Plastics Pipe Institute
BUILDING & CONSTRUCTION

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

A presentation by the Plastics Pipe Institute

ASPE American Society of Plumbing Engineers CEU PROVIDER

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The Plastics Pipe Institute

PPI Represents the Plastic Pipe Industry www.plasticpipe.org

- PPI was 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

PPI Mission

- Improving quality of life today, and for generations to come, by championing the advancement, acceptance, and use of sustainable and resilient plastic pipe systems

PPI Members

- ~200 member firms involved with the North American plastic pipe industry

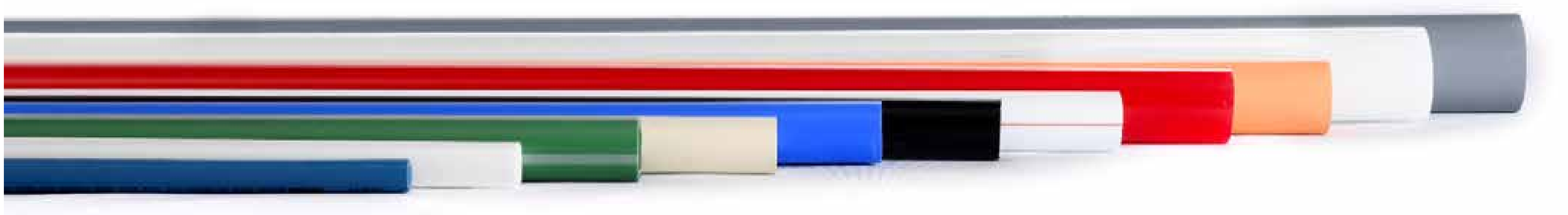
The Plastics Pipe Institute

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

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

BCD homepage: 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

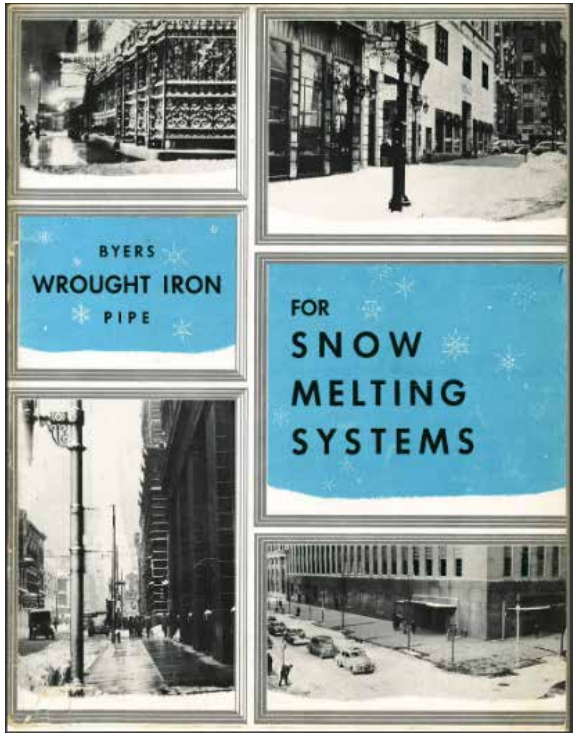
- The piping material for SIM distribution systems is typically:
  - **PEX**: Crosslinked Polyethylene, or
  - **PE-RT**: Polyethylene of Raised Temperature Resistance
  - **PP** (polypropylene) pressure pipe and **CPVC** may also be used for supply piping

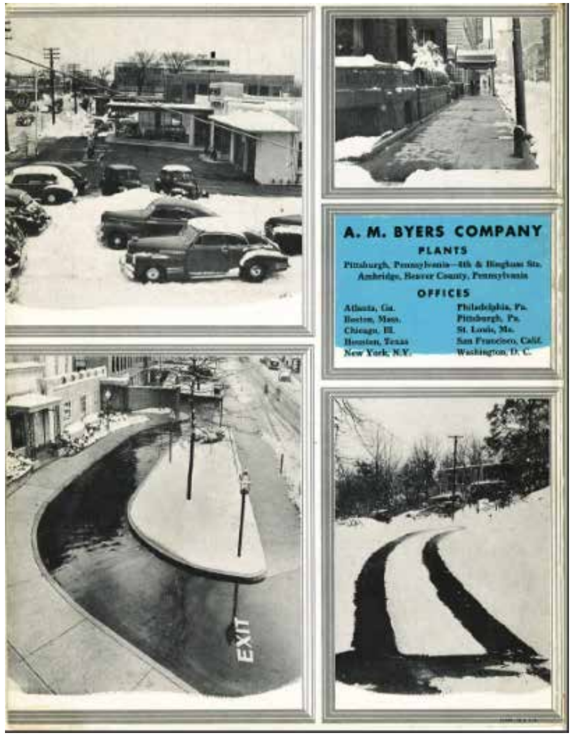
- Learn more about these materials at plasticpipe.org/buildingconstruction

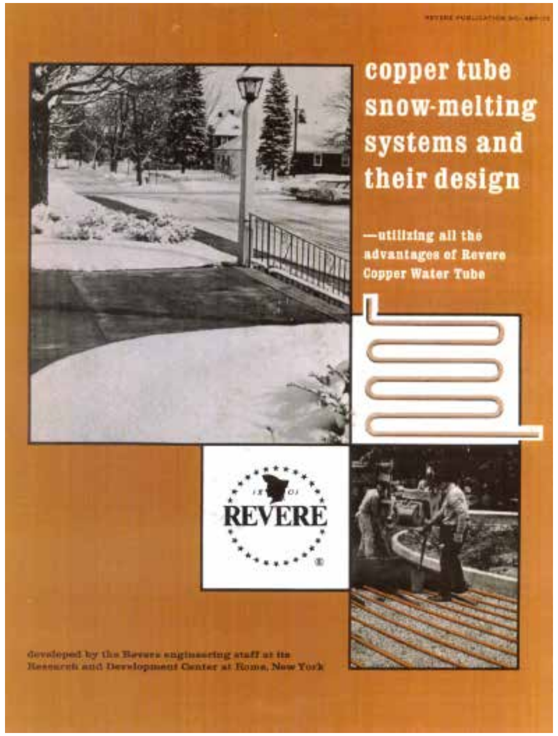
What Is A Hydronic SIM System?

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

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

Courtesy REHAU

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

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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 entrances free of snow and ice improves access and safety, while eliminating a source of liability
- 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 convenience, SIM systems clear outdoor surfaces, leaving them dry
- No snowbanks 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

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 building entrances

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, ground source heat pumps, geothermal energy, 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


Courtesy REHAU

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
- The piping material for SIM systems is typically **PEX** (crosslinked polyethylene) and **PE-RT** (polyethylene of raised temperature resistance)
- With proper design and installation, hydronic SIM systems provide decades of reliable operation with virtually no maintenance to piping systems

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 475 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 piping**

Benefits of Snow and Ice Melting Systems - Summary

To summarize, typical benefits pf SIM systems include:

1. Better safety

2. Reduced liability

3. Healthier convenience

4. Lowered maintenance costs

5. Minimized environmental impact

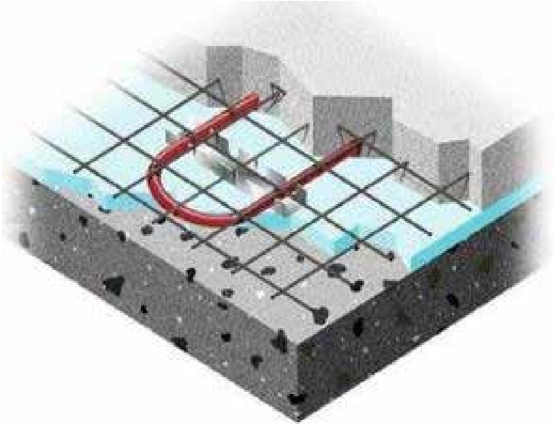
6. Long-term reliability

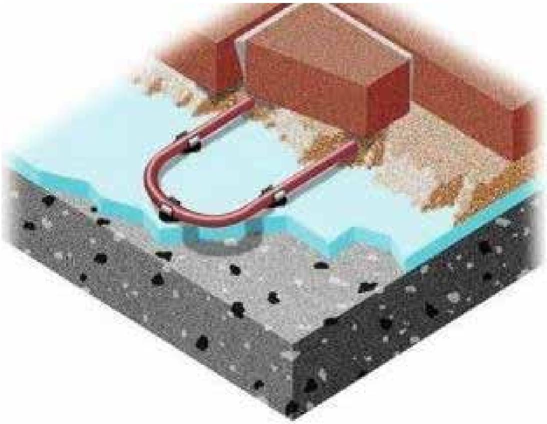
Courtesy REHAU

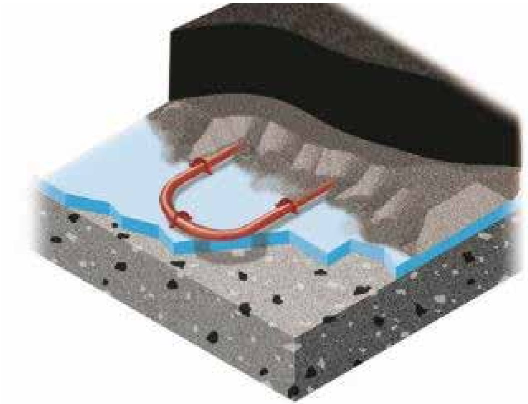
2. SIM Installation Techniques

This section describes three typical installation types for outdoor surfaces:

1. Poured concrete
2. Interlocking pavers
3. Asphalt







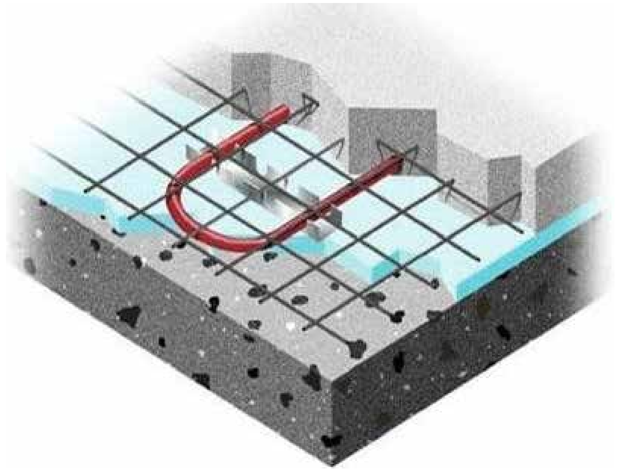
Hydronic snow and ice melting systems can be successfully installed in practically all types* of external surfaces

