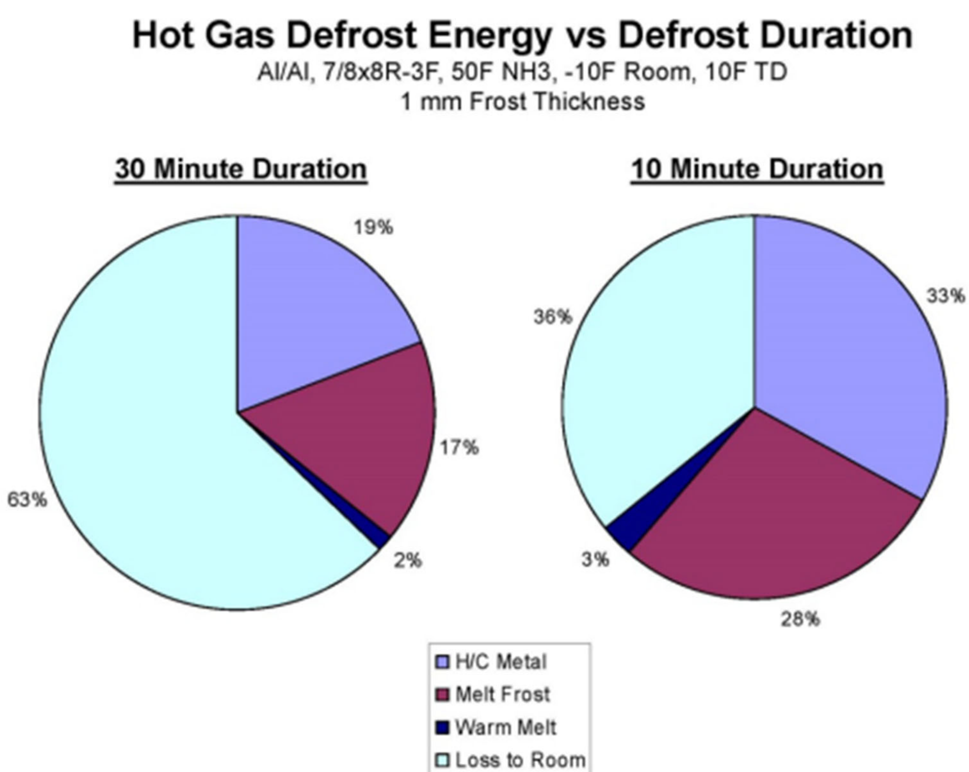
By Grant Brookover

Energy Efficient Defrost

Background

Defrost is a mandatory process for any industrial air cooler operating at temperatures below freezing. At freezing temperatures frost builds up on the evaporator fins, causing units to lose cooling capacity and efficiency. Frost is normally removed by heating the evaporator to the point that the frost is melted and then drained away. The heating process uses energy which comes at a cost, however. Depending on frost load, temperature, fin spacing, etc., a typical defrost will cost somewhere around $0.15 to $0.20 per cycle per TR (Cole 1989).

For a typical ceiling-hung evaporator the defrost process is quite inefficient. As much as 40% to 60% of the energy input during defrost is lost due to heat convection. A perfectly efficient defrost would have 100% of the energy working to melt the frost attached to the evaporator fins. Unfortunately, this is impossible since defrost energy inevitably ends up heating the fins, tubes, frame, drain pan, surrounding air, etc. The figure below shows where the thermal energy is used during two typical defrost processes, one with 30 mins defrost duration and one at 10 mins (Nelson).



In a typical cold storage that operates at -10F, up to *63%* of thermal energy used during defrost will be lost to the room and wasted!

Improving Defrost Efficiency

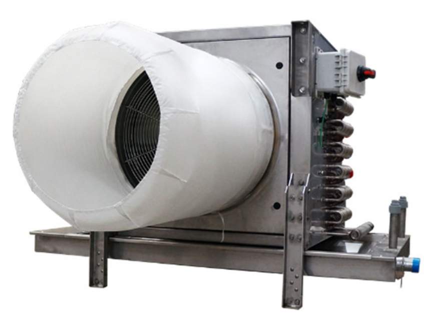
Colmac Coil has developed two proven designs that can work in tandem to inhibit energy from escaping the evaporator of an A+Series™ air cooler during defrost. At the same time, these designs don't restrict the function of the unit as the air cooler runs. This translates directly into significant energy savings. For example, assuming 50% of the heat that normally escapes an evaporator is captured, savings could reach $0.06 per defrost per TR, or $19,710/year for a 300 TR cold storage operating with 3 defrosts 3 per day!

Return Air Defrost Hood

A traditional evaporator has the intake side of the evaporator completely exposed so that air can freely flow as it is pulled in by the cooler's fan. During the defrost process, however, this exposed area creates a major energy-loss problem. Due to convection, the warm air that should be used to melt frost and ice moves upward and easily escapes out of the evaporator. Defrost hoods minimize this loss of heat due to convection. Colmac Return Air Defrost Hoods are fully insulated hoods that are hinged so that they can collapse for easy storage and transportation. When fixed in operating position, the hoods allow unrestricted movement of air as it is pulled into the evaporator but denies the upward movement of warm air as it tries to escape, trapping it inside the evaporator for optimal defrosting. This increased efficiency means several benefits for the customer: faster and more thorough defrost, reduced ice buildup on surrounding walls and ceilings, and lower cost per defrost!

