able. Where lint in an eminently dry state predominates, a dry filter obviously may be preferable to other types because of its lint-holding capacity. If the lint is greasy, or if oil vapor exists in the air, the dry filter, if it is of the cleanable type, may be troublesome, since grease tends to make it difficult to clean. Most dry types, however, employ a throw-away type of medium which is held in permanent metal frames so that the difficulty of cleaning the medium is avoided. Some dry filters are capable of high efficiencies, compared to other unit filters on fine particles, but their dust-holding capacity for such dust may be inferior to that of the viscous-impingement type.

Viscous-impingement unit filters are practically standard in size, and their overall dimensions are small when compared with their ratings.

Throw-away units are often installed in series so that the one in front, which usually becomes plugged with lint, can be discarded, after which the downstream unit is moved to the front and replaced by a new unit.

Viscous-impingement unit filters do not have efficiencies as high as can be expected with some other types of unit filters, but their first cost and upkeep are generally lower, whether of the cleanable or the throw-away type. They require more careful attention than the moving-curtain type if the resistance is to be maintained within reasonable limits.

FILTER INSTALLATION

Many air cleaners are available in units of convenient size for handling when installing, cleaning, or replacing. Such units are usually designated as filters or unit filters. A typical unit filter may be 20 in. square and from one to several inches thick, depending on the manufacture and proposed use. In large systems, a number of such units are installed adjacent to each other and collectively called a bank of filters.

Air cleaners are commonly installed in the outdoor-air intake ducts of buildings, and generally in the recirculating and bypass air ducts as well. Cleaners are logically placed ahead of heating or cooling coils and other air-conditioning equipment in the system to protect them from dust. The character of the dust arrested by the filters in an air-intake duct is likely to be mostly particulate matter of a greasy nature, while lint may predominate in dust from within the building.

The published performance data for all air filters are based on *straight-through* unrestricted air flow. Filters should be installed so that the face area is at right angles to the air flow whenever possible. Eddy currents and dead air spaces should be avoided, and air should be distributed uniformly over the entire filter surface, using baffles or diffusers if necessary.

Failure of air-filter installations to give satisfactory results can, in most cases, be traced to faulty installation or improper maintenance or both.

The most important requirements of a satisfactory and efficiently operating air filter installation are:

1. The filter must be of ample size for the amount of air it is expected to handle. An overload of 10 to 15 percent is regarded as the maximum allowable. When air volume is subject to increase, a larger filter should be installed.
2. The filter must be suited to the operating conditions, such as degree of air cleanliness required, amount of dust in the entering air, type of duty, allowable pressure drop, operating temperatures, and maintenance facilities.
3. The filter type should be the most economical for the specific application. The first cost of the installation should be balanced against efficiency and depreciation as well as expense and convenience of maintenance.

The following recommendations apply to filters installed with central fan systems:

1. Duct connections to and from the filter should change size or shape gradually to insure even air distribution over the entire filter area.
2. Sufficient space should be provided in front as well as behind the filter to make it accessible for inspection and service. A distance of two feet may be regarded as the minimum.
3. Access doors of convenient size should be provided in the sheet-metal connections leading to and from the filters.
4. All doors on the clean-air side should be lined with felt to prevent infiltration of unclean air. All connections and seams of the sheet-metal ducts on the clean-air side should be as air-tight as possible.
5. Electric lights should be installed in the chamber in front of and behind the air filter.
6. Filters installed close to an air inlet should be protected from the weather by suitable louvers, in front of which a large mesh wire screen should be provided.
7. Filters, other than electronic air cleaners, should have permanent indicators to give a warning when the filter resistance reaches too high a value.

Safety Requirements

An investigation of safety ordinances should be made by the engineer when the installation of an air cleaner of any considerable size is contemplated. It is possible that combustible filtering media may not be permitted in accordance with some existing local regulations. Combustion of dust and lint on a filtering medium is possible, though the medium itself may not burn.

ADSORPTION OF VAPORS OTHER THAN WATER

Many of the foreign gases in the atmosphere are selectively adsorbed by charcoal. Included are many of the organic gases, such as those emanating from animals and people, some of the gaseous constituents of combustion, alcohols, ketones, esters, and gaseous products of putrefaction.

Charcoals differ widely in their adsorptive capacity. Those which have marked adsorption characteristics, such as properly prepared coconut shell charcoals, are sometimes called *activated charcoals* or *activated carbon*.[3] These materials can adsorb approximately 50 percent of their own weight of many organic gases at 70 F. The charcoal may be used for a long time by reactivation at high temperatures, under which condition it gives up the adsorbed gases. Temperatures of approximately 1000 F are desirable for reactivation. Charcoals for use in air handling systems should be able to stand physical handling, including reactivation, without excessive loss by breakage or dusting.

As applied in air handling systems, the charcoal is placed in perforated metal containers which are grouped in frames and set in the air stream. The percentage removal of an organic gas, such as carbon tetrachloride, is 95 percent or above, when placed in intimate contact with the carbon at 70 F. In commercial apparatus there may be a bypass effect which depends on the physical arrangement of the charcoal containers. This bypassing reduces the percentage removed in the total gas passing through the adsorber. Resistance to air flow is usually selected within the general range of resistance of impingement filters.

