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Heat Exchangers for Animal Shelters

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Introduction

Heat exchangers are used in livestock and poultry facilities to recover a portion of the heat lost by the continuous running fan. The heat lost through the minimum ventilation air exchange is very significant, amounting to as much as 80 percent of the total heat loss from a swine nursery facility. Thus, with even modest efficiency, a heat exchanger can reclaim a sizable amount of heat if warm room temperatures (greater than 60° F) are maintained. This recovered heat not only saves on fuel bills but also eliminates frosting and condensation problems at and near air inlets since the incoming air is preheated. The warmer inlet temperatures also reduce the density differences between incoming and room air in the winter, resulting in improved air distribution.

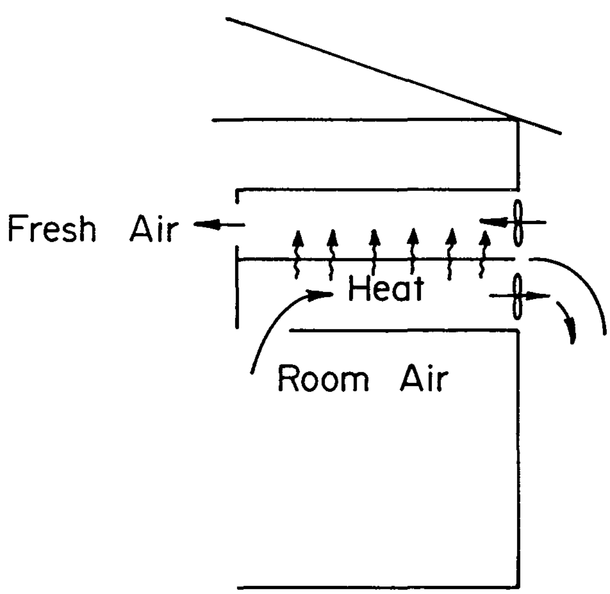

Figure 1. Schematic cross-sectional view of a heat exchanger with an exhaust fan and an inlet fan.

The heat recovery process is accomplished in any air-to-air heat exchanger by moving warm moist air past cold inlet air separated by plastic or metal plates (Figure 1). The two airflows may be in opposite directions (counter flow), at right angles to one another (cross flow), or in the same direction (parallel flow). No matter which design is selected, it should meet the criteria of proper airflow, cleanability, compatibility, distribution, durability, and economic return.

Proper Airflow

A heat exchanger may be sized acording to its ability to function as a 'heater' or as an air-moving 'fan.' The airflow capacity is the most important factor, and should be the major feature in selecting a heat exchanger. The capacity of the heat exchanger, as measured in cubic feet of air per minute (CFM), should be at or above the minimum ventilation rate, which is determined by the type and number of animals. These rates are listed in Table 1, as

Table 1. Minimum ventilation rates for various types of livestock and poultry.

Type of Animal	Minimum Ventilation Rate* CFM/animal
Swine	
sow & litter	20
pre-nursery pig	2
nursery pig	3
Dairy	
0 — 2 months	15
Poultry	
chick	0.1
layer, pullet breeder, broiler	0.5
turkey poults	0.17/lb

*An alternative minimum ventilation rate for any livestock and poultry facility is four air changes per hour which, in units of CFM, is found by dividing the room volume (cubic feet) by 15 (minutes).

given in the Midwest Plan Service (MWPS) Structures and Environment Housing Handbook, 11th edition, 1983.

The above ventilation rates are guidelines to follow when selecting any type of minimum ventilation system, either continuous fans or heat exchangers. These rates are generally sufficient to remove moisture, manure gases, and other airborne contaminants from the animal shelter. By selecting heat exchangers which deliver airflows at or slightly above these rates, you are reasonably assured of providing sufficient air exchange in the facility. Do not, however, ventilate at an appreciably higher level than what is shown in the table, unless you are willing to provide larger amounts of energy with supplemental gas or electric heaters.

Since it is critical to ventilate at or near the minimum ventilation rates, it is essential to obtain a unit which has rated CFM values for its fan(s) (see Extension Fact Sheet AG-FS-0956). A heat exchanger should have two fans, one fan exhausting air and another fan blowing air into the barn (Figure 1). A single fan system (exhaust fan) provides too large a restriction on the inlet side of the unit to allow a significant percentage of the air to enter via the heat exchanger rather than through other inlets and leaks into the barn. In a two fan unit, the *exhaust* fan is the one which should be rated at the minimum ventilation rate.