Discharge Duct Sock

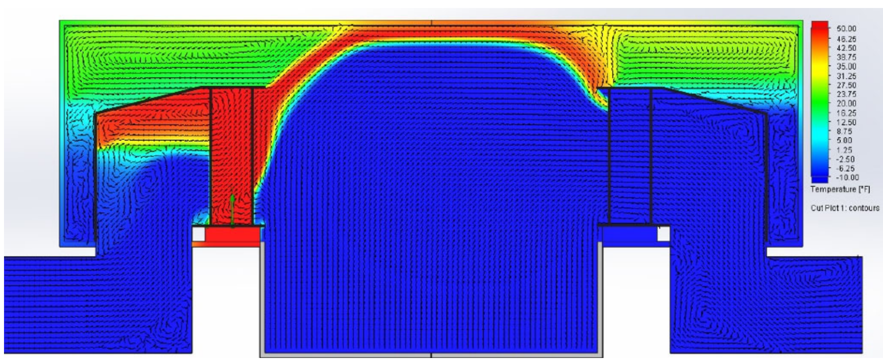
Designed to work in conjunction with the Return Air Defrost hood, the Colmac Discharge Duct Sock helps prevent warm air from escaping the area of the air cooler that is second most vulnerable to convective heat loss during defrost: the fan discharge. The Duct Sock accomplishes this, while still allowing air to freely flow out the discharge, by an innovative design. As its name suggests, the Duct sock is a nylon fabric "tube" that is attached via belt to the edge of the discharge duct. When the defrost process starts and the air cooler fan stops, the sock folds down. In this folded position, the sock keeps warm air from escaping the evaporator, further increasing defrost efficiency. In addition, the sock is very lightweight, meaning that minimal fan power is needed for inflation.



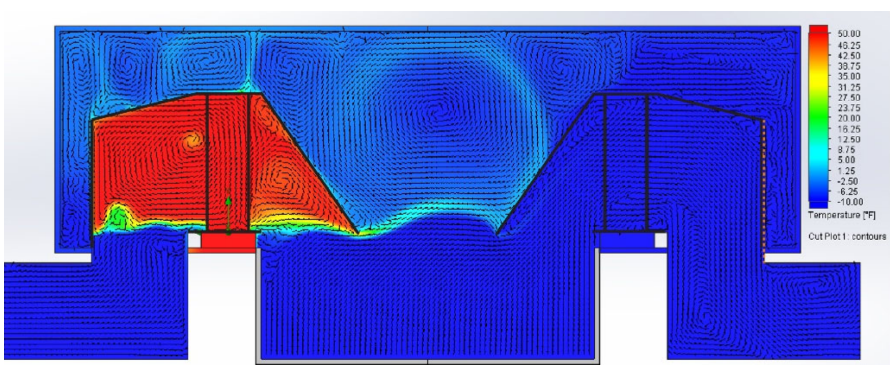
Applications

Penthouse configuration

Evaporators mounted in a rooftop penthouse enclosure offer a number of advantages for access and ease of service. The A+Series™ A+L air coolers with penthouse fan sections are designs specifically for mounting in built-up rooftop penthouses. Because of the 90-degree fan discharge section on these types of air coolers, the Duct Sock is unnecessary. However, the Return Air Defrost Hood still adds significant energy benefits. Given for visual comparison, the results from a thermal finite element analysis on two penthouse arrangements are shown below. The red, yellow, and green areas represent higher temperatures, and the blue shows areas where there is little to no energy dissipation.



Finite Element Thermal Analysis
A+L Penthouse Without Hoods



Finite Element Thermal Analysis
A+L Penthouse With Hoods

The top image shows an A+Series™ air cooler penthouse arrangement *without* defrost hoods. As the defrost cycle on the left air cooler runs, it is easy to see thermal energy escaping the evaporator and moving to the top of the ceiling. Instead of melting ice buildup, this unused energy is wasted by heating surrounding air and metal.

The bottom image, however, tells an entirely different story. With the Defrost Hood installed, very little heat escapes the evaporator. Other benefits include: faster more complete defrosting, elimination of frost formation on penthouse ceiling and walls, and more effective sequential defrosts when multiple air coolers are mounted in the same penthouse enclosure.

Ceiling-mounted configuration

When this is the configuration of choice, both the Defrost Hood and the Duct Sock work together for maximum energy retention and defrost efficiency.

References

Cole, R.A. 1989. "Refrigeration Loads in a Freezer Due to Hot Gas Defrost and Their Associated Costs." *ASHRAE Transactions*, V.95, Pt.2.

Nelson, B.I. "Optimizing Hot Gas Defrost" Technical Bulletin, Colmac Coil Manufacturing Inc.

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