VENTILATION AND INSULATION FOR FARM BUILDINGS

by
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A visit to the average dairy barn, poultry or hog house during the winter months will convince one that ventilation is needed to make inside conditions satisfactory. Ventilation is merely a process of bringing fresh air into a shelter and removing foul air and moisture. If this process of exchanging fresh air for foul air is carried on during a cold winter day, a great deal of heat is lost from the building, thus reducing the inside temperature of the livestock shelter to an uncomfortable point. Animals are usually the only source of heat in livestock shelters. In order to maintain a uniform temperature in a livestock shelter, the following heat balance must be maintained:

Heat supplied by animals equals heat losses through ceilings, walls, windows, doors, and ventilating system.

To help maintain this heat balance storm doors, storm windows, weather stripping, and insulation in the walls and the ceiling are used. In order to do a good job of ventilating, a livestock shelter must be properly insulated.

Ventilation

Gravity Systems

Chimney-like outlet flues are commonly used in dairy barns and hog houses. They are not generally recommended for poultry houses because of drafts. The successful operation of a flue depends upon the following factors:

1. Difference between inside and outside temperatures. Warm air is lighter than cold air. This causes warm air to move up the flue and be replaced by the cold but heavier air from the fresh air inlets. The greater the temperature difference, the greater will be the amount of air flowing in the flue system. This is not always desirable.

2. The velocity of the wind blowing across the flue. Wind blowing over the top of the flue will create a suction which causes more air to move up the flue. Generally the greater the wind velocity, the greater will be the amount of air flowing in the flue.

3. Height of the flue. High flues having a large distance between the air intake and the top of the flue will move more air than can be moved by short flues of the same cross-sectional area.

4. Insulation of the outlet flue. Air that moves in ventilating flues is heavily laden with moisture. This moisture will condense in uninsulated flues in the form of frost and decrease the capacity of the flue.

5. Suitable fresh air intakes. The fresh air intakes should be well distributed over the barn wall areas at about 10 to 15 ft. intervals. The total cross-sectional area of all fresh air intakes should be slightly

larger than the cross-sectional area of the outlet flue or flues. Windows do not make satisfactory intakes, especially on cold, windy days. Doors and windows should be kept closed in order to make a flue system work satisfactorily.

From conditions 1 and 2 above, it is obvious that flue ventilating systems move more air when the outside weather conditions are cold and windy, and they move less air on a mild calm day. However, when properly designed and installed, flue ventilating systems operate quite well with a minimum of attention.

Dairy barns: The outlet flue area necessary for dairy barns under North Dakota conditions can be calculated from the following formula:

$$A = \frac{178}{\sqrt{H}}$$

A = square inches of flue cross-sectional area per 1,000 pound cow unit.
H = height in feet of top of flue above barn floor.

Table I. was prepared from the above equation.

Table I. Square Inches Flue Area Per 1,000 lb. Cow Unit for Various Flue Heights.

Flue height above barn floor	Sq. in. flue area per 1,000 lb. cow unit
20	39.7
22	37.9
24	36.3
26	34.9
28	33.6
30	32.5
32	31.4
34	30.5
36	29.6

Example: Calculate the outlet flue area required for a dairy barn in North Dakota housing: 25.....1,200 lb. cows
6..... 300 lb. calves
1.....2,000 lb. bull

Height of the flue above the floor is 36 ft.

1. From the above equation or from Table I., each 1,000 lb. unit will require the following area $A = \frac{178}{\sqrt{H}} = \frac{178}{\sqrt{36}} = \frac{178}{6} = 29.6$ sq. in.

2. The number of 1,000 lb. units are calculated as follows:
1 bull..... 2,000 lbs.
6 calves at 300 lbs..... 1,800 lbs.
25 cows at 1,200 lbs.....30,000 lbs.

33,800 lbs. = 33.8 one thousand pound units.

3. Total outlet flue area = 29.6 x 33.8 = 1,000 sq. in.

4. An outlet flue 30 x 33.3 inches inside dimensions will give the necessary capacity.

5. The total cross-sectional area of all fresh air inlets should be slightly more than the area of the out-take flue.

Hog houses: Hogs require about 20 square inches of outlet flue area per 300 lb. hog. Outlets should be three to five pens apart with an intake at every other pen. Provide dampers in outlets and intakes to control air flow. The total cross-sectional area of all intakes should be slightly larger than the area of the out-take flue.

Poultry houses: When gravity systems are used for poultry house ventilation, the following systems are recommended:

A. Straw loft with muslin front. (Best suited to houses with gable roof).

B. Muslin front. (For shed roof buildings and buildings that do not have enough room for a straw loft).

One square foot of muslin to about 15 sq. in. of floor area is satisfactory for each of the above systems. The muslin frame should be adjustable so it can be lowered during mild days and closed during cold weather and at night.