Cleanability

Historically, a major problem with heat exchangers in animal shelters has been clogging of the exhaust air channels with moisture and dust. Although this fouling can reduce heat transfer and the unit's efficiency, the primary concern is reduction in airflow. Since a heat exchanger supplies the minimum ventilation, serious environmental complications can result in a facility if this rate is significantly reduced. Thus, it is essential that any heat exchanger be easily cleaned. Depending upon the internal design of the unit, there can be considerable differences in how often units need cleaning. However, significant reductions in airflow will result if units are not cleaned periodically or according to manufacturers' suggestions.

Compatibility

The installation of a heat exchanger involves more than selecting one that delivers the proper air flow. Another important criterion is compatibility with the remaining components of the ventilation system. Since a heat exchanger replaces the continuous running fan, special consideration must be given to the inlet system. Under most conditions an additional exhaust fan, controlled by a thermostat, needs to be present to operate when temperatures are too high. When this fan does operate, a negative pressure or vacuum is created. There must be sufficient inlets to allow air into the room when this occurs.

Under minimum ventilation conditions when a heat exchanger (two-fan unit) is used, the barn is essentially under "neutral" or zero negative pressure (Figure 2). Thus, when the heat exchanger is operating, either no inlets can be present, or those which are present must automatically close so that air does not backdraft into the attic or directly outside. The inlets must open automatically when the thermostat-controlled fan turns on (Figure 3) to provide needed airflow for temperature control in the barn. Therefore, some type of damper controlled inlets must be used. If no baffles or dampers are present, backdrafting will occur and serious deterioration of building materials and significant heat loss can result (Figure 4).

Some commercial heat exchangers operate under an unbalanced airflow scheme. That is, they exhaust more air than they blow into the barn. Under these conditions a slight negative pressure is maintained and the difference between airflows will enter through designed and undesigned inlets as in a normal negative pressure system. These units will not deliver as much heat as a balanced system, since not all of the inlet air is routed through the

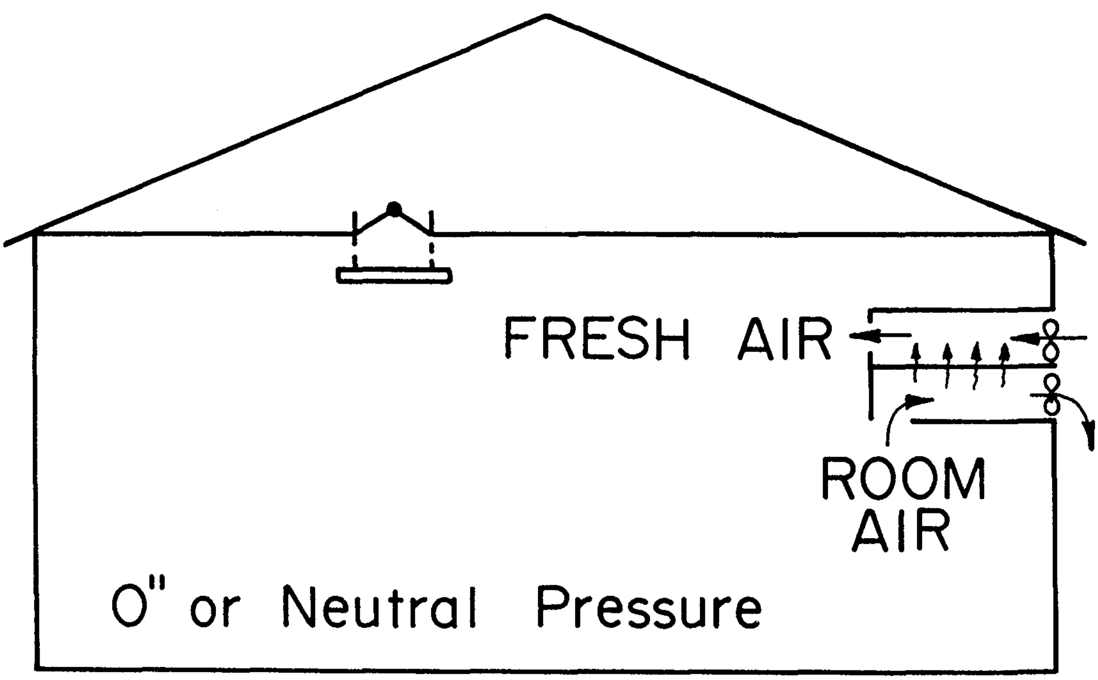

Figure 2. Facility with only the heat exchanger operating, resulting in a zero or neutral pressure difference. Baffled inlets are needed.

heat exchanger. However, such a heat exchanger would be compatible with a traditional negative pressure ventilation system, if the difference between exhaust and inlet rates can overcome buoyancy forces.

