Design of Dilution Systems

The first step in the design of a system employing the dilution method is to determine as exactly as possible the nature and extent of the contaminating load. This will often be difficult, and may require construction of pilot production models. Often, however, the required data will be available from production records, showing the weight or volume rate of loss of the contaminating agent to the atmosphere, or it may be estimated from parallel operations in other plants, or by applying experienced engineering judgment. However obtained, the determination of the nature and magnitude of the contaminating load is an indispensable step in the proper design of the corrective system. Designs based on number of air changes per hour, or other rule-of-thumb methods, are hopelessly inadequate, and lead either to unsuccessful operation or to excessive and unnecessarily high cost of installation.

1. *Gases and Vapors*. Once having established the nature and magnitude of the contamination load, it is rarely necessary to completely remove contaminating agents from the atmosphere. For cases involving diffusible vapor or gas contaminants, maximum allowable concentrations (MAC), of commonly encountered gases and vapors have been established, and these data are tabulated in Chapter 8. From these data, and the previously established rate of addition of the contaminant to the space, the volume of air required to dilute the addition to a tolerable level can be calculated by the equation:

$$Q = \frac{V \times 10^6}{(\text{MAC}) - (\text{SAC})} \qquad (1)$$

where

Q = quantity of air circulated, cubic feet per minute.
V = rate of generation of contaminant, cubic feet per minute.
MAC = maximum allowable concentration, ppm by volume.
SAC = concentration in supply air, ppm by volume.

The rate of generation of the contaminating vapor will often be available as a *weight* or *volume* of liquid evaporated into the space per unit time. These may be converted to the units of Equation 1 by applying the principle that a pound-mol of a gas or vapor will occupy approximately 359 cu ft at standard pressure and temperature. Thus,

$$\text{cfm (vapor)} = \frac{W}{M_w} \times 359 \times \frac{t + 460}{492} \qquad (2)$$

where

W = rate of generation of contaminant, pounds of liquid solvent per minute.
M_w = molecular weight.
t = air temperature, Fahrenheit.

A special case occurs where local concentrations of solvent vapors *at the breathing zone*, resulting from concentrated sources of contamination, are intolerably higher than the average design concentration when using dilution methods. Data are available for calculations, but involve many assumptions regarding boundary conditions, such as convection area and random air movement in the vicinity.

2. *Dusts and Fumes*. Maximum allowable concentration of various dusts, fumes and mists are also tabulated in Chapter 8. However, the dilution method as a means of treating particulate contaminating agents should be used with care, since the allowable air movement in spaces will ordinarily be lower than the capture velocity required for such particles. Exhausting at the source (see Chapter 46) will generally be the recommended treatment for these particulate contaminants.

3. *Sensible Heat*. Excessive sensible heat contamination is subject to treatment, similar to that for vapors, by the dilution method, the difference being that the rate of generation of the contaminant must be expressed in units of energy rather than volume or weight, and that the effect will be expressed as excessive temperature. In this case, the circulated air required will be:

$$Q = \frac{H}{(t_1 - t_o) \times d \times c} \qquad (3)$$

where

Q = quantity of air circulated, cubic feet per minute.
H = rate of generation of heat, Btu per minute.
t_1 = allowable temperature in the space, Fahrenheit.
t_o = temperature of supply air, Fahrenheit.
d = density of air in pounds per cubic foot.
c = specific heat of air.

In some cases, such as ventilation systems not employing refrigeration, unusually large and uneconomical air quantities may be required when the desired or tolerable temperature t_1 approaches too closely the temperature t_o of the dilution air. This condition may sometimes be corrected by a combination of treatment by dilution and central exhaust, large sources of heat load being eliminated by exhaust through hoods at the source.

Heat Storage in Structure

A special condition is sometimes encountered in large masonry structures when, due to the heat storage capacity and time lag of the structure, a prolonged period of hot weather may cause storage of such large quantities of heat in the structure that they continue to be a source of heat load after the outside weather has moderated.

In general, the solution to ventilation problems by the simple *dilution method* is limited to cases where a practical and economical equilibrium may be established between the maximum rate of generation of the contaminant distribution and cost of the air required for its removal.

LOCAL RELIEF IN HOT AND HOT HUMID INDUSTRIAL ENVIRONMENTS

In many areas in industrial buildings, it is not economically feasible to provide acceptable working conditions by the conventional means of ventilation and air conditioning. In such cases, local control of the environment (spot cooling) may be provided by means of shielding, air cooled booths, and spot cooling by means of air motion to provide a relatively cool area for the worker. These methods of local control may be used in conjunction with the natural or mechanical ventilation systems of the building to obtain the desired conditions for the worker, process or equipment.

Spot cooling may be defined for the purposes of industrial environment control as heat relief of a local area within a larger space, independently of the general surroundings; a so-called oasis to provide conditions of relative comfort.

Environmental Considerations

In the preliminary design for hot environments the following should be considered:

1. Estimate the conditions of dry-bulb temperature, humidity, air motion, radiant