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Control of Condensation in Curling Rinks

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Please note

The growing popularity in recent years of curling as a winter sport in Canada has led to the construction of an increasing number of new buildings for curling rinks and to the renovation and improvement of existing ones. Mechanical refrigeration equipment is now normally provided to ensure a more uniform ice surface and to extend the curling season from early fall to late spring. These changes, coupled with increased serious interest in the game, have brought about a growing awareness and concern for problems associated with the performance of curling rinks, particularly the problem of "dripping" on the ice surface.

Dripping describes the condition arising from the melting of frost that has accumulated on the underside of the rink roof or ceiling. Frost forms during the curling season and subsequently melts in mild weather, dripping to the ice sheets where it refreezes and forms undesirable "bumps." Under normal weather conditions on the Prairies the problem occurs only in the spring, but in regions of Canada having more moderate or variable winters it may occur frequently. In natural ice curling rinks the curling season was more closely related to the outside weather, and although dripping was a problem in the spring the season was almost at an end and the ice itself beginning to show other signs of deterioration.

The accumulation of frost on the ceiling of a curling rink is the result of the condensation of moisture originating from flooding and "pebbling" operations, from, the curlers; and spectators, and from the ice surface itself. These sources of moisture tend to produce high humidity conditions within a rink, resulting in dew-point temperatures approaching the interior air temperature. Under cold weather conditions the interior surfaces of the rink enclosure will be at a temperature lower than that of the air. If these temperatures fall below the dew-point temperature condensation results.

It is evident that any efforts to lower the humidity and hence the interior dew-point temperature will reduce the possibility of condensation. It is also apparent that raising the temperature of interior surfaces will serve a similar purpose. Consideration of these two principles is essential in any attempt to reduce or eliminate condensation.

Condensation normally occurs as frost in a curling rink because of the temperature levels involved. The frost itself is not objectionable, as it might be in other buildings, nor is the subsequent melting of the frost of concern provided that it does not fall or drip onto the ice surface. The problem is in this way unique from the practical point of view, and suggests yet another solution involving proper control of condensed moisture during the curling season.

Application of the foregoing principles may be undertaken using a number of different techniques, depending on the particular circumstances involved and the resources available. It is the purpose of this Digest to outline some of the various methods that may be used and to discuss their possible effectiveness.

The Removal of Moisture by Ventilation

Some form of ventilating system is normally included in most curling rinks as a means of removing moisture. Such systems usually rely on natural ventilation and consist of vent openings at the roof ridge with inlet air vents in or above the side walls. The size and location of these vents will have an important bearing on their performance, but their effectiveness is also largely dependent on the inside to outside air temperature difference.

Neglecting the influence of wind, the rate of ventilation will increase with increasing inside to outside temperature difference. The capacity of the ventilating air to remove moisture will also increase; at lower outside temperatures the ventilating air will have a lower initial moisture content. Natural ventilation systems have themselves an inherent moisture control feature which is most desirable. At low outside temperatures, when the potential for condensation is greatest, increased moisture removal capacity is available. Under warm weather conditions, when the introduction of moist outside air may result in fogging, the ventilation rate is reduced. The full benefits of this operating characteristic will only be realized, however, if the inside temperature of the rink is held at a reasonably constant level.

A curling rink is normally an unheated building and the interior temperatures of a particular rink will be determined by the natural balance between the unintentional sources of heat and the cooling loads associated with the building. Heat gains will be experienced from adjacent waiting and viewing rooms, lights, the curlers themselves and solar radiation. This will be augmented or counteracted by the heat exchanged with the ice surface, the exterior walls and roof, and the ventilating air.

The temperature of the ice surface remains reasonably constant throughout the curling season as it is controlled by the temperature of the brine circulating in the pipes. During periods of cold weather the ice sheet acts as a heating panel because its temperature is above the air temperature within the rink. This heating effect is a major factor in keeping the air temperature in a well constructed rink at a comfortable level. Observations indicate that the air temperature remains reasonably constant and seldom, drops below a well defined minimum. This minimum varies with the location and design of the rink, but in the colder parts of Canada it will be above outside air temperature during most of the winter months. When this is the case, natural ventilation is most effective. It is important to remember, however, that when the inside air temperature is below the ice surface temperature, the ice is not only giving up heat but moisture as well. This increased. supply of moisture will offset the increased ability of the ventilating air to remove moisture.

Mechanical ventilating systems experience the same difficulty. They have little advantage over natural ventilating systems when the outside temperatures are low, although they do provide better control during pebbling and flooding operations. Condensation control by either system will be much more effective during cold weather if some heat is introduced into the rink. The higher temperature will improve ventilation and will also reduce the moisture gain from the ice surface.

Moisture Removal by Dehumidification

Dehumidification, using mechanical refrigeration, has been used to some extent in rinks in Eastern Canada. In some cases the equipment used for ice making is adapted for the purpose, and in others a separate refrigeration system is employed. Both methods require some air handling equipment and a considerable capital investment is necessary. Operation may also be complicated by the problem of coil defrosting.

From the limited information available on air conditions within curling rinks in the colder areas of Canada it would appear that below freezing temperatures will be experienced during most of the season. Coil temperatures for dehumidification would necessarily be considerably below freezing and some means for manual or automatic defrosting would be required. It is probable under these circumstances that the application of mechanical dehumidification in the solution of the dripping problem in curling rinks has limited application.