**Permeable concrete is the most difficult surface*

SIM Installation Techniques - Concrete

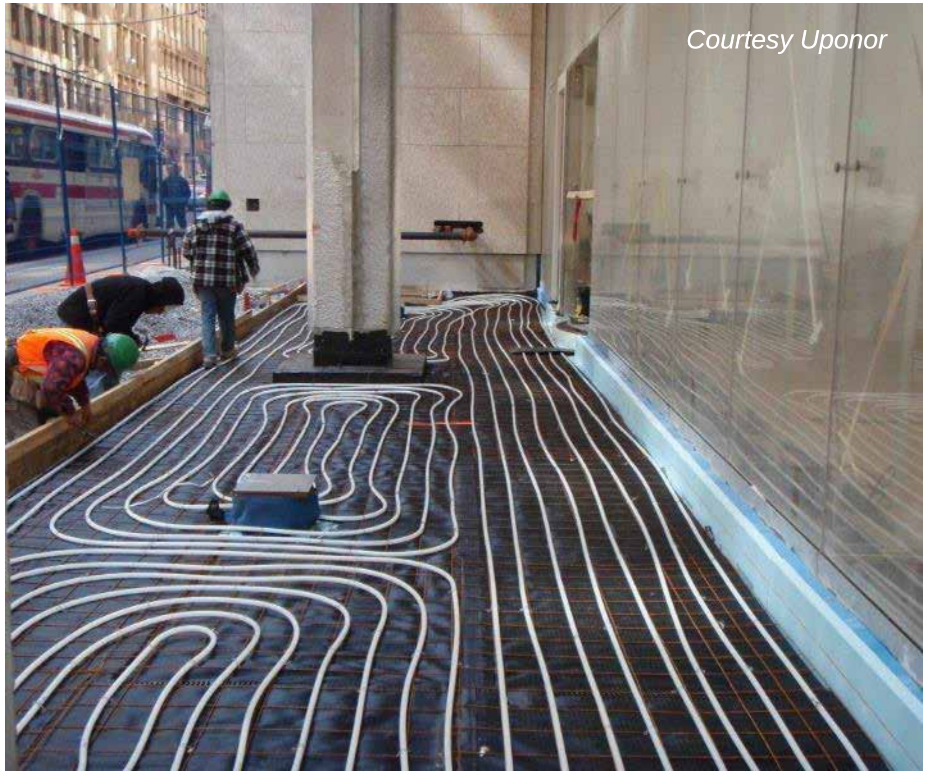
1. Tubing embedded within poured concrete

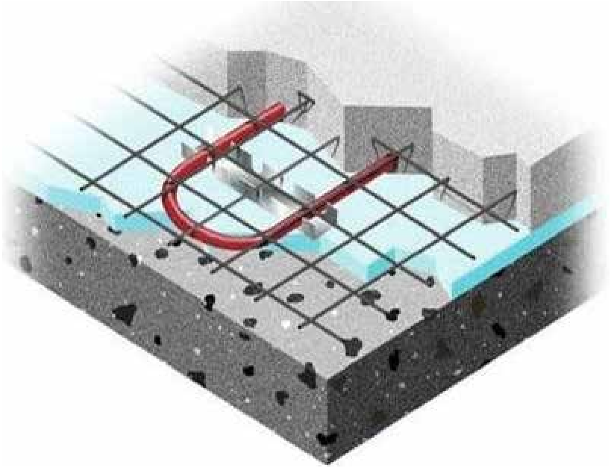
- In poured concrete, the tubing is simply embedded within the concrete
    - Very popular for stained concrete
- Recommended to place the tubing 2 to 3 inches (5 - 8 cm) below the surface for faster response time (not always practical)
- Tubing is sometimes stapled directly onto the insulation board 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 - Concrete

1. Tubing embedded within poured concrete

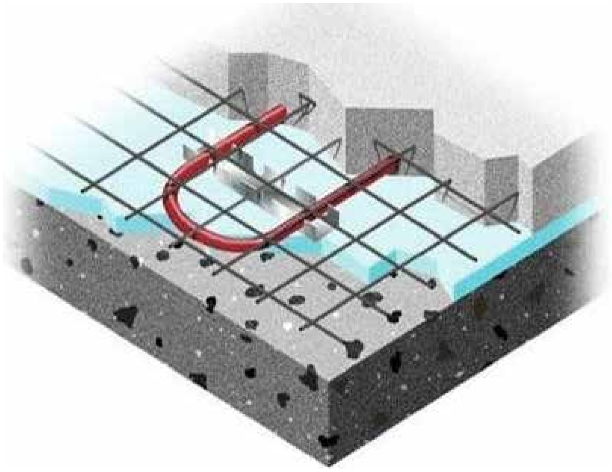




Poured concrete with tubing embedded 2 to 3 inch from top surface

SIM Installation Techniques - Concrete

1. Tubing embedded within poured concrete



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

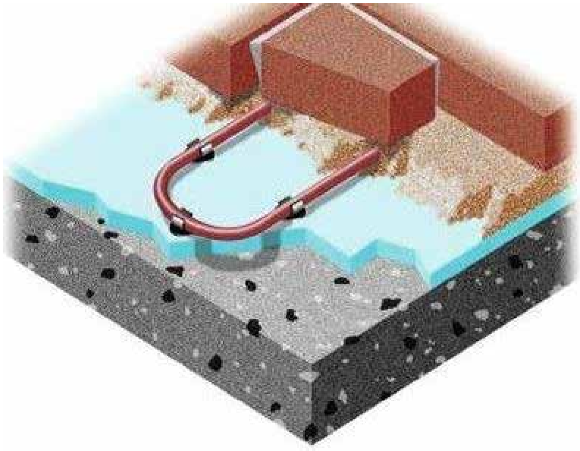
SIM Installation Techniques - Pavers

2. Tubing installed under interlocking pavers (one method)

- Tubing installed above insulation using plastic rails, staples, screw clips, mesh clips
- Tubing 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

Media

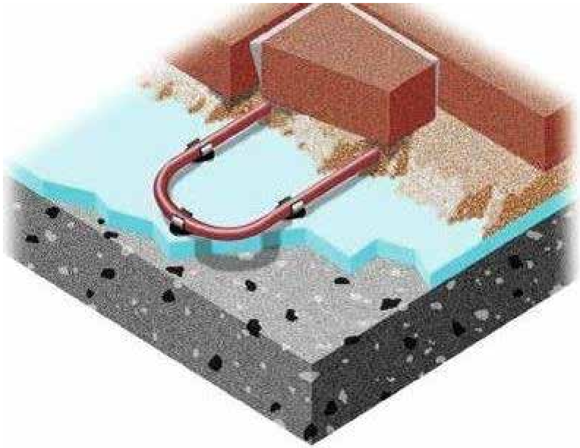
- Compacted sand bed is recommended
- Stone dust loses strength when wet, and can heave when frozen



Pavers installed over sand bed with embedded heating tubing

SIM Installation Techniques - Pavers

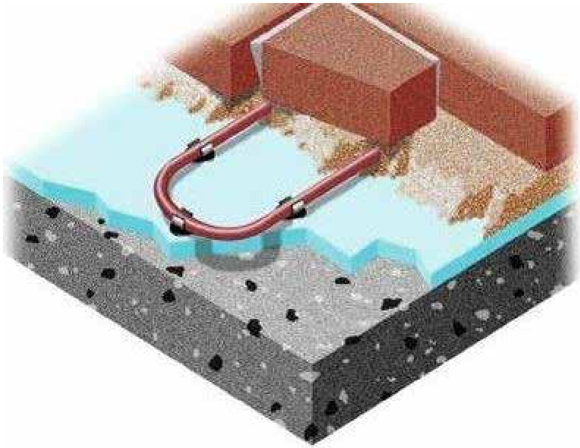
2. Tubing installed under interlocking pavers



Pavers installed over sand bed with embedded heating tubing

SIM Installation Techniques - Pavers

2. Tubing installed under interlocking pavers

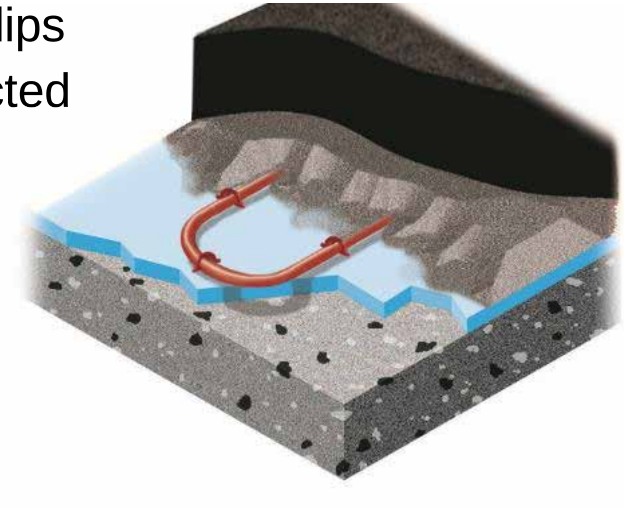


Pavers installed over sand bed with embedded heating tubing

SIM Installation Techniques - Asphalt

3. Tubing installed under asphalt

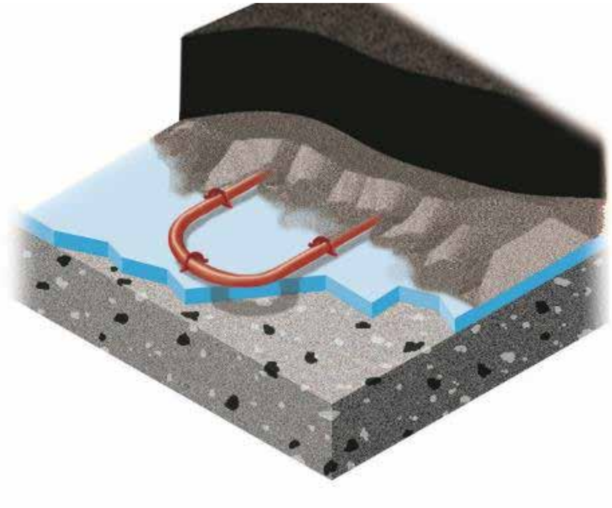
- Tubing installed above insulation using plastic rails, staples, screw clips, mesh clips
- Tubing is encased within 3 inches (7.5 cm) of stone dust or sand media, compacted
- Asphalt is placed above the media (dust or sand) and compacted normally
- Cold water is flushed through pipes during placement of hot asphalt and until it cools significantly, to protect pipes
- Water flow is regulated to be less than 150°F (65°C) at the distribution manifold outlet to keep the tubing from overheating until the asphalt cools off (this may take several hours)



Media: Compacted stone dust works best, not pea stone or crushed gravel

SIM Installation Techniques - Asphalt

3. Tubing installed under asphalt



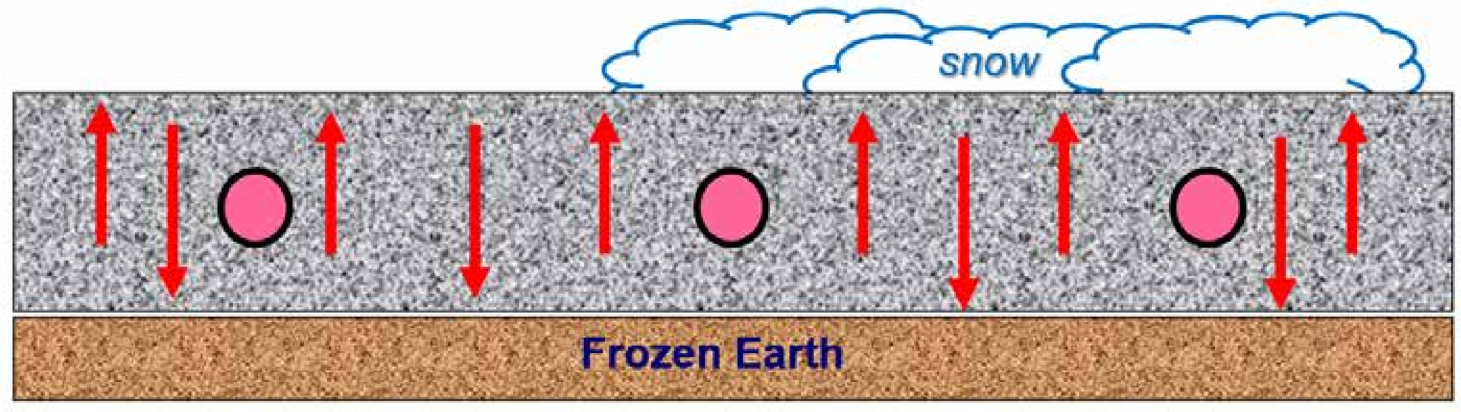
Tubing embedded within sand or stone dust below asphalt

SIM Installation Techniques - Insulation

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!)

