$$\text{MTR-PWR}_{\text{output-act}} \text{ (watts)} = (\text{Volts} \times \text{Amps} \times \text{CF} \times \text{Efficiency} \times \text{PF}) \quad \textbf{[7.20a]}$$

$$\text{MTR-PWR}_{\text{output-act}} \text{ (horsepower)} = (\text{Volts} \times \text{Amps} \times \text{CF} \times \text{Efficiency} \times \text{PF}) \div 746 \quad \textbf{[7.20b]}$$

$$\text{MTR-PWR}_{\text{output-std}} = (\text{MTR-PWR}_{\text{out-act}}) \div \text{df}$$
(Equation 7.16)

where:

$\text{MTR-PWR}_{\text{output}}$ = motor output power, hp (W, kW)
Volts = avg supply voltage to motor
Amps = avg amp draw at motor
CF = 1.732 for 3 phase motors ($\sqrt{3}$)
1.0 for single phase motors
Efficiency = motor rated efficiency
PF = motor power factor
746 = unit conversion from watts to horsepower

Motor Service Factor (SF): The motor service factor is a multiplier applied to the motor nameplate power for intermittent service above the nameplate power when rated voltage and frequency is supplied to the motor. Motor service factors range from 1.0 to 1.25, depending on the application and power with 1.15 being most common. Motors on inverter drives (VFDs) will normally operate with a 1.0 service factor.

Motor Speed (RPM): AC motor speed is a function of the line frequency and the number of poles in the motor.

$$N_x = (120)\ (\text{Hz})/p \quad \textbf{[7.21]}$$

where:

N_x = motor synchronous speed (rpm)
Hz = line frequency, 50 or 60 hertz
p = number of poles

Motors run at speeds slightly below their synchronous speed. For example, a four pole, 60 Hz motor has a synchronous speed of 1800 rpm but will normally run between 1725 and 1770 rpm. The difference in the motor synchronous speed and the motor full load speed is called slip. Most motors will operate with a slip of 5% or less.

Motor Efficiency: Motor efficiency is the ratio of the motor output power to the electrical input power. Motor efficiency η_m is not constant but changes with the operating load of the motor. Motor manufacturers typically supply motor efficiency values at full, 75%, 50% and 25% load.

$$\text{Motor Efficiency, } \eta_m = \text{MTR-PWR}_{\text{output-act}} \div \text{MTR-PWR}_{\text{input-act}} \quad \textbf{[7.22]}$$

Motor Efficiency Standards require motor manufacturers to certify that their motors meet minimum efficiency values. In the United States the Energy Independence and Security Act of 2007 (EISA 2007) defines energy efficiency standards for general purpose electric motors and specialty motor designs. The standards require electric motors to have a nominal full load efficiency that is equal to or greater than the energy efficiency defined in National Electrical Manufacturers Association (NEMA) Standards Publication MG1.

Power Factor (PF): The power factor for three phase power is a measure of phase difference between voltage and current in the motor circuit. The power factor value is always less than 1.0.

Motor Frame: NEMA sets industry standards for certain motor dimensions and designates them by frame size. Motors with common frame sizes have the same shaft diameter, centerline height, and mounting dimensions. To determine the shaft centerline height of a NEMA motor, divide the first two (2) digits of the motor frame size by four (4) to calculate the motor shaft centerline height in inches. Example: 182T frame motor shaft centerline height = 18/4 = 4.5 inches.

Motor Enclosure: The selection of the motor enclosure depends on the site conditions. The type of enclosure indicates the type of protection for the internal motor components from the ambient environment and the method of motor cooling.

Open Drip-Proof (ODP) motors have openings in the motor enclosure allowing air movement directly through the motor. Air drafts into the motor and across the rotor and windings for cooling. ODP motors should only be used for clean, low moisture, indoor applications.

Totally Enclosed Fan Cooled (TEFC) motors do not have openings in the motor enclosure, but are not necessarily airtight. An integral cooling fan blows air over the motor enclosure to cool the motor. TEFC motors are used in indoor or outdoor applications where dust and water are present in modest amounts. They are not water tight or designed to withstand direct water spray or washing.

Total Enclosed Air Over (TEAO) motors are similar to TEFC motors except there is no integral cooling fan. These motors are frequently used on fans where the motor is in the air stream, providing cooling to the motor.