Another suggested means of dehumidification involves the use of the walls of the building as frost collecting surfaces. As has been mentioned, frost accumulation is usually of concern only on the rink ceiling. Frost accumulation and subsequent melting on the walls presents only a problem of snow or water removal from the walkways adjacent to them.

Following this principle the exterior walls of the curling rink might be designed with as low a thermal insulation value as possible. This is not difficult; the materials usually selected to meet the structural requirements for the wall have high thermal conductivity. Thin masonry walls, for example, act as condensing panels, especially when they face north and do not pick up radiant energy from the sun.

From a limited investigation of such a design, it appears that although the condensing wall system may not prevent ceiling condensation it is effective in reducing the amount that accumulates. The temperature difference between the wall and ceiling will promote some migration of moisture to the walls but the vapour pressure differences involved are probably not large enough to move enough moisture by diffusion alone. This might be rectified by circulating air within the rink to promote condensation on the walls. It is also possible that increasing the temperature difference between the ceiling and walls by raising the ceiling temperature would result in improved performance.

Elevation of Ceiling Temperatures

The greater the over-all insulation value of the roof-ceiling construction, the closer the interior surface temperature will be to the temperature of the air adjacent to it. It is desirable, therefore, to select materials for the roof that are inherently good insulators. Fortunately, in the design of many curling rinks the roof deck is constructed of wood planking two or more inches in thickness, an excellent choice because of its thermal insulation value.

Through metal fasteners must be avoided as their high thermal conductivity would give the nail or bolt an inside surface temperature far below that of the adjacent wood surfaces and cause condensation on the fasteners. This can occur even when the remainder of the ceiling is completely dry. Although the drip from bolts or nails might not amount to very much, any bumps formed on the ice can be annoying.

A dropped ceiling will also provide insulation, but it must incorporate a vapour barrier to prevent condensation in the attic space. Vapour barrier materials are available which in themselves have a high degree of resistance to the flow of water vapour and air, but they do not perform their intended function unless they can be applied without breaks or openings. It is almost impossible to install lighting fixtures and concealed wiring without leaving some holes in the vapour barrier, and the natural movement of moist air through these openings may easily result in condensation and subsequent dripping through the ceiling. Ventilation of the attic space provides some measure of protection, but the rate of vapour removal possible in a curling rink attic is considerably less than that in a heated building. Some rinks with this type of construction have performed satisfactorily, but only after a great deal of time and effort has been applied to ensure a tightly sealed vapour barrier.

The introduction of heat into curling rinks has been suggested as a means of improving ventilation effectiveness and of reducing moisture gains during periods when the outside temperatures are low. It may also serve to raise ceiling surface temperatures so as to inhibit condensation and aid its removal. Where cold walls serve as condensing panels and ridge ventilators are not provided, warming of the ceiling will control condensation there and allow the walls to act as dehumidifying surfaces. Where ridge vents are included in the design, the warmed air passing over the ceiling surface will also serve to carry condensed moisture from the building.

It is difficult to estimate the size or arrangement of the heater and distribution system required, but a unit with a capacity of 100,000 Btu/hr should be suitable for rinks with four to six sheets of ice. Some estimate of the requirements for a particular rink may be obtained by a simple heat balance calculation. The heating unit might well be operated on automatic controls to ensure a minimum air temperature (measured at the 5-ft level) slightly above the brine temperature, with a manual switch provided so that heat may be supplied at any time that increased moisture removal is desired.

Control of Dripping by Absorption

At some periods during the curling season condensation at temperatures above freezing may introduce a dripping problem. Under such conditions a ceiling with a surface capable of absorbing moisture would be most desirable, so that water taken up by the ceiling material would evaporate as ventilation continues. This is one characteristic of wood plank roof decking that has led to its popularity and success.

Metal roof decks, on the other hand, invariably give trouble in unheated rinks because of their inability to absorb moisture. Special materials (such as sprayed-on insulation) with a high water-absorbing capacity have been suggested as alternatives. Materials of this type, consisting chiefly of asbestos fibre and a cementitious binder, have a low conductivity when dry, but under the conditions existing in curling rinks they can be expected to become wet. The loss of insulating value is not of paramount importance, however, and their moisture retention characteristic is appealing. Ice will most certainly accumulate in the colder layer of the material during the curling season and some degree of surface condensation can also be expected. This is acceptable provided that the water is held or absorbed when melting occurs and provided also that the strength of the material and its bond to the roof are sufficient to support the increased weight. Assurance must also be given that the fibres will stay in place. Any tendency to drop to the ice surface would create serious problems.

Summary

The problem of dripping in curling rinks may be approached in a number of ways, depending on the characteristics of the particular rink and the resources available. This Digest has attempted to outline the principles involved and to discuss some of the methods that might lead to a solution of the problem.

The analysis suggests that some means of introducing heat into the building is probably the most generally applicable and effective condensation control, particularly in the colder areas in Canada. In conjunction with heating, a roof deck having some thermal insulation value should be used for reasons of heat economy and to provide maximum ceiling surface temperatures.

Ceiling finishes having water-absorbing characteristics offer considerable advantage over finishes incapable of taking up moisture. Wood roof decking is an ideal ceiling finish as it not only provides thermal insulation but is also capable of absorbing water.