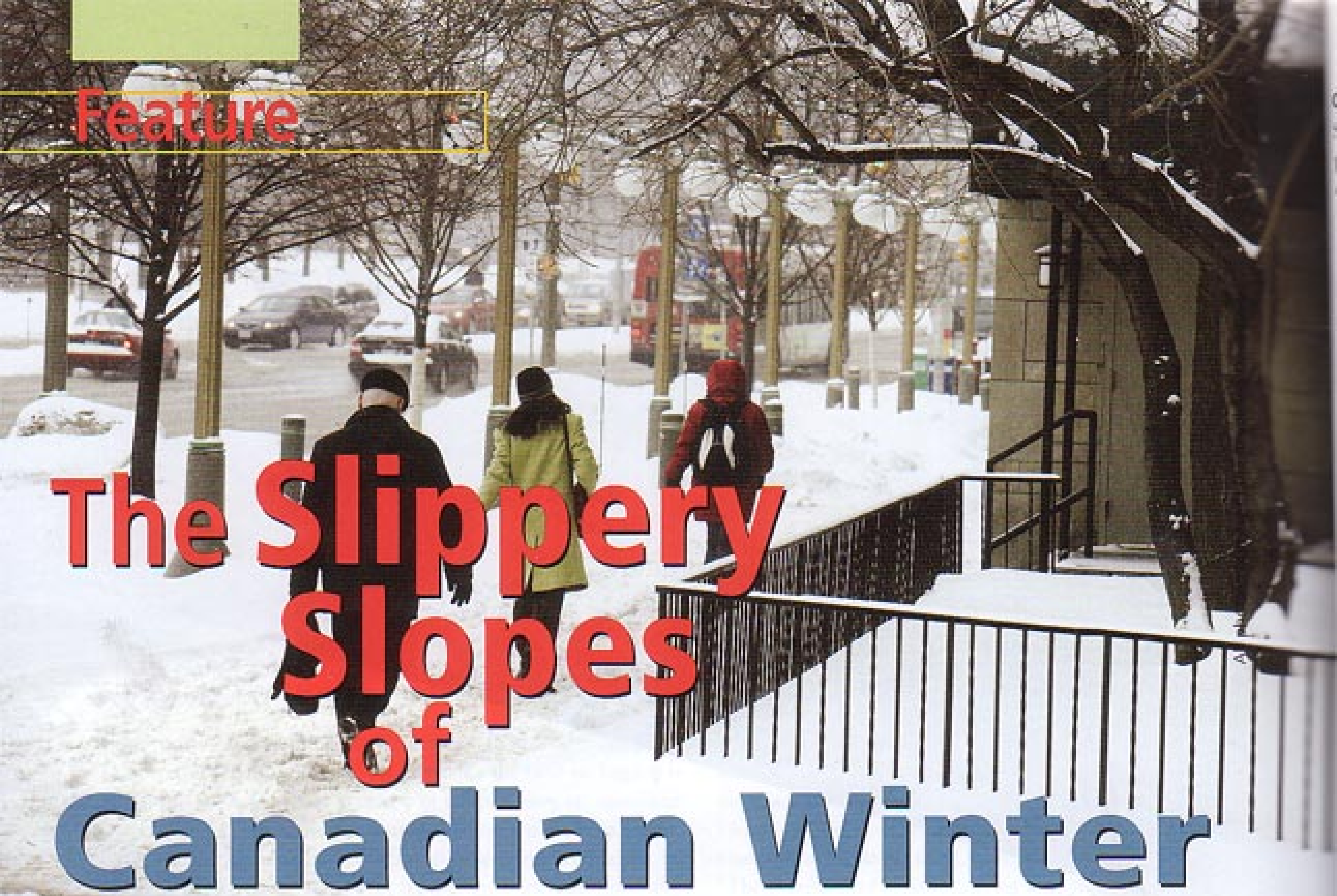


Feature

The Slippery Slopes of Canadian Winter

Automatic snow-melting systems

By Gerry Lemieux

With summer nearly in full swing throughout the majority of the country, winter is the furthest thing from most people's minds. Nevertheless, for projects currently in the design stage, it makes sense to consider what must be faced when the seasons once again turn cold. During typical Canadian winters, building owners, tenants, and facility managers have to wrestle with frozen walkways, impassable driveways, slippery ramps, and snow removal contractors working through the night.

