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Nonducted Air Flow with Unit Coolers

A look at how nonducted air flow affects the performance of refrigeration unit coolers

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Effective refrigeration unit cooler performance depends on a combination of coil surface and air movement. Therefore, careful consideration should be given to the placement of the unit coolers and the stacking of the refrigerated products as well as the refrigeration equipment chosen for the application. A solid understanding of nonducted air flow will help ensure the refrigeration equipment application meets all the customer's needs.

The walls of a duct, through friction, reduce the velocity of the air within a ducted air flow system. And if the cross section remains constant, the cubic feet per minute (cfm) is reduced as distance from the fans is increased.

Nonducted air flow is unique because although the air velocity decreases with distance, the cfm increases. For example, the cfm at the point where the velocity has decreased to 50 feet per minute (fpm) may be 10 times larger than the cfm at the outlet. Air moving within a medium identical to itself easily causes still air to begin to move. This process is called entrainment, which causes a void.

The cfm printed in unit cooler catalog specifications refers only to the quantity of air flowing over the finned-tube surface. It is not easy to predict the cfm at any given distance because the air movement is so sensitive to disruptions in the free air path. The actual distance air will travel from the unit cooler depends on the height the unit is installed off the ground, air differences, shelving, the disruptions caused by the products residing in the cooler, and even ceiling beams.

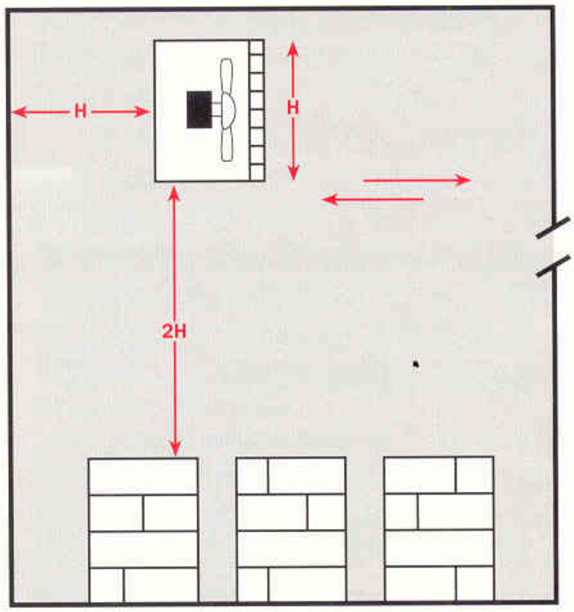

Fig. 1: Adequate clearances must be maintained on all sides of a unit cooler to ensure peak performance.

Improper Clearances

Air flow restrictions caused by improper clearances on the return side of the unit cooler are sometimes overlooked by the installers utilizing nonducted air flow systems. Improper clearances result in a poor supply of return air. Propellers are particularly sensitive to pulling against low pressure caused by a poor supply of return air. Additionally, air throw distances are significantly reduced if the refrigerated product restricts the amount of return air. To obtain an adequate supply of air, clearances at least equal to the height of the coil must be maintained on the return side.

Continued on Page 2

Nonducted Air Flow with Unit Coolers

(Continued from Page 1)

For example, a unit cooler that is 50 inches in height must be at least 50 inches from the wall. In a narrow box where the unit cooler "fills" the wall, refrigerated products should not be permitted to block the return air duct under the unit cooler (Fig. 1).

In nonducted systems, separation of return and supply air streams is essential. Air can not travel in opposite directions at high velocity without the air streams being separated by a duct member. If there is no separation, the natural result is turbulence. If no physical barrier between the discharge and return air streams exists, there should be a neutral zone to enhance the separation of air steams and unit cooler air throw (labeled 2H in Fig.1). Without a neutral zone, air tends to recirculate without any downstream direction when refrigerated products block the return air side.

A unit cooler's air throw distance is measured to the point where the velocity has decreased to 50 feet per minute (fpm). The velocity is called *zero useful* because the normal air gradient caused by air stratification in an unoccupied room naturally reaches 50 fpm. Unit coolers can blow air much farther than they can draw it in. Thus, a unit cooler mounted in the center of the room can blow air downstream 50 to 60 feet, but probably affects upstream air no more than 3 to 4 feet.