Totally Enclosed Explosion Proof (TEXP): Explosion Proof motors are special versions of TEFC motors with design features making them suitable for applications where explosive dust or gases are present. The enclosure is designed to withstand an explosion inside the motor and contain the flame and sparks within the motor. There are different NEMA classifications of explosion proof construction, depending on the characteristics of the explosive gas or dust.

Severe Duty Motors are another variation of TEFC motors having features that make them durable in hostile environments. They have better shaft seals, corrosion resistant paint, and are available with stainless steel shafts.

Temperature Ratings: Motors are available in different temperature ratings which are identified by insulation classes. The most common insulation class is Class B, which is used for general purpose applications. Class F and H insulation are used in motors for high ambient temperature applications. High temperature applications may occur from frequent overloading of the motor, from the use of variable frequency drives or from ambient conditions greater than 104 F [40 C].

Motor Inertia Load Capacity: In some cases, it is not only the power requirements that determine the size of motor but the number of times the motor is started and the motor's ability to accelerate the fan to full speed. This is particularly true when using small motors on large fans. Motors must have an inertia load capability greater than the inertia of the fan corrected for the drive ratio, as shown in the equation below:

$$WK^2_{motor} > WK^2_{fan} (RPM_{fan} \div RPM_{motor})^2 (1.1) \qquad [7.23]$$

where:

WK^2_{motor} = inertia load by the motor at the shaft

WK^2_{fan} = inertia load of the fan

RPM_{motor} = motor speed

RPM_{fan} = fan speed

1.1 = 10% factor for V-belt drives

If the motor does not have enough inertia capacity, either it will not be able to start the fan or it will take an excessive amount of time to bring the fan up to speed. If this occurs, consult the fan or motor manufacturer for acceptable solutions.

7.7.2 Motor Installation. The National Electric Code specifies the requirements for motor installation and wiring. The sizing of motor lead wires and overload protection must consider any higher than normal amp draw that occurs when a motor is started and brought up to full speed. For across the line starting, an in-rush current load of 6 to 10 times the motor full load nameplate amps is not uncommon (for a few seconds). As a result, motor branch circuits for fans are often sized differently than other types of branch circuits. There are also requirements that specify how close motors and disconnects should be located. These are important since they provide personnel protection for servicing the fan and motor.

If a fan is belt driven, the motor must be mounted on an adjustable base. When loosened, this base allows motor movement for aligning the drive and tensioning and replacing the belts. Figure 7-51 shows the AMCA designated motor positions for centrifugal belt driven fans. For direct drive fans, the motor mounting base should include horizontal alignment blocks or a similar device allowing motor adjustment both parallel to and perpendicular to the motor shaft. For all fans, motors should only be adjusted in the vertical plane using machined shims.

REFERENCES

7.1 Gibson, N.; Lloyd, F.C.; Perry, G.R.: Fire Hazards in Chemical Plants from Friction Sparks Involving the Thermite Reaction. Symposium Series No. 25. Institute of Chemical Engineers London (1968).

7.2 Air Movement and Control Association, Inc.: Standards Handbook, AMCA Publication 99-16 (2016).

7.3 Air Movement and Control Association, Inc.: Field Performance Measurement of Fan Systems, AMCA Publication 203-90 (2011).

7.4 Air Movement and Control Association, Inc.: Fans and Systems, AMCA Publication 201-02 (R2011).

7.5 Air Movement and Control Association, Inc.: Air Systems, AMCA Publication 200-95 (R2011).

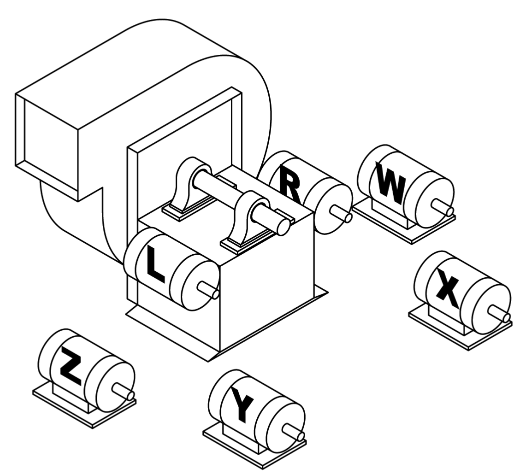
7.6 Air Movement and Control Association, Inc.: Vaneaxial Fan, Exploded View, AMCA Publication 99-16 (2016).

ACKNOWLEDGMENTS

Fan drawings depicted in Figures 7-3, 7-4, 7-5, 7-6 and 7-7 are courtesy of Twin City Fan Company.