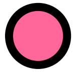
= Tubing filled with warm glycol

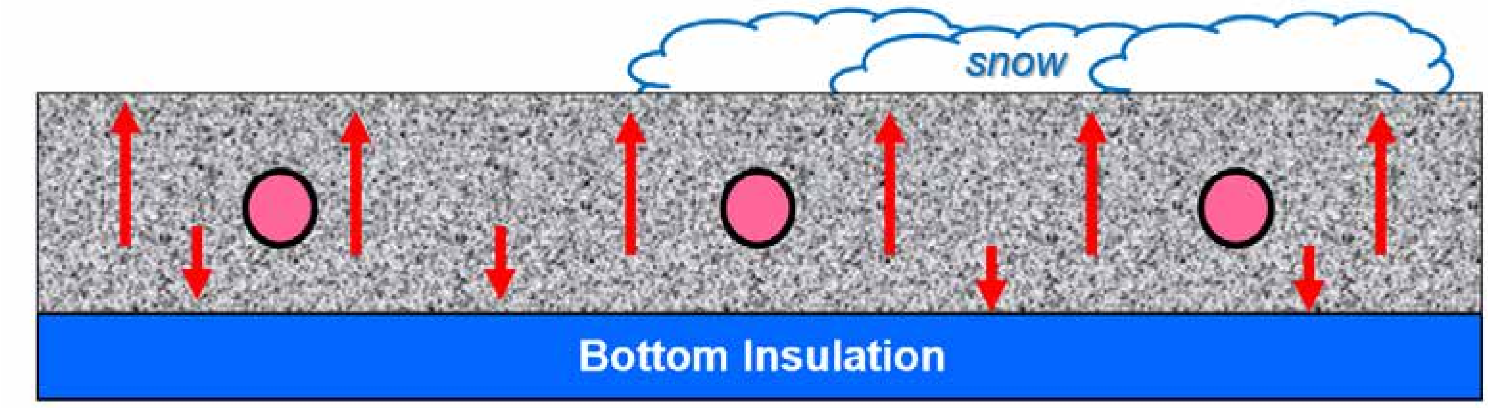


SIM Installation Techniques - Insulation

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, and system will have better response time
- Smaller heat source and circulators, better efficiency

 = Tubing filled with warm glycol



SIM Installation Techniques - Insulation

Importance of Appropriate Insulation

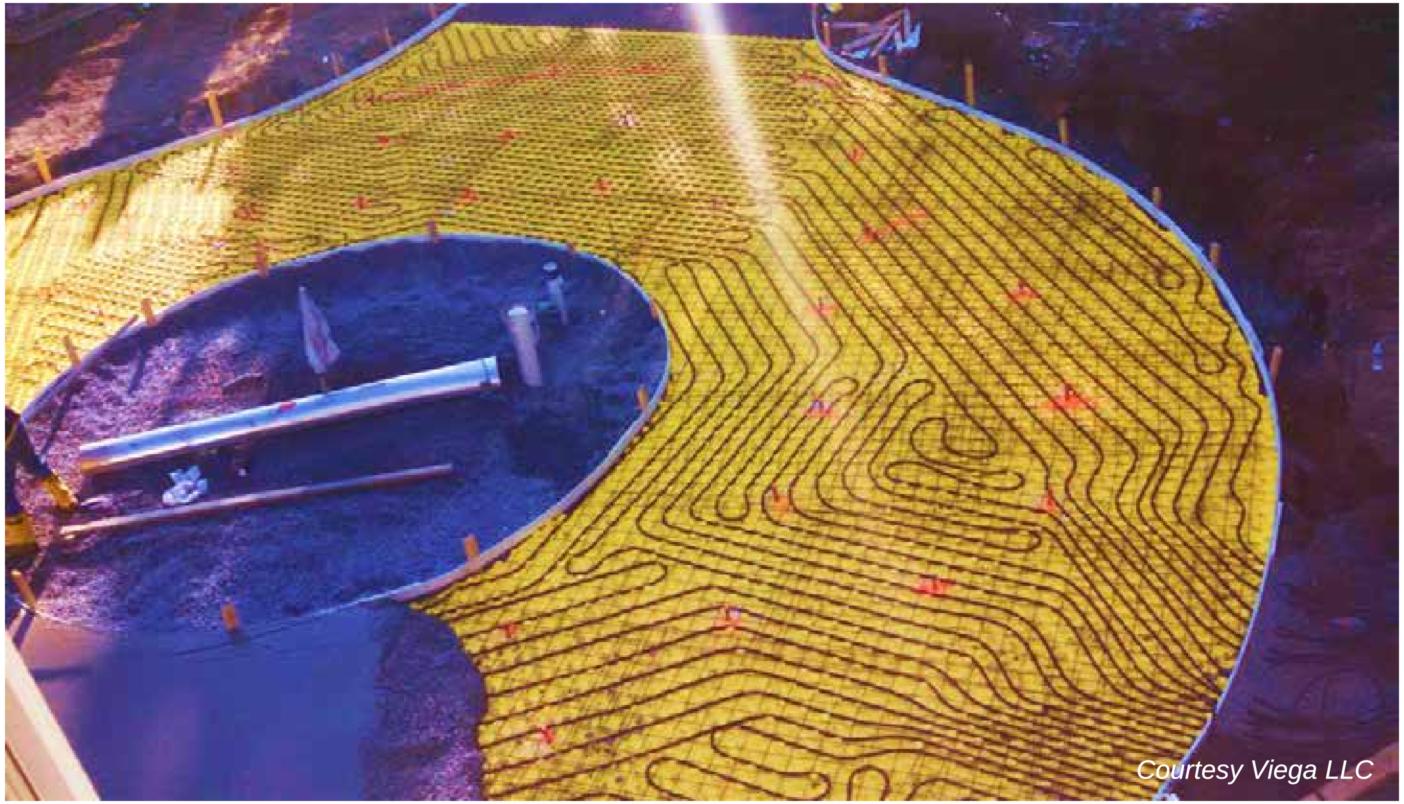
- Codes typically require **at least R-5** insulation below SIM areas, but many designers specify **R-10**, since insulation also improves response time
- Typical insulation thickness is 1 in., 1 ½ in. or 2 in. (25 mm, 38 mm, 50 mm)
- Insulation is typically extruded polystyrene (XPS), polyurethane (PU), 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

Left: Spray-foam insulation on old stone steps (church)

Right: Medivac landing pad on hospital rooftop

SIM Installation Techniques - Insulation

Importance of Appropriate Insulation



Insulation panels with preformed knobs for holding tubing

SIM Installation Techniques - Drainage

Importance of Drainage

- Just like rain, melted snow must have a good drainage path
- Slope surfaces downward for natural drainage
- Drain to lowest points of the property

- Control the run-off so as not to create hazards
- Plan locations of trench drain box/es

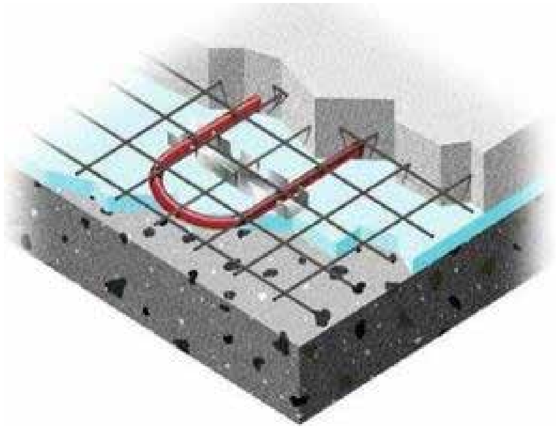
- Be sure that drains will not freeze (place pipes under
  or around drain (see image)

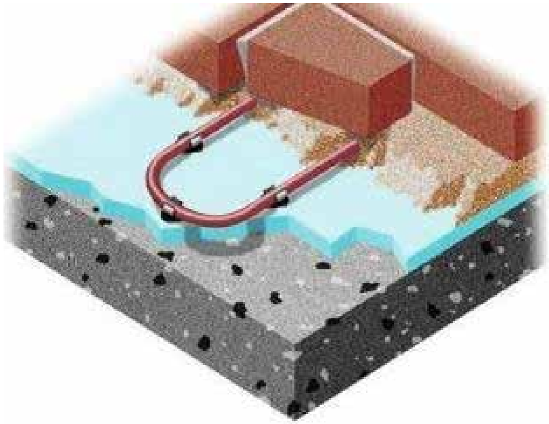
- Connect drain to available storm sewer system,
  within code requirements, or to a nearby pond, ditch, etc.

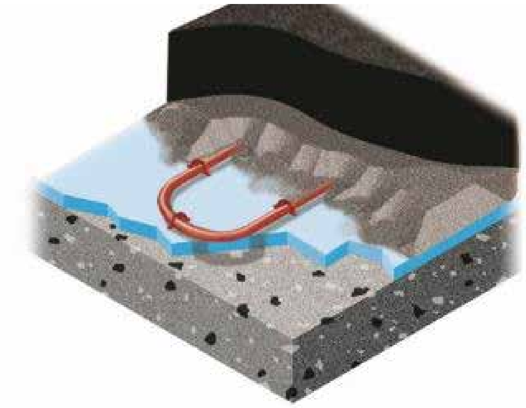
SIM Installation Techniques - Summary

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 homes

Typical Applications of SIM systems

1. Sidewalks

- Commercial buildings


Courtesy Zurn

Typical Applications of SIM systems

1. Sidewalks

- Public sidewalks (e.g., downtown Anchorage)
- Manifold vaults are within the sidewalks

Typical Applications of SIM systems

1. Sidewalks

- Public square (e.g., downtown Montréal)

Courtesy HeatLink

Typical Applications of SIM systems

1. Sidewalks

- Public areas, parks (e.g., This is the Place Heritage Park, UT)

Courtesy REHAU

Typical Applications of SIM systems

1. Sidewalks

- Municipal buildings

Courtesy Klimatrol

- University (handicapped parking)

Typical Applications of SIM systems

1. Sidewalks

- Casino/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 to pools, hot tubs
- 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 for free heating

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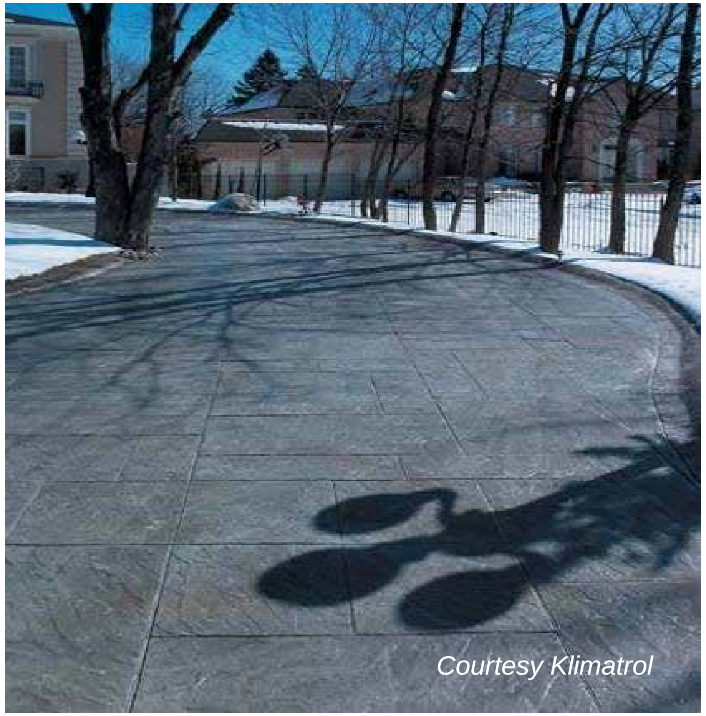
Typical Applications of SIM systems