The required quantity of recirculated air to be treated

is determined by dividing the requirements for contaminant-free air, minus the outdoor air, by the fraction denoting the percentage removal of the gas in question in the adsorber bank which is to be used.

Adsorbers may be applied to reduce objectionable gases entering through the outdoor air inlet. They may also be used to reduce the odors caused by exhausts from processing. Adsorber beds, in all cases, should be protected from dust, free oil, and grease.

PART II—INDUSTRIAL AIR AND GAS CLEANERS

Industrial development and growth of industrial areas have had a cumulative effect upon the problem of controlling contaminants. Not only has the atmosphere in many cities become more polluted, but the intensity of pollution at the points of control has increased. Accompanying this increase in pollution there has been a growing consciousness of the need for more effective air cleaning among housewives, store managers, industrialists, and legal inspectors, and this has resulted in increasing severity of regulations pertaining to collection of dust and contaminants.

Air cleaning for the supply system is usually accomplished by means of some type of air filter. To prevent escape of industrial dust into the atmosphere, some type of collector is required. An industrial air-cleaning installation is designed to perform one or more of the following 6 functions:

1. Prevent a nuisance or physical damage to an individual, a plant, or adjacent property.
2. Prevent re-entry of contaminants to working spaces.
3. Reclaim usable material.
4. Reduce fire, explosion, or other hazards.
5. Permit recirculation of cleaned air to working spaces.
6. Allow utilization of cleaned gases for processes.

DEGREE OF AIR CLEANING REQUIRED

The amount of material which can be discharged to the atmosphere is established by local or state regulations prepared by pollution control, labor, or health departments. Standards are established to prevent injury to persons or property. The need for control within the plant is often of prime interest to the industrialist for protecting his equipment, improving his product, and providing a clean working environment. The re-entry of contaminants to working spaces is prevented by effective air-cleaning devices since only a clean effluent is discharged to the ambient atmosphere. Public nuisance complaints often occur even when the effluent concentration discharged to the atmosphere is below the permissible limits of concentration and visibility. Plant location, contaminants involved, and meteorological condition of the areas must be evaluated in addition to existing regulations or codes of good practice.

Fire and explosion hazards are created by combustible dusts, vapors, or gases. Safety may be affected by loss of visibility, settlement, or accumulation of various materials. The cleaning device can prevent these hazards by providing an effluent below the inflammation limit, visibility index, and point where settlement or accumulation will occur.

The degree of air cleaning for the recovery of usable material is a matter of economic evaluation which will vary with such factors as quantity and value of material collected, capital cost, and operating cost.

Air cleanliness must be of the highest order where toxic materials are involved and the cleaned air is recirculated to the workroom. Such recirculation is considered poor practice and is prohibited by many regulations where toxic materials are involved, except for those cases where discharge to atmosphere is impossible or decidely impracticable. Where air is recirculated, its contamination must not exceed the established maximum allowable concentrations listed in Chapter 7. Usual requirements are a fraction, often $\frac{1}{5}$ to $\frac{1}{2}$, of this standard, depending on: regulation involved, air quantities recirculated in relation to the cubical content of working space, and the presence of other exhaust systems discharging to the atmosphere.

Cleaning requirements for the utilization of cleaned gases are dependent on the process and are generally of the *highest order (usually comparable to atmospheric air cleanliness)*.

Regardless of standards it is good practice to install the most effective collection equipment available in the light of practical operation features, installation, and equipment costs. This is warranted because the required degree of cleaning is increasing continually.

FACTORS AFFECTING SELECTION

Selection of an industrial air cleaner for a given application requires an evaluation of the following 5 considerations:

1. Concentration, particle size, and size distribution of the contaminant.
2. Degree of cleaning required.
3. Conditions of air or gas stream with reference to temperature, moisture content, and chemical composition.
4. Characteristics of the contaminant, corrosiveness, solubility, adhesion, or packing, and its specific gravity, surface, and shape.
5. Methods of disposal or salvage that meet the conditions imposed by material, process, or plant location.

In view of the range of these variables, all available test data, application experience, and manufacturers' performance data should be considered.

TYPES AND APPLICATION

There are a number of principles involved in the operation of industrial air and gas cleaners. They are illustrated by the following types of cleaners:

1. *Inertial Separators* (Gravitational or inertial force principle): *Baffle Chambers, Centrifugal Collectors.*
2. *Scrubbers and other Wet Collectors:* Air Washers, Wet Filters or Packed Towers, Spray Towers, Centrifugal or Inertial Scrubbers, Venturi Scrubbers.
3. *Filters:* Fabric Filters, Ultra or Absolute Filters.
4. *Electrostatic Precipitators.*
5. *Adsorbers, Absorbers, and Combustion Devices.*

Units employing these principles may apply them singly or in combination. The important characteristics of any unit are: its collection efficiency, resistance to air or gas flow (power requirements), ability to maintain specified air or gas flow during its operating cycle, and maintenance requirements.

In relation to industrial air cleaners, efficiency of collection is generally presented on a basis of weight removal. In many instances, collection efficiency is expressed in terms of weight removal in specific particle size ranges. Occasionally efficiencies are given in terms of visibility or photometric evaluation. Under other circumstances efficiencies are stated by particle count. For most process recovery problems and air pollution control, the weight basis has been adequate. When loss of visibility is the major problem, light opacity measurements may be required.