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Establishing an Effective Respiratory Protection Program

REDUCTION AND CONTROL OF RESPIRATORY HAZARDS

A primary objective of respiratory protection is to reduce or eliminate hazards at their source by means of sound engineering control methods.

THE CONTROL of air contaminants in the industrial environment is both a moral and a legal obligation—particularly in view of our present emphasis on health, safety, and

ecology. The *Occupational Safety and Health Act* of 1970 is specific relative to the control of the in-plant environment. The following is quoted from the May 29, 1971 issue of the *Federal Register*, which details the present standards applicable to the act:

Subpart G—Occupational Health and Environmental Control

1910.93 Air contaminants. (Gases, vapors, fumes, dust, and mists.)

a) Exposures by inhalation, ingestion, skin absorption, or contact to any material or substance 1) at a concentration above those specified in the *Threshold Limit Values of Airborne Contaminants for 1970* of the American Conference of Governmental Industrial Hygienists, listed in Table G-1, except for the American

National Standards listed in Table G-2 of this section and except for values of mineral dusts listed in Table G-3 of this section, and 2) concentrations above those specified in Table G-1, G-2, and G-3 of this section, shall be avoided, or protective equipment shall be provided and used.

b) To achieve compliance with paragraph (a) of this section, feasible administrative or engineering controls must first be determined and implemented in all cases. In cases where protective equipment, or protective equipment in addition to other measures, is used as the method of protecting the employee, such protection must be approved for each specific application by a competent industrial hygienist or other technically qualified source.

Establishing an Effective Respiratory Protection Program

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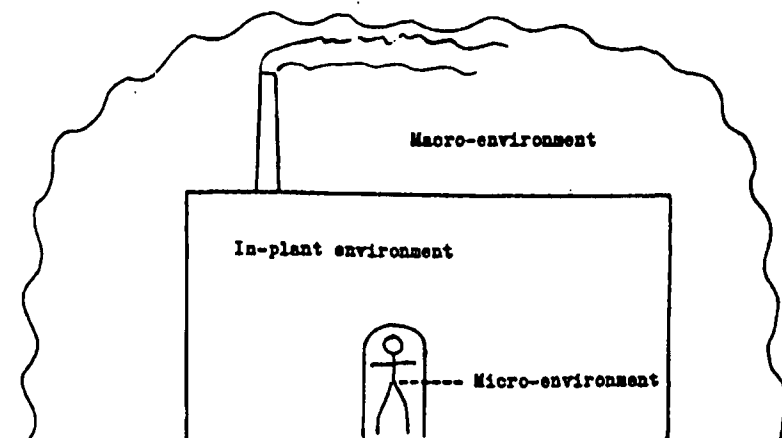
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The *Clean Air Act* of 1967, and its amendments, likewise details the standards for ambient air quality governing the "macro-environment" or outer plant. In this regard, it is particularly important to be aware of the state and local air pollution control laws that prevail.

The control of the in-plant environment is specifically directed at providing respirable air and a clean "micro-environment" for the worker (see accompanying illustration). (Control on the macro-environment entails not only health but other considerations—both ecological and aesthetic.)

Control of both the macro- and micro-environments are equally important, however. But the controls exercised for each are not totally compatible with each other. For example, one can provide effective individual environmental control, and thereby a clean micro-environment for the worker, at the expense of contaminating the outside air to excessive levels. Merely sweeping the ashes under the rug, so to speak, or sweeping contaminants up the chimney is not the total answer. However, air pollution control is a total subject in itself.

The scope of this article is limited to the control of respiratory hazards in the "in-plant environment." Even so, the subject is extremely broad, and only basic principles and guidelines are presented here.

The primary objective is to reduce or eliminate respiratory hazards at their source by means of sound engineering control methods. The process development, equipment selection, and plant design stages

are the "opportunity stages" where the possibility of airborne effluents should first be considered, and means of reduction and control should be instituted. The industrial hygienist and safety engineer should participate as members of the process development and plant design team, along with other specialists in ventilation and process control. Ideally, process consideration should include the selection of raw materials of the lowest toxicity and of equipment with built-in contamination controls whenever possible. Moreover, during the plant design and layout stage, consideration should be given to isolation and encapsulation of the critical process units most likely to contribute to air contamination. Likewise, prevailing topography and meteorological conditions might suggest safer locations for the critical process units to reduce exposure to other

plant areas and personnel in emergency situations.

Because the "opportunity stages" generally knock but once, we are confronted mostly with the control of existing operating processes and equipment. In any case, assessment of the hazard relative to type, concentration under various conditions, and other pertinent characteristics—such as particle size, flammability, etc., is requisite to the selection of the proper control methods.