Figures 7-28, 7-29, 7-30, 7-31, 7-32 and 7-33 are courtesy of The New York Blower Company and M&P Air Components, Inc.

The Affinity Laws are adapted from *Fan Engineering, An Engineer's Handbook on Fans and Their Applications*, Eighth Edition, by Buffalo Forge Company.



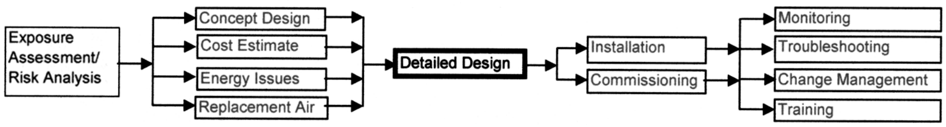
Location of motor is determined by facing the drive side of the fan and designating the motor position by letters W, X, Y, or Z as the case may be.

Adapted from AMCA Publication 99-16, STANDARDS HANDBOOK by permission of the Air Movement and Control Association, Inc.[7.2]

FIGURE 7-51. Motor locations for belt driven centrifugal fans

Chapter 8

AIR CLEANING DEVICES



NOTE: Equations with notation followed by (IP) are designated for inch-pound system only; equations followed by (SI) are designated for metric use only. If equation bears neither, then it applies to both systems.

8.1 INTRODUCTION

Air cleaning devices remove or render harmless contaminants from an air or gas stream. They are available in a wide range of designs to meet variations in air cleaning requirements. Degree of removal required, typically dictated by governmental standards, quantity and characteristics of the contaminant to be removed, and conditions of the air or gas stream will all have a bearing on the device selected for any given application. In addition, fire safety and explosion control should be considered in all selections (see Section 8.11).

This chapter will give an overview of major contaminant control devices, whether the contaminant is in solid, liquid (aerosol) or in a gaseous state. In order to choose the proper control device, it is of absolute importance to know the chemical constituents, particle or aerosol size distribution and relative concentration of those pollutants. The U.S. Environmental Protection Agency (USEPA) has accepted methods of determining the constituents of different air streams. Testing done outside of these sanctioned test methods are likely not to be accepted as proof of compliance (see www.epa.gov).

For particulate contaminants, air cleaning devices are divided into two basic groups: air filters and dust collectors. Air filters are designed to remove low dust concentrations of the magnitude found in atmospheric air. They are typically used in ventilation, air-conditioning, and heating systems where dust concentrations seldom exceed 1.0 grains per thousand cubic feet of air, and are usually well below 0.1 grains per thousand cubic feet of air [0.23 mg/m^3]. (One pound equals 7,000 grains. A typical atmospheric dust concentration in an urban area is 87 micrograms per cubic meter or 0.000038 grains per standard cubic foot of air.)

Dust collectors must be capable of handling concentrations 100 to 20,000 times greater than those for which disposable air filters are designed.

8.2 SELECTION OF DUST COLLECTION EQUIPMENT

Dust collection equipment is available in numerous designs utilizing many different principles and featuring wide variations in effectiveness, first cost, operating and maintenance cost, space, arrangement, and materials of construction. Consultation with the equipment manufacturer is the recommended procedure in selecting a collector for any problem where extensive previous plant experience on the specific dust problem is not available.

8.2.1 Efficiency Required. Previously, there was no accepted standard for testing and/or expressing the efficiency of a dust collector. It was virtually impossible to accurately compare the performance of two collectors by comparing efficiency claims. The filter materials could be, and still are, compared based on the minimum efficiency reporting value (MERV) rating (see Section 8.9.6). However, ANSI/ASHRAE has recently developed Test Method 199-2016 to provide operational performance including emissions and total energy consumption under simulated operating conditions. This test method is intended to allow owners to compare performance of different design collectors using third party test data. Process applications involving temperature, humidity, and non-standard gas compositions do not lend themselves to standardized testing. In these cases, consumers should consider the collector manufacturer's experience with the same or similar processes. Currently, ANSI/ASHRAE Method 199-2016 applies only to fabric collectors. Evaluation of performance for other equipment types such as high voltage electrostatic precipitators, oxidizers, wet collectors, or dry centrifugal collectors, will require field measurements. The best measure of performance for any collector is the actual mass emission rate, expressed in terms such as mg/m^3 or grains/ft^3, conducted under actual operating conditions.