Industrial, commercial, institutional, and residential buildings are all candidates for properly designed and installed snow-melt systems. These assemblies can increase value, reduce accidents (people and vehicles), eliminate the use of corrosive chemicals from walkways and driving surfaces, and cut the cost of plowing and removing snow.

Snow-melting systems also reduce housekeeping duties by keeping snow and slush away from foyers, lobbies, and loading docks, lessening the chances of injury due to slippery surfaces. Wheelchair ramps and access points also become more accessible, clean, and aesthetically pleasing.

The history of snow melting

Electric snow-melting systems have been used internationally since 1927, when the first resistant heating cables were introduced in Norway. Today, in several Scandinavian cities, neither plows nor loaders work through the night due to the heating cables installed under many city streets and sidewalks.

Over the years there have been many advances in snow-melt and ice-control technology. The costs of maintenance and operation have decreased, while efficiencies have risen. Cable technology is continually developing to meet the demands of the market, including more sophisticated control systems and new cable installation methods to provide maximum life, effectiveness, and energy efficiency. Snow-melt systems come in three general styles:

- electric cables embedded in or under asphalt, concrete, or interlock;
- circulated hot fluid fed from a natural gas, electric, oil, or propane heating device through pipes or tubes buried in or under concrete, asphalt, or interlock; and
- overhead radiant systems consisting of a high-intensity electric or gas-fired element mounted high above the surface.

Snow-melting electric cables are generally series-resistant, providing continuous heat output along the length of the cable. They are sized according to the required heat per metre of cable and heat necessary for the application. They are made with non-heated (*i.e.* cold) leads extending from the area to be warmed to a sensor/controller.

Cabling needs

Series-resistant cables come in two types. The first is cross-linked polyethylene (PEX)-coated cables, which consist of a copper alloy conductor surrounded by an extruded layer of cross-linked polyethylene with a tinned copper ground wrapped around the inner cable, a layer of metallic armouring, and a further layer of PEX. Used in Europe for decades, these cables are flexible, easily installed, and cost-effective. Due to their ease of use, they can also save on installation expenses. Cable can be installed by tying directly onto rebar or through the use of a galvanized or stainless steel mounting strip to clip the cables in place while the surface is being installed.

The alternate option is mineral-insulated (MI) cables, which have been used for years in Canada and, until recently, were considered the standard product for this application. MI cables consist of a seamless die-drawn copper tube or stainless steel alloy sheath, which is filled with magnesium oxide and contains one or two alloy elements. Common MI cables are die-drawn copper with a high-density polyethylene (HDPE) jacket to protect the copper from calcium chloride or abrasion. Great care must be taken to ensure the HDPE is not damaged; installers must avoid crimping or cracking the copper tube. Water entering the cable immediately degrades the value of the magnesium oxide insulation, which is hygroscopic (*i.e.* absorbs moisture from the air), causing a short circuit to ground. Copper should also be kept away from all iron or steel bars due to electrogalvanic action on the iron or steel.

Popular for freeze prevention on exposed piping systems, self-regulating cables are designed to send the heat where needed. However, a lot of power is required to warm the cable to operating temperature, normally requiring about twice their rated amperage draw to warm the cable. This increases demand charges, breaker sizes, contactor sizing, wiring, and connected load.

Hydronic systems

Hydronic systems consist of a series of serpentine loops of tubing or piping fed from a boiler. Standard systems include:

- a boiler;
- tubing/piping;
- heat exchangers (to separate the glycol antifreeze from the boiler water);
- solenoid or control valves;
- bleed valves; and
- pump(s).