In addition to substitution with less toxic materials, isolation, and encapsulation, the basic control methods include *local exhaust ventilation* and *collection of contaminants at the source*. *Dilution ventilation* is not as effective due to the large volumes of air generally required and the high cost of its conditioning. Also, dilution ventilation may disperse the contaminants to other working areas. Suggested methods of control according to the type of hazard are listed in Table 1.

Common Control Devices

Oxygen deficiency control

Oxygen deficiency can occur in confined spaces due to displacement of air by other gases and vapors and due to consumption of oxygen through metabolic or oxidation processes.

Immediate ventilation with fresh air is the most expeditious solution. Fan blowers and venturi-type air movers can be used effectively for this purpose.

TABLE 1

Hazard Control Methods	
Hazard	Types of Control
Oxygen Deficiency	Ventilation Oxygen Supply
Gaseous Contaminants	Ventilation Scrubbers Sorbent Bed Combustion
Particulate Matter	Ventilation Inertial Separators Centrifugal Separators Electrostatic Separators Scrubbers Fibrous Filters

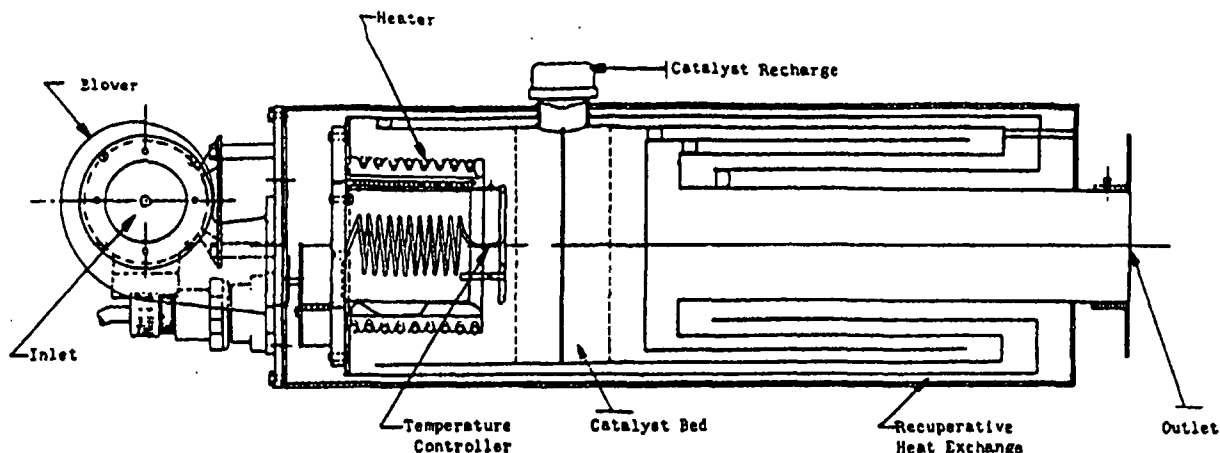


Figure 2 is a schematic of a catalytic burner, typical of those used in the control of gaseous respiratory contaminants.

age price of 65 cents a pound for a reasonably good, effective charcoal. A charcoal cartridge ranges in price from \$125 to \$450 with an average cost of \$250 for a good performance cell. Shortcomings of activated charcoal are:

- 1) The sorbent bed must be protected from particulate matter—an efficiency greater than 50 per cent NBS particulate filter is necessary;
- 2) The activated charcoal must be replaced or regenerated;
- 3) In most applications the gas temperature through the cell should be less than 110 F.

Combustion—Most vapors and gases that can be removed by homogeneous and heterogeneous combustion are hydrocarbons or organic compounds. Homogeneous or thermal combustion is a very high temperature operation (greater than 1,000 F), and it is mostly employed in air pollution control systems. Heterogeneous combustion or catalytic combustion is usually used when no other system is available. For example, hydrogen, carbon monoxide, and some hydrocarbons are not effectively removed by means of a granular sorbent. A typical flow diagram for a catalytic system is illustrated in Figure 2. Figure 3 depicts typical hydrocarbon performance at various temperatures.

The system cost depends upon the application. It is not unusual to figure a minimum cost of \$10 per cfm.

Particulate contaminant control

Basically, there are three mechanisms available for removing particulate matter from a gas system: disposable fibrous filters; electrostatic precipitators; mechanical separators.

Disposable fibrous filters are probably the most widely acceptable method used today for removing particulate matter from the air that is used in a working environment. Table 2 lists the most common type of filters. The viscous impingement-type filter (common furnace) traps particulates much the same way molasses traps flies. A tacky material is sprayed on the glass or metal filter medium, and it captures the particles by inertial impaction with subsequent adhesion. These fil-

ters are normally used as prefilters, because they have poor dust holding capacities, and their efficiency on particles less than two microns in size is very low (less than 10 per cent).

