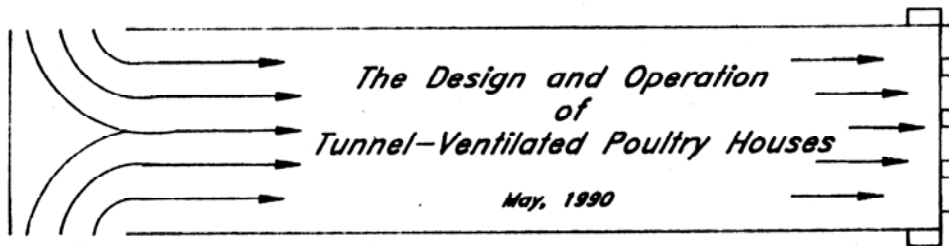




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Tunnel ventilation is quickly gaining popularity in the Southeast as an efficient method of minimizing heat stress problems in poultry houses. Poultry producers have discovered that with tunnel ventilation mortality can be decreased and performance increased during even the warmest times of the year.

In a tunnel-ventilated poultry house exhaust fans are located in one end of the building and two large openings are installed in the opposite end. Air is drawn through these openings and then down the house in wall-like fashion. The air entering the house can be cooled by drawing it through evaporative cooling pads, or by the use of misting nozzles located throughout the house.

The most significant difference between tunnel-ventilated and conventional poultry housing is the uniformity of air movement. In conventional curtain-sided housing a significant level of air movement only exists in limited areas around each circulation fan (Czarick, 1989) (Figure 1). In totally enclosed houses as air travels from the sidewall inlets to the center of the house, the velocity of the air jet decreases by more than 50 percent due to expansion (Wilson, 1983). In a tunnel-ventilated poultry house air velocity at bird level remains relatively constant from the inlet end to the fan end of the house (Figure 2). The uniform air movement results in increased cooling for the birds throughout the house.

Air movement in poultry houses increases the amount of heat loss from the birds. During the cold winter months this increased heat loss can result in poor feed conversions, as the bird tries to eat more feed to offset the increased heat loss. During the summer months this increased heat loss can allow the bird to continue to eat and produce as temperatures begin to rise (Figure 3, 4).

A number of studies have shown that birds can be effectively cooled through air movement even at relatively high air temperatures (Drury and Siegel, 1966, 1968a, 1968b; Mitchell, 1985). Researchers have correlated this increase in heat loss with increased performance. Zimmerman and Snetsinger (1975) found that by increasing air velocity at high ambient

PUTTING KNOWLEDGE TO WORK

temperatures from 20 to 60 feet per minute feed consumption in laying hens was increased by 9 percent and weight loss was reduced. Drury (1966) discovered that increased air movement at high ambient temperatures improved weight gain in broilers. The improved weight gain was nearly proportional to the square root of air velocity.

The benefits associated with increased air movement only occur until the air temperature reaches approximately 104°F. As the air temperature of the air increases beyond 104°F increased air movement actually increases heat stress because the air temperature is greater than the birds body temperature.

Though most poultry producers who use tunnel ventilation have found it to be very beneficial, there are a growing number which have had less than favorable results. In many instances, production problems associated with tunnel-ventilated houses are the direct result of poor ventilation system design and operation. Unlike conventional curtain-sided houses where air exchange and distribution are mostly uncontrollable, the operator of a tunnel-ventilated house has a high level of control over the environment. If the ventilation system is not properly designed or installed, the producers ability to control the environment will be limited and production will suffer.

HOUSE DESIGN AND OPERATION

Air Exchange Rates

In order to minimize heat buildup in the house it is important that the air within the house is exchanged on a frequent basis. If the air exchange isn't on a rapid basis there will be a significant air temperature difference between the front and rear of the house. This temperature differential is due to the heating of the air as it moves down the house. The largest contributor to this temperature differential is bird heat.

A second problem associated with slow air exchange rates in the creation of large air quality differences between the front and rear of the house. As air moves down the house it not only picks up heat but contaminates as well, ie. ammonia, dust, carbon dioxide, and humidity. The result is not only the rear of the house warmer than the front of the house but more humid, dusty, ammonia filled too.

