

## Ventilation of Brooder Houses

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### Introduction

A 2-week old tom turkey weighing 0.9 lb will produce 336 Btu of total heat and 0.1 lb of moisture (through respiration and in feces) per day (Janni and Jacobson, 2003). This same bird will produce 0.5 ft<sup>3</sup> of carbon dioxide (CO<sub>2</sub>). Additionally, unvented propane heaters in the will add 1.2 ft<sup>3</sup> of CO<sub>2</sub> per 1,000 Btu of heat produced. Carbon monoxide (CO) can also build up inside houses with unvented propane heaters, particularly, those that are poorly maintained and in tight houses. As CO<sub>2</sub> concentration increases inside the house, oxygen concentration will decrease which in turn, can impact bird performance. Another gas of concern is ammonia which is produced when microbes and enzymes break down nitrogen (mainly uric acid) in the feces and feed.

While the impact of excessive temperature on bird performance is well known, high relative humidity (RH) levels (>70%) can also be very harmful. High RH contributes to wet litter and spurs the growth of microorganisms which, in turn, exacerbate the impacts of poult enteritis and mortality syndrome (PEMS) (Edens et al., 1998). High humidity can also increase ammonia formation, which adversely impacts bird performance. Very low humidity levels (<40%) may also impact bird health by creating dust problems in the house. Researchers have emphasized the need to maintain ammonia levels <25 ppm in animal houses; however, even 10 ppm ammonia over 7 weeks of exposure reduced resistance to infection in turkey (Nagaraja, 1983). Hence, in brooder houses, keeping ammonia concentration <10 ppm may be beneficial. Since high CO<sub>2</sub> can stress the respiratory system and can also kill through asphyxiation, Janni and Jacobson (2003), recommended keeping CO<sub>2</sub> <5,000 ppm. Carbon monoxide is a colorless and odorless gas that can kill without warning and hence, Czarick and Fairchild (2007) recommend keeping its concentration below 50 ppm.

Hence, to maintain desirable conditions inside the brooder houses, it is necessary to bring in fresh, balance air from outside through ventilation. During summer, the main purpose of ventilation is to prevent heat buildup by moving large amounts of air over the birds to cool them down; however, this can chill the very young poults. Summer ventilation rate is adequate for maintaining acceptable RH and concentrations of gases. However, during winter and/or brooding (when supplemental heating is required), the main objectives of ventilation are to maintain acceptable oxygen and RH levels. Cold weather or minimum ventilation rates (MVR) will generally be adequate for maintaining acceptable levels of CO<sub>2</sub>, CO, and ammonia in turkey brooder houses where fresh litter is used for every flock. During cold weather or minimum ventilation, small amounts of fresh air are introduced high above the birds so as not to chill them. The objectives of transitional or mild weather ventilation are to moderate temperature and RH inside the house using airflow rates that are in between minimum and summer ventilation rates, as dictated by temperature and size of the birds. As in minimum ventilation, fresh air is released high over the birds in mild weather ventilation.

In a naturally-ventilated brooder house, it may be more difficult to maintain desirable environmental conditions than in a mechanically ventilated structure. However, mixing fans can improve environmental conditions in naturally ventilated houses. There are two types of

mechanically-ventilated brooder houses: sidewall- and tunnel-ventilated houses. Compared to the sidewall design, the newer, tunnel-ventilated houses are more effective in cooling the house with large birds and during hot weather. While both types of mechanical ventilation system provide similar methods of cold (or minimum) and mild weather ventilations, the tunnel houses reduce heat losses and provide a more uniform internal environment because they are built tighter (and in many cases with solid sidewalls). This presentation will focus mainly on mechanically-ventilated brooder houses.

### Ventilation Rates for Turkey Poults

Heat and moisture production rates from the poults and brooder house components are the main determinants of ventilation rates. However, most data in the literature are 30-50 years old (Xin et al., 1998). Changes in genetics, diets, housing, and management, highlight the need to reexamine ventilation rates under current conditions. However, very little work has been done in this area recently, probably because this type of research requires considerable time and resources. Figure 1 compares ventilation rates from three different sources.

