Table 3 . . . .Characteristics of Fabric Filters

Kind	Efficiency: Particle size range in microns			Resistance	Filtering Velocity fpm	Maintenance
	>10	10 to 1	<1			
Cloth collector (shaken or rapped)[a]	High	High	Moderate to high	Medium	1–6	Medium to high (periodic)
Cloth collectors (reverse air or jet cleaning)[b]	High	High	Moderate to high	Medium to high	10–35	Medium to low
Absolute type[c]	High	High	High	Medium	3–14	None (see remarks)[c]

[a] Space requirements large. Requires scheduled cleaning.
[b] Space requirements medium. Cleaning constant during operating cycle. Added horsepower used for reverse jet action.
[c] Space requirements small. Requires replacement of unit when predetermined resistance is attained. Ordinary cleaning not possible.

layer for their effectiveness. Their basic or initial efficiency depends upon the type of fabric employed; felted media such as wool gives higher initial removal than woven fabrics. The increase in resistance to air flow, resulting from the accumulated dust layer, is related to rate of flow, concentration, and characteristics of the contaminant. Removal of the collected material is accomplished through periodic shaking by single mechanisms or combinations of them employing rapping, or through reversal of air flow, or by means of high-velocity reverse air jets. With shaking or rapping, air flow is not constant and filtering velocities are usually held under 6 fpm. With reverse jets or reverse air flow, substantially constant air flow is maintained and filtering velocities are generally higher (up to 35 fpm). Filtering velocities in all fabric collectors are highly dependent upon the aerosol, fume, or dust being collected.

The ultra or absolute type of filter[19] may consist of pleated cellulose asbestos paper, deep sand beds, composite glass wool layers, compressed glass fiber in the form of paper, or batts and resin wool. The use of this type of filter is limited to concentrations in the range of outdoor air where very high efficiencies, greater than 99.95 percent are required.

Fabric filters are not suitable for high temperatures, above 300 F, acid mists or vapors, or mixed contaminants such as wet corrosive gases and solid or liquid particles. Cotton fabrics are limited to 180 F, whereas wool is limited to temperatures under 200 F. A wide variety of natural and synthetic filter media are available for various temperature and corrosion conditions but caution must be exercised relative to rupture, high temperatures, and corrosive gases. When properly selected, efficiencies are often high enough to permit recirculation of air except, possibly, when handling toxic contaminants. On the basis of their important characteristics, fabric filters may be classified according to Table 3.

ELECTROSTATIC PRECIPITATORS

Electrostatic precipitators for industrial air and gas cleaning differ materially from the low-voltage designs described in Part I of this chapter, although the principles of operation are similar. For industrial concentrations, it is obvious that more severe demands are made upon methods of cleaning the collector, disposal of collected material, and servicing practices. Low-voltage cleaners for industrial loadings to date do not have sufficient inherent dust-holding capacity. One exception in the field of exhaust systems is that of the oil-mist collector, which functions satisfactorily on a liquid aerosol with the conventional low-voltage type (2 stage) electrostatic precipitator.

Industrial precipitators employ an assembly of parallel collector electrodes of various constructions, including corrugated plate, rod curtains, or perforated plate. Air flow is usually horizontal, although special construction may permit vertical air flow. High-voltage collectors were made in the form of vertical pipes, and are used for high operating pressures and for *wet-collector* designs where water continuously flows downward inside the pipe walls of the collector electrode. The negative discharge electrodes or rods are accurately centered between the usual 9 in. collector electrode spacing, the latter being of positive charge. Precipitation occurs in a single stage wherein ionization and collection are carried on simultaneously throughout the unit, and depend on high potentials of 25,000 to 75,000 volts. The high-voltage direct current is supplied by either mechanical or electronic rectifiers.

High efficiencies are obtained by allowing suitable time for contact in the collector zone, and by proper ratio of air flow velocity to that of transverse velocity of the negatively charged particles toward the positively charged collector plates.

Air velocities vary from 240 fpm to 480 fpm with a constant pressure drop of less than ½ in. water. Since the maximum efficiency is obtained with the finer particles at low concentrations, and the precipitation is not effective for large particles, inertial separators are frequently used in series with these units.

Attention should be directed to the prohibition of air recirculation to occupied spaces. High-voltage cleaning equipment produces ozone and nitrogen oxides in excessive quantities. The major source of maintenance usually will be in conjunction with the high-voltage rectifying equipment rather than the collector. Although usually used for elevated temperature work, unless the gases are preconditioned, temperatures in excess of 700 F should be avoided.

Collector electrode cleaning is accomplished by a rapping device, either electrical or pneumatic, without interrupting operation. The dry plate surfaces release the dust into hoppers below the plates. Some wet cleaning methods are also used.

Electronic precipitators require large spaces, maintenance may vary widely, and initial costs are high. Efficiency is a function of the aerosol encountered and usually ranges above 90 percent.

ABSORBERS, ADSORBERS, AND COMBUSTION DEVICES

One of the important problems in industrial air and gas cleaning is the removal of soluble, insoluble, or combustible gases and vapors from fluid streams before their discharge to the atmosphere. These contaminants may create problems which are distinct from the particulate removal discussed previously. It has been pointed out that scrubbers and other wet collectors may remove gases and particulate matter from contaminated air streams. However, the units

described are intended primarily for particulate removal with the exception of the spray or packed towers or wet cell devices.