To avoid these problems the ventilation system should be capable of exchanging the air in the house approximately once a minute. This rate will vary slightly from house to house due to differences in house construction, bird number and size, and level of insulation.

In order to determine how many fans are required for a given house simply divide the volume of the house by the air exchange time (1 minute):

$$\text{Fan Capacity Required (cfm)} = \frac{\text{Length} \times \text{Width} \times \text{Average Height}}{\text{Air Exchange Time (1 minute)}}$$

It is important to realize that it won't be necessary to exchange the air this rapidly most of the time. During mild conditions this air exchange rate can easily be reduced by half or more and no adverse conditions will occur. But, a ventilation system has to be designed for a worse case scenario, the summer months.

A Tunnel ventilation system is only a summertime ventilation system. If used during cold weather production problems can occur. When one 48" fan is running the air will move down the house at a speed of approximately 50 feet per minute (Figure 5). At this rate it would take nearly 10 minutes for the air to move from the front to the rear of the house. During this time the temperature, ammonia, carbon dioxide concentration, and humidity levels will increase dramatically (Figure 6). In addition there will be a slight depletion of oxygen in the fan end of the house. This will lead to cold stress problems in the front of the house and near "suffocation" conditions in the rear of the house.

To avoid this potential disaster tunnel ventilation should only be used if approximately one half of your exhaust fans will be running. If it is too cool to run half of your exhaust fans you should use air sidewall inlets or go to curtain ventilation.

Air Velocity

In a tunnel-ventilated house the proper air exchange rate is not the only factor which needs to be considered when designing the ventilation system. Air velocity is just as important, because it is the air movement which produces much of the cooling.

It is important that the birds are exposed to enough air movement to offset the detrimental effects associated with high air temperatures, but not so much as to have an adverse affect on production. Excessively high air velocities have been noted to have a detrimental effect upon performance. Drury (1966) discovered that there was a limit to the benefits associated with air movement. Increases in weight gain were observed up to an air velocity of nearly 600 ft/min. Once this was exceeded, detrimental effects were noted.

From Drury's work it was shown that 67 percent of the potential benefits associated with increased air movement in poultry were obtained with a velocity of 350 ft/min. Above 350 ft/min the potential benefits associated with increased air movement did not increase as fast as the number of fans required to give that velocity (Figure 7). As a result it would be advisable to use a minimum air velocity of approximately 350 ft/min when designing tunnel-ventilated structures.

Air velocity can be determined by dividing the total fan capacity by the cross sectional area of the house (Figure 8). The cross sectional area can be determined by multiplying the width of the house by the average height of the house:

$$\text{Velocity} = \frac{\text{Total Fan Capacity}}{\text{Width} \times \text{Height}}$$

It is important to note that air velocity will vary slightly within any cross section as a result of friction. Air velocity will be the highest at the center of the cross section and will slow toward the walls, floor and ceiling due to friction.

To ensure sufficient air movement at bird level, the mean air velocity should be at least 10 percent greater than the desired target velocity to take into account the decrease in air velocity near the floor. If the mean air velocity is below this value, it can be increased either by increasing the number of exhaust fans or by installing air deflectors.

Air deflectors

Air deflectors are devices which temporarily reduce the cross sectional area of a poultry house. They are typically made of curtain material and are installed from the ceiling to the top of the sidewalls. The reduction in cross sectional area increases the velocity of the air in the vicinity of the deflector (Figure 9). The increase in velocity typically exists for a distance equal to one opening height in front of the deflector to four opening heights downwind of the deflector. If deflectors are placed on a frequent enough basis, 40 feet or less, the increase in air velocity will become fairly consistent throughout the house.

Air deflectors have been shown to be particularly effective in houses with large cross sectional areas, i.e., houses without a drop ceiling. Opening ceiling houses require nearly the same air exchange rate as do drop ceiling houses to minimize the temperature differential within the house, but since the cross sectional area is approximately 20 percent greater, the resultant air velocity is substantially less. Air deflectors can be attached to the exposed trusses reducing the effective cross sectional area of the house and increasing air velocity at minimal cost.