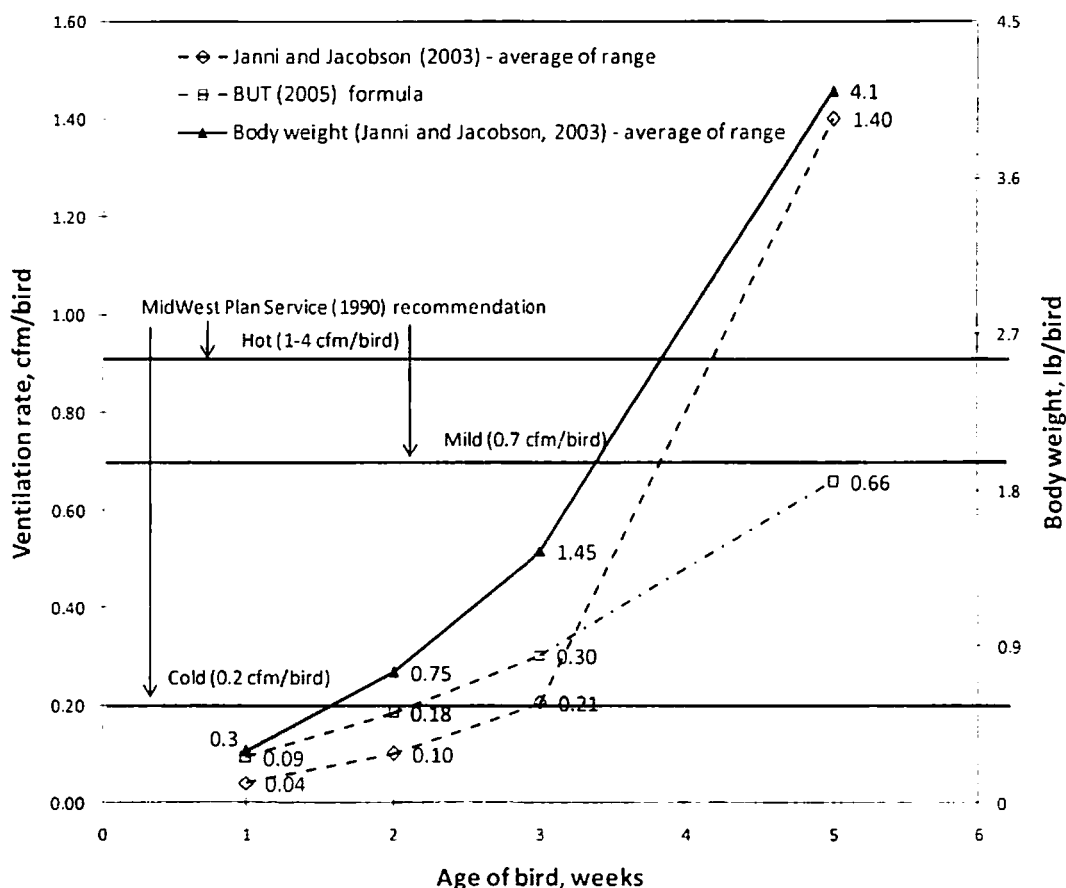


Figure 1. Comparison of recommended ventilation rates for turkey poults from different sources. The ventilation rates reported by Janni and Jacobson (2003) were for set point temperatures of 80 and 75 F for 1- and 2-wk poults (toms), respectively; for other ages, 70 F was used as the set point temperature. Janni and Jacobson (2003) reported single ranges of weight and ventilation rates for poults 4-6 weeks in age; hence, it is expressed as average at 5 weeks. BUT stands for British United Turkeys Ltd.

While MidWest Plan Service (MWPS) (1990) recommended ventilation rates that varied based on weather conditions, it did not vary ventilation rate based on poult age. Janni and Jacobson (2003) suggested ventilation rates (Figure 1) based on discussion with extension and industry people in Minnesota. Poult weights and ventilation rates were reported by Janni and Jacobson (2003) in ranges (except week 1) while they are shown in Figure 1 as average values. The range of ventilation rates reported by Janni and Jacobson (2003) varied by as much as  $\pm 100\%$  from the average values (Figure 1) for the older poult; the ranges were narrower for the younger poult. The BUT formula used for calculating MVR (cfm) was a modification of the equation given in BUT (2005) and is expressed as:

$$MVR = 0.4129 \times BW^{0.75} \quad [1]$$

where BW is the body weight of the poult in kg (1 kg = 2.204 lb). Xin et al. (1998) also calculated MVRs during turkey brooding in Iowa (cool to cold outside conditions) based on heat and moisture production. They reported that during the first week, the MVRs recommended by MWPS (1990) were 165 to 557% higher than their MVRs (Xin et al., 1998). However, between weeks 2 and 5, when MWPS (1990) MVR was based on per pound bird (0.08 cfm/lb), the overestimation ranged from only 20 to 49%. Based on conditions in the UK, Clayton et al. (1985) reported that MVR for 1.1-lb poult was 0.4 cfm whereas, a 4.4-lb bird required 0.7 cfm. They also reported that MVR was 5775 cfm/ton of daily feed intake.