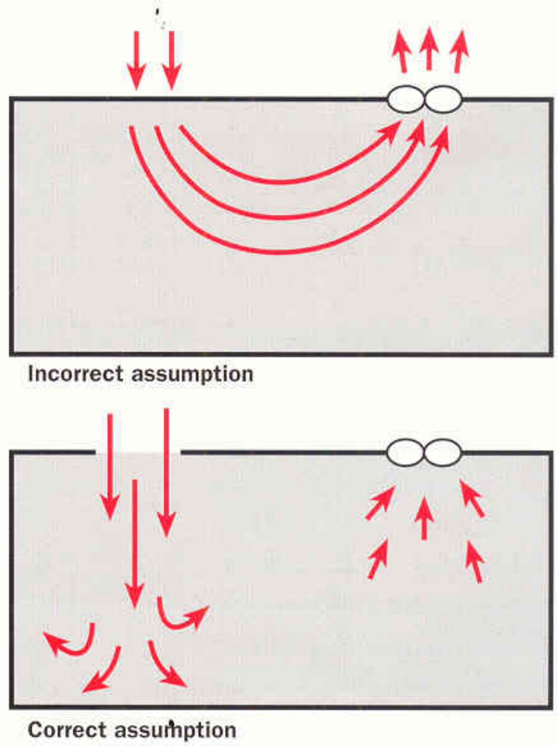

Fig. 2: An airstream blowing into a room is not affected by an exhaust fan located on the same wall.

To illustrate, consider the air quantity on the supply side is drawn from an area defined by a spherical contour located at the point of zero useful or 50 fpm. An 1800 cfm unit cooler, measuring one x three feet in length, obtains its air supply from a sphere less than four feet in diameter. The entire quantity of air is forced downstream of the fan blade. The stream's momentum is reinforced by the continuous pushing of air from the unit.

Distributing the Air

Distributing the air throughout the room is another matter. For applications where no product temperature reduction is required, the volume of air equal to the volume of the room should be circu-

Continued on Page 5

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Table 1 – Air circulation requirements for various appications based on 1000 cu ft room volume (10' by 10' by 10').

Application	Minimum circulation requirement, cfm
Temperature holding	1000
Temperature reduction	2000
Blast freezing	5000

lated through the unit cooler once each minute. A 10' x 10' x 10' room should have enough unit coolers to total 1000 cfm. For temperature reduction applications, a circulated air volume at least three times the room volume is required and in cases of product freezing, at least five times the volume is necessary (Table 1).

Adequate air distribution is not guaranteed by having enough cfm. Air distribution should be measured and judged by the air temperature throughout the room, as opposed to the air velocity. More air will be required nearer the heat load of an outside wall than at the center of a holding room. In temperature holding rooms air should only be circulated over the heat source. Therefore, it is recommended air be directed parallel to aisles in a holding application and perpendicular to aisles in the temperature reduction or freezing process.

In all types of operations – holding, freezing, or temperature reduction – the refrigerated products should be separated from the heat source by the air stream. This means the refrigerated products must be raised off the floor and kept away from outside walls. At least six inches of clearance should be maintained between the products and floor or outside wall. In the holding product application, the unit cooler should be placed where air will flow around the refrigerated products, using the products, walls, or floor to form a duct or path for the return air (Fig.3). The six inch duct clearance is based on a 10 foot duct length. For every two feet of additional duct length, add one inch for clearance. For instance, a 14 foot duct length requires eight inches of duct clearance.

Freezing Operation

While more air is required at the walls in a holding operation, the opposite is true of freezing operation. Sixty-five percent of the total load can be involved in the process of freezing and all the air would be required at the product.

The use of auxiliary fans should be considered to help increase the velocity over the product in freezing operations. Unit coolers typically do not produce velocities in excess of 200 to 300 fpm when the air reaches the product, and velocities in the range of 1000 fpm are required to significantly reduce the freezing time. Since both air velocity and increased temperature difference between the products and air can speed the freezing process, it may be much less expensive to increase the air speed over the refrigerated products than to operate at lower temperatures.

