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## **Hydronic Snow/Ice Melting Systems**

**Richard E. White, P.E.** *This article is the first in a series dealing with the theory and practice of snow melting utilizing hydronic heat transfer. As always, we invite your comments.*

### **Reasons for snow-removal**

Snow removal has, traditionally, been undertaken for a variety of reasons: a desire to make a facility's environs friendlier and more inviting; an imperative to reduce floor maintenance costs by minimizing tracked snow/slush; compliance with state/municipal mandates to reduce the likelihood of personal injury or property damage resulting from pedestrian falls or vehicular collisions.

### **Reasons for snow-melting**

The objectives cited above for snow-removal around a property provide the motivation for the installation and operation of a snow-melting system. Snow-melting systems offer the following advantages in accomplishing the listed objectives:

- 1** Snow-melting systems can dispose of snow as fast as it falls, depending on the heat capacity of the system. This capacity is selected by the designer and is based on the probable peak snowfall rate, the importance of minimizing any snowfall accumulation, the capital cost of the desired installation, and primary fuel availability.
- 2** With modern controls, snow-melting systems can be turned on automatically as soon as snow is present, and they will shut off when the snow is cleared. Formerly, it was necessary to turn on systems based on weather forecasts for snow, or, in the case of surprise accumulations, after a significant amount was already on the ground. Operation only when needed, and always when needed, results in minimum operating cost combined with optimum snow removal.
- 3** Operation of the system at the earliest time of need creates the

### **Improved Communications**

If you require Installation Instructions for any product — for whatever purpose: design application, installation planning, client presentation, etc. — we'd be pleased to accommodate your request.

### **Wait 'til Next Year...**

No, we're not thinking about Notre Dame (or the Cubs, Jets, et al). A recent decision to establish a project year — April 1, 1997 through March 31, 1998 — promises both increased marketing integration and improved stability. Our goal is to introduce new products, distribute catalogs and application guides, and announce appropriate pricing at the onset of the year, thereby

to liability from falls, minimizing snow and dirt being tracked into the premises, enhancing the environs, and assuring best tire traction. Manual snow removal has to wait until an accumulation is present before it can begin, and snowfall often continues after the manual operation is completed. If significant snowfall occurs afterward, the manual operation must be performed additional times.

**4** Manual operations usually result in snow piles located wherever they can be placed. Melting systems (actually snow-evaporation systems) cause the snow to disappear. This feature is especially desirable where shoveling sidewalks results in snow piles along a curb. Visitors parking along the curb are often severely impeded in exiting from their vehicles because of such snow piles.

## Operating costs for snow-melting

It takes about 1220 BTU per pound to change solid water (snow) to water vapor. This value is the same (within 2 BTU) for ambient temperatures from 0°F–32°F (-17.7°C–0°C). If snow contains 1" of water for each 10" of snow, a 1" snowfall would contain 52 lbs per 100 sq ft of surface area ( $0.1 \times 1/12 \times 62.4 \times 100 = 52$  lbs). This amount of solid water requires  $1220 \times 52 = 63,440$  BTU to evaporate. Table 1, below, presents representative costs to generate this quantity of heat using various fuels.

Fuel Type	Unit Cost	Assumed Efficiency	Cost to melt 1' on 100 sq ft
Electricity	\$0.08/kWh	95%	\$1.57
Natural Gas	\$0.60/therm	70%	\$0.54
#2 Oil	\$0.85/gal	65%	\$0.59

Table 1. Operating Cost For Various Fuels

(Note: The cost of electricity does not include any demand charges, which, if applicable, could greatly increase the unit cost shown.)

It has to be pointed out that while the cost to remove a 1"-2" snowfall is not great, the operating cost for, say, a 10" snowfall would be considerable! Depending upon the typical snow pattern in an area, there may be mostly lesser or greater snowfalls, significantly impacting the annual cost of operating a snow-melting system.

Two Examples as guides: First, snow plowing with a small vehicle (e.g., Blazer, Bronco, Jeep) could clear a 3000 sq ft parking area of a 3" snowfall in about an hour at a cost of \$50 to \$60 (labor, fuel, and wear and tear), vs  $3(0.54)(30) = \$48.60$  for the natural gas snow melting option. Of course, the plowed snow will still be there in piles with the potential of drifting on the cleared surface.

Second, manually shoveling a 3" snowfall from a 130 sq ft sidewalk would take about 1.5 hours at \$12.00/hour, or \$18.00, assuming that there is an employee available whose hourly cost

minimizing the proliferation of periodic enclosures accompanying (the print version of) this publication.

The October, 1996 issue of Cahners Publishing Co's Monthly tabloid, **CONTRACTOR**, contains articles featuring three recently completed hydronic installations of significance. "Hydronic snow melt job ends at airport," page 5, reports on a 14,400 sq ft heated concrete pad at Lambert St. Louis International Airport: utilizing four 1460 Mbh hot water boilers and 36,000 linear ft of 3/4" radiant piping, the system is capable of melting (and draining) 6 ft of loose snow or as much as 22 inches of compacted snow from runway/taxiway plowing operations in a 24-hour period. "Dual heating mix delivers for FedEx in Alaska," page 37, describes a combined radiant slab / hot water forced air system providing both comfort heating and deicing/snow melting for a 72,800 sq ft, 92 ft high aircraft hangar in Anchorage: employing four 35,000 cfm hot water fan-coil air handlers and 43,000 linear ft of radiant piping, the system provides rapid recovery from air temperatures as low as -20°F as well as melting and evaporating the snow and ice load on a 747. "Warm welcome," page

is only \$12.00! The gas cost to clear this sidewalk would be  $3(130/100)(0.54)=\$2.11$ .