Absorption devices are intended primarily for the removal of readily soluble gases which can be removed by simple absorbing agents such as water or alkali; for example, the removal of hydrochloric acid gas by a caustic spray.

Adsorption apparatus is intended primarily for removal of organic vapors in either high concentration (solvent recovery) or low concentration (odor removal). The first process is usually carried on as a matter of economic recovery. In the second process, the concentration of the contaminant must be low enough so that the adsorbent will have a reasonable life before replacement or reactivation.

Combustion, either total or catalytic, may be used to destroy organic compounds, either gaseous or particulate, which create odor problems. The use of catalysts to reduce the temperature needed for combustion is comparatively recent in this field. In some instances the heat of combustion may be recovered for utilization. The temperature necessary for destruction of compounds varies with the nature of the contaminant. However, partial combustion may alter the compound to render it innocuous. The temperature required for complete destruction is usually above 1100 F. Catalysts may only require heating to 500 F or may operate without heating if the gas temperature is above 500 F.

Absorbers

These may consist of spray chambers, packed towers, or wet-cell washers through which an absorbing agent is recirculated. The gases collected may be converted to insoluble salts or usable acids and other compounds. The performance of these devices depends upon several factors such as the solubility of the gas, its vapor pressure, its rate of reaction with the absorbent, the velocity through the collector, and area of the absorbing surface either as spray droplets or wetted media. These are generally designed for the specific purpose intended. They usually are intended to collect over 95 percent of the contaminant. Resistance depends upon the particular design and ranges from 1 to 10 in. of water in most installations. Their resistance during their operating interval is constant unless serious plugging of packing occurs. Spray units are seldom affected by plugging. Packed absorption devices require a precleaner to remove particulates if long trouble-free service is desired. Maintenance of spray nozzles is a function of the degree of atomization used and of conditions encountered, such as purity of spray liquids.

Protection against corrosion and freezing may be necessary and disposal of waste liquids may create secondary problems.

Adsorbers

These units consist of a chamber filled with a granular adsorbent. The adsorbent may be activated charcoal, silica gel, alumina, and other treated solids. Activated charcoal is the most common and has the highest retention per unit weight for organic solvents. Performance of adsorbent beds depends upon their thickness, velocity of the gas passing, mesh size (surface area) of adsorbent, and temperature of the vapor being removed. They can be designed to obtain almost complete removal of organic vapors and some inorganic gases. They may be reactivated by the use of steam or heat. Resistance depends upon the adsorbent mesh size, depth, and velocity. It may range from less than one inch of water to several inches of mercury.

Adsorbent beds are usually limited, because of their cost, to applications where recovery may be economically feasible. Removal of particulate matter by use of precleaners is necessary if significant loadings are involved as the adsorbent voids are readily plugged. They are not suitable for high temperature conditions. Silica gel and alumina exhibit a strong preference for water vapor whereas charcoal does not.

Combustion Devices

This group of industrial air cleaners entails the use of high temperatures or catalysis combined with some elevation in temperature to destory or decompose organic and some inorganic gases which create obnoxious odors. The devices are divided into those in which combustion is obtained by use of liquid or gaseous fuels and the secondary air for combustion is provided by the contaminated air. In essence, the simplest form involves passing the contaminated air through the combustion chamber of a boiler or fire box. Special fire boxes or brick checkerwork may also be employed. Catalytic devices consist of noble metal packed into frames in the form of ribbons or screens or may be ceramic granules coated with noble metal catalysts. The frames or packing are placed in a housing over which the gas stream to be decontaminated is passed. The contaminants break down and are reduced to elemental gases of an innocuous nature. Catalysts reduce the amount of heat necessary but may become contaminated by sulfur or other elements.

The performance of a combustion device is dependent upon the retention period of the contaminant in the high temperature zone. Removal or destruction is thus dependent on velocity and surface area of the heat-transfer device. If properly designed, obnoxious odors are removed.

The resistance of the direct combustion unit is negligible since it is an integral part of the fuel-combustion system. Catalytic devices behave in a manner comparable to packed beds or filters except that they are not plugged by organic particulates but may be affected by inorganic solids.

Maintenance of these types of units is essentially dependent upon the contaminants encountered. The direct-combustion system requires little care other than that required by ordinary fuel-burning equipment. Catalytic units become contaminated slowly and will require removal for reactivation at certain intervals depending upon the application.

Economic factors may limit the use of direct-combustion methods unless there is a demand for the heat generated. They may best be applied to processes employing combustion. Catalytic units require temperatures of at least 500 F and consequently it may be necessary to preheat the contaminated air to this value.

REFERENCES

[1] S. S. Leopold and C. S. Leopold: Bronchial asthma and allied allergic disorders (*Journal of the American Medical Association*, March 7, 1925, p. 731).

[2] L. H. Criep, M.D., and M. A. Green, M.D.: Air cleaning as an aid in the treatment of hay fever and bronchial asthma (*Journal of Allergy*, January 1936, p. 120).

[3] O. M. Lidwell: The bacterial filtration efficiency of an electrostatic air cleaner (*Journal of the Institution of Heating and Ventilating Engineers*, London, June 1951, p. 139).