Distribution

Whenever a facility is being ventilated at the minimum ventilation rate there is concern for proper distribution of air in the room. This is especially true in rooms longer than 25 feet. Since most heat exchangers exhaust air at a single discharge point, air distribution may be inadequate since, in a balanced (exhaust equals inlet) airflow heat exchanger, no air enters the room except at this point. One solution is to connect some type of distribution duct to the discharge point of the heat exchanger (Figure 5). These ducts should have 1 square foot of cross-sectional area for every 800 CFM airflow (based on a duct air velocity of 800 feet per minute). Since most ducts are relatively short (less than 50

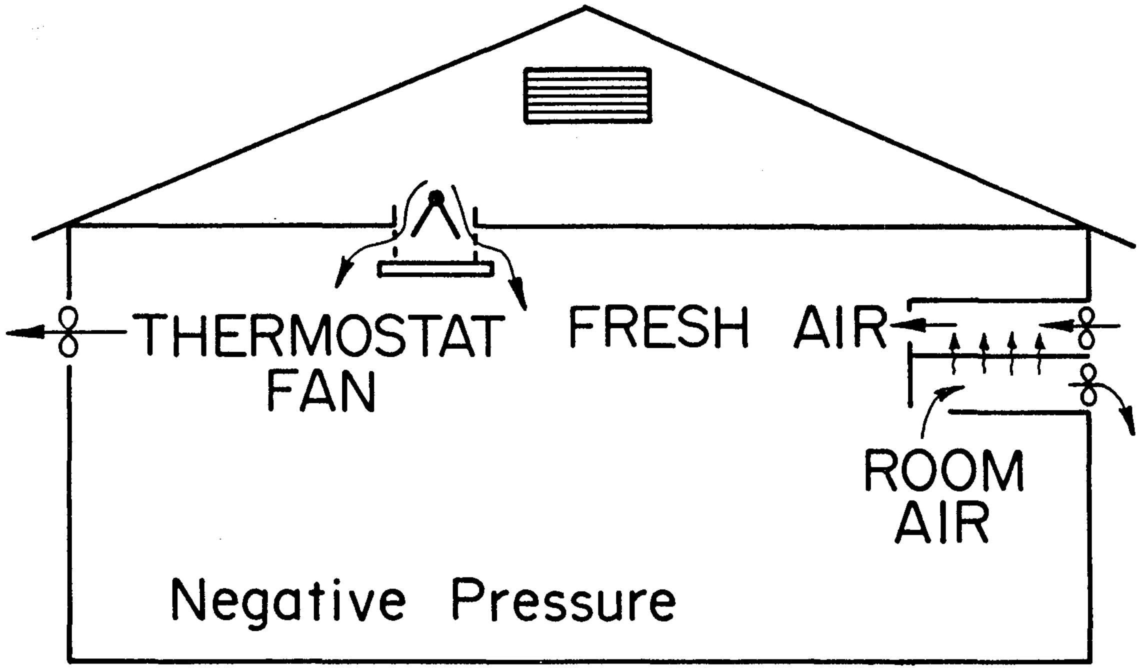

Figure 3. Facility with additional exhaust fan operating (too warm a temperature) resulting in a negative pressure or vacuum in the barn and the need for an automatic open baffle on the inlets.