Air deflectors also can be used in houses less than 400 feet in length to increase air velocity. Ventilation system capacity is generally less in short houses due to the decreased heat load. As a result, the air velocity down the house is typically minimal. Air deflectors can increase air speed over the birds without having to install more exhaust fans.

Caution should be exercised when installing air deflectors. If the velocity beneath the deflector is excessive, production problems may result. In addition, the static pressure drop

across the deflectors may become large enough to affect fan performance. To avoid these problems the air velocity below a deflector should be kept below 600 ft/min.

Fan and Inlet Placement

In poultry houses up to 500 feet in length it is best to pull the air from only one end of the house. This produces the maximum air velocity and minimizes dead air spots (Figure 10). Once house length exceeds 500 feet, the fan capacity required to minimize the front to rear temperature differential may lead to excessively high air velocities. In these instances, it may be best to place the fans in the sidewalls at the center of the house and the inlets on the ends of the house (Figure 11, 12). Since half of the air is being pulled from each end of the house, air velocity will be reduced by 50 percent. The temperature differential between the air at the fans and the inlet will remain essentially the same since the air exchange rate has not been changed.

Exhaust fans should be installed symmetrically in the end of the house. If all the fans are placed on one side of the house, a dead air spot will occur in the corner opposite the fans. This is due to air moving toward the fans immediately prior to be exhausted. Since air temperature in the rear of the house is typically the highest, minimal air movement in this area could increase mortality.

It is advantageous to place some of the exhaust fans in the end wall of a house. When exhaust fans are placed in the sidewalls, a triangular area of minimal air movement near the end wall is created (Figure 13). If all the fans are operating this zone tends to be fairly small. But if a minimal number of fans are running the size of the zone becomes significant.

Installing the proper amount of inlet area is very important to the successful operation of a tunnel ventilation system. Too much or too little inlet can have an adverse effect upon both production and fan performance.

In houses which are using fogging nozzles for cooling it is generally recommended that amount of inlet should be approximately equal to the cross sectional area of the house. For instance, a 40' wide house with an average sidewall height of 10' would have a cross sectional area of 400 square feet.

$$\text{Cross Sectional Area} = \text{Average Sidewall Height} \times \text{House Width}$$

The house would therefore need approximately 400 square feet of inlet to be used when tunnel-ventilating.

If the inlet area is equal to the cross sectional area of the house the velocity of the air entering the house will be approximately equal to the velocity of the air moving down the

house. If the inlet velocity is too low, the birds in the vicinity of the inlets will receive insufficient cooling. Low inlet velocity will also reduce the suspension time of mist generated near the inlets. The decreased suspension time will lead to increased litter moisture and decreased evaporative cooling efficiency.

If the inlet velocity is significantly greater than the velocity of the air moving down the house the birds may tend to move toward the inlets to increase cooling. As more and more birds move into the vicinity of the inlets, the ratio between the birds and feeder-drinker space is increased. This makes it more difficult for the birds to obtain the necessary feed and water leading to a decrease in production efficiency. In addition, crowding has been reported by some integrating companies to result in increased level of condemnations at the processing plant.

When using evaporative cooling pads, installing the proper amount of pad area is very important to the successful operation of a tunnel ventilation system. Too much or too little inlet can have an adverse effect upon both production and fan performance.

The amount of pad required for a tunnel ventilated house is dependent upon both fan capacity and pad thickness. For a four inch pad, one square foot of pad should be allotted for every 250 ft³/min of air moving capacity. For a six inch pad, one square foot of pad is required for every 400 ft³/min of air moving capacity.

Evaporative cooling pads should be placed on both sides of a poultry house. With two opposing air jets entering the house there is better mixing of the incoming air. It has been observed that in some houses where the pads are only on one side of the house the incoming air moved through the pad, across the house, and remained there for nearly half a house length. This resulted in as much as a 50 percent imbalance of air movement between the two sides of the house (Figure 14).