When the cleaned air is to be discharged outdoors, the required degree of collection can depend on facility location, nature of contaminant (its salvage value and its potential as a health hazard, public nuisance, or ability to damage property), and the regulations of governmental agencies. In remote locations, damage to eco-sensitive farms or contribution to air pollution problems of distant cities can influence the need for and importance of effective collection equipment. Many industries, originally located away from residential areas, failed to anticipate the construction of residences that frequently develop around a facility. Such lack of foresight has required installation of air cleaning equipment at greater expense than initially would have been necessary. Today, the remotely located manufacturer should comply, in most cases, with the same regulations as if it were located in an urban area. With present and future emphasis on public nuisance, public health, and preservation and improvement of community air quality, management can continue to expect criticism for excessive emissions of air contaminants whether located in a heavy industry section of a city or in an area closer to residential zones.

A safe recommendation in equipment selection is to select the collector that will allow the least possible amount of contaminant to escape and is reasonable in first cost and maintenance while meeting all prevailing air pollution regulations. For some applications, even the question of reasonable cost and maintenance should be sacrificed to meet established standards for air pollution control or to prevent damage to health or property. However, in areas designated as above the established National Ambient Air Quality Standards (NAAQS) for a pollutant, for example, multiple control devices may be required in order to minimize emissions to the lowest achievable emission rate (LAER) as designated by the USEPA.

It should be remembered that visibility of an effluent will be a function of the light reflecting surface area of the escaping material. Surface area per pound increases inversely as the square of particle size. This means that the removal of 80% or more of the dust on a weight basis may still remove only the coarse particles without altering the stack appearance.

8.2.2 Gas Stream Characteristics. The characteristics of the carrier gas stream can have a significant impact on equipment selection and performance. Temperature of the gas stream may limit the media choice in fabric collectors. High temperatures and low gas densities will reduce the collection efficiencies for centrifugal collectors. Condensation of water vapor will cause packing and plugging of air or dust passages in dry collectors. Corrosive chemicals can attack fabric or metal in dry collectors and when mixed with water in wet collectors can cause extreme damage.

8.2.3 Contaminant Characteristics. The contaminant characteristics will also affect equipment selection. Sticky materials, such as metallic buffing dust impregnated with buffing compounds, can adhere to collector elements and plug collector passages. Linty materials can adhere to certain types of collector surfaces or elements. Abrasive materials such as mill scale or silica in moderate to heavy concentrations will cause rapid wear on dry metal surfaces. Particle size, shape, and density (specific gravity) can reduce collection efficiency of centrifugal collectors. For example, the parachute shape of particles like the bee's wings from grain are more challenging to collect because their shape causes them to behave like a much smaller particle having a low terminal velocity. The equivalent spherical diameter of these particles is referred to as the aerodynamic particle size. In addition, the combustible nature of many finely divided materials will require specific collector designs to assure safe operation.

Contaminants in exhaust systems cover an extreme range in concentration and particle size. Concentrations can range from less than 0.1 to more than 10 grains of dust per cubic foot of air [0.229 g/m^3 to 22.9 $\times$ 10^5 g/m^3] and in excess of 100 grains per cubic foot [229 g/m^3] for pneumatic conveying systems. In low pressure conveying systems, the dust ranges from 0.5 to 100 or more microns in size. Deviation from mean size will also vary with the material (Figure 8-15).

8.2.4 Energy Considerations. The cost and availability of energy makes essential the careful consideration of the total energy requirement for each collector type that can achieve the desired performance. The cost of all energy sources should be considered when evaluating collector technologies such as fan power, pump power, compressed air, etc. An electrostatic precipitator, for example, might be a better selection at a significant initial cost penalty because of the energy savings due to its lower pressure drop.

8.2.5 Dust Discharge and Disposal. Dust removed from the collector becomes either a solid waste stream, liquid waste stream, or is re-introduced to the process. Methods of removal and disposal of collected materials will vary with the material, plant process, quantity involved, and collector design. Dry collectors can be unloaded continuously or in batches through dump gates, trickle valves, and rotary airlocks to conveyors or containers. Dry materials can create a secondary dust problem if careful thought is not given to dust-free material disposal. See Figures 8-1, 8-2, and 8-3 for some typical discharge arrangements and valves.