4. Driveways

- Under stained concrete or pavers



Courtesy Klimatrol

Courtesy Ridgeway Home Services

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 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

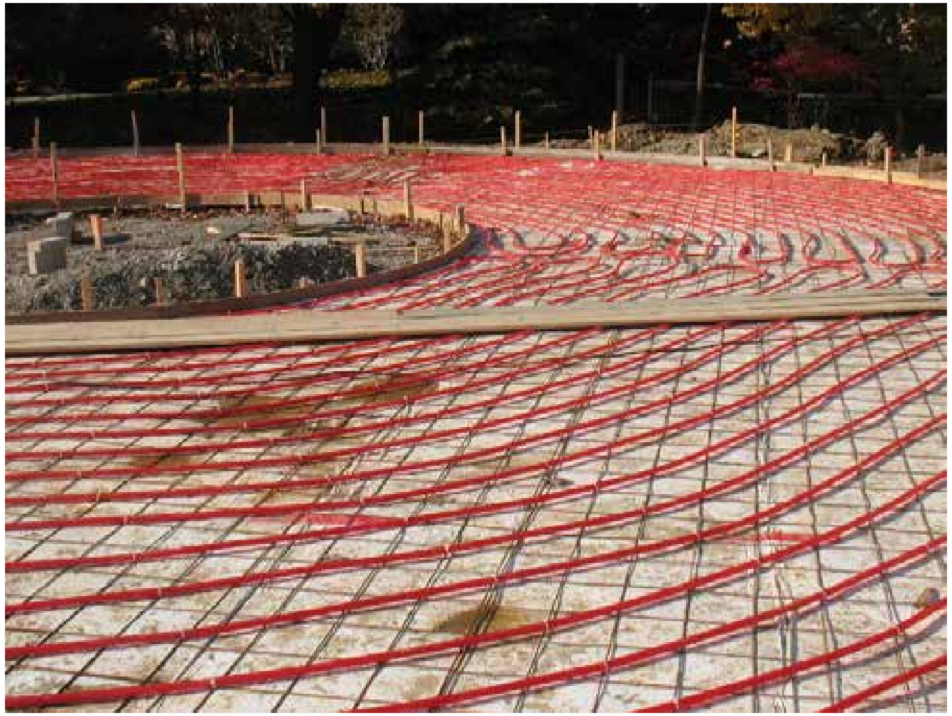
5. Ramps

- 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

Courtesy Uponor x 2

Typical Applications of SIM systems

6. Roadways

- SIM systems add safety on roads with steep inclines (e.g., ski villages)

Courtesy REHAU

Typical Applications of SIM systems

7. Parking garages

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


Courtesy REHAU

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Typical Applications of SIM systems

7. Parking garages

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

Courtesy MrPEX Systems

Typical Applications of SIM systems

8. Train stations

- Add safety and convenience to outdoor train stations and platforms

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 (e.g., rubber-tired railcar tracks)

Typical Applications of SIM systems

10. Aviation

- Medivac landing pads (e.g., hospital rooftop)

Courtesy REHAU

Plastics Pipe Institute
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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 using diesel, utilizing massive amounts of fuel with expensive equipment and labor

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, utilizing massive amounts of fuel with expensive equipment and labor

Typical Applications of SIM systems

Melting Hot Pads

- What to do with all that city street and parking lot snow?
- Build a hydronic SIM system surrounding drains
- Push snow onto the "hot pad" or "melting pad", melt away
- Just like a Zamboni melting pit!

- Drainage is essential
- May need to "mix" pile to ensure contact with hot surface

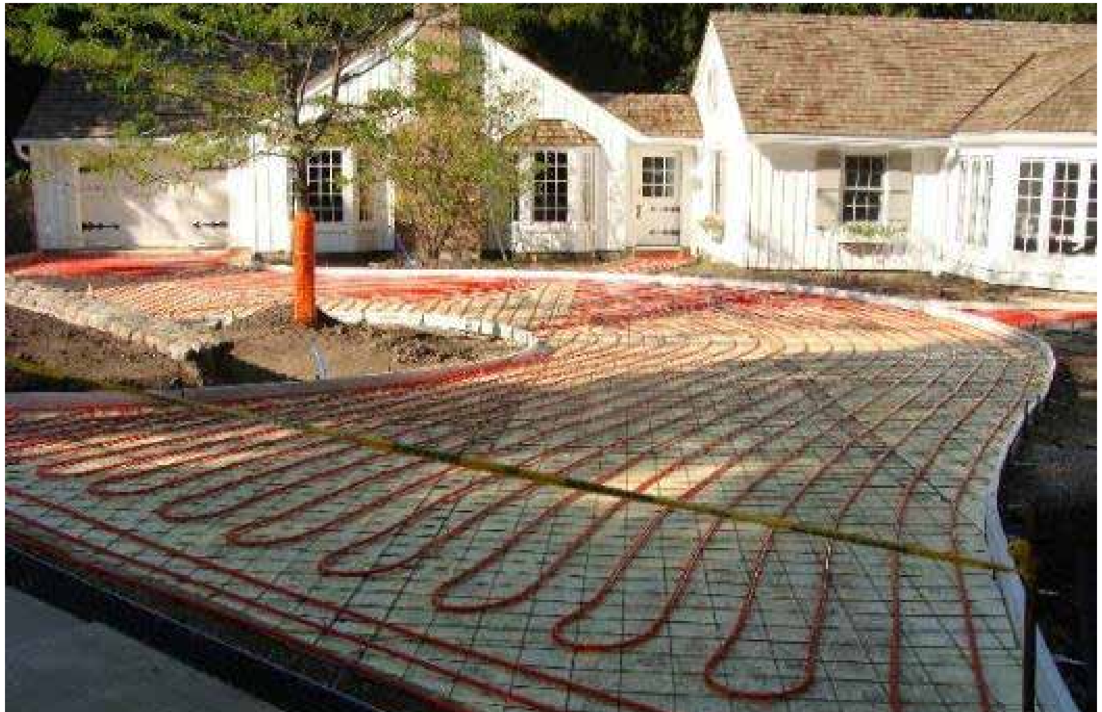
- Helpful in congested cities and many commercial facilities

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

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 most of it drain away, which uses less energy)


Courtesy VIEGA LLC

SIM Design - Overview

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

Five SIM Design Steps

This section will introduce the five main design steps for SIM systems:

1. Select the appropriate performance level with the customer
2. Determine the required heat output/heat flux for the area
3. Select and size heat source to meet the required heat output
4. Design the piping distribution system (e.g., pipe diameter and spacing, circuit lengths)
5. Size hydronic equipment such as circulator pumps, compression tanks, etc.

Note: Approved antifreeze is required in practically every hydronic SIM system to prevent freezing of fluid when systems are not operating and to prevent fluid from becoming “gelled” or unpumpable when cold. It is generally recommended to fill all SIM systems with premixed 50% propylene glycol with water for freeze protection and normal operation.

SIM Design - Performance Levels


Courtesy Thornton Plumbing & Heating

1. Select the Appropriate Performance Level

- ASHRAE HVAC Applications "Ch. 52 Snow Melting and Freeze Protection" includes tables showing *Frequencies of snow-melting surface heat fluxes at steady state conditions* for 46 major US cities
    - For cities not found in that table, a series of calculations can be performed to estimate the heat loads based on historical weather data for that location
- In principle, the designer and customer should collaborate and agree to the 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 - Performance Levels

1. Select the Appropriate Performance Level

- ASHRAE HVAC Applications "Ch. 52 Snow Melting and Freeze Protection"
- See excerpt below for Albany, NY:

Table 1 Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions*

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

Table 1 extract Courtesy ASHRAE

SIM Design - Step 1

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

*E.g., **Ar = 1.0** is 100% snow-free during snow fall. Requires the highest heat flux/heating load capacity.*

*E.g., **Ar = 0.5** is 50% snow-free during snow fall, with some allowed accumulation. Snow will be completely melted, evaporated and dried before system turns off.*

*E.g., **Ar = 0.0** is 0% snow-free during certain snow fall events. Snow will be allowed to accumulate short-term, but area will be completeiy melted and dried before system turns off.*

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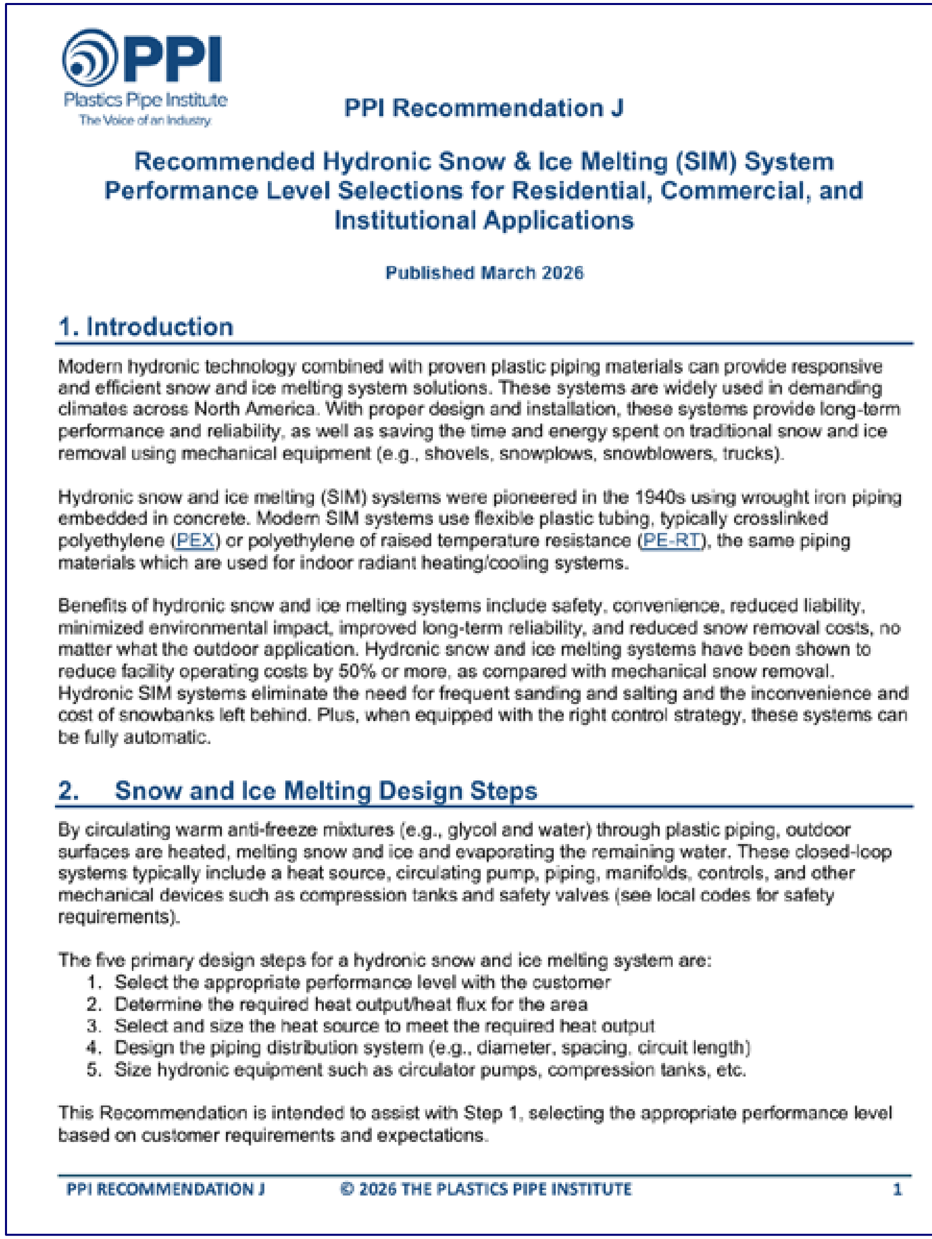
SIM Design - Step 1

See **PPI Recommendation J** for explanation of the design process and selection of performance levels

- Free download

- plasticpipe.org/buildingconstruction


Plastics Pipe Institute
The Voice of an Industry

PPI Recommendation J

Recommended Hydronic Snow & Ice Melting (SIM) System Performance Level Selections for Residential, Commercial, and Institutional Applications

Published March 2026

1. Introduction

Modern hydronic technology combined with proven plastic piping materials can provide responsive and efficient snow and ice melting system solutions. These systems are widely used in demanding climates across North America. With proper design and installation, these systems provide long-term performance and reliability, as well as saving the time and energy spent on traditional snow and ice removal using mechanical equipment (e.g., shovels, snowplows, snowblowers, trucks).