Most hydronic systems use cross-linked polyethylene, PEX-coated aluminum, or another flexible tubing type that resists corrosion. Tubing is installed in a similar way to heating cables clipped to a track. Care should be taken to size the loops to ensure there is sufficient heat at the end of each one and subfreezing liquids do not shock the heat exchanger. It is also important to make certain air is properly vented and liquid velocities are not such that they erode tubing or allow water 'hammering.' A standalone hydronic system is a complicated installation that should be carefully engineered and installed by an experienced and competent contractor.

An important requirement in designing a system is establishing the standard of operation required. This involves deciding an acceptable percentage of heated pavement that can be covered during snowfall.

High-intensity infrared

High-intensity gas or electric systems have not proven as popular in Canada as their hydronic counterparts. Normally used for spot heating of small areas, these products are very useful on loading docks or areas where the warming of people and the pavement is required. When calculating system heat requirements, one should allow a correction factor of 1.6 or more for most applications.

For snow-melt systems, the addition of a pavement-sensing, field-adjustable thermostat can reduce the necessary heat. In certain cases, these systems can be used in conjunction with other, more traditional, snow removing methods.

Most failures in a snow-melting system are a direct result of improper installation of the poured concrete, asphalt, or interlock in which the cables are installed.

Controls

Snow-melt controls come in a variety of makes and models. Current technology includes installing a snow sensor on the exterior wall of the building where it can detect the prevailing winter winds. Pavement-mounted snow sensors are expensive, subject to abuse by traffic, and may become saturated with water when located at a low point on the surface.

Snow sensors normally consist of a precipitation sensor with an integral heater (heated cup) to melt a sample of the falling snow and bridge a contactor, sending a signal to start the system. Sensors stay wet for the duration of the storm. Once snow or freezing rain has stopped, an adjustable time delay starts and keeps the system operating for a selected period to allow the pavement to dry.

The addition of a pavement-sensing, field-adjustable thermostat to sense and control the temperature of the surface at an optimum output reduces the heat requirement. This also serves to lower energy consumption on days when a light snowfall turns the system on and the surface is warmed soon afterward by the sun or a warm wind. The temperature sensor helps adjust for the heat of vaporization required to dry the surface. Normally, a surface temperature just above freezing is adequate.

Design requirements

In the United States, snow-melt systems are designed according to a specific set of guidelines determined by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE), and sized according to the rate or urgency of melting required for a given application and geographic location:

- Class I Systems (minimum): residential walks or driveways;
- Class II Systems (moderate): commercial sidewalks, driveways, ramps, and hospital steps; and
- Class III Systems (maximum): airport aprons and taxiways, toll plazas, and hospital emergency areas.

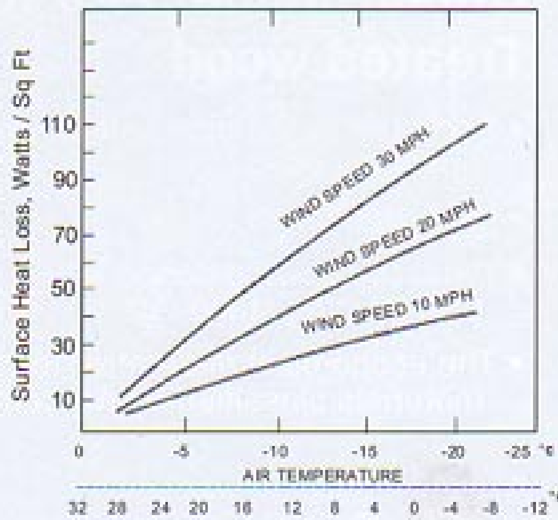
Traditional heat outputs determined by ASHRAE are calculated and published to vary from 250 W/m^2 (23 W/sf) for a residence in Vancouver to more than 1400 W/m^2 (130 W/sf) for a hospital emergency area in a heavy snowfall region. The National Research Council of Canada (NRC) has also published guidelines for snow-melt systems that vary from the ASHRAE guidelines (Figure 1, page 90).[1]

The design of a system focuses on pavement, controls, heat requirement, and system selection. Heat requirement is determined by snowfall rate, air temperature, wind velocity, and humidity.

