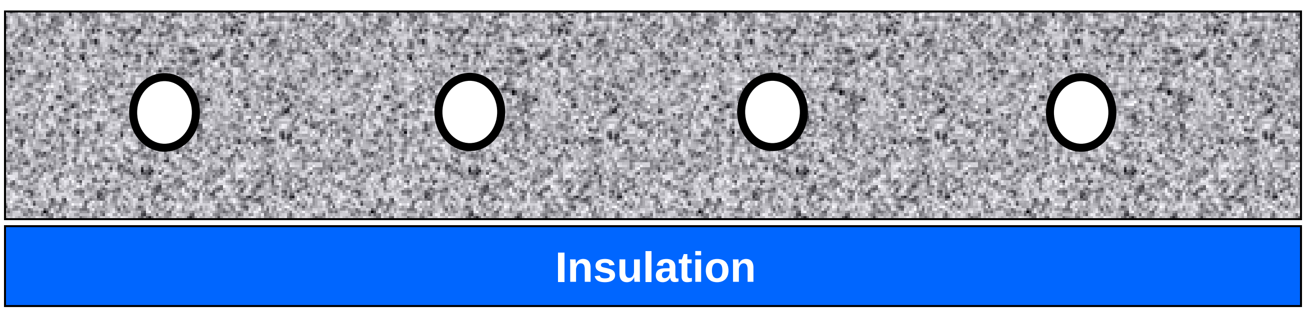
4. Design the Piping Distribution System

The designer has several options:

a. Tube size (3/4 in. 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 to 3 in. from top surface is ideal for faster response time

SIM Design Steps

4. Design the Piping Distribution System

The designer’s choice for this project:

a. **¾ Tube size**
b. **8 inch (20 cm) on-center Tube spacing** (works well for 20 ft. width)
c. **250 ft. (76 m) Circuit lengths** (to keep head loss low)

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

SIM Design Steps

4. Design the Piping Distribution System

- Chosen design uses ¾ 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. ÷ 6 Circuits = **250 ft/circuit** (each circuit covers 167 ft^2)

- Heat load per circuit: **150,000 Btu/h ÷ 6 = <u>25,000 Btu/h per circuit</u>** (peak load)

SIM Design Steps

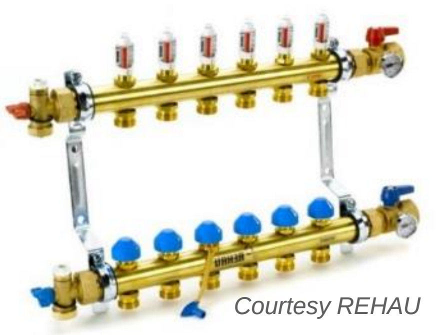
4. Design the Piping Distribution System

- **Tubing layout will have 6 equal circuits, each delivering up to 25,000 Btu/h through a nearby manifold**

- Using 50% PP Glycol and a 25ºF T:

- $\frac{\text{150,000 Btuh}}{\text{11,030* Btu/GPM}}$ = **13.6 GPM** flow rate (2.2 GPM/circuit)