Hence, it is clear from the preceding discussion that there may be multiple MVRs for the same age of poult and it is difficult to say which MVR will be best suited for a producer since the MVR will depend on weather conditions as well as management (e.g., type of ventilation). Figure 1 and the analyses by Xin et al. (1998) indicate that MVR of 0.2 cfm/poult (MWPS, 1990) during the week 1 may be too high; a lower ventilation rate will save energy. For weeks 1-3, the BUT MVR (equation [1] and Fig. 1) being higher, may be more suited to the warm conditions in NC than the MVR reported by Janni and Jacobson (2003) for Minnesota. Finally, for birds older than 3 weeks, the MVR provided by Janni and Jacobson (2003) seems more appropriate since it more closely tracks the weight gain by the birds (Figure 1). It is important to add at least 2.5 cfm of additional ventilation to every 1,000 Btu/hr of heater capacity when the propane heaters are unvented (MWPS, 1990).

It may be noted that MVR controls are based on time, not temperature. However, as it gets warmer inside the house, temperature controls will allow the fans to run longer or turn on larger number of fans than are required for MVR with the air being pulled through the sidewall or ceiling inlets, high above the birds. When the air pulled through the sidewall or ceiling inlets is no longer adequate to maintain target temperatures, more fans will turn on and air will enter the house through the cool cell pads (tunnel houses). In sidewall houses, under summer ventilation conditions, the sidewall curtains are dropped to increase airflow. However, it is important for the grower to walk his/her houses daily to observe the behavior of the poult; if necessary, he/she should modify the ventilation protocol to improve inside conditions.

### **Maximizing the Performance of the Ventilation System**

A proper ventilation system brings in the correct amount of fresh air through the planned inlets, mixes the fresh and exhaust air streams to warm up the fresh air (only for minimum ventilation), and exhausts the right amount of stale air. Hence, the ventilation system not only helps maintain the proper air quality in the house but also more uniform temperature and humidity regimes that benefit the birds. Therefore, the ventilation system includes not just the fans but also the inlets (including, the cool cell pads during summer). Specific steps to help maximize the performance of the ventilation system for brooding are discussed below.

1. Monitor the RH, ammonia, and CO concentration in the houses. Relative humidity should be monitored during the cooler parts of the day, when the capacity of the air to hold moisture is reduced. If the RH is more than 70%, increase ventilation rate slightly; however, higher RH may also be due to leaky drinkers. Consider monitoring RH in the house. Ammonia concentrations should be measured when the house is the warmest; this can be done quite inexpensively using gas detector tubes. If the ammonia concentration exceeds 10 ppm, a temporary solution is to increase the MVR but it is better to use some chemical amendment like PLT (Shah et al., 2006) in consultation with the supplier/manufacturer.

Carbon monoxide concentrations can be monitored with a handheld meter when the brooders are running. Concentrations should be kept below 50 ppm. Soot on the brooders and yellow flame are indicative of higher CO levels (Czarick and Fairchild, 2007) as clean burning flames produce very little CO. Replacing worn out orifices, ensuring proper gas pressure, and keeping air filters clean can help reduce CO in the houses (Czarick and Fairchild, 2007).