Figure 1 Average Rate of Snowfall During Storm

Average Rate of Snowfall During Storm (in./hr)	Estimated Maximum Hourly Rate of Snowfall (in./hr)	Heat Required to Melt Maximum Hourly Rate (Watts/ sq ft)
0.25	0.5-0.9	12-20
0.5	1.1-1.8	24-40
1.0	2.2-3.6	48-80

Figure 2 Combined Surface Heat Loss



Figures courtesy National Research Council of Canada

To operate a system effectively and economically, it must start at the onset of snowfall. Allowing snow to accumulate or having ice form requires greater heat for longer periods to ensure the area is ice-free. Snow- and ice-melt systems need to provide sufficient heat to melt snow and prevent ice accumulation by offsetting surface temperature losses by evaporation, radiation, and convection, and through the slab below grade (Figure 2). Starting the system at the onset of snowfall allows the slab to start warming early, thus preventing significant accumulation.

With high wind speeds, heat loss from convection is the largest component. With low wind speeds and large air-surface temperature differences, radiation or heat loss from the pavement surface becomes more significant. The rate of evaporation is limited by the vapour pressure difference between the surface and the air. It is an important part of the total heat balance at high wind speeds, particularly from wet pavement after snow has melted.

It is important to provide adequate drainage for snow-melting systems and maintain the heat for a period after the storm to dry the surface. As surface heat loss is directly proportional to wind speed, the heat loss at sheltered sites will be substantially less than at exposed sites.

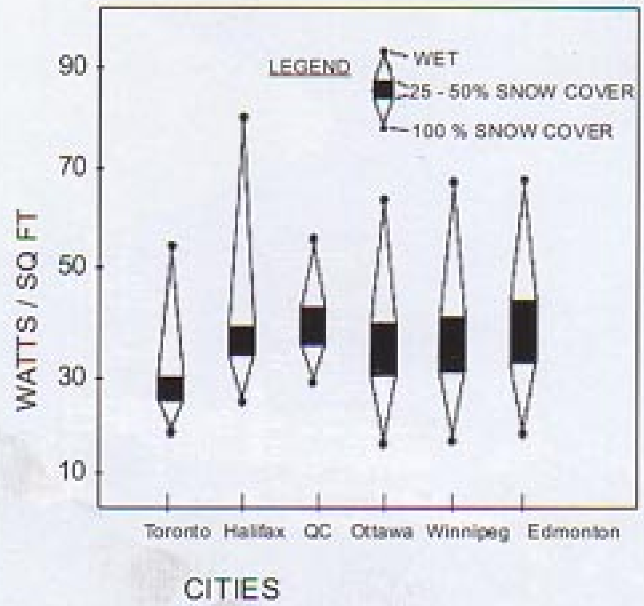
Heat loss to ground and edges should also be considered. It is customary in calculating design heat requirements of snow-melting systems to allow for heat loss downward from the heating coils to the ground, or from the underside of a heated bridge or ramp slab to the atmosphere. In deciding how much ground heat loss to allow for, it is necessary to distinguish between continuous operation and intermittent operation. With intermittent operation, the slab is heated only when snow is falling or expected to fall. Allowance must be made for substantial ground heat loss during the warm-up period. However, with a continuously heated slab, heat stored in the slab can melt snow during the early hours of a storm.

Allowing accumulation

An important requirement in designing a system is establishing the standard of operation required. A decision must be made regarding the acceptable percentage of heated pavement that can be covered during a snowfall. Research and experience indicate it is neither necessary nor economical to design systems to maintain bare pavement conditions at all times. Designing for 25 to 50 per cent snow cover during a storm is a reasonable compromise. If a surface becomes snow-covered (as will happen in severe storms), surface heat losses are reduced and more heat becomes available for melting snow, creating a built-in safety factor.