**Capacity of 50% pp glycol; details not shown*



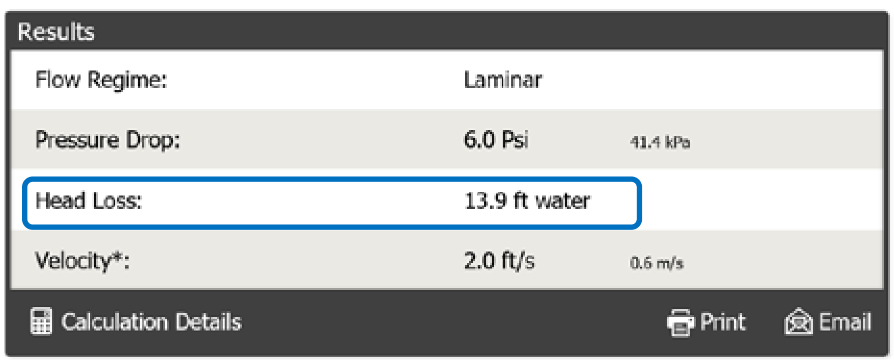
Courtesy REHAU

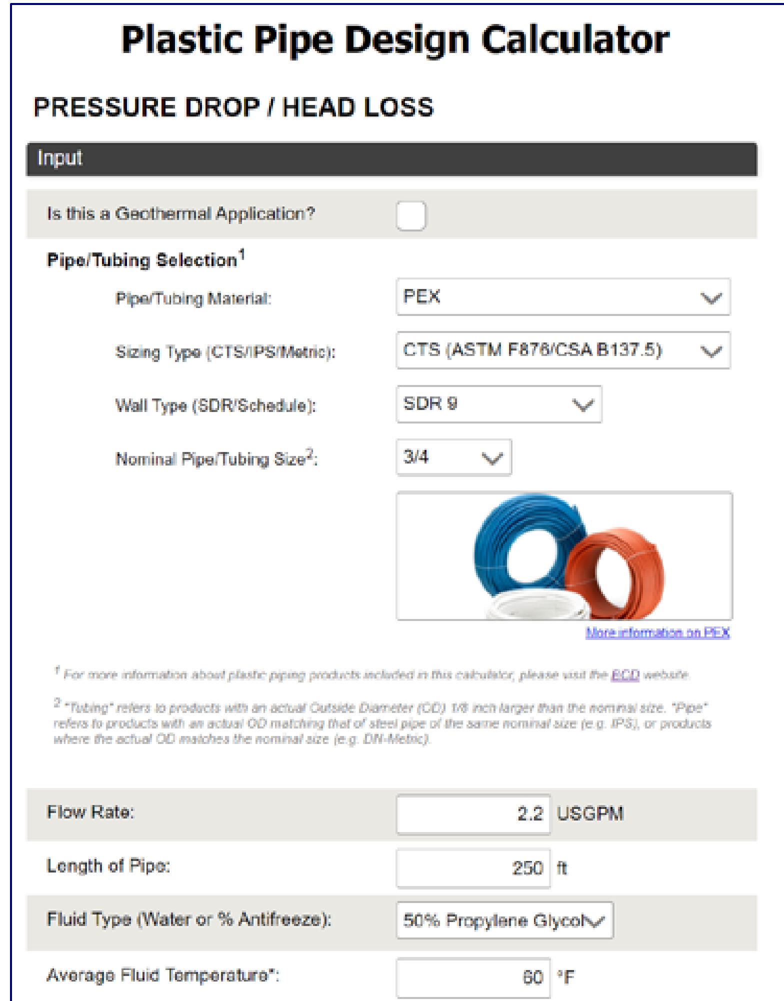
- This info can be used to determine head loss through the piping network using PPI's **BCD Plastic Pipe Design Calculator**

SIM Design Steps

4. Design the Piping Distribution System

- Use the **BCD Plastic Pipe Design Calculator**
- www.plasticpipecalculator.com
- Calculate the head loss with **2.2 GPM** flowing in ¾ PEX or PE-RT tubing, **250 ft.** circuits
- Head loss @ 60°F is **13.9 ft** in the pipes





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 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 (13.9 ft of loss in distribution tubing + head loss through other components)

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.

<u>**All equipment can be accurately sized based on these steps**</u>

5. Control Strategies

This section discusses three types of control strategies

1. 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

2. Idle/Melt: Idles (i.e., runs gently) when dry + cold, heats up with moisture + cold

- Reduces response time to start melting
- Consumes much more energy to stay warm in between events

3. Always On: Constantly keeps outdoor surfaces warm, always ready to melt

- Electronic control will monitor supply/return fluid temperatures to modulate the fluid temperature and the heat output, as needed
- Will consume the most energy, if that's a concern (e.g., waste energy)

Control Strategies

1. 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, <u>starting with human initiation</u>
- A “fully automatic” systems turns itself on and off, no human intervention needed