Thus, snow melting of smaller surface areas is very economical compared with hand shoveling. It is less economic for large areas or considerable snowfalls when compared to the cost of snow plowing, but if nearly simultaneous clearing and no remaining snow piles are important considerations, nothing can match snow-melting systems.

## General Description of Installation

There are two ways to heat a concrete slab to remove snow – the first way is to pass a warm fluid through piping that is contained within the concrete, and the second is to pass electric current through heating cables that are contained within the slab. Each method has its partisans, and advantages and disadvantages can be listed for each.

**Piping in concrete:** This method uses pipe coils in the concrete slab which contain a warm heat-transfer fluid that is pumped through the coils. This system requires a means of heating the fluid, pump(s), valves, and controls to form a complete system. In most cases, the fluid is heated in a heat exchanger that, in turn, receives its heat from either steam or hot water from a boiler. The fuel that fires the boiler would be that which is most economical for the locale in which the system is located. In many cases, the snow-melting load is small compared with the other loads on the boiler. In other words, the boiler is needed for process or space heating loads, and the snow melting is, more or less, incidental to those other uses. In some situations, however, snow melting is the sole purpose of the boiler (a stand-alone system).

For any fossil-fuel-fired hot water boiler, the snow-melting-fluid heat exchanger is necessary for two reasons: first, because the boiler cannot cope with the very low fluid temperatures encountered in a snow-melting system, especially during the heat-up stage; and second, because the snow-melting fluid is usually a mixture of water and antifreeze. The heat-up period can last for an hour or more, and the products of combustion of any fossil fuel would produce unacceptable condensation in flue passages in the boiler. In addition, if the boiler serves other loads, the boiler water would be too hot to be sent directly to the target slab, and it is an unnecessary cost (and complication) to have the entire system filled with the snow-melting fluid, which would be the case if a heat exchanger were not used.

**Electric Heat Cables in Concrete:** While an electric boiler could be used to supply the warm fluid described above, in most cases, if electric heat is to be the source of the snow-melting energy, the energy will be delivered by heating cable placed directly in the slab. These systems require less capital for construction, but they are usually limited to small areas because both service switchgear and operating costs become prohibitive for larger target areas.

43, features Baltimore's Memorial Stadium: 180,000 l ft of radiant piping installed beneath the 85,000 sq ft playing field provides both turf conditioning and snow melting for the NFL's Ravens during their inaugural season. Cahners Publishing Company, (847) 390-2111.

To Be Continued...

## National Electrical Code Considerations

Previously (Vol. 2, No. 8 — September, 1996), ground-fault protection of fixed outdoor electric snow melting or deicing branch circuits was reviewed to promote compliance with Section 426-28 of the 1996 NEC. Having adopted this imperative, a logical progression in planning or installing branch circuit wiring for such a system is to explore the requirements for determining the proper size (rating or setting) of the overcurrent protection device(s).

Irrespective of the period of time heating cables are energized to achieve their intended purpose, they are defined by the NEC as *continuous* loads (Articles 100 — "A load where the maximum current is expected to continue for three hours or more."). As such, Section 426-4 requires the ampacity of branch circuit conductors and the rating of their overcurrent protective device be not less than 125% of the total load of the connected heaters. (Usage of the plural, *heaters*, permits aggregating multiple runs of heating cable or mats on a single branch circuit; also see 426-52.) As heaters are, essentially, resistive loads (unity power factor), the maximum steady state current, if unknown, may be determined using one of the following forms of Ohm's Law:

$$I=P/E$$

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where **I** = current in amperes

**E** = voltage in volts (either phase-neutral or phase-phase, as connected)

**P** = power rating of heaters in watts (or kilowatts x 1000)

**R** = total heater resistance in ohms (ohms per foot x total footage of wire)

Multiplying this current, **I**, by 1.25 provides the **minimum** permissible branch circuit rating to be employed in selecting both overcurrent protective device rating (i.e. breaker trip rating) and wire size (ampacity). Should this actual value not correspond to a standard trip rating, Section 240-3(b)(3) permits applying the next higher rated device. Below 100 amperes, standard ratings for fuses and thermal-magnetic circuit breakers, per Section 240-6(a) are: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80 and 90 amperes. Table 310-16 is utilized to select a conductor size having an ampacity equal or greater than required for the branch circuit. This tabulation displays ampacities of both copper and aluminum/copper-clad aluminum conductors; determination must be made if the latter two are permitted (U-L Listed) for connection to **all** elements of the branch circuit. For circuits rated 100 amperes, or less, Section 110-14(c)(1) requires conductor selection be predicated upon the ampacities in the 60°C (140°F) column even though the use of 75°C or 90°C temperature rated conductors is contemplated. Additionally, all pertinent adjustments and corrections, such as ambient temperature, number of current-carrying conductors and voltage drop, should be observed.

The results obtained by this procedure yield branch circuit ampacities and ratings appropriate for most applications of heaters employing constant wattage resistance wire. However, because self-regulating type heating wire,

inherently, exhibits inrush currents inverse to ambient temperature, the selected/specified wire manufacturer's recommendations regarding overcurrent protective device ratings should be employed with a corresponding increase in branch circuit conductor ampacity.