The dry fibrous-type filter uses an extended surface for the filter area, and, in general, it operates on a straining principle. The filter medium is usually in a pleated form, which permits the effective filter surface to be much higher than the projected face area of the filter cartridge. The extended area offers lower filtering velocity and generally a high dust holding capacity. It is not unusual to hold greater than 3,200 gms of NBS dust on a dry fibrous filter that has a particle efficiency of greater than 97 per cent on particles greater than one micron in size.

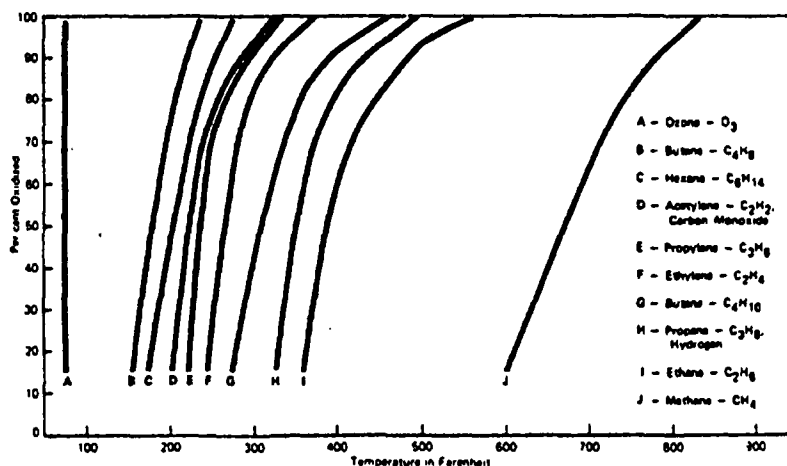


Figure 3 shows an example of typical catalytic performance curves.

TABLE 2

Classes of Particulate Filters						
Classes of Filters	Initial ΔP @ Rated Capacity (In Inches)	Typical Size (In Inches)	Typical Rated Flow (In CFM)	NBS Atmospheric Stain Efficiency (In Per Cent)	AFI Artificial Weight (In Per Cent)	Approximate Element Cost
Viscose (oiled) Fibrous, Impingement (Common Furnace Filter)	.08-.12 WG	24 x 24 x 2	2500	5-12	65-75	.25-2.00
Viscose (oiled) Metallic, Impingement	.08-.12 WG	24 x 24 x 2	2500	5-12	65-75	\$8-\$12
**Dry, Fibrous Low-Medium Efficiency	.20-.4 WG	24 x 24 x 29 24 x 24 x 11 1/2	2000	50-55	100*	\$25-\$35
**Dry, Fibrous Medium Efficiency	.20-.50 WG	24 x 24 x 29 24 x 24 x 11 1/2	2000	80-85	100*	\$25-\$40
**Dry, Fibrous High Efficiency	.35-.60 WG	24 x 24 x 29 24 x 24 x 11 1/2	2000	90-95	100*	\$25-\$45
Dry, Fibrous Hospital Type	.30-.50 WG	24 x 24 x 11 1/2	1000	100*	100*	\$50-\$90
Dry, Fibrous, High Inter- ception High Efficiency Particulate Air Filter	.70-1.2 WG	24 x 24 x 11 1/2	1000	100*	100*	\$60-\$100

*Essentially 100 per cent—Evaluation method not sufficiently critical to detect penetration.
 **NOTE: To identify these classes better, the efficiencies reported are comparable to those for commercial electrostatic precipitators on the atmospheric air NBS dust spot test.

It should be noted that manufacturers report filter efficiencies various ways. Hence, a full understanding of type of filter and the filter efficiency is necessary to obtain a satisfactory system.

Shortcomings of a fibrous particulate filter are:

- 1) It adds resistance to the existing ventilation system;
- 2) It must be replaced about once a year;
- 3) It requires relatively large space.

Electrostatic precipitators use a high intensity electrical field to charge particles, which are collected on an opposite charged surface. The units vary in size from less than 100 cfm to thousands of cfm. A good average cost of a 500 cfm unit would be approximately \$500. The collecting efficiency would be equal to the previously mentioned dry fibrous medium-type filters. The units offer excellent efficiency at low pressure drops. However, in gen-

eral, the initial cost is high, frequent maintenance is required, and it is not uncommon to generate ozone and oxides of nitrogen.

Mechanical separators range from simple settling chambers, which employ gravitational forces, to sophisticated devices such as centrifugal separators. Usually dry-type mechanical devices have poor removal efficiencies on particles less than 10 microns in size. Excellent efficiencies are obtained by combining mechanical separators with a wet method, such as a venturi-type scrubber. Due to the numerous combinations of mechanical separators, their cost varies depending upon the application. Usually, they require less maintenance than other type separators. The most likely use for a dry-type separator is pre-filtration for high efficiency filters.

In situations where it is not feasible to create and maintain engineering controls, proper respiratory protective devices must be provided and used. Because there are many types of such devices, it is impor-

tant that they be selected with utmost care to ensure that proper protection is afforded.—End.

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