Pros

- “Semi-automatic” control lowers capital cost, may be good for small 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

2. 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 to snow

Pros

- Reduces response time to start melting (fastest reaction)
- Better safety and reduced liability
- 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

3. Always On: Constantly keeps outdoor surfaces 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
- E.g., 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 (like outdoor radiant patios)

Cons

- Always using energy (but maybe this is waste heat, helping to cool the building)

Control Strategies

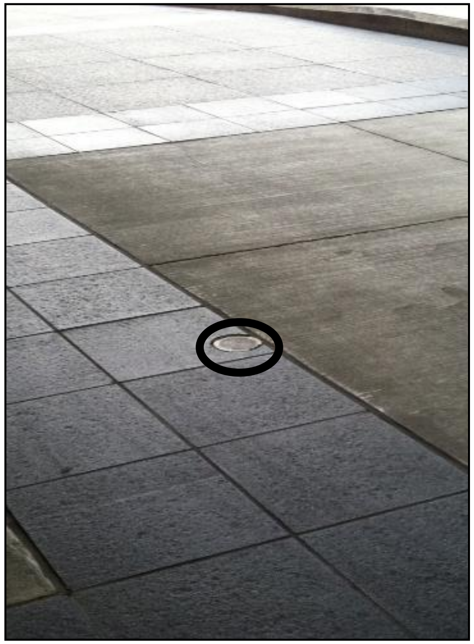
“Smart” controls with weather anticipation, high-end residential & commercial

- 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 even optical sensors
- May be programmed to start warming SIM area hours 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

Outdoor sensor close-up

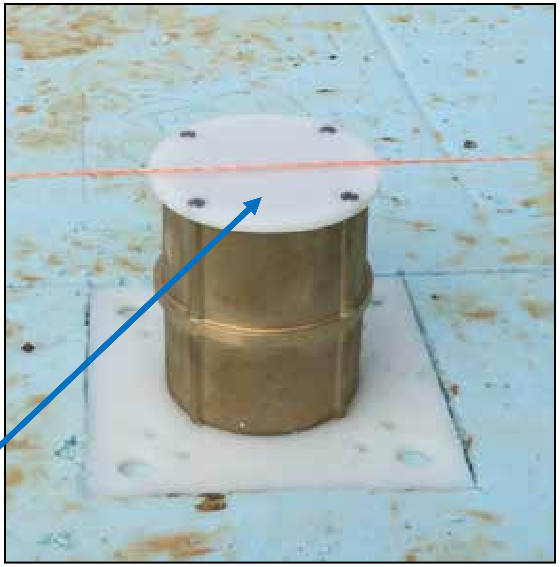
Control Strategies

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
Protective plastic cover in place during concrete pour

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

6. Comments on Operating Costs

Following a careful design, it is possible to estimate operating costs, if you know or can reasonably predict:

1. Project location (for weather data)
2. Melting area (of the surface)
3. Annual hours of operation (melting)
4. Number of events (for pick-up loads)
5. Heat flux/load during operation (melting load)
6. Annual hours of idling (a control strategy)
7. Heat flux/load during idling (if selected)
8. Fuel type (e.g., gas, electric, propane)
9. Fuel cost (cost of energy)
10. Efficiency of heat source (%)

Comments on Operating Costs

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

1. Project location: Albany, NY
2. Melting area: **1,000 ft^2** (92 m^2)
3. Annual hours of operation: **156 hours of snowfall**
4. Number of events: **20 times/year** (assumption)
5. Heat flux/load during operation: **150 Btu/hr-ft^2** (maximum)
6. Annual hours of idling: no idle
7. Heat flux/load during idling: no idle
8. Fuel type: **Natural gas**
9. Fuel cost: Approximately **$0.50/Therm** (100,000 Btu)
10. Efficiency of heat source: **95% AFUE** boiler

Comments on Operating Costs

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

Part A: Energy Usage Estimate (Annual)