Hydronic snow and ice melting (SIM) systems were pioneered in the 1940s using wrought iron piping embedded in concrete. Modern SIM systems use flexible plastic tubing, typically crosslinked polyethylene (PEX) or polyethylene of raised temperature resistance (PE-RT), the same piping materials which are used for indoor radiant heating/cooling systems.

Benefits of hydronic snow and ice melting systems include safety, convenience, reduced liability, minimized environmental impact, improved long-term reliability, and reduced snow removal costs, no matter what the outdoor application. Hydronic snow and ice melting systems have been shown to reduce facility operating costs by 50% or more, as compared with mechanical snow removal. Hydronic SIM systems eliminate the need for frequent sanding and salting and the inconvenience and cost of snowbanks left behind. Plus, when equipped with the right control strategy, these systems can be fully automatic.

2. Snow and Ice Melting Design Steps

By circulating warm anti-freeze mixtures (e.g., glycol and water) through plastic piping, outdoor surfaces are heated, melting snow and ice and evaporating the remaining water. These closed-loop systems typically include a heat source, circulating pump, piping, manifolds, controls, and other mechanical devices such as compression tanks and safety valves (see local codes for safety requirements).

The five primary design steps for a hydronic snow and ice melting system are:
1. Select the appropriate performance level with the customer
2. Determine the required heat output/heat flux for the area
3. Select and size the heat source to meet the required heat output
4. Design the piping distribution system (e.g., diameter, spacing, circuit length)
5. Size hydronic equipment such as circulator pumps, compression tanks, etc.

This Recommendation is intended to assist with Step 1, selecting the appropriate performance level based on customer requirements and expectations.

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SIM Design - Step 1

PPI Recommendation J explains SIM design process, frequency distribution % and snow-free area ratios

3. Snow and Ice Melting Performance Levels

Unlike in an indoor heating system, where the methods to calculate heating loads are well defined, for SIM systems the designer and customer collaborate to select the capability of each system based on factors such as the type of outdoor area, its exposure, and customer requirements and expectations.

In the 2023 ASHRAE Handbook *HVAC Applications*, Ch. 52 "Snow Melting and Freeze Protection" provides guidance to designers of SIM systems. Ch. 52 includes Table 1 *Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions* for forty-six (46) major US cities.

The heat flux values are listed under the sub-heading "Heat Fluxes Not Exceeded During Indicated Percentage of Snowfall Hours from 1982 to 1993, Btu/h-ft^2" with percentage values of 75%, 90%, 95%, 98%, 99%, and 100%. For example, a 95% value indicates that 95% of the time, the snow melting heat flux load should be at the given value, or lower. These are referred to as **Frequency Distribution** values.

Within Table 1, each city also has three rows referring to **Snow-Free Area Ratios (Ar)**, defined as:

- **Ar = 1.0** Snow-Free Area of 100% (i.e., no accumulation during snowfall, see Fig. 1)
- **Ar = 0.5** Snow-Free Area of 50% (i.e., some accumulation allowed during snowfall, see Fig. 2)
- **Ar = 0** Snow-Free Area of 0% (i.e., the surface is allowed to be covered with snow during heavy snowfall, melting snow from the bottom of the layer, see Fig. 3)

Table 1: Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions*

Location	Ar	75%	90%	95%	98%	99%	100%
Albany, NY	1	89	125	149	187	212	321
	0.5	60	86	110	138	170	276
	0	37	62	83	119	146	276

*Table extracted from 2023 ASHRAE Handbook *HVAC Applications*, Ch. 52 "Snow Melting and Freeze Protection"

Note 1: The data in Table 1 from Chapter 52 of the 2023 ASHRAE Handbook was generated from a large dataset covering a period from 1982 -1993; this data may have shifted since that time. Additionally, those numbers are for only the surface of the slab, and specifically for a slab of width 20 ft (6.1 m) and an emittance value of 0.9. For cities not found in Table 1 of the Handbook, designers can select a city listed in the table that closely matches the snowfall rates, winter temperatures, wind speeds, and elevation for the system location. Otherwise, a series of calculations, shown in Ch. 52 of the Handbook, can be performed by the designer to estimate the heat flux requirements based on historical weather data for the location.

Selecting the snow-free area for each SIM system is a design choice. Although having the SIM area completely free of snow during the snowfall is typically preferred, maintaining a snow-free area of 100% (Ar = 1.0) requires that the system melts all snow on contact and requires far more energy than if a thin layer of snow is allowed to accumulate on the surface during the snow event.

SIM Design - Step 1

PPI Recommendation J explains SIM design process, frequency distribution % and snow-free area ratios

Note: *PPI Recommendation J includes courtesy suggestions to help manage customer expectations. Each customer should decide and confirm what is expected for their project.*

Table 2: Suggested Snow-Free Area Ratio and Frequency Distribution Values for Typical SIM Applications*

Application	Snow Free Area Ratio (Ar)	Frequency Distribution %
Private residential sidewalk, steps, ramp	0.5 or 1.0	75 or 90
Private residential driveway	0.0 or 0.5	75 or 90
Private residential driveway, inclined	1.0	90
Apartment building sidewalk, steps, ramp	1.0	95 or 98
Apartment building parking lot	0.5	75 or 90
Apartment building parking ramp	1.0	90 or 95

Table 2: Suggested Snow-Free Area Ratio and Frequency Distribution Values for Typical SIM Applications*

Application	Snow Free Area Ratio (Ar)	Frequency Distribution %
Private residential sidewalk, steps, ramp	0.5 or 1.0	75 or 90
Private residential driveway	0.0 or 0.5	75 or 90
Private residential driveway, inclined	1.0	90
Apartment building sidewalk, steps, ramp	1.0	95 or 98
Apartment building parking lot	0.5	75 or 90
Apartment building parking ramp	1.0	90 or 95
Public building sidewalk, steps, ramp	1.0	90 or 95
Public building parking lot	0.5	90
Public building parking ramp	1.0	90 or 95
Public building loading dock	1.0	90 or 95
Commercial building sidewalk, steps, ramp	1.0	90 or 95
Commercial building parking lot	0.5	75 or 90
Commercial building parking ramp	1.0	90 or 95
Commercial building loading dock	1.0	90 or 95
School sidewalk, steps, ramp	1.0	90
School parking lot	0.5	90
School parking ramp	1.0	90 or 95
Fire/rescue station sidewalk, steps, ramp	1.0	95, 98, or 99
Fire/rescue station parking lot	0.5	95
Fire/rescue station vehicle ramps	1.0	95 or 98
Hospital sidewalk, steps, ramp	1.0	95, 98, or 99
Hospital parking lot	0.5 or 1.0	90 or 95
Hospital parking ramp	1.0	95
Hospital MediVac landing pad	1.0	99
Airport public entrances	1.0	95
Airport ramp/apron/taxiway/runway	0.5	95
Private landing pad (helicopter)	1.0	90 or 95
Private ramp/apron/taxiway/runway (airplane)	0.5 or 1.0	90
Car wash and aprons	1.0	90

*This content includes courtesy suggestions to help manage customer expectations. Each customer should decide and confirm what is expected for their project.

SIM Design - Example Project

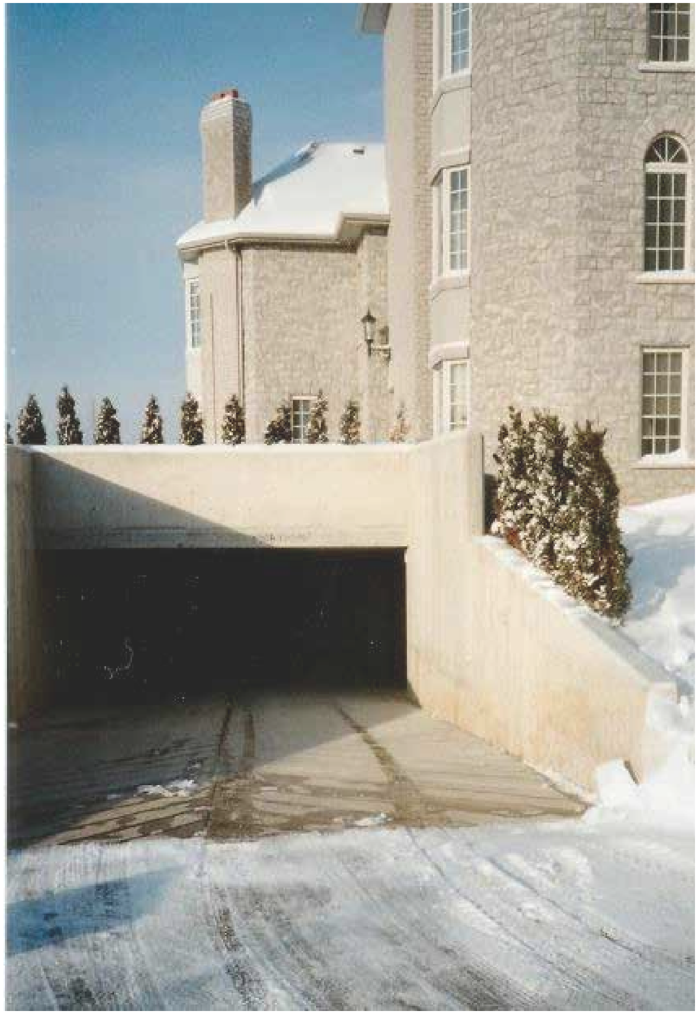
1. Select the Appropriate Performance Level

Design Example: Parking Ramp in Albany, NY

- Melting area: **1,000 ft^2** Garage ramp (20 ft. wide x 50 ft. long)
- 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
- Selection: **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