2. A poultry house fan can gather up to ¼ lb of dust in a day (Donald, 200x). Dirty shutters require more effort to open and can hence, reduce airflow rate considerably, resulting in degraded air quality in the house. Donald (200x) reported that a 36 in fan at 0.05 in. static pressure with clean shutter had an airflow rate of 8,519 cfm compared with 6,617 cfm with dirty shutter. Hence, it is important to keep shutters, guards, inlets, and cool cell pads clean.
3. Loose and worn belts ride lower in their pulleys and also slip more. So, they can reduce the fan airflow rates by up to 30% by running slower. Running a single 1.5 hp 48 in. fan 30% more to compensate for loose belts will cost an extra \$55 per year (at \$0.055/unit for 3900 vs. 3000 hours/year). Growers are conscientious about tightening their fan belts between flocks but it is time consuming. A self tensioning system (combination of motor weight and spring action) will keep the belt tight and save money and time over the long run. If a retrofit self-tensioning kit is unavailable, an adjustable tensioner (that would have to be adjusted periodically) would still be a reasonable compromise. It is also important to make sure that the pulleys are properly aligned with one-another, otherwise, belt wear will be high and airflow rate will be reduced.
4. Select a replacement fan that gives the desired airflow rate at the static pressure at which the house is operated (0.08 to 0.12 in. under cold and mild weather conditions) and has a high efficiency (cfm/watt). It is commonly assumed that a 36 and 48 in. fans have airflow rates of 10,000 and 20,000 cfm, respectively, at a static pressure of 0.1 in. However, each fan is different and has a unique fan curve, i.e., the plot of airflow rate vs. static pressure and efficiency vs. static pressure. As shown in Figure 2, while fan A has higher airflow rate at 0 in. static pressure, fan B has 500 cfm higher airflow rate at 0.1 in. Furthermore, fan B is more efficient than fan A and will hence, consume less power. The bottom line is that fans with flatter curves are better. It should also be noted that using fans of different makes and models complicates management. For example, all 36 in. fans used for minimum ventilation should, preferably, be of the same make and model.

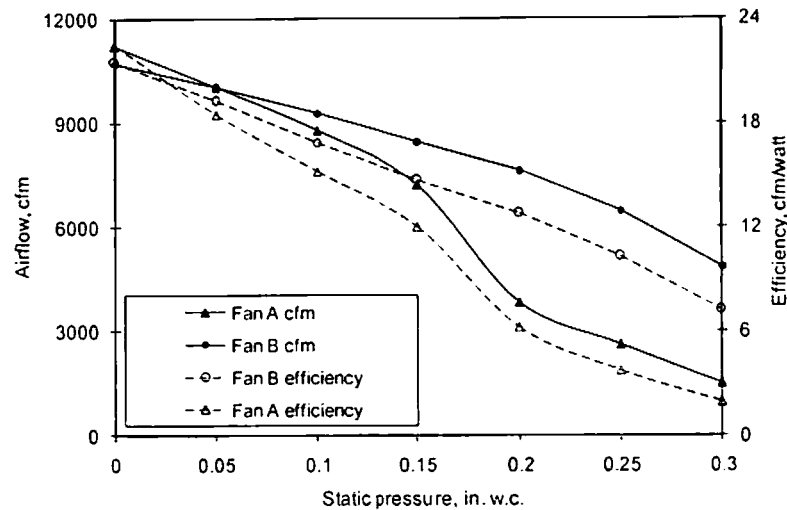


Figure 2. Comparison of the fan curves of fans A and B from the same manufacturer and with the same set of accessories. Both fans are powered by ½ hp motors. (Source: BESS Labs) The accessories on a fan can also affect its performance. Compared with a straight wall fan, a slant wall fan has 2-3% higher efficiency and is easier to clean. However, a cone fan has 7-8% higher cfm and 15-20% higher efficiency than a straight wall fan. Hence, installing cones on fans can save money in the long run.

5. A 36 in. fan requires 7-8 inlets while a 48 in. fan requires 15-16 inlets. Consider unlatching only those inlets that are required for the number of fans in use. As the poultts grow older and more fans are required for ventilation, more inlets can be unlatched. Sidewall inlets should open 1.5 to 2 in. while ceiling inlets should open 1 to 1.5 in.: when inlets open the correct width, fresh air is thrown at 800-1,000 ft/min into the middle of the house where it properly mixes with the warm rising air, transferring some of the heat down to the birds. When inlets do not open enough, static pressure is increased and the fans are choked down while inlets that open wider than desired, cause the cold air to trickle down to the floor causing wet spots on the litter. Also, all inlets should open the same, uniform width. Latch shut all inlets within 8 ft of fans because the fresh air drawn through these inlets will be short circuited.
6. Use a 5-min timer instead of a 10-min timer for the minimum ventilation fans to reduce temperature swings inside the house.
7. In turkey brooding, conventional pancake brooders are still popular. Compared with radiant tubes or radiant brooders, these brooders can increase thermal stratification with floor temperatures being 10 F lower than ceiling temperatures. Paddle fans operating in the updraft mode can help transfer some of that heat from the ceiling to the floor, thereby saving energy.
8. Last but not the least: tightening the house can greatly improve the uniformity of ventilation, thereby, reducing energy use and improving the environment for the birds. However, this is a full topic by itself that will have to be dealt with separately.

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