Thermal Design

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ENERGY CONSERVATION AND CONTROLLING CONDENSATION IN INDOOR ICE ARENAS

Indoor ice arena buildings are similar to cooler buildings in their design and have several unique problems that cooler buildings do not have. An ice arena should be designed and constructed with as tight of construction as possible on the exterior. There should be a continuous vapor barrier on the exterior side of the insulation to prevent the inward migration of water vapor and minimize air infiltration into and out of the insulation cavity and the interior space as well.

Although it is impossible to achieve a zero permeability in the exterior of a building, it is possible to get a very low (nearly zero) permeability into the wall and roof systems. Metal panel systems on the exterior provide very low permeability when all laps and flashings are effectively sealed. Extreme diligence should be maintained during the sheeting application to assure an effective seal everywhere. Common problem areas are eave and gable flashings and junctions with other construction materials such as masonry or framed walls. Moisture should be prevented from going around the vapor barrier. With tight construction of the exterior vapor barrier achieved, it will be possible to obtain good control of condensation. However, this does not mean that there will never be condensation. There is a certain amount of moisture in the form of water vapor (humidity) and possibly some liquid water from dew, rain, snow, etc. that will get into the insulation cavity during construction. This moisture can move around to some degree in the insulation cavity since the insulation itself is very porous. Some minor condensation (sweating) can be expected resulting from this and should not be a major cause of concern.

Seasonal rinks, where the buildings are open and humidity is allowed to enter in an uncontrolled manner, will have entry of water vapor from the interior of the building into the insulation cavity as well. Upon start-up of the ice rink in new buildings and seasonal rinks there is a transition period where the moisture within the building envelope must be drawn out. This includes not only the moisture in the interior air, but also the building materials as well. This transition period will vary in length depending upon a number of factors which include:

- The amount of air (humidity) infiltration into the rink. This should be minimized during start-up. Shut down ventilation systems if possible during start-up and close all doors.
- The volume and size of the building.
- The amount of moisture that is within the building prior to start up. New construction will have a lot of water vapor in the building materials and space. This causes a longer transition period the first year as all of the excess moisture must be drawn out.
- The outside temperature (the lower the better).
- The amount of dehumidification capacity designed to control humidity in the inside air. Ventilation and infiltration should be minimized at all times during operation. Staging or variable adjustment of ventilation air is a good idea to limit ventilation to the required amount for the number of people in the building. If you have 200 people in the rink, why ventilate for 400 or 2,000 people? This requires management, but will substantially reduce interior humidity and energy costs. The most common problem in indoor arenas is excessive ventilation.

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- Air rotation within the space is important at all times. Warm air holds more water vapor and warm air rises, so a very strong gradient from 20° F to possibly 90° F is present in an ice arenaduring start-up. Water vapor will be highest by the ceiling and will be constantly removed by the ice sheet if air rotation is present in the arena. Rotation can be done with simple ceiling fans and a six times per hour air rotation rate. This should not be done directly above the ice sheet, but off in the corners. The goal is to bring the warmer moister air down and remove as much of the moisture and heat gradient as practical. This practice will significantly reduce start-up transition period by accelerating the building dehumidification. A 17,500 sq. ft. cold ice sheet will condense a lot of moisture if it is brought down to it.

Building purlins should be isolated and insulated from the inside air. If they are not, conduction of heat (solar) energy through the roof causes the purlins to heat up dramatically. The warm purlins, if left exposed, radiate heat into the interior space increasing the load on the refrigeration equipment. In addition, the warm purlins warm the air around the purlins causing the air to absorb and hold moisture from the interior of the building. When the sun goes down, the roof temperatures may drop as much as 80 to 90 degrees and the purlin temperatures dramatically drop over a very short period. The warm moisture laden air around the purlins then deposits its moisture on the rapidly cooling purlins resulting in sweating and dripping of condensed water off the purlins. The long term effects of this will cause severe corrosion on the purlins and shortened roof life. The short-term effects are stalagmite-like water deposits on the rink surface. To prevent this, the purlins should be isolated from open contact with the interior air and insulated.

It is common in all ice arenas during start-up that there will be condensation in the building during the transition period. This is because of the nature of the building. A well-insulated building will cool down much faster than a poorly insulated building such as those with the low emmisivity liners and minimal insulation. Because of this, there will be more visible condensation at start-up as the heat is drawn out of the building surfaces more quickly. Once the transition period is over, the building will be drier than those with the low emmisivity liners will because the building will be cooler. The well-insulated building will cost significantly less to maintain ice in than those with the low emmisivity liners and minimal insulation.

During start-up of ice arena buildings, it is common to see condensation droplets on the ceiling surfaces directly above the ice sheet, but not on ceiling surfaces outside of the oval. This is because the ice sheet is drawing the heat out of all the surfaces in view of the ice sheet. Heat is drawn out of all other surfaces as well, however, the surface directly above the ice sheet will be a few degrees colder and here water vapor will condense while it will not on other surfaces. This condensation will be present until the building air is sufficiently dehumidified to allow for the revaporization of the condensed water and the subsequent dehumidification of it. Adding a little dry heat to the building during this process along with air rotation will accelerate the drying process. Keeping the ceiling surface temperature above the dew point temperature with dry heat will minimize condensation on the ceiling above the ice sheet but will prolong the cool-down process and the dehumidification of the inside air. Once the building interior is dried out, there should be negligible condensation on the interior surfaces.

This drying out process is independent of the problem of water vapor entry through the building envelope from the outside toward the inside. Water vapor infiltration will be greatest during the most humid, hottest exterior conditions. If the building is well sealed, the dehumidification capabilities of the interior of the building will draw out more moisture than can migrate in, allowing control. If more moisture can go through the exterior vapor barrier than can be drawn out by the dehumidification process, there exists a potential for excessive condensation in the envelope materials.

A well insulated, well-sealed building exterior envelope will give the most energy efficient and driest ice arena environment.

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