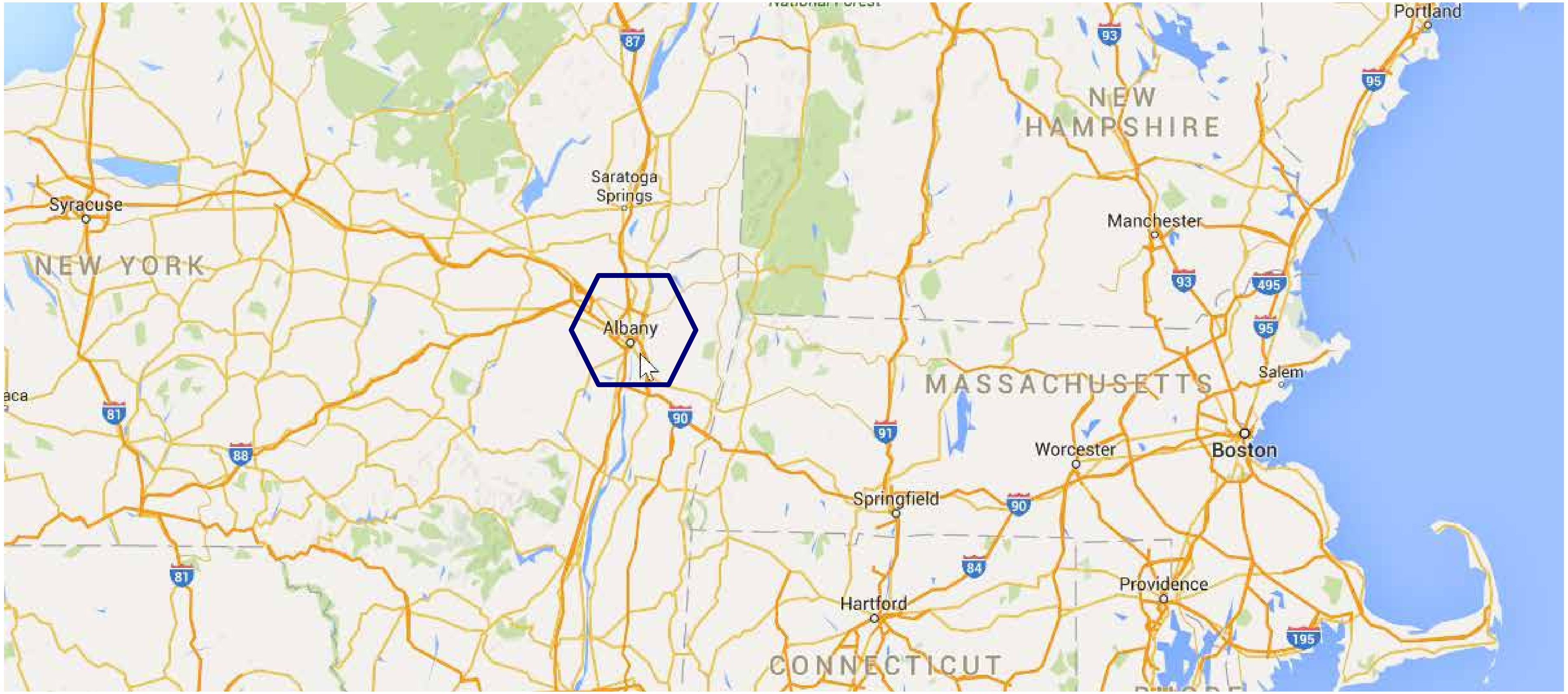
Ramp is 50 ft. long



Ramp is 20 ft. wide

SIM Design - Example Project

Design Example: Albany, NY (a wintry place)



SIM Design - Example Project

2. Determine Required Heat Output: Melting Operation

- Use ASHRAE Handbook Table 1 to find the “heat flux” (load) based on **Ar = 1.0** and **90%**
- Table 1 shows **125 Btu/h-ft^2** as the required output for this particular project in Albany

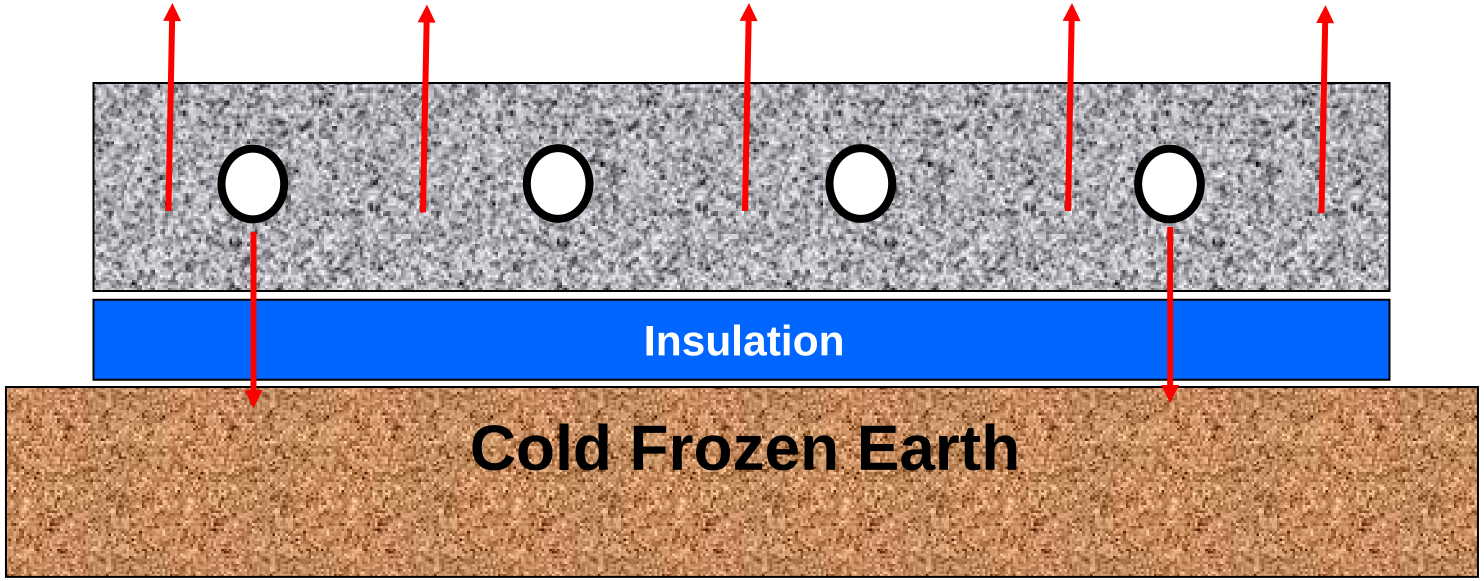
Table 1 Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions*

Location	Snowfall Hours per Year	Snow-Free Area Ratio, A_r	Heat Fluxes Not Exceeded During Indicated Percentage of Snowfall Hours from 1982 to 1993, Btu/h·ft^2					
			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 - Example Project

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**

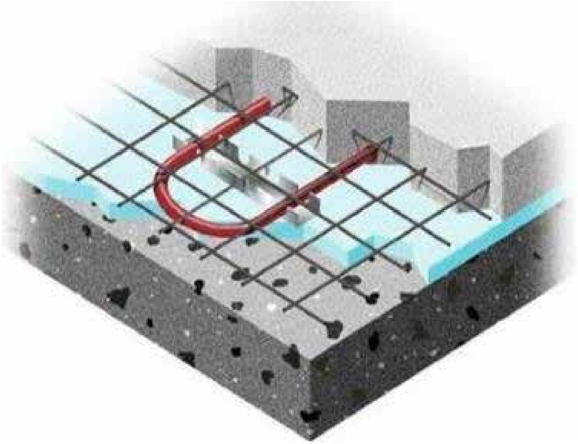


Even with appropriate insulation under the slab, there will still be some downward loss

SIM Design - Example Project

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-˚F

***38°F** is used as the target temperature of the concrete slab during melting operation
to allow for losses due to wind, to avoid striping, etc.; higher temperatures are typically not necessary

SIM Design - Example Project

2. Determine Required Heat Output: Pick-up

- Albany ramp is 6 in. thick concrete
- Requires **15 Btu per ft^2 per °F** based on the "specific heat" of concrete: **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 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 - Example Project

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

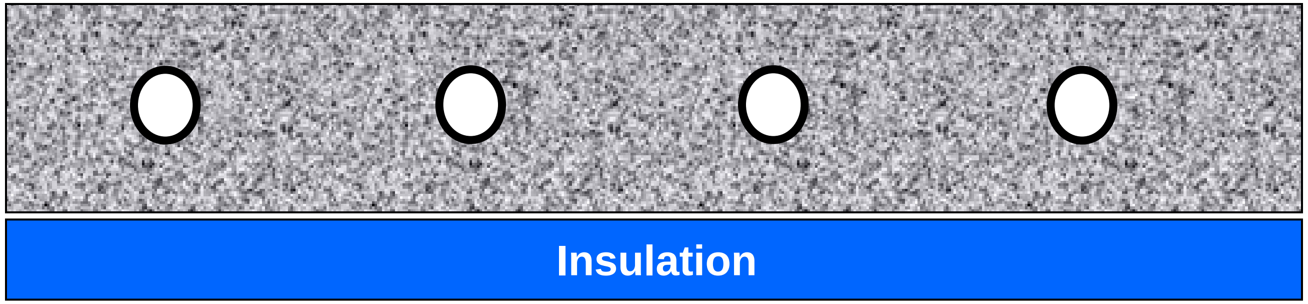
This system will use a dedicated boiler

SIM Design - Example Project

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 diameter, 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 - Example Project

4. Design the Piping Distribution System

The designer's choice for this project:

a. **¾ Tubing diameter**

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 - Example Project

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 in./8 in. = 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 (for example):

- 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 heating load)

SIM Design - Example Project

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**

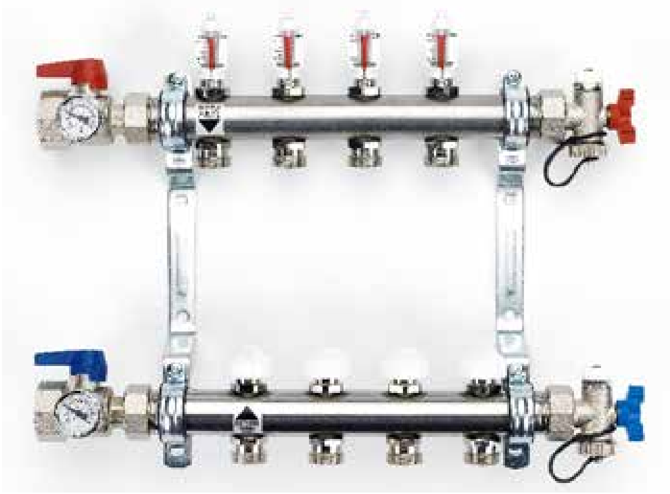
- Using 50% PP Glycol and a 25ºF ΔT:

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

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

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

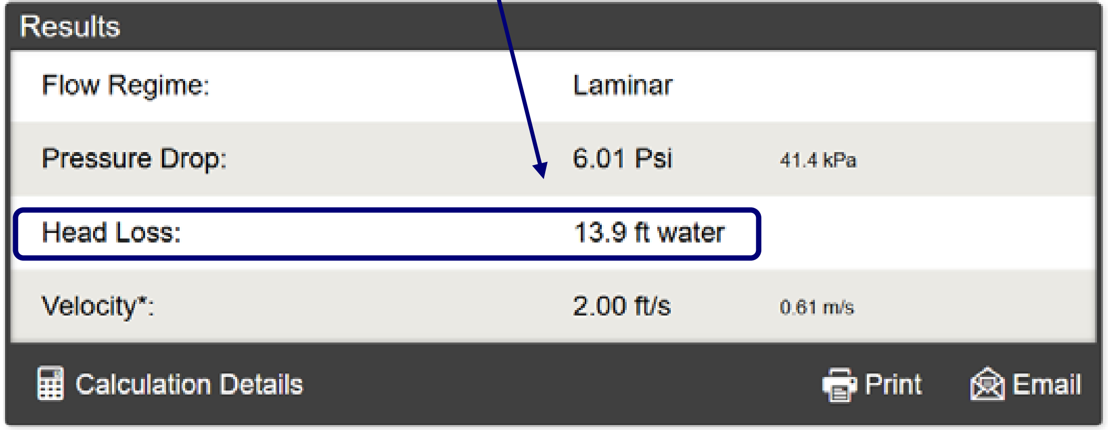
Courtesy REHAU



SIM Design - Example Project

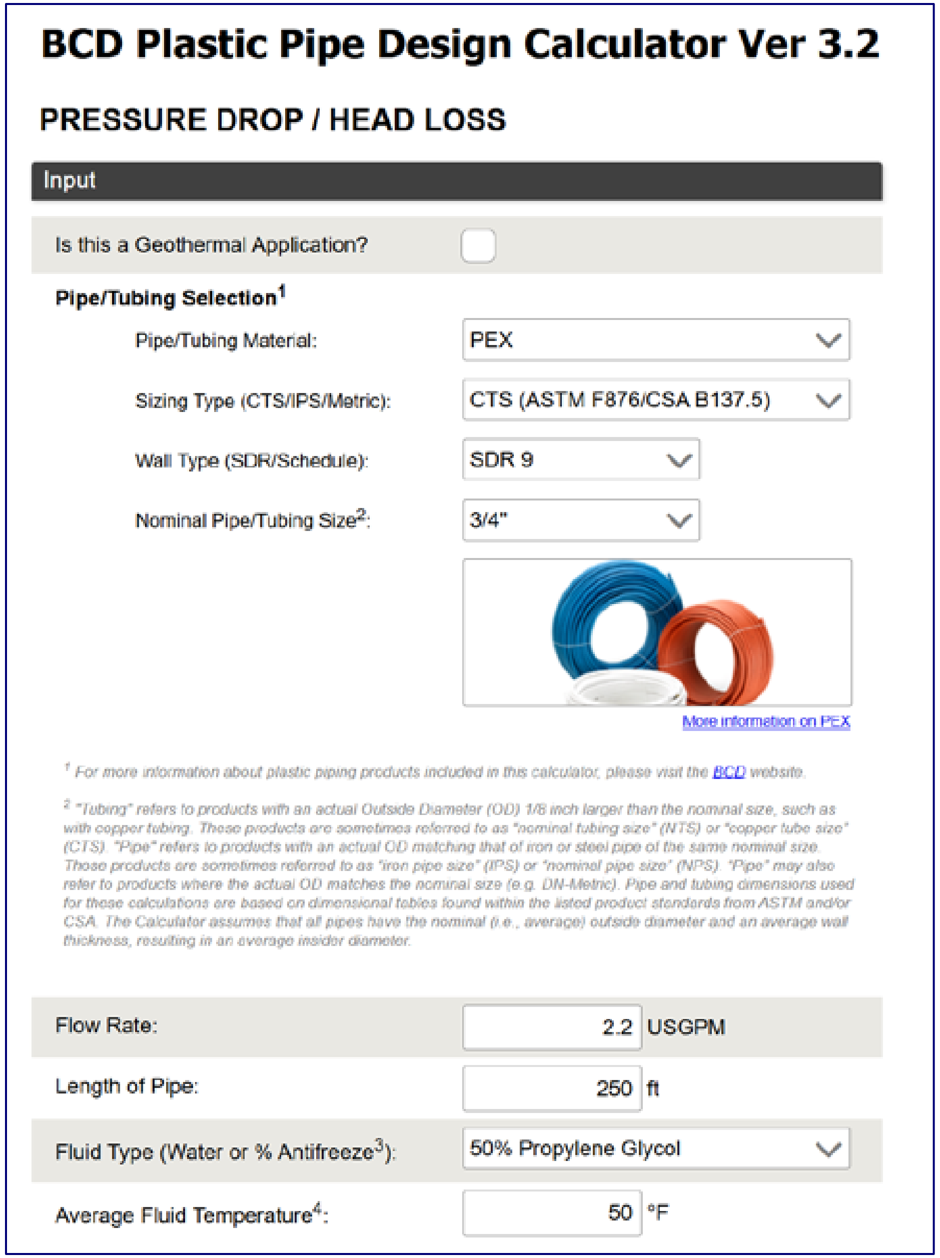
4. Design the Piping Distribution System

- Use the **PPI 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 alone



Results		
Flow Regime:	Laminar	
Pressure Drop:	6.01 Psi	41.4 kPa
Head Loss:	13.9 ft water	
Velocity*:	2.00 ft/s	0.61 m/s

Calculation Details   Print   Email



BCD Plastic Pipe Design Calculator Ver 3.2

PRESSURE DROP / HEAD LOSS

Input

Is this a Geothermal Application?

Pipe/Tubing Selection[1]

Pipe/Tubing Material:	PEX
Sizing Type (CTS/IPS/Metric):	CTS (ASTM F876/CSA B137.5)
Wall Type (SDR/Schedule):	SDR 9
Nominal Pipe/Tubing Size[2]:	3/4"

More information on PEX

[1] For more information about plastic piping products included in this calculator, please visit the BCD website.

[2] "Tubing" refers to products with an actual Outside Diameter (OD) 1/8 inch larger than the nominal size, such as with copper tubing. These products are sometimes referred to as "nominal tubing size" (NTS) or "copper tube size" (CTS). "Pipe" refers to products with an actual OD matching that of iron or steel pipe of the same nominal size. Those products are sometimes referred to as "iron pipe size" (IPS) or "nominal pipe size" (NPS). "Pipe" may also refer to products where the actual OD matches the nominal size (e.g. DN-Metric). Pipe and tubing dimensions used for these calculations are based on dimensional tables found within the listed product standards from ASTM and/or CSA. The Calculator assumes that all pipes have the nominal (i.e., average) outside diameter and an average wall thickness, resulting in an average insider diameter.

Flow Rate:	2.2 USGPM
Length of Pipe:	250 ft
Fluid Type (Water or % Antifreeze[3]):	50% Propylene Glycol
Average Fluid Temperature[4]:	50 °F

SIM Design - Example Project


Courtesy Arndt & Son

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 pipe)
- 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) is the minimum required circulator performance

SIM Design - 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 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, starting with human initiation
- A “fully automatic” system turns itself on and off, with 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 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 snowfall or ice and activate before the first snow falls (if programmed)
- Computer uses outdoor moisture sensors or even optical sensors, if selected
- May be programmed to start warming SIM area hours before forecasted snowfall to reduce response time

Control Strategies - Sensors

Moisture and temperature sensors are installed in outdoor areas (e.g., ramps, sidewalks, driveways)

Sensor socket before concrete

Sensor within a ramp

Outdoor sensor close-up

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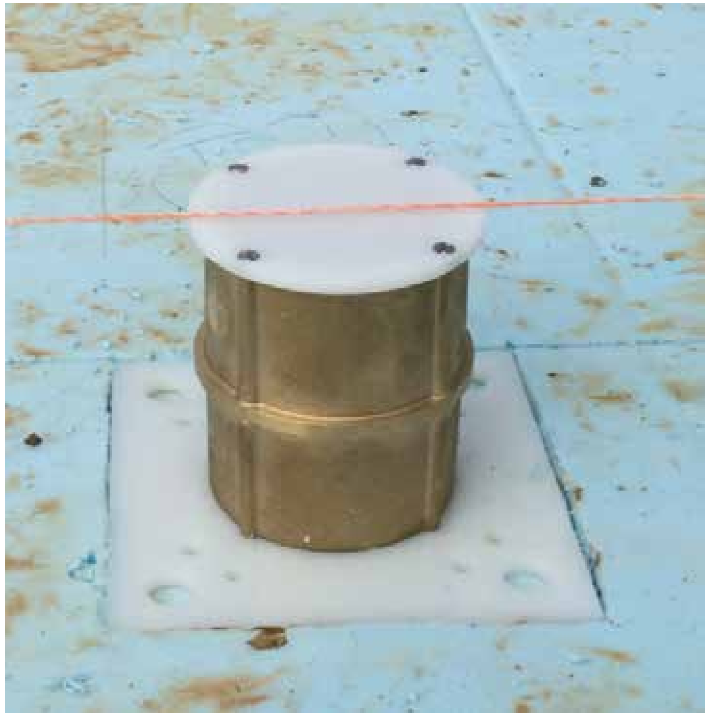
Control Strategies - Sensors

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

Avoid placing sensors:
- Under parked cars
- In vehicle tire tracks
- In protected areas, like beside bushes or under the roof
- Near sources of heat, like boiler/water heater exhaust vents



Sensor height being aligned with future top surface
Protective plastic cover in place during concrete pour

Control Strategies - Summary

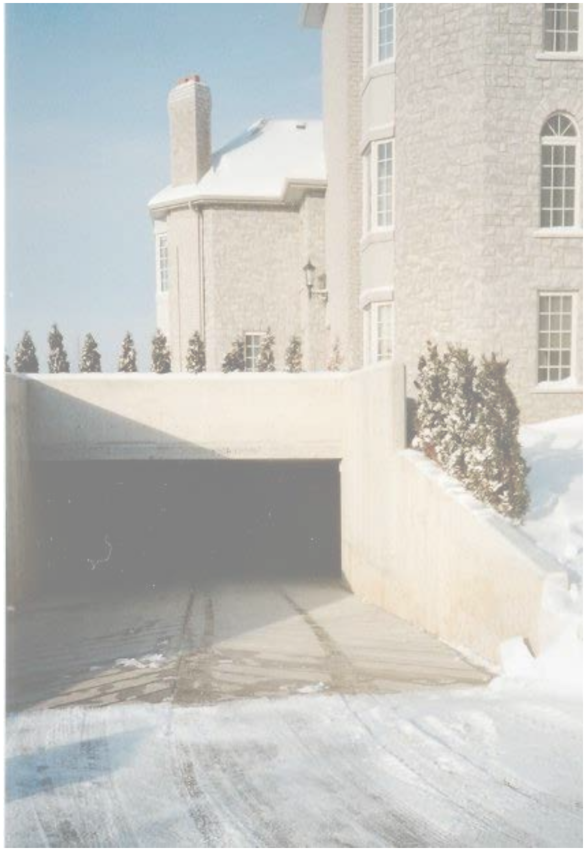
This section discussed three types of control strategies

- Plus smart web-based controls, or “apps”
- There are many specific options available from experienced firms

6. Comments on Operating Costs

Following careful design, it's possible to estimate operating costs, if you know or can reasonably predict the following:

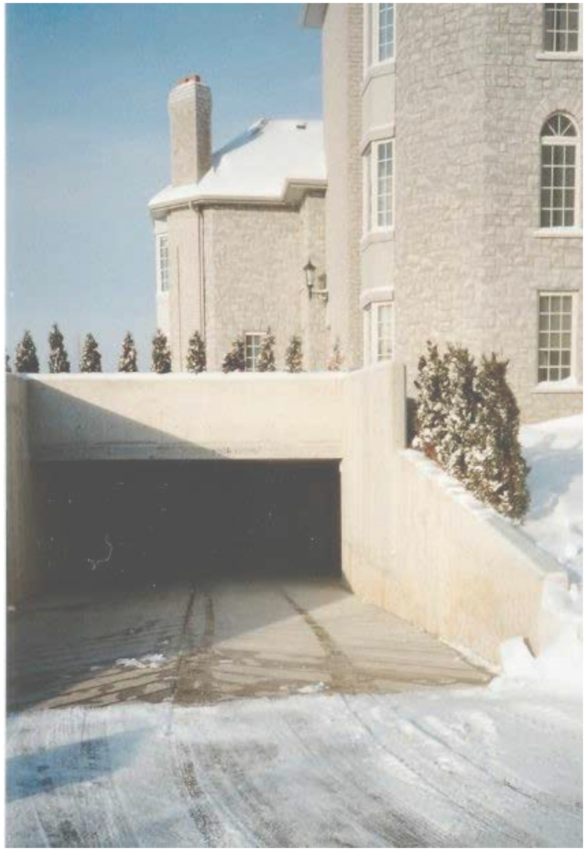
1. Project location (for weather data)
2. Melting area (of the surface)
3. Annual hours of operation (melting)
4. Number of events (for pick-up loads)
5. Heat flux/load during operation (melting load)
6. Annual hours of idling (a control strategy)
7. Heat flux/load during idling (if selected)
8. Fuel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



Comments on Operating Costs

Example: 1,000 ft^2 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 **$0.75/Therm** (100,000 Btu)
10. Efficiency of heat source: **95% AFUE** boiler



Comments on Operating Costs

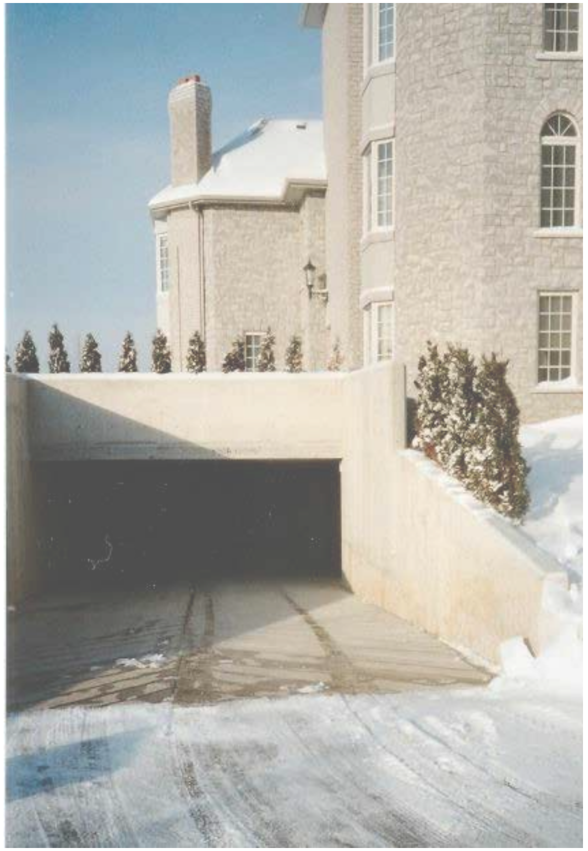
Example: 1,000 ft^2 ramp in Albany, NY. On/off automatic operation (no Idling)

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**



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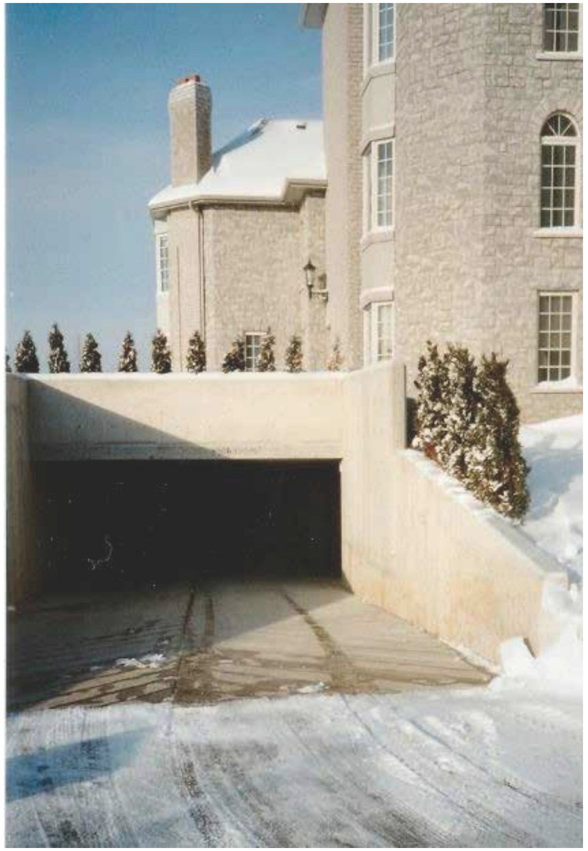
Comments on Operating Costs

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
- **$0.75/Therm*** is an estimate based on several sources – use local pricing!

*Source: National Grid, January 2026
https://www.nationalgridus.com/NY-Home/Bills-Meters-and-Rates/Service-Rates

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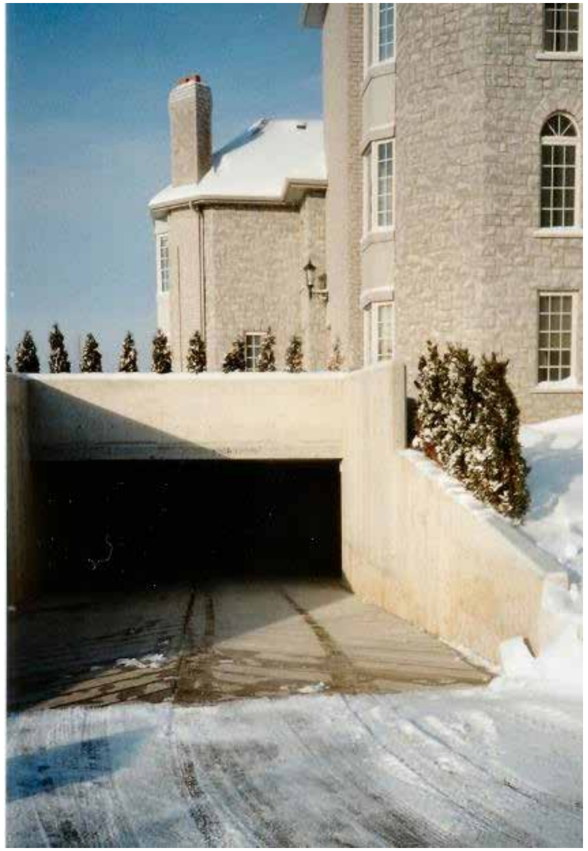
Comments on Operating Costs

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



Part B: Cost of Energy Produced

- Fuel cost: **$0.75/Therm**
- Efficiency of heat source: **95% AFUE** condensing boiler
- Energy Content of gas: 100,000 Btu / Therm

- Cost per 1 million Btu = $0.75/Therm ÷ 100,000 Btu/Therm ÷ 95% x 1 million
  = **$7.90 per million Btu produced and delivered**

Comments on Operating Costs

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

Part C: Hourly Cost Estimate

- **150,000** Btu/hr x **$7.90** per million Btu produced = **$1.18/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.

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 **$7.90** per million Btu produced = **$240/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 **$240/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 $2,500 for annual snow removal costs via plowing
- **$240 vs. $2,500 = 90% cost savings**

- Plus, the SIM system is automatic and is always on time!
- Added benefits of safety, convenience, reliability, etc.

Comments on Operating Costs

Summary: This section explained methods to estimate operating costs

- $240 for melting vs. $2,500 (quoted snow removal cost) is a **90% reduction** on annual costs
- All the benefits and safety, plus costs saving for the owners

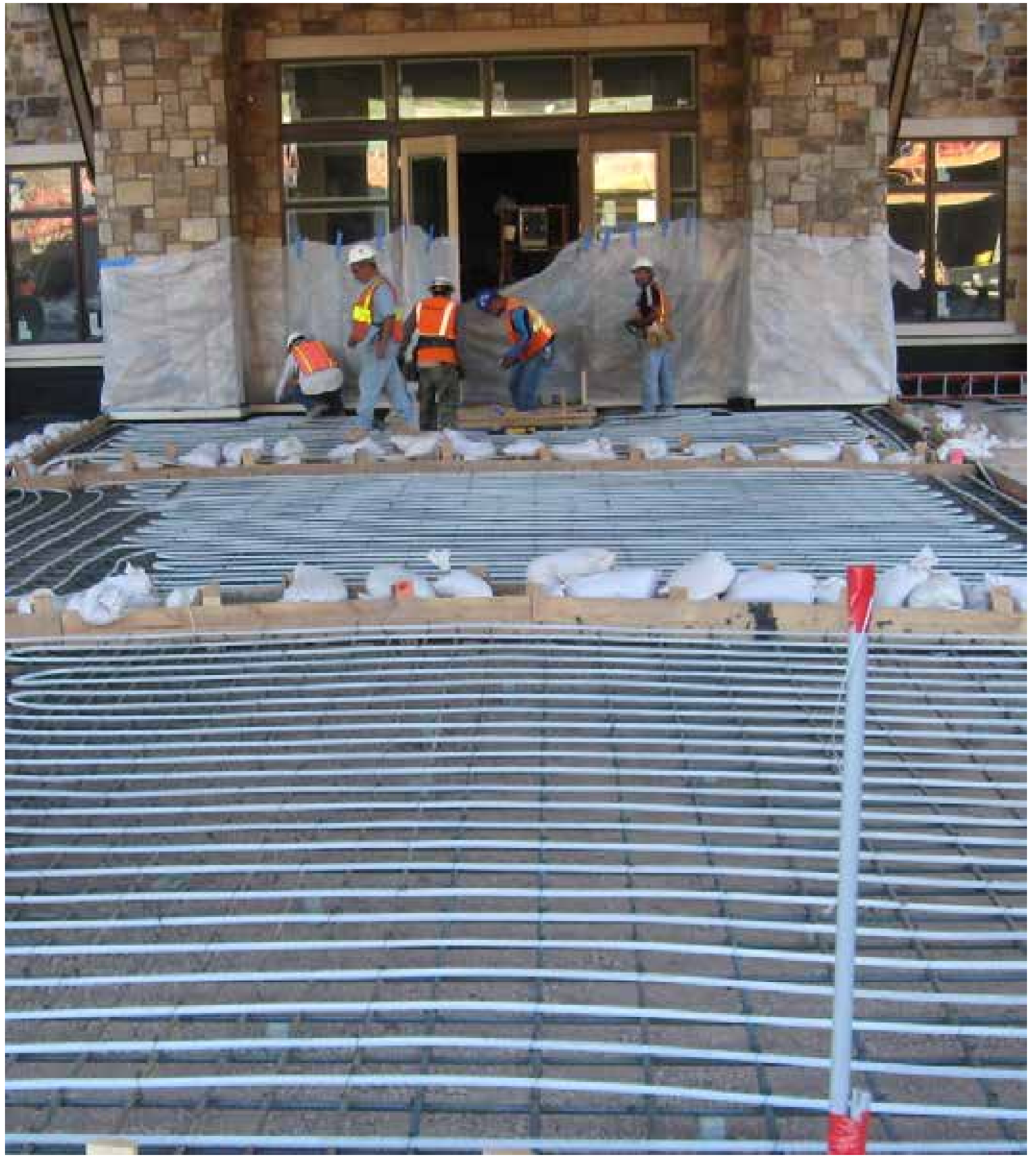
Courtesy Thornton Plumbing & Heating

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

Conclusion: Hydronic SIM systems are convenient, safe, reliable, and often provide cost savings vs. mechanical snow removal. Contact PPI or our members for more assistance.



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

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