There is a point at which snow accumulation impedes traffic. Conditions following a storm should be taken into consideration, particularly in regions where snowfall may be followed by a drop in temperature. The 'design storm' approach has been used to calculate surface heat losses for several locations in Canada. The five worst snowstorms occurring over a 10-year period were chosen as a basis for design calculations. The average values of weather data observed during the storms were used to obtain design requirements.

Figure 3 Surface Heat Losses During Design Storm for Different Surface Conditions on Heated Pavement



Allowances were made for essentially bare, 50 per cent snow cover, and complete snow cover during the storm. In addition, heat losses from wet, bare pavement were calculated for 10 hours immediately following storms (Figures 3 and 4).

These results illustrate that design heat requirements depend on the required surface standard (*i.e.* on whether bare pavement is to be maintained or a completely snow-covered surface tolerated). For example, in locations subject to low temperatures and high winds, such as Winnipeg and Edmonton, weather conditions after the storm determine design heat requirements.

These calculations were made based on an average wind exposure. The heat required for sheltered sites, where wind effects are smaller, can probably be reduced by about 15 per cent. Similarly, an increase in the design load of approximately 15 to 20 per cent should be made for extremely exposed sites. In making adjustments for exposure, the possibility drifting snow accumulates at a site should also be considered.

While everyone has heard stories of failed heating cables or piping, most of these are a direct result of improper installation of the poured concrete, asphalt, or interlock in which the cables are installed.

During construction

Proper drainage practices should be observed, with snow-melt systems draining to a heated trench or an area below the elevation of the slab. The hardest problem to resolve is a failure during the construction process to look at snow melting as a system. If the pavement cracks in shear or moves with expansion and contraction, the system fails. When this occurs, the pavement may still look good and support traffic—suggesting it is still doing its job—but it is not protecting the system from damage.

Figure 4 Surface Heat Losses (W/sf) for Maintaining a Bare, Wet Pavement after Design Storm Conditions

Toronto	Halifax	Quebec City	Ottawa	Winnipeg	Edmonton
18	29	33	50	66	65

A common fault is poor bonding of the top cap of a two-pour slab. If the concrete installer does not properly prepare the base slab for the new cap, delamination can occur. Another problem happens when the elevation of the base slab is too high and the cap is poured thin to achieve the correct final elevation. This thin slab, containing the cable or tubing, is subject to cracking and delamination. If a soft membrane is in place between the cap and base slabs, the problem worsens, since the cap is subject to increased flexing. Once the tubing or cable is laid, it can be damaged by other trades. Communication and understanding are required to minimize problems.

After completion

To prevent cables or tubing from being destroyed during work on the concrete, activity on heated slabs should be governed by the 'call before you dig' rule used by utilities. To prevent this, a facility manager should be strongly encouraged to place a sign indicating a snow-melt system is installed below the surface.

While most heating systems can be repaired if damaged, the cost of purchasing and maintaining specialized equipment and training is impractical for the average contractor. There are a few specialized companies dealing with these problems. Finding a fault in an electric cable may be as simple as a test to measure the resistance of the heating cable with an ohm meter, and dividing this measurement by the resistance in ohms per foot printed on each cable. If this is insufficient to locate the fault accurately, the services of a technician with a thermographic camera may be required. Also, hydronic tubing can develop leaks that do not show up in the area of the leak, but elsewhere.

At first glance, snow- and ice-melt systems can seem expensive to operate, but they are a cost-effective alternative to personal injury, snow plowing, insurance claims, and erosion of concrete by salts and other chemicals. An investigation of local area conditions and historical weather data can help ascertain whether a well-constructed and well-engineered system is right for your application.

Notes

1. See NRC's Canadian Building Digest (CBD) 160, *Design Heat Requirements for Snow Melting Systems.* Visit irc.nrc-cnrc.gc.ca/pubs/cbd/cbd160_e.html.

Gerry Lemieux is president of Britech Corp., the Canadian representative for Nexans Heating Cables. He can be reached at (416) 335-7790. This article was prepared with files from Len Duke (Emli Cables).