In product freezing or temperature reduction, it is essential that air be blown through and over the refrigerated products. Just pointing a fan at the products does not guarantee proper results. Fig. 4 illustrates one approach to blast cooling or freez-

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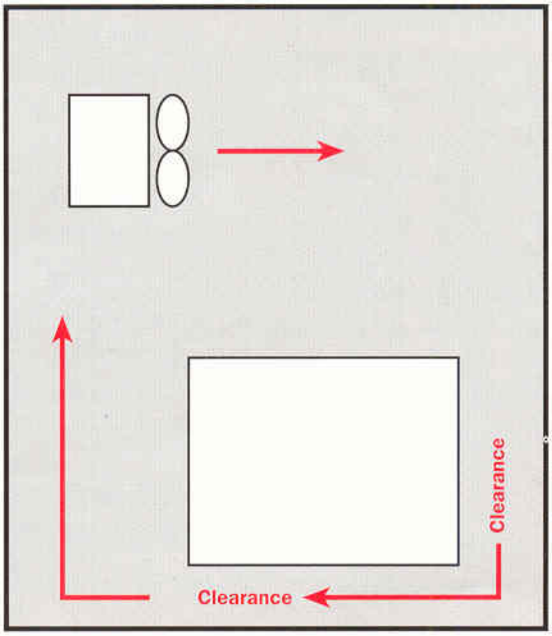

Fig. 3: For product holding applications, the unit cooler is placed so that the product, walls, and floor form a duct for the return air to travel around the product.

NONDUCTED AIR FLOW WITH UNIT COOLERS

(Continued from Page 5)

ing. One problem associated with the approach is the short-cycling of the air around the unit cooler. Shortcycling causes air turbulence which adversely affects unit cooler performance and causes poor air distribution over the refrigerated products. In Fig 5. the same capacity unit coolers were used, but with a clear definition of return and discharge air streams, resulting in peak unit cooler performance and enhanced heat removal.

Optimum performance of nonducted refrigeration systems requires careful consideration of evaporator and product placement. Proper planning before the installation is crucial and will ensure that the equipment is effectively utilized.

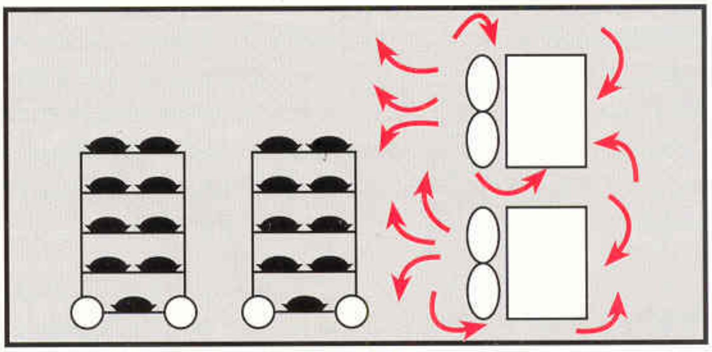

Fig. 4: Shortcycling of air around the unit coolers and poor distribution of air over the product are problems associated with blast cooling or freezing.

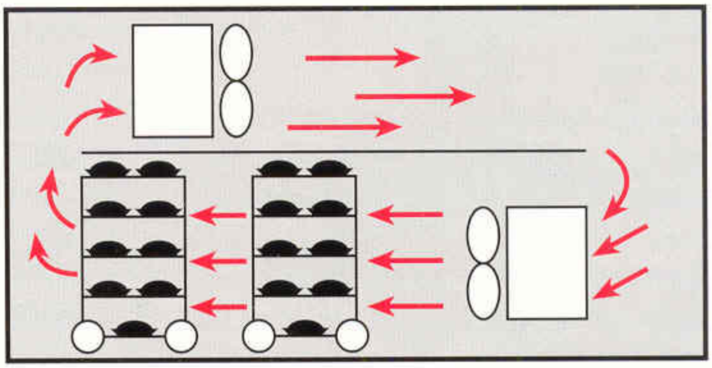

Fig. 5: Clearly defined return and discharge air streams result in peak unit cooler performance.

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