

5. In order that temperature difference may produce a motive force, there must be vertical distance between openings. That is, if there are a number of openings available in a building, but all are at the same level, there will be no motive head produced by temperature difference, no matter how great that difference might be.

6. In the design of window ventilated buildings, where the direction of the wind is quite constant and dependable, the orientation of the building together with amount and grouping of ventilation opening can be readily arranged to take full advantage of the force of the wind. On the other hand, where the direction of the wind is quite variable, it may be stated as a general principle that windows should be arranged in sidewalls and monitors so that there will be approximately equal area on all sides. Thus, no matter what the wind's direction, there will always be some openings directly exposed to the pressure force of the wind, and others opposed to a suction force, and effective movement through the building will be assured.

It is entirely possible to calculate, with a fair degree of accuracy, the air changes in a factory building for various conditions of wind and temperature difference, and to plan a schedule of control of ventilator openings that will give adequate ventilation under all conditions. The natural forces of wind and temperature difference are active at all times, and must be reckoned with even in a mechanically ventilated building, unless the construction is air tight, which may be considered an impossibility.

Control of natural ventilation depends upon hand regulation, which may be applied in two ways, *first*, by the selection of appropriate localities about the building at which to make openings, with regard to direction of the wind, and *second*, by regulation of the amount of opening, which is accomplished by window operative devices, dampers, or louvers. Control may be effected by the regulation of either inlet or outlet openings, or both and for satisfactory results needs careful study and close attention.

Dairy Barn Ventilation¹

The following are the salient requirements of dairy barn ventilation:

1. For good ventilation, there should be provided about 3,500 cu ft of fresh air per hour per 1,000 lb of live stock weight.
2. A strong convective circulation is generated by the heat from the bodies of the stock, causing an upward movement toward the ceiling, about them, and a consequent downward movement at the walls.
3. Intake openings should be located in the walls near the ceiling so that incoming cold air, falling toward the floor, will accentuate the convective action induced by the heat within.
4. Outlet openings seem to function merely as exhaust ports, to relieve the interior pressure, and appear to have little influence on the direction of air currents. Hence, the spacing or distribution of outlet openings is rather immaterial, so long as the required aggregate area is provided. Area of outlet openings should be about one-third greater than intake.
5. It is better to take the air out at the floor than at the ceiling, since by the former there appears to be a larger volume of warm air held in the stable, which contributes to better temperature control.
6. The active circulation resulting from the down-flowing cold air entering at openings in the walls near the ceiling, cooperating with the convective action induced by the heat of the animals, effectually prevents condensation and keeps the air fresh and odorless.

Although the foregoing statements were derived from a study of dairy stables, it will be found that some of them are general in their application.

¹For additional information on this subject, refer to paper, entitled, *Dairy Stable Ventilation*, by F. L. Fairbanks (A.S.H.V.E. TRANSACTIONS, Vol. 34, 1928).

Chapter 27

PRINCIPLES OF AIR CONDITIONING

Air and Water Vapor; Vapor Pressure and Dalton's Law; Humidity; Wet, Dry-Bulb and Dew-Point Temperatures; Relation of Dew-Point to Relative Humidity; Temperature of Evaporation; Temperature of Adiabatic Saturation; Psychrometric Chart; Calculation of Vapor Pressure; Total Heat; Rate of Evaporation.

AIR conditioning in its broadest sense is the practice of simultaneously controlling two or more of the physical or chemical properties of air. In the development of air conditioning, however, the term has been more generally associated with the control of temperature and humidity, which are the two most important physical properties of air bearing on the comfort and health of man and on industrial processes.

Air conditioning may be used to maintain conditions most suitable for the comfort and health of man (see Chapter 28) or to control some of the physical properties of materials in the process of manufacture (see Chapter 29). The usual requirement in air conditioning as applied to processing hygroscopic materials is to maintain a definite moisture content of the product. In some cases, however, it is desired to control merely a definite moisture content of the air. In problems involving human comfort, it is necessary to maintain certain limiting or desirable effective temperatures¹ which depend upon the experimentally-determined relationships of wet- and dry-bulb temperatures and air motion.

AIR AND WATER VAPOR

Air is a mixture of a number of gases and water vapor. The percentage of the gases contained in air remains relatively constant, and is usually given no consideration by the air-conditioning engineer. The percentage of moisture mixed with air varies over wide limits, and this percentage affects the health and feeling of warmth of man, and the behavior of many materials in the process of manufacture.

Air is said to be *saturated* at a certain temperature when it has mixed with it the maximum possible amount of water vapor at that temperature. The amount of vapor a given space will hold is independent of the presence of air. It is dependent entirely on, and increases with, the temperature.

VAPOR PRESSURE AND DALTON'S LAW

The vapor pressure of water also depends upon its temperature. According to *Dalton's Law of Gaseous Mixtures*, each gas or vapor in a

¹For definition of effective temperature, refer to Chapter 1.