Air Technologies

Dust Collectors

Dust collectors vary widely in design, operation, effectiveness, space requirements, construction, and capital, operating, and maintenance costs. Each type has advantages and disadvantages. However, the selection of a dust collector should be based on the following general factors:

- Dust concentration and particle size - For minerals processing operations, the dust concentration can range from 0.1 to 5.0 grains (0.32 g) of dust per cubic feet of air (0.23 to 11.44 grams per standard cubic meter), and the particle size can vary from 0.5 to 100 µm.
- Degree of dust collection required - The degree of dust collection required depends on its potential as a health hazard or public nuisance, the plant location, the allowable emission rate, the nature of the dust, its salvage value, and so forth. The selection of a collector should be based on the efficiency required and should consider the need for high-efficiency, high-cost equipment, such as electrostatic precipitators; high-efficiency, moderate-cost equipment, such as baghouses or wet scrubbers; or lower cost, primary units, such as dry centrifugal collectors.
- Characteristics of airstream - The characteristics of the airstream can have a significant impact on collector selection. For example, cotton fabric filters cannot be used where air temperatures exceed 180° F (82°C). Also, condensation of steam or water vapor can blind bags. Various chemicals can attach fabric or metal and cause corrosion in wet scrubbers.
- Characteristics of dust - Moderate to heavy concentrations of many dusts (such as dust from silica sand or metal ores) can be abrasive to dry centrifugal collectors. Hygroscopic material can blind bag collectors. Sticky material can adhere to collector elements and plug passages. Some particle sizes and shapes may rule out certain types of fabric collectors. The combustible nature of many fine materials rules out the use of electrostatic precipitators.
- Methods of disposal - Methods of dust removal and disposal vary with the material, plant process, volume, and type of collector used. Collectors can unload continuously or in batches. Dry materials can create secondary dust problems during unloading and disposal that do not occur with wet collectors. Disposal of wet slurry or sludge can be an additional material-handling problem; sewer or water pollution problems can result if wastewater is not treated properly.

Baghouse Filters

Fabric filters, or baghouses, remove dust from a gas stream by passing the stream through a porous fabric. The fabric filter is efficient at removing fine particles and can exceed efficiencies of 99 percent in most applications. The selection of the fiber material and fabric construction is important to baghouse performance. The fiber material from which the fabric is made must have adequate strength characteristics at the maximum gas temperature expected and adequate chemical compatibility with both the gas and the collected dust. One disadvantage of the fabric filter is that high-temperature gases often have to be cooled before contacting the filter medium

Advantages:

- almost any size to suit available location or process
- ability to work in any reasonably dry, dusty atmosphere
- parts and/or retrofits are commonly available for maintenance
- wide array of filter media available
- limited by operating temperatures and chemical conditions

Cyclones

Cyclones provide a low-cost, low-maintenance method of removing larger particulates from a gas stream. The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream. The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper. The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral. Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.

Because the particulate control devices discussed above capture the pollutants but don't destroy them, proper disposal of the collected material is needed. Collected solid particles are most often disposed of in a landfill. Wastewater generated by scrubber must be sent to a wastewater treatment facility. When possible, collected particle matter is recycled and reused.

Wet Scrubbers

A wet scrubber's ability to collect small particles is often directly proportional to the power input into the scrubber. Low energy devices such as spray towers are used to collect particles larger than 5 micrometers. To obtain high efficiency removal of 1 micrometer (or less) particles generally requires high energy devices such as venturi scrubbers or augmented devices such as condensation scrubbers. Additionally, a properly designed and operated entrainment separator or mist eliminator is important to achieve high removal efficiencies. The greater the number of liquid droplets that are not captured by the mist eliminator the higher the potential emission levels.

Wet scrubbers that remove gaseous pollutants are referred to as *absorbers*. Good gas-to-liquid contact is essential to obtain high removal efficiencies in absorbers. A number of wet scrubber designs are used to remove gaseous pollutants, with the packed tower and the plate tower being the most common.

If the gas stream contains both particle matter and gases, wet scrubbers are generally the only single air pollution control device that can remove both pollutants. Wet scrubbers can achieve high removal efficiencies for either particles or gases and, in some instances, can achieve a high removal efficiency for both pollutants in the same system. However, in many cases, the best operating conditions for particles collection are the poorest for gas removal.

In general, obtaining high simultaneous gas and particulate removal efficiencies requires that one of them be easily collected (i.e., that the gases are very soluble in the liquid or that the particles are large and readily captured) or by the use of a scrubbing reagent such as lime or sodium hydroxide.

Some *advantages* of wet scrubbers over these devices are as follows:

- Wet scrubbers have the ability to handle high temperatures and moisture.
- In wet scrubbers, the inlet gases are cooled, resulting in smaller overall size of equipment.
- Wet scrubbers can remove both gases and particulate matter.
- Wet scrubbers can neutralize corrosive gases.

