CONTROL OF ENVIRONMENTAL GASES AND VAPORS, DUSTS, AND FUMES

In general, the systems for the control of these atmospheric contaminants in industrial plants will be of three types:

1. *Local exhaust systems* will be indicated where the contamination originates at concentrated areas and is characterized by low or imperceptible air motion, or where the contaminant is a dust, mist, or fume requiring a capture velocity exceeding 25 fpm. Design of this type system is discussed in Chapter 21, and will not be further treated in this chapter.

2. A system employing the *dilution* method will usually be indicated where the contamination originates at scattered points dispersed generally throughout the area. Except for low rates of liberation of fumes, dilution ventilation requires such high, wasteful volumes of air, with no positive assurance that safety will be provided, that such systems should be used only as a last resort.

3. Combination of local *exhaust* and *dilution* methods is often economical, since well designed exhaust hoods or openings, removing from the space that portion of the contamination load which is susceptible to such treatment, will often reduce greatly the air volumes required for dilution purposes. The choice of the type of system should be made on the basis of economic comparisons.

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 10 of the 1961 Guide And Data Book. 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:

$$Q_a = \frac{Q_c \times 10^6}{(MAC) - (SAC)} \qquad (9)$$

where

Q_a = quantity of air circulated, cubic feet per minute.
Q_c = 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 9 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,

$$\text{cfm (vapor)} = \frac{W}{M_w} \times 359 \times \frac{t + 460}{492} \qquad (10)$$

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 10 of the 1961 Guide And Data Book. 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 21) will generally be the recommended treatment for these particulate contaminants.

REFERENCES

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CHAPTER 21

INDUSTRIAL EXHAUST SYSTEMS

Elements of Exhaust Systems, Hoods or Enclosures, Capture Velocities, Air Volume, Exterior Hoods, Special Exhaust Requirements, Exhaust of Hot Processes, Induced Air Flow, Duct System Design, Calculations, Construction Specifications, Materials, Details, Air Flow Producing Equipment, Air Cleaning Equipment, Make-up Air, Maintenance of Performance, Materials for Corrosion Resistance

IN industrial plants, some type of exhaust system designed to collect and remove dusts, fumes, mists, vapors, and gases is installed to protect health and safety of industrial personnel, promote worker efficiency, salvage usable material, or improve plant housekeeping. This chapter will not include consideration of systems similar in design, but used to convey heavy loadings (100 or more grains per cu ft) of materials. Definitions of various air contaminants, their particle sizes, maximum allowable concentrations, and upper and lower explosion limits are included in Chapter 10, Air Contaminants, in the 1961 Guide And Data Book.

Exhaust systems are extensively used for control of contaminants from:

1. Mechanical cutting and abrading operations including abrasive blasting and rock cutting.
2. Fuel-burning and exhaust gas producing operations.
3. Molten materials handling operations.
4. Welding, burning, and soldering operations.
5. Fiber handling operations.
6. Volatile and gaseous material handling operations.
7. Chemical processes.

Local exhaust systems should be considered whenever possible rather than general ventilation methods which allow contaminants to be dispersed within the workroom. The former provide more positive control, as well as a great reduction in exhaust volume handled, thereby reducing the cost of air cleaning equipment required.

ELEMENTS OF EXHAUST SYSTEMS

An exhaust system consists of (1) hoods or enclosures at sources of air contamination, (2) branch and main ducts through which an air stream transports the contaminant to air cleaning devices or to the atmosphere, (3) air moving equipment to produce the required air flow into hoods or enclosures, and (4) air cleaning equipment when required. See Part II of Chapter 48 in the 1961 Guide And Data Book for discussion of types, applications, and principles of operation.

HOODS OR ENCLOSURES [1-19]

The most effective hood or enclosure is one that will require the minimum exhaust volume for effective contaminant control. The design must therefore be based upon a knowledge of the process or operation for which control must be obtained. The more complete the enclosure, the more economical and effective will be the installation.

Many designers give first consideration to a hood completely enclosing the operation and then provide necessary access and working openings. The familiar hoods, such as booths, sidedraft or downdraft hoods (with or without side shields) have been developed from this complete enclosure concept. Openings in hoods are kept to a minimum size and are placed away from the natural path of the contaminant travel when possible. Doors should be provided for inspection and maintenance when needed.

Capture Velocities and Air Volume Exhausted

Only after the hood design has been determined can the exhaust volume requirements be calculated. With enclosures, volumes are calculated from the known open area of the hood and the selected capture or indraft velocity sufficient to prevent outward escape.

Usual capture velocities for typical operations are listed in Table 1 and refer in the case of remote hoods to the air movement required at the zone of air contaminant generation. Required capture velocities for any operation will vary with the magnitude of the air volume handled, with uncontrolled air movement in the area, and often with the location of the process or operation and size of the workroom. Large remote hoods exhausting large air volumes will provide effective control at lower maintained capture velocities than will small remote hoods handling lower exhaust volumes. A hood at one end of a small narrow room with air supply at the opposite end will provide control with a lower capture velocity than that required from the same hood in a large room where no

Table 1.... Minimum Air Velocities Required at Point of Origin to Capture Contaminant Effectively

Condition of Generation of Contaminant	Minimum Capture Velocity, Fpm	Process
Released without noticeable movement	50–100	Evaporation of vapors, exhaust from pickling, washing, degreasing, plating, welding, etc.
Released with low velocity	100–200	Paint spraying in booth; inspection, sorting, weighing, packaging, low speed (less than 200 fpm) conveyor transfer points, blending, mixing, barrel filling.
Active generation	200–500	Foundry shakeout, high speed (over 200 fpm) conveyor transfer points, crushers, screens.
Released with great force	500–2000	Grinding, tumbling mills, abrasive cleaning.