

Article #1: SIM Software  
Article #2: Heat Exchangers

## **Review of ASHRAE Snow Melting Research Project and Modeling Software.**

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Last year ASHRAE Technical Committee (T.C.) 6.1 Hot Water and Steam Systems handed over to T.C. 6.5 Radiant and Convective Systems, the responsibility for the Snow Ice Melting Chapter of the Applications Handbook. Whilst in their hands, T.C. 6.1 guided some significant research and development on this topic which we're happy to share with our readers. One of the most useful publications was released in August of 2001, by Jeffrey D. Spitler, Simon J. Rees, Xiao Xia and Manoj Chulliparambil all from Oklahoma State University, School of Mechanical and Aerospace Engineering. The document ASHRAE 1090-RP, DEVELOPMENT OF A TWO-DIMENSIONAL TRANSIENT MODEL OF SNOW-MELTING SYSTEMS, AND USE OF THE MODEL FOR ANALYSIS OF DESIGN ALTERNATIVES is one of the most thorough examinations of designing snow melting systems that I have come across.

With permission from ASHRAE we provide readers the executive summary below:

“Previous research and design guidelines published by ASHRAE for snow-melting systems (e.g. Chapman 1957, Ramsey et al. 1999) have been based on steady-state conditions. Design loads (surface heat fluxes) have been calculated by taking the instantaneous weather conditions and calculating the flux required at the surface to provide a given free area ratio. In this type of calculation, no account is taken of the history of the storm up to the point of interest, and no account is taken of the dynamic response of the heated slab. However, this design heat flux can never be provided at the surface instantaneously. As current practical snow-melting systems employ heated elements – either hydronic or electrical – embedded some distance below the surface of a slab, the system's time constant is on the order of hours. Not only does the heating system have significant thermal mass but also the weather is highly transient.

Designers of snow melting systems are not only concerned with determining the required flux to melt snow at a particular location. A significant part of the design problem is to determine the necessary depth and spacing of the heating elements, along with the operating temperature (or electrical power) as well as the disposition of insulation, in order to achieve the design surface flux. It is furthermore necessary to consider the losses from the system at the back and edges of the heated slab.

ASHRAE 1090-RP has resulted in a new computer tool that can aid in this design problem. The key features include the following:

- The tool performs transient simulations and accounts for back losses. Furthermore, it uses a boundary-fitted grid to accurately represent the geometry of the hydronic tubing or embedded cable.
- A boundary conditions model accounts for accumulation and melting of snow and ice. As requested by the PMSC (Project Monitoring Sub Committee), the model has a level of detail that exceeds what was originally proposed by the investigators. Consequently, the simulation is capable of taking into account parameters, such as density, porosity, and thermal conductivity of snow that

are not currently available. Should these data become available in the future, it would be possible to account for them with the current model. Another consequence of the model detail is that the simulation program runs rather slowly, on the order of 20 minutes with currently available microcomputers.

- A library of design storms, compiled from the 926-RP weather data allows the program user to select sample storms from a wide range of U.S. locations.
- The program is capable of modeling control systems where the system is automatically turned on when snow is detected, as well as scheduled operation, which could be used to model a system that is idled.
- The program has a user-friendly interface, with libraries for pavement properties, tube types, etc.”

(The complete report is 365 pages and is available on line from the ASHRAE Bookstore)

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Having demonstrated the software, there a few things which do disappoint - mainly the omission of Canadian weather data and absent in the pipe selector was a 5/8” pipe option. Lastly, the computational time to run a modeling function is about the length of a long coffee break...so it’s well advised to plan ahead before one hits the run simulation button.

On the plus side this author has not come across a software program which looks at all the variables of snow ice melting as well as this one. It allows the user to fix the flux per linear foot of pipe or the fluid temperature<sup>1</sup>. The default material data base is adequate for most applications and can be edited. As far as the weather data, there are over forty U.S. cities including Fairbanks, Alaska, and several others which share similar conditions north of the border. Also of importance is the reintroduction and reinforcement of the “Non-exceedance Load” principal which replaced the Class System several years ago. The report and software is full of useful information for hardcore designers and clears up any debate about practical and realistic performances.

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<sup>1</sup> CSA A23.1 limits the maximum recommended fluid temperature of embedded pipes in concrete to 150 deg F.