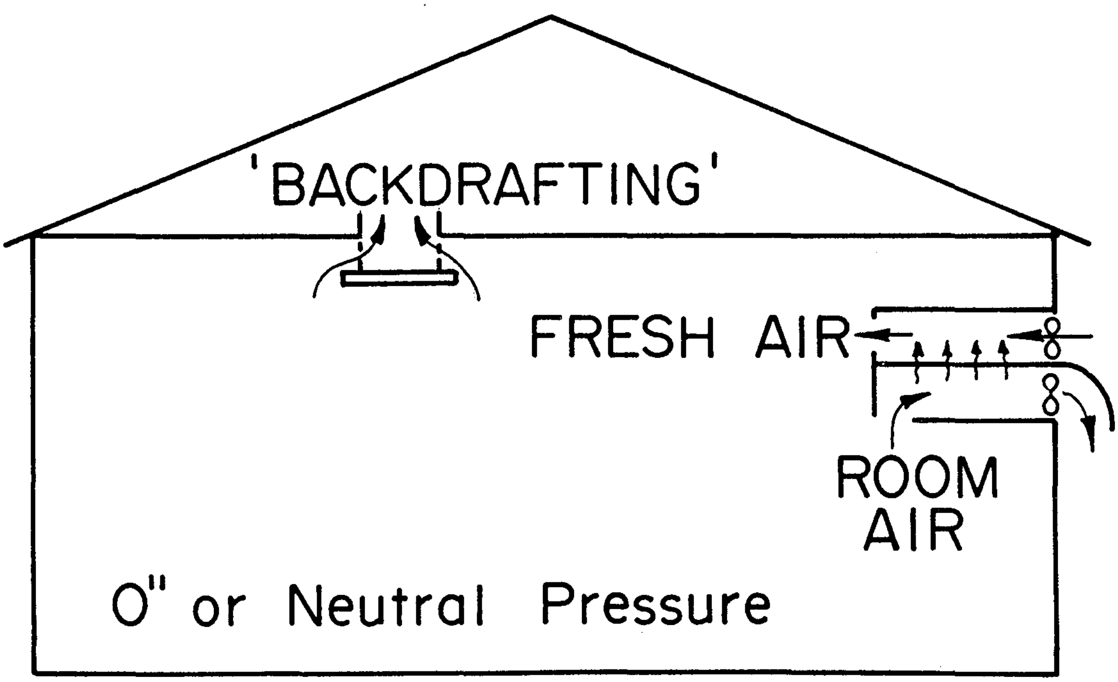

Figure 4. Facility with no baffles in the inlets, resulting in backdrafting when only the heat exchanger is running.

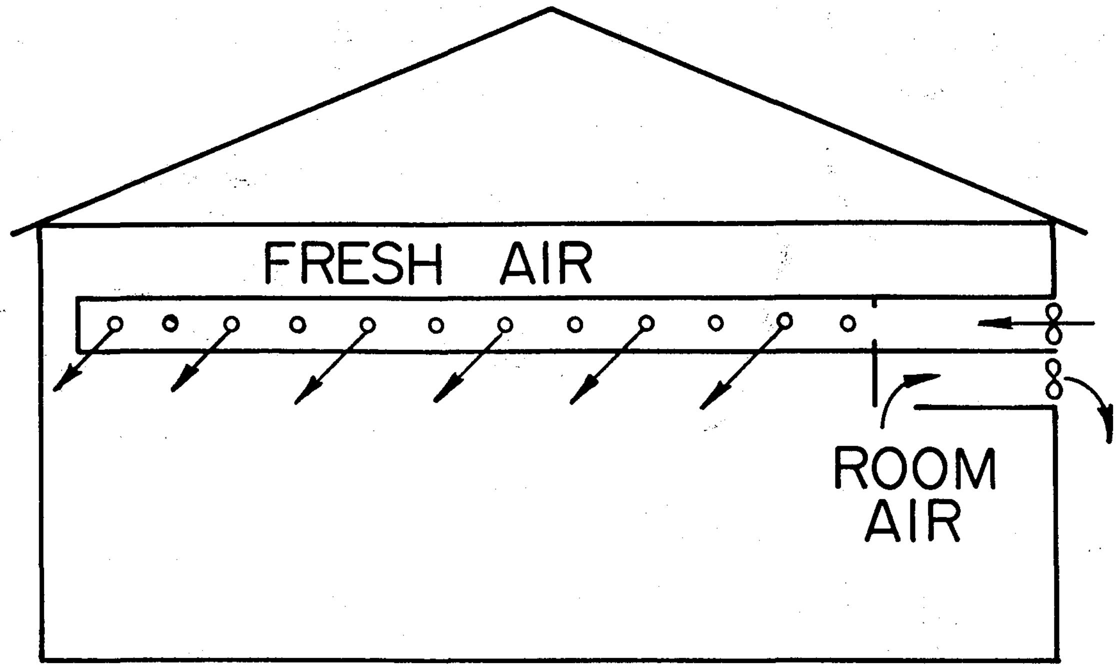

Figure 5. Facility showing duct on inlet fan of heat exchanger to distribute incoming air and heat.

feet), evenly spaced holes or continuous slots which, when added together, equal the cross sectional area of the duct, will evenly distribute airflow down the length of the duct.

Durability

Any equipment in an animal shelter must be constructed of durable materials to withstand physical abuse and corrosion. Generally, heat exchangers are made from wood, plastic, fiberglass, or aluminum to avoid problems with corrosion and hold down costs. Heat transfer rates are essentially *not* affected by differing (metal vs. plastics) plate construction, since almost all the resistance to heat exchange is the air films on each side of the surface.

Economic Return

The economic return or payback period for heat exchangers is an important consideration when choosing a unit. Many factors will affect this return on investment, including initial cost, unit's efficiency, and price of fuel. An estimate, from limited research and field observations, would be from 5 to 10 years for most of the commercial systems sold today. This is based only on fuel savings and not on improved performance of the livestock or poultry housed, which, if it occurs, would be difficult to translate into dollars and cents.

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