Material should never be stored in the collector hopper unless it was specifically designed for this purpose. Selection of rotary valves should consider the material characteristics for proper selection. Rotor speeds should not be selected such that they create a "fan effect" in the discharge of the hopper. The "fan effect" can reduce collection efficiency of centrifugal collectors and reduce airlock capacity. Selection speeds of 20 RPM or less for fabric collectors and 15 RPM or less for centrifugal collectors will usually avoid the "fan effect" and ensure the rotary valve is able to remove the material as designed.

Wet collectors should have a continual ejection of collected material unless the recycle tank is specifically designed to separate the solids from the scrubbing water. Secondary dust problems are eliminated although disposal of wet sludge and treatment of liquid slurry can be a material handling problem. Solids or dissolved toxins carry-over in waste water can create a sewer or stream pollution problem if it is not properly addressed.

Material characteristics can influence disposal problems. Packing and bridging of dry materials in dust hoppers, and floating or slurry forming characteristics in wet collectors are examples of problems that can be encountered.

In addition, waste materials originating from air pollution control devices are hazardous waste as described by U.S. regulators unless they can be proven otherwise.

8.3 DUST COLLECTOR TYPES

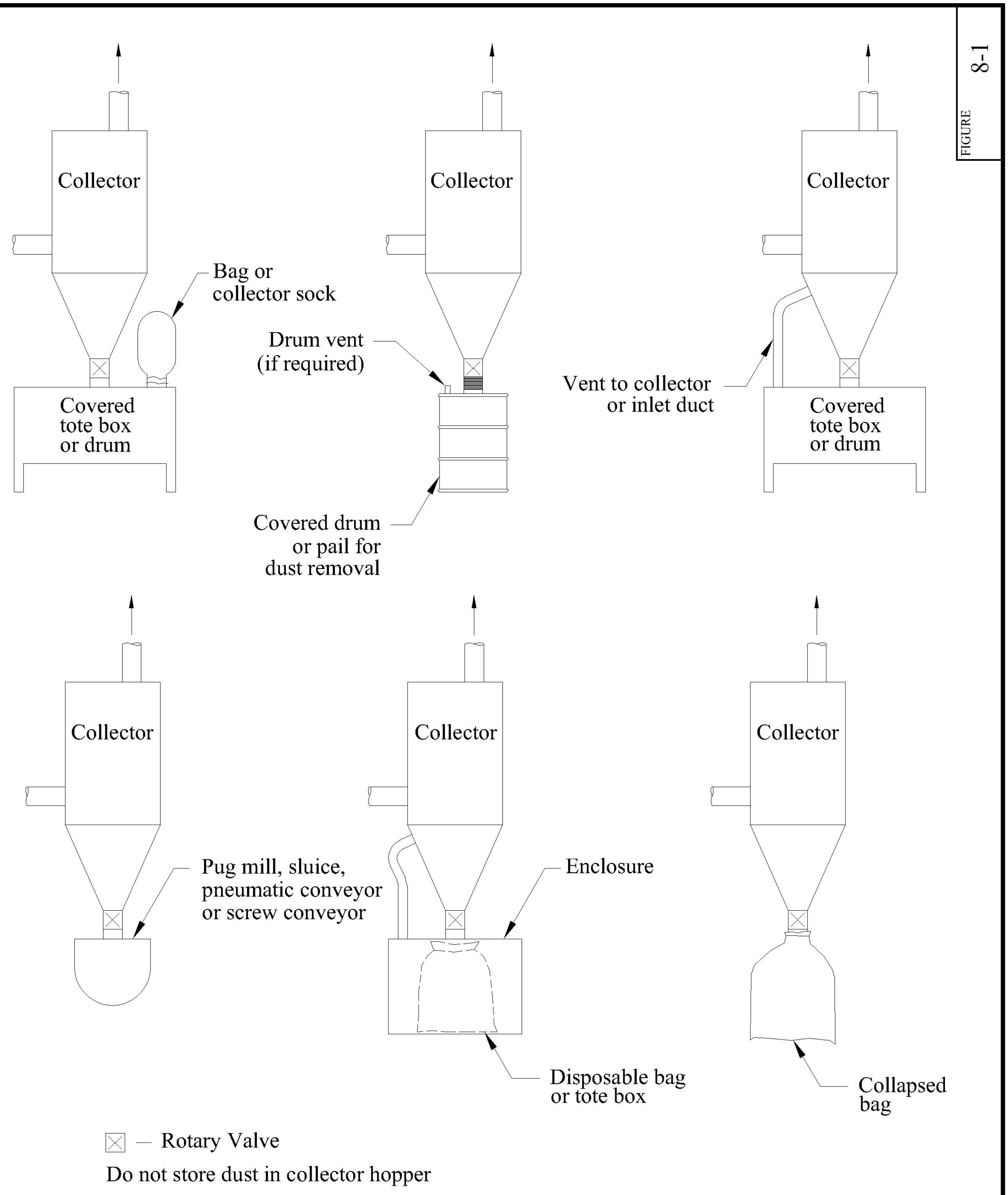
The four major types of dust collectors for particulate contaminants are electrostatic precipitators, fabric collectors, wet collectors, and mechanical collectors.

8.3.1 Electrostatic Precipitators. In electrostatic precipitation, a high potential electric field is established between discharge and collecting electrodes of opposite electrical charge. The discharge electrode is a small cross-sectional area, such as a wire or a metal bar, and the collection electrode is large in surface area such as a plate.

The gas to be cleaned passes through an electrical field that develops between the electrodes. At a critical voltage, the gas molecules are separated into positive and negative ions. This is called ionization and takes place near the surface of the discharge electrode. Ions having the same polarity as the discharge electrode attach themselves to neutral particles in the gas stream as they flow through the precipitator. These charged particles are then attracted to a collecting plate of opposite polarity. Upon contact with the collecting surface, dust particles lose their charge and then are removed by washing, vibration, or gravity.

The electrostatic process consists of:

1) Ionizing the gas;
2) Charging the dust particles;
3) Transporting the particles to the collecting surface;



ACGIH®

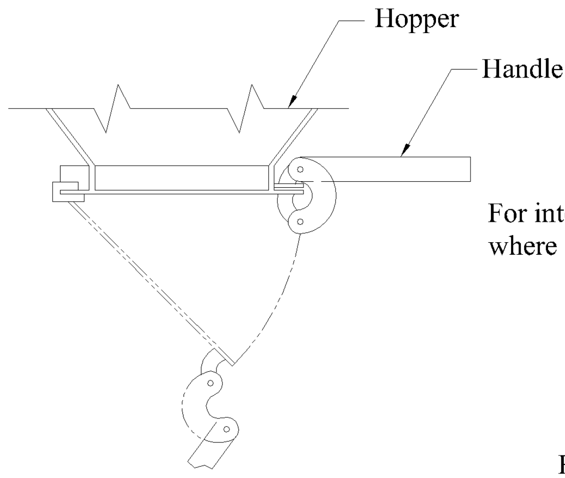
TITLE: DRY TYPE DUST COLLECTORS DUST DISPOSAL

FIGURE 8-1

DATE 1-19

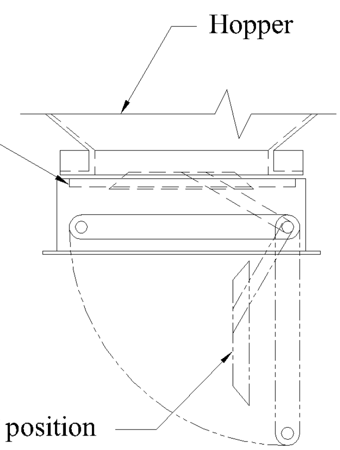
CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL)
TO ENSURE THAT DESIGN IS COMPLIANT.

FIGURE 8-2



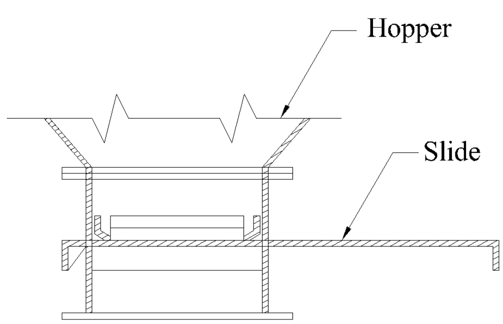
For intermittent manual dumping where dust loads are light.

DUST DOOR



Similar to dust door but designed for direct attachment to dust chute, external pipe or canvas connection.

DUST GATE

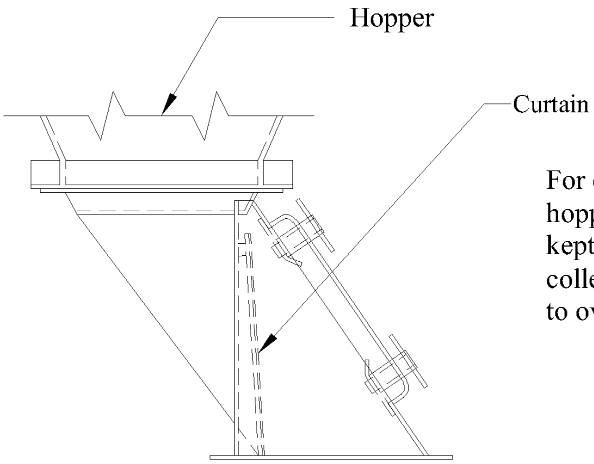


For intermittent, manual dumping where dust loads are light. Flange for connection to dust disposal chute.

SLIDE GATE

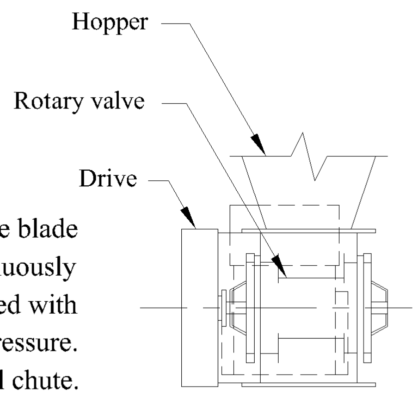
ACGIH®	TITLE DRY TYPE DUST COLLECTORS DISCHARGE VALVES	FIGURE 8-2 DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.



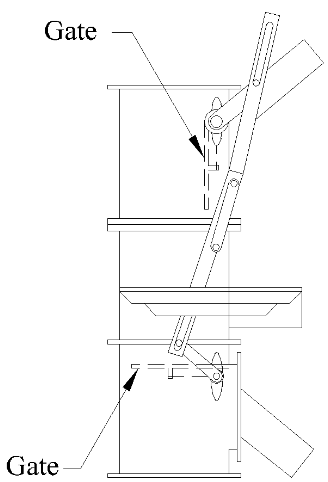
For continuous removal of collected dust where hopper is under negative pressure. Curtain is kept closed by pressure differential until collected material builds up sufficient height to overcome pressure.

TRICKLE VALVE



Motor-driven or pneumatic-driven multiple blade rotary valve provides an air seal while continuously dumping collected material. Can be used with hoppers under either positive or negative pressure. Flanged for connection to dust disposal chute.

ROTARY LOCK

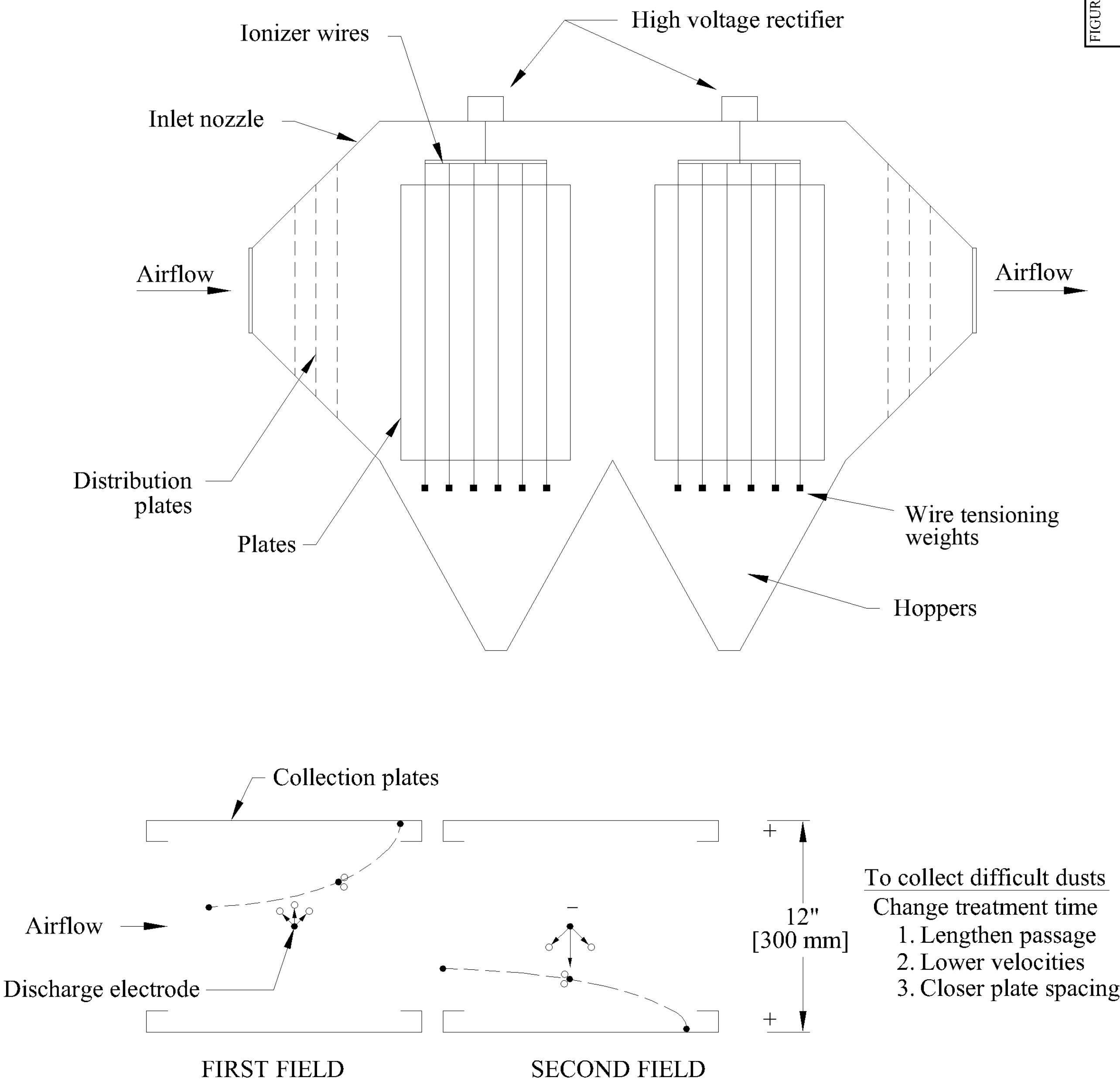


Gravity operated, motor-driven, or pneumatic-driven double gate valve for continuous removal of collected dust. Gates are sequenced so only one is open at a time in order to provide air seal. Flanged for connection to dust disposal chute.

DOUBLE DUMP VALVE

ACGIH®	TITLE: DRY TYPE DUST COLLECTORS DISCHARGE VALVES	FIGURE 8-3 DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.



TITLE
ELECTROSTATIC PRECIPITATOR
HIGH POWER DESIGN
(40,000 TO 75,000 VOLTS)

FIGURE 8-4

DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL)
TO ENSURE THAT DESIGN IS COMPLIANT.

4) Neutralizing, or removing the charge from the dust particles; and
5) Removing the dust from the collecting surface.

The two basic types of electrostatic precipitators are Cottrell (single-stage) and Penny (two-stage) (Figures 8-4 and 8-5).

The Cottrell single-stage precipitator (Figure 8-4) combines ionization and collection in a single stage. Because it operates at ionization voltages from 40,000 to 75,000 volts DC, it may also be called a high voltage precipitator and is used extensively for heavy duty applications such as utility boilers, larger industrial boilers, and cement kilns. Some precipitator designs use sophisticated voltage control systems and rigid electrodes instead of wires to minimize maintenance problems.

The Penny two-stage precipitator (Figure 8-5) uses DC voltages from 11,000 to 15,000 for ionization and is frequently referred to as a low voltage precipitator. Its use is limited to low inlet concentrations, normally not exceeding 0.025 grains per cubic foot [0.057 g/m^3]. It can be the most practical collection technique for the many condensable hydrocarbon applications where an initially clear exhaust stack turns into a visible emission as vapor condenses. Some applications include plasticizer ovens, forge presses, die-casting machines, and various welding operations. Care should be taken to keep the precipitator inlet temperature low enough to ensure that condensation has already occurred.

For proper results the inlet gas stream should be evaluated and treated where necessary to provide proper conditions for ionization. For high-voltage units a cooling tower is sometimes necessary. Low voltage units may use wet scrubbers, evaporative coolers, heat exchangers, or other devices to condition the gas stream for best precipitator performance.

The pressure drop of an electrostatic precipitator is extremely low, usually less than 1 "wg [250 Pa]; therefore, the energy requirement is significantly less than for other techniques.

A modified style of electrostatic collector is used for sticky submicron aerosol particulate and incorporates some properties of wet scrubbers and ESPs. It utilizes a continuous coating of the collection plates with water to cause particulate to collect on the water surface instead of sticking to the collection plates themselves. Wet electrostatic precipitation (WESP), once