# Heat Exchangers - Snow Melting

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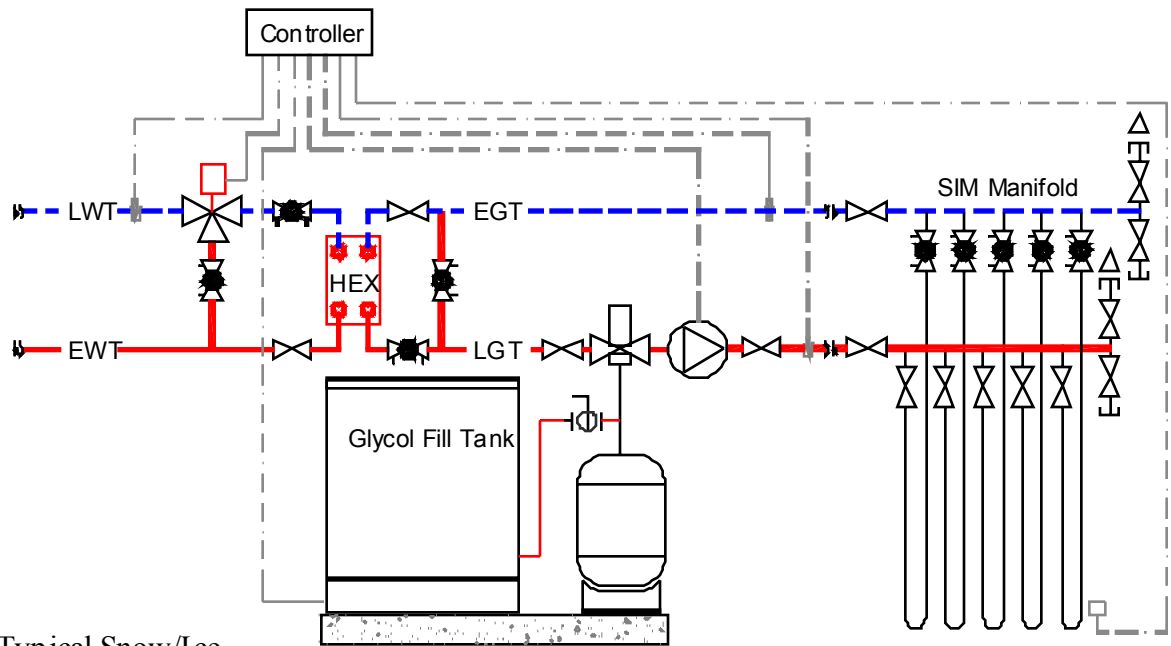
The number one cause of performance anxiety amongst hydronic system designers is equipment selection based on improper information. Setting ones self up for success begins with an operating specification obtained from the client. For snow melting applications, it is imperative to define what the customer expects, as this is the number one influence on the load calculation and size of heat exchanger. A retired couple living in a residential area may tolerate complete build up of snow as long as it is melted in a reasonable period. The owners of a condominium which is accessed by an underground parking ramp could not accept a build up of snow but would find it reasonable to have some slush build up as long as it did not freeze. The facility manager at a hospital would not accept for its emergency helicopter pad, anything but a clear surface. Though these projects may exist in the same city and exposed to the same climatic conditions their expectations are completely different as are the calculations. Furthermore, the designer should ask the client if they expect 100% performance satisfaction for the few times the system is exposed to maximum load conditions or would they accept some occasional reduction in design performance if it meant reduced capital investment and operating expense. Only when the operating specifications has been defined can the designer begin to evaluate weather data including snow fall rates, density, temperatures, wind speed, elevation and building and landscape features which can influence such things as snow drifting and banking. Below are **hypothetical load examples** for the three systems described above. In all cases, the slab is insulated.

Item	Unit	Application		
		Residential	Commercial	Institutional
Snow Fall Rate	inch/hr	1.25		
Wind Speed	mph	10		
Design Temperature	deg F.	10		
Flux (Output)	btu/hr/sf	99	144	190
Average Fluid Temp	deg. F.	80	102	130
Exchanger Load	btu/hr	60,000	87,000	114,000

A typical nominal heat exchanger performance specification for each case might look like this:

System	Boiler Side			Snow Melt Side (50/50)			Exchanger Surface Area
	EWT	LWT	Flow	EGT	LGT	Flow	
	deg F.	deg F.	US gpm	deg F.	deg F.	US gpm	Sq. Ft.
Residential	180	150	4	70	90	7	1.5
Commercial			6	90	110	9	1.8
Institutional			8	120	140	12	4.3

The risk in classifying snow-melting systems based on project definition is the real possibility of the retired couple owning a home with a very steep driveway attached to a busy street. Aside from property or vehicle damage, anything but a clear pad could pose a threat to the health and safety of the driver, passengers, or pedestrians if the car slid down and out of control into oncoming traffic.



Typical Snow/Ice  
Melting Schematic

To prevent under or oversized system including heat exchangers, determine clients needs and wants before the design process.