Some *disadvantages* of wet scrubbers include corrosion, the need for entrainment separation or mist removal to obtain high efficiencies and the need for treatment or reuse of spent liquid.

Table 1. Relative advantages and disadvantages of wet scrubbers compared to other control devices

Advantages	Disadvantages
Small space requirements Scrubbers reduce the temperature and volume of the unsaturated exhaust stream. Therefore, vessel sizes, including fans and ducts downstream, are smaller than those of other control devices. Smaller sizes result in lower capital costs and more flexibility in site location of the scrubber.	**Corrosion problems** Water and dissolved pollutants can form highly corrosive acid solutions. Proper construction materials are very important. Also, wet-dry interface areas can result in corrosion.
No secondary dust sources Once particulate matter is collected, it cannot escape from hoppers or during transport.	**High power requirements** High collection efficiencies for particulate matter are attainable only at high pressure drops, resulting in high operating costs.
Handles high-temperature, high-humidity gas streams No temperature limits or condensation problems can occur as in baghouses or ESPs.	**Water-disposal problems** Settling ponds or sludge clarifiers may be needed to meet waste-water regulations.
Minimal fire and explosion hazards Various dry dusts are flammable. Using water eliminates the possibility of explosions.	**Difficult product recovery** Dewatering and drying of scrubber sludge make recovery of any dust for reuse very expensive and difficult.
Ability to collect both gases and particulate matter	

Scrubbers

Condensation is the process of converting a gas or vapor to liquid. Any gas can be reduced to a liquid by lowering its temperature and/or increasing its pressure. The most common approach is to reduce the temperature of the gas stream, since increasing the pressure of a gas can be expensive

Removal efficiencies of condensers typically range from 50 percent to more than 95 percent, depending on design and applications

Venturi Scrubber

Venturi scrubbers use a liquid stream to remove solid particles. In the venturi scrubber, gas laden with particulate matter passes through a short tube with flared ends and a constricted middle. This constriction causes the gas stream to speed up when the pressure is increased. A water spray is directed into the gas stream either prior to or at the constriction in the tube. The difference in velocity and pressure resulting from the constriction causes the particles and water to mix and combine. The reduced velocity at the expanded section of the throat allows the droplets of water containing the particles to drop out of the gas stream. Venturi scrubbers are effective in removing small particles, with removal efficiencies of up to 99 percent. One drawback of this device, however, is the production of wastewater.

Biofilters

When applied to air filtration and purification, biofilters use microorganisms to remove air pollution. The air flows through a packed bed and the pollutant transfers into a thin biofilm on the surface of the packing material. Microorganisms, including bacteria and fungi are immobilized in the biofilm and degrade the pollutant. Trickling filters and bioscrubbers rely on a biofilm and the bacterial action in their recirculating waters.

The technology finds greatest application in treating malodorous compounds and water-soluble volatile organic compounds (VOCs). Industries employing the technology include food and animal products, off-gas from wastewater treatment facilities, pharmaceuticals, wood products manufacturing, paint and coatings application and manufacturing and resin manufacturing and application, etc.

Compounds treated are typically mixed volatile organic compounds and various sulfur compounds, including hydrogen sulfide. Very large airflows may be treated and although a large area (footprint) has typically been required -- a large biofilter (>200,000acfm) may occupy as much or more land than a football field -- this has been one of the principal drawbacks of the technology.

A biofilter/bio-oxidation system is a fairly simple device to construct and operate and offers a cost-effective solution provided the pollutant is biodegradable within a moderate time frame (increasing residence time = increased size and capital costs), at reasonable concentrations (and lb/hr loading rates) and that the airstream is at an organism-viable temperature. For large volumes of air, a biofilter may be the only cost-effective solution. There is no secondary pollution (unlike the case of incineration where additional CO_2 and NO_x are produced from burning fuels) and degradation products form additional biomass, carbon dioxide and water. Media irrigation water, although many systems recycle part of it to reduce operating costs, has a moderately high biochemical oxygen demand (BOD) and may require treatment before disposal. However, this "blowdown water", necessary for proper maintenance of any bio-oxidation system, is generally accepted by municipal POTW's without any pretreatment.

Thermal Incineration

These devices are not well-suited to vapor streams that fluctuate, because the efficiency of the combustion process depends on the proper mixing of vapors and a specific residence time in the combustion chamber. Residence time is the amount of time the fuel mixture remains in the combustion chamber. Often, supplementary fuel is added to a thermal incinerator to supplement the quantity of pollutant gases being burned by the incinerator. Energy and heat produced by the incineration process can be recovered and put to beneficial uses at a facility. Thermal incinerators can destroy gaseous pollutants at efficiencies of greater than 99 percent when operated correctly.