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Cooling Through Air Movement

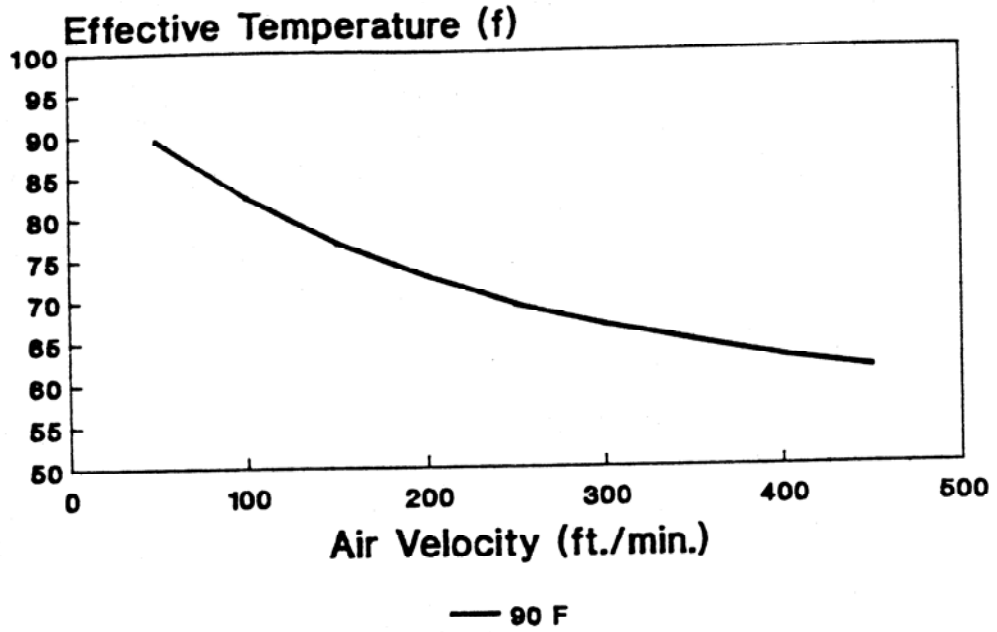


Figure 4. Cooling Through Air Movement

Air Velocity

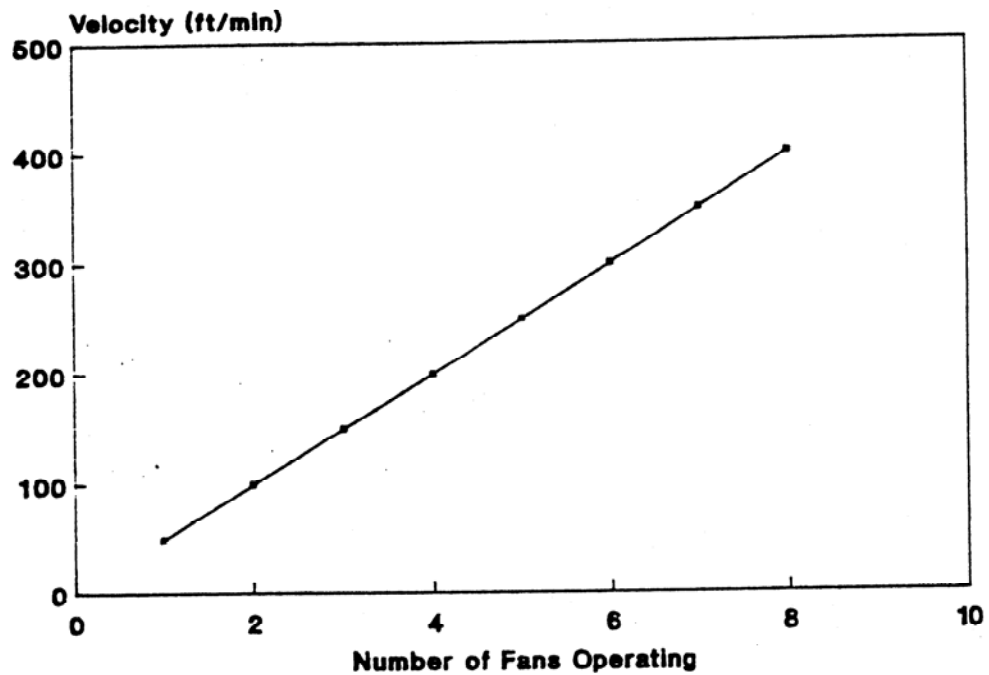