- Operation: 156 hours x 150 Btu/hr-ft^2 x 1,000 ft^2 = **23,400,000 Btu/year**

- Pick-up: Based on "specific heat" of concrete of 0.23 Btu/lb-°F, it requires **15 Btu per ft^2** to increase the temperature by **1°F** (for a 6 inch slab)
  Typical temperature pick-up is **20°F**
  Allow for **15%** downward heat loss while warming the slab
  1,000 ft^2 x 15 Btu/ft^2 -°F x 20°F x 1.15 = **345,000 Btu/event**
  20 events x 345,000 Btu/event = **6,900,000 Btu/year**

- Total Annual Load: 23,400,000 Btu + 6,900,000 Btu = **30.3 million Btu/year**

Comments on Operating Costs

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

Energy Cost – Natural Gas

- 1 Therm = 100,000 Btu (by definition)
- Cost per Therm varies by utility, customer type, and time
- 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 ft^2 ramp in Albany, NY. On/off automatic operation (no idling)

Part B: Cost of Energy Produced

- Fuel cost: **$0.50/Therm**
- Efficiency of heat source: **95% AFUE** condensing boiler
- Energy Content of gas: 100,000 Btu / Therm

- Cost per 1 million Btu = $0.50/Therm ÷ 100,000 Btu/Therm ÷ 95% x 1 million
  = **$5.25 per million Btu produced**

Comments on Operating Costs

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

Part C: Hourly Cost Estimate

- **150,000** Btu/hr x **$5.25** per million Btu produced = **$0.79/hour in fuel costs**

Based on stated assumptions and estimates

Other control strategies can affect cost
E.g., 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.

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Comments on Operating Costs

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

Part D: Annual Cost Estimate

- **30.3** million Btu/year x **$5.25** per million Btu produced = **$160/year in fuel costs**

Based on stated assumptions and estimates

Other control strategies can affect cost
E.g., 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

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

Reality check:

- Compare **$160/year** in fuel costs with typical contracting costs for mechanical snow removal plus frequent sanding and salting
- And the inconvenience and cost of snowbanks 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 costs saving for the owners

Courtesy Thornton Plumbing & Heating

Course Summary

This course covered:

1. Typical benefits of SIM systems

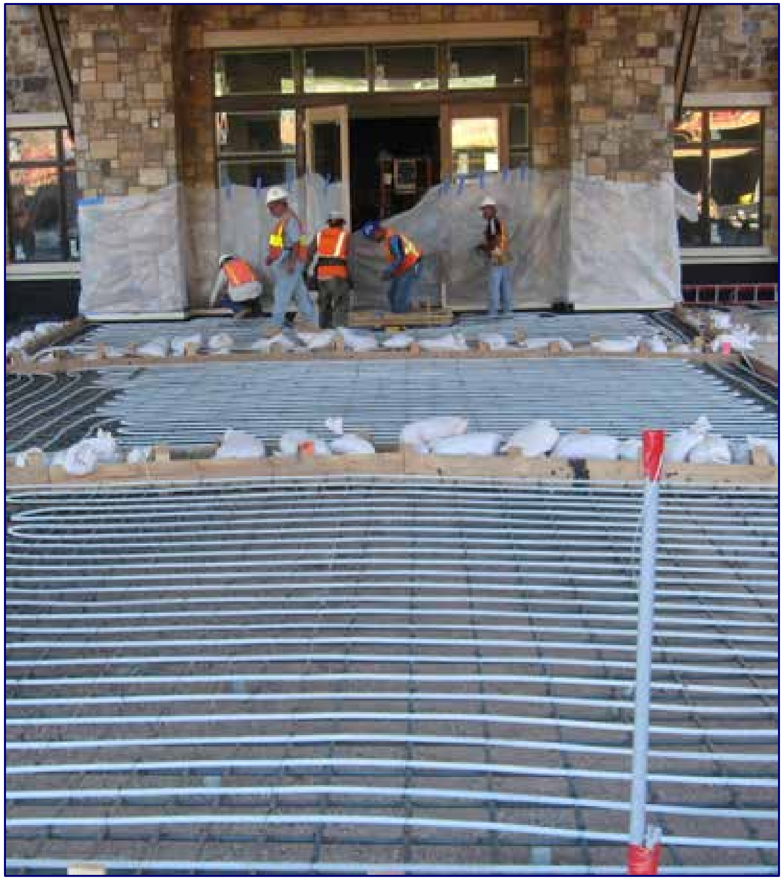
2. The three most common installation techniques