Forced-Air Ventilating Systems

On farms where electricity is available, the forced-air or fan system can be used to advantage. This system provides the same amount of ventilation regardless of the outside wind or temperature conditions. The cost of operating a fan to ventilate a barn housing 25 dairy cows would be about $2 to $3 per month. The cost of operating a fan for a 125-bird poultry house is about 60 cents to $1 per month.

Dairy barns: Two fans are recommended for dairy barns; one should run continuously, and one should be controlled by a thermostat that will shut off the fan when the temperature in the barn goes below 40°F. or some other predetermined temperature. The combined capacity of all fans in the barn should be 125 cu. ft. per minute per 1,000 lbs. of livestock. Fans are usually installed so that they discharge directly outside. Intakes should be provided in the same manner as for the flue system of ventilation.

Hog houses: Use one or two discharge fans, depending on the size of the house. The fan capacity should be 20 cu. ft. per min. per 100 lbs. of hogs. A thermostat should be used on one fan. Set the thermostat to shut off the fan when the temperature goes down to about 35°F. Place thermostat at ceiling. Provide fresh air intakes as for flue system.

Poultry houses: Use one fan thermostatically controlled to shut off at 35°F. Place thermostat at ceiling. Fan capacity should be about 75 cu. ft. per min. per 100 lbs. of poultry. When a poultry house is divided into several units, it is desirable to have a fan in each unit.

If the fan is installed to blow foul air out, it should be placed at the front of the house near the ceiling. Provide fresh air inlets that are well distributed, but do not cause drafts on roosting areas.

If the fan is installed to blow fresh air into the house, it should be placed in the attic in such a way that it will blow air downward through

a hole in the ceiling. Provide a baffle plate near the ceiling to diffuse incoming air. Two foul air outlets must also be provided per 125-bird pen. Louvers at the gable ends are used to admit fresh air into the attic.

Table II. Summary of Air Requirement for Animals When Fan Systems Are Used.

Cattle	125 cu. ft. of air per min. per	1,000 lbs. of live weight
Poultry	75 cu. ft. of air per min. per	100 lbs. of live weight
Swine	20 cu. ft. of air per min. per	100 lbs. of live weight
Sheep	8 cu. ft. of air per min. per	100 lbs. of live weight

Table III. Approximate Fan Capacities (Blade Type)

Size inches	R.P.M.	H.P.	Cu. ft. of air per min. at free delivery
8	1,550	....	350
9	1,740	1/20	600
12	1,740	1/20	1,200
14	1,740	1/8	1,800
18	1,160	1/8	2,500

Insulation

During cold weather heat losses through walls, windows, and doors must be kept at a minimum in order to make it possible to change air and provide ventilation. Some heat is lost in the ventilation process of all livestock shelters. The livestock is usually the only source of heat. If the rate of heat removal is faster than the rate at which the livestock supply the heat, then temperatures become uncomfortably cold.

Insulation in the walls and ceiling will greatly reduce heat flow through the wall and ceiling areas. North Dakota Experiment Station Bulletin 336 gives the insulating value of many constructions. It also shows methods of insulating buildings.

An important factor in the use of insulation that is often overlooked or minimized is the use of vapor barriers to prevent moisture accumulation in the insulation.

Water vapor is always present in the air. This vapor is under pressure. The pressure of the vapor is proportional to the temperature and relative humidity of the air. The vapor pressure is high when the air temperature and the relative humidity is high. When the air temperature and relative humidity is low, the vapor pressure is low. For this reason the vapor pressure on the inside of a livestock shelter or house is higher than it is on the outside during the winter months. This causes water vapor to pass through the wall from the warm side to the cold side. When the dew point is reached, condensation takes place. If the dew-point is reached within the wall, then condensation takes place within the wall and moisture accumulates in the insulation. Wet insulation has a low insulation value.

To prevent passage of water vapor into the wall, a vapor barrier must be used on the warm side of a wall. This vapor barrier is usually in the form of a special paper. These papers are available at most lumber yards. Two or three coats of aluminum paint having a spar varnish vehicle make a fairly good vapor barrier. Two or three coats of a good oil paint will also form a fairly effective vapor seal.

The cold side of the wall should have little resistance to the passage of water vapor because if any vapor does get into the insulation, it will eventually pass through the outside wall and escape into the air. Never use a vapor barrier on the cold side of a wall. Use a permeable building paper such as tarred felt.

Insulation and ventilation are dependent upon each other for proper performance. The insulation eliminates excessive heat losses and keeps the temperature of the inside wall above the dewpoint of the atmosphere in the building, and thus helps to keep the wall dry. The ventilating system also helps prevent accumulation of excessive moisture because moisture is carried out by the air that is removed, and drier air is brought in.

References

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