Figure 5. Air Velocity as Determined by Number of Fans Operating

Air Quality

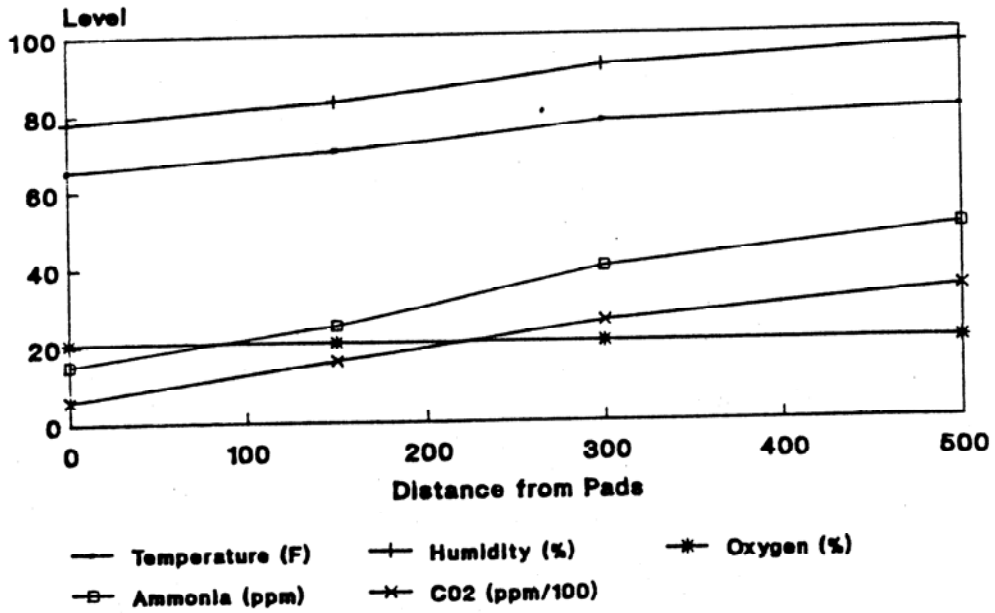


Figure 6. Air Quality in a Tunnel-Ventilated Poultry House (cold weather)