3. Selection of typical applications

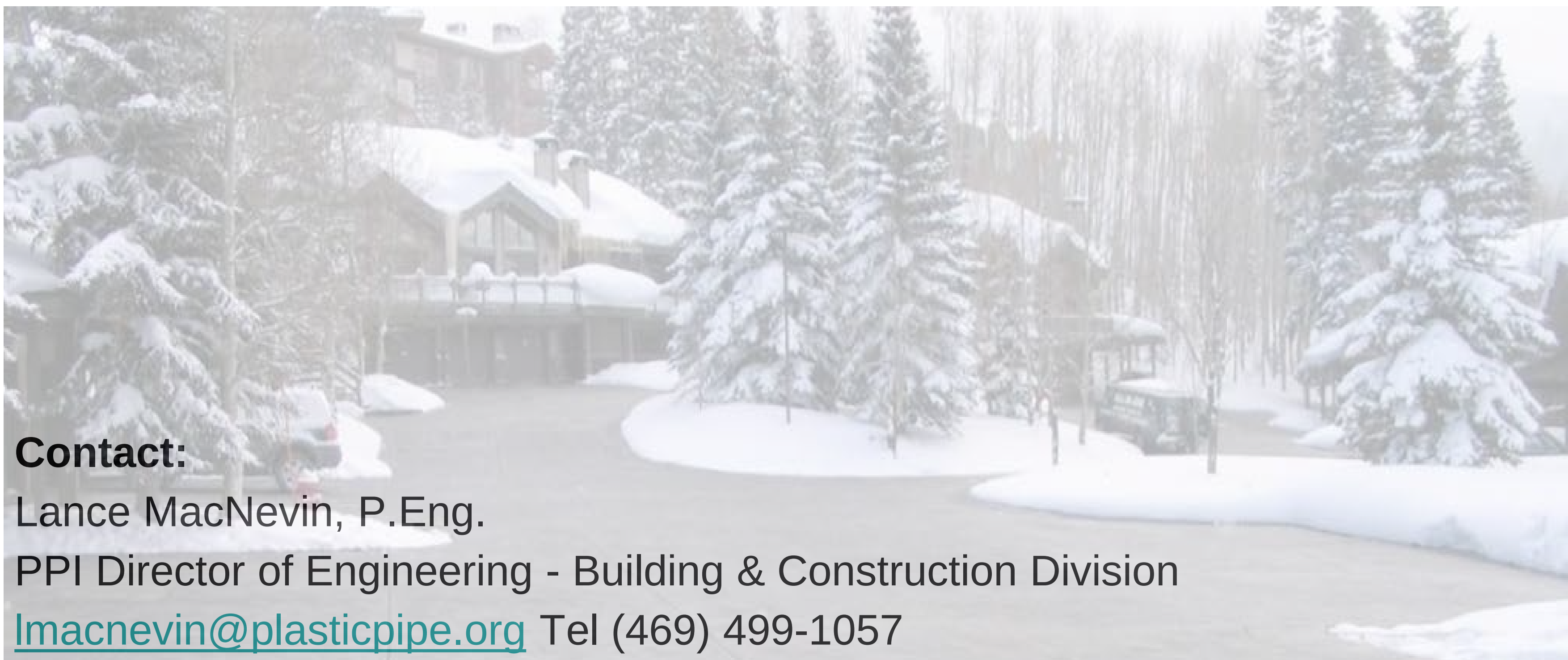
4. The five main design steps

5. Most common control strategies

6. Operating costs



Design and Installation of Hydronic Snow & Ice Melting Systems to Optimize Performance and Efficiency



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