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VENTILATION FOR ANIMAL FARM STRUCTURES

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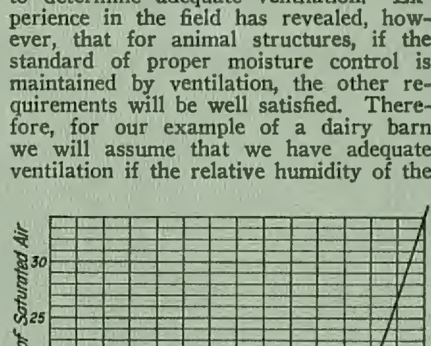
You should not expect to ventilate your farm animal structures properly unless you appreciate the true purpose of ventilation and have a general understanding of the fundamental principles involved. A ventilating system must be designed according to the size of building, the amount of insulation, and the number of livestock being housed in it. It is for this reason that it is difficult for engineers to answer questions except in a general way unless they are familiar with the particular set of conditions involved. Merely having air pass through a building does not constitute a ventilation system.

To best illustrate what is involved in a properly designed ventilation system, a simplified example will be presented along with the general information. Consider a dairy barn 32 feet by 40 feet and 8 feet from floor to ceiling, which houses 20 cows. From the accompanying table it is seen that an average cow in lactation gives off about 3,000 BTUs of heat per hour. Therefore, in winter if no artificial heat were supplied, the total heat supplied to the interior of this barn would be 60,000 BTUs per hour. To design for a typical winter condition, the outside temperature will be assumed to be 0° F. (degrees Fahrenheit) and the inside temperature requirement will be set at 45° F. There is a steady heat loss from a barn by only two distinct methods: namely, (1) the heat leaving the building with the ventilation air and that which filters through cracks, windows, doors, etc. and (2) the heat passing through the walls by conduction. For clarity and convenience the above principle will be stated in equation form:

Heat from cows = heat lost by ventilation air + heat lost by conduction through walls and roof

In the foregoing equation the filtration air is considered as part of the ventilating air, and the statement holds only when no artificial heat is supplied. For our example the total heat given off by the cows or the total heat being supplied to the building equals 60,000 BTUs per hour. Next let us consider how much heat will be lost by the ventilation air.

First of all we must know how much ventilation is required to provide desirable conditions for a dairy cow. The purpose of ventilation includes the simultaneous control of temperature, humidity, movement, and purity of the air. Several standards have been set up in the past to determine adequate ventilation. Experience in the field has revealed, however, that for animal structures, if the standard of proper moisture control is maintained by ventilation, the other requirements will be well satisfied. Therefore, for our example of a dairy barn we will assume that we have adequate ventilation if the relative humidity of the



CURVE SHOWING RELATION BETWEEN TEMPERATURE OF AIR AND ITS MOISTURE CARRYING CAPACITY

inside air is maintained at not more than 85 per cent. Referring to the table, it is seen that each cow in the building gives off approximately 4,375 grains (1 grain equals 1/7,000 of a pound) of moisture per hour. This moisture must be carried out of the building in the form of water vapor in the air or condensation will occur on the walls and other fixtures, a very undesirable thing to occur in any structure. How is this additional moisture from the cows carried out by the air if it enters the building already almost saturated?

A cubic foot of warm air can hold much more moisture than a cubic foot of cold air. From the curve in the accompanying illustration, it is seen that air at 45° F. can hold eight times as much moisture as air at 0° F. In the case of our example of a dairy barn, the temperature of the air is increased from 0° F. to 45° F. due to the heat from the cows, giving the air more moisture carrying capacity. If the temperature of the air were increased to 70° F. for instance, the carrying capacity would be increased 17 times over its capacity at 0° F. Finally, if we determine how many cubic feet of ventilating air are required to remove all the moisture added by the cows, we have determined the amount of ventilation required according to the present day recommended standards. The 20 cows add 87,500 grains of moisture to the air each hour. Each cubic foot of air raised to 45° F. is capable of carrying 2.32 grains of additional moisture. Therefore, it would take 87,500 divided by 2.32 or 37,600 cubic feet of air per hour to maintain proper humidity. Since the volume of air in the barn is 10,240 cubic feet, there should be approximately three and one-half air changes per hour in this barn to prevent moisture condensation. In general three and one-half to four changes of air per hour is a recommended practice as good ventilation for a dairy barn of this size.

How is this amount of ventilation provided? The air should enter the building through small intakes that are well distributed around the barn to prevent excessive drafts and located in the walls just under the ceiling, the air entering at the ceiling level. The recommended cross-sectional area for each intake is 60 square inches, the number of intakes depending upon the amount of air change required. In this problem six intake flues are necessary. In general for a dairy barn, there should be an intake of this size for every three and one-half cows. To remove the ventilation air, requires outtake flues with natural draft or forced draft provided by electric fans. If a natural draft system is used, it should be remembered that the flues must be airtight and well insulated to prevent condensation of moisture in the flue due to a drop of temperature. The number of outtake flues and their cross-sectional area depends upon the height of the flue and the air carrying capacity desired. In the example if the total height between the inlet and the outlet of the flue is 30 feet, 788 square inches of flue area are required which might be obtained by a square flue 28¼ inches on each side. For a forced draft system the capacity of the fan is determined by the manufacturer's specifications.

To determine the heat loss by the ventilation air, one needs only to know how much heat is lost by each cubic foot of air, and multiplying this by the number of cubic feet of air change per hour gives in our fundamental equation "heat lost

Over

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by ventilation air," and in this example it amounts to 30,400 BTUs per hour.

To maintain a temperature of 45° F. in our barn the difference between the heat produced by the cows and that lost by ventilation, or 60,000—30,400=29,600 BTUs, is all that can be lost by conduction through the walls and roof. This means for most structures the provision of some form of insulation or if the insulation is not sufficient there will be a temperature drop resulting in the building becoming too cold for the cows.

It is now apparent that to maintain the moisture carrying capacity of the air, proper temperature must be maintained which can be done either by adding more cows or cutting down heat losses through the walls by conduction. Since the number of cows in a barn is limited to the floor space, in many cases insulation is the only answer to ventilation problems, a most important fact to be appreciated.

It is hoped that this sketchy example has illustrated the fundamental principles involved in the ventilation of any farm structure. However, more practical information as to the design and/or construction of ventilation intakes and outtakes may be secured through your county agent or from the Agricultural Engineering Division, University Farm.

Data for the Design of Ventilation Systems

	*Recommended environmental temperature ° F.	*Heat production BTU per hour per animal	*Moisture production grains per hour per animal
Light horse	40-50	1,342	2,975
Heavy horse	49-50	2,840	4,060
1,000 lb. milk cow	40-55	3,000	4,375
100 lb. hog	50-60	520	870
200 lb. hog	50-60	800	1,380
300 lb. hog	50-60	1,000	1,700
Laying hen	40-50	40	....

* The figures in the above table are indicative of general conditions only and do not hold true for all conditions animals are subjected to.