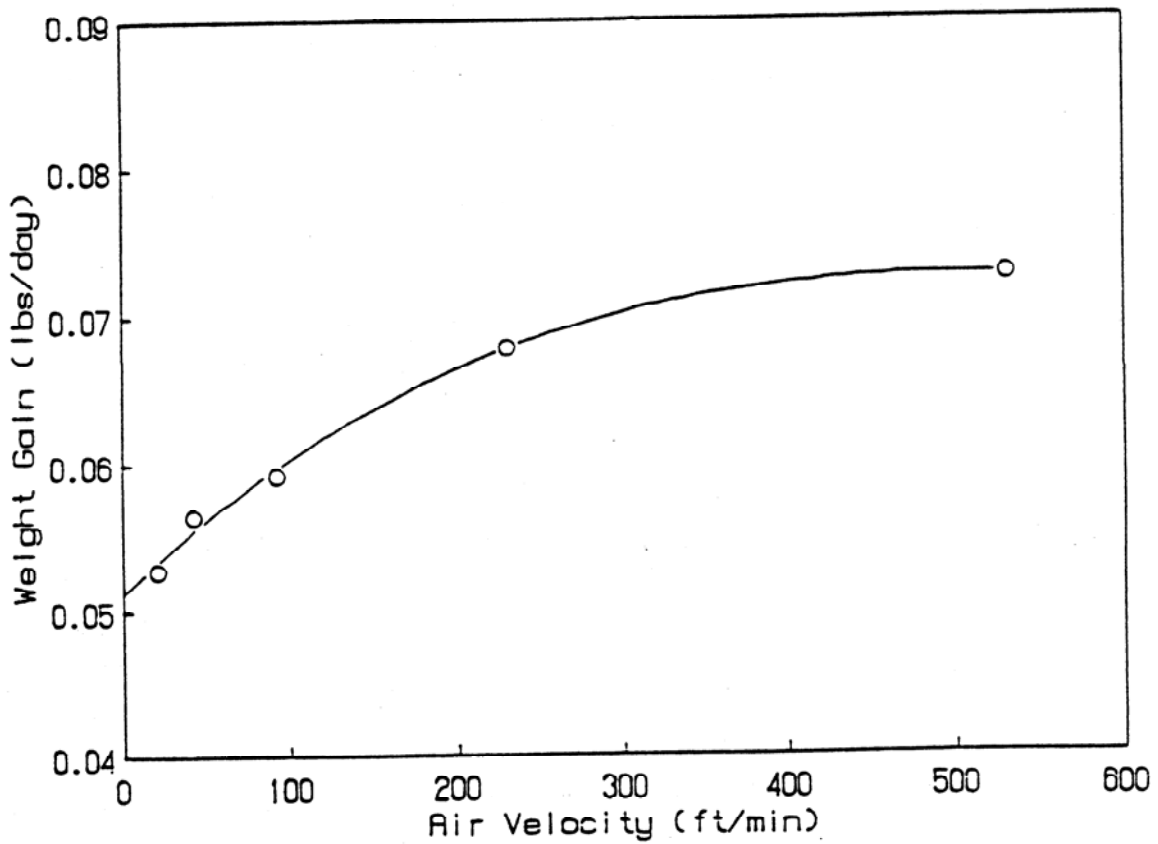


Figure 7. Air Velocity and Weight Gain in Broilers

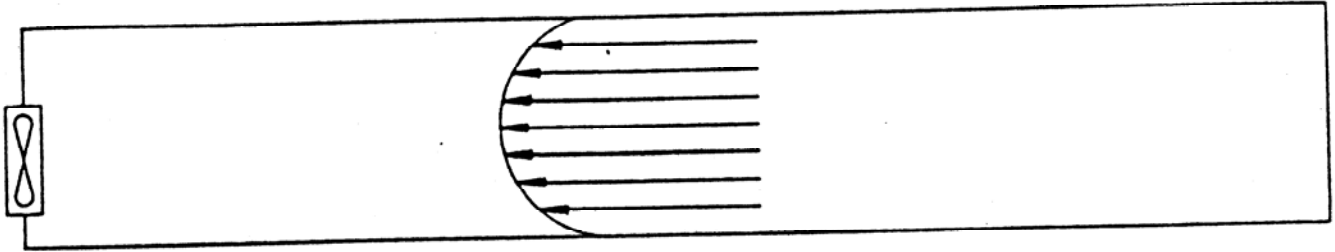


Figure 8. Velocity Profile in a Tunnel-Ventilated House

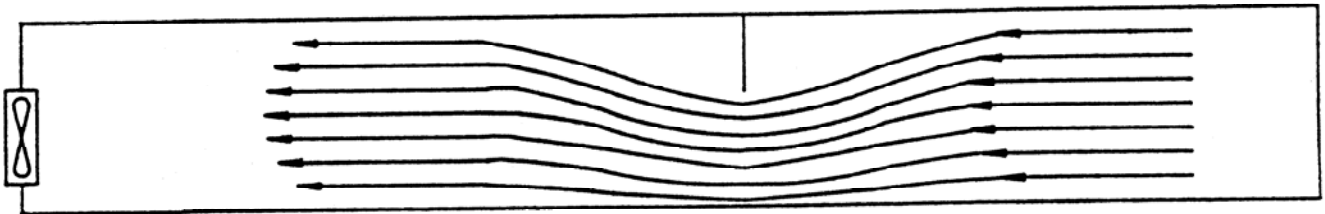


Figure 9. Air Deflector

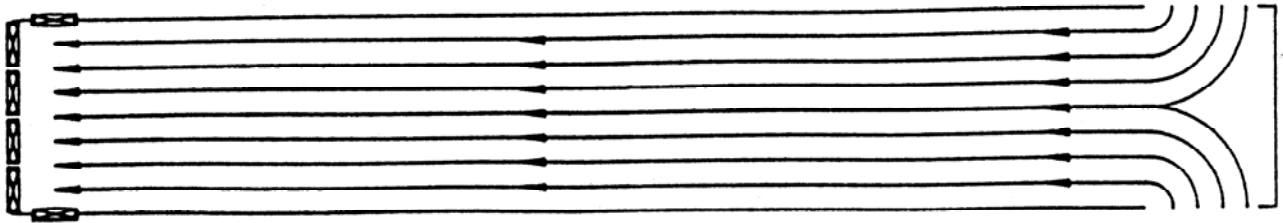


Figure 10. Even Air Flow

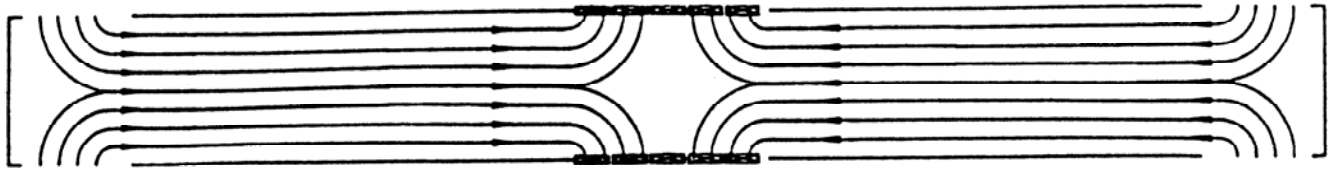


Figure 11. Two Direction Tunnel Flow

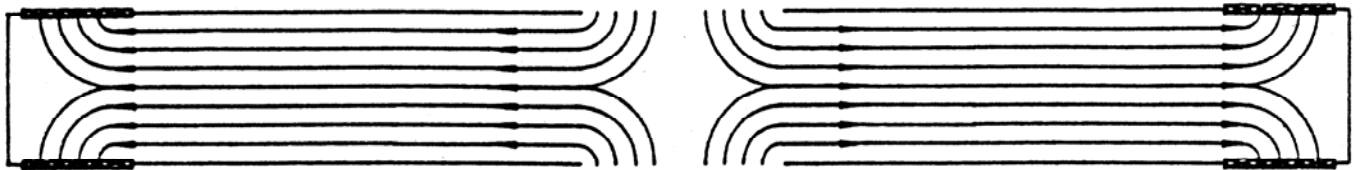


Figure 12. Two Direction Tunnel Flow

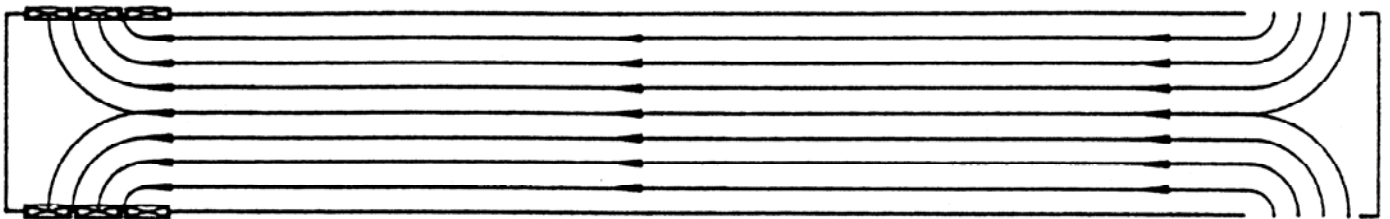


Figure 13. Dead Air Spot Near Exhaust Fans

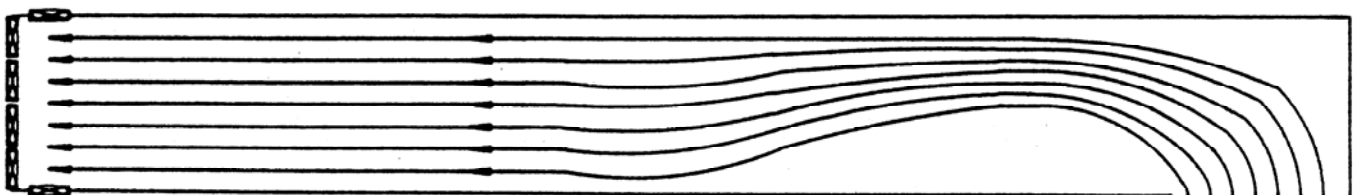


Figure 14. Dead Air Spot Near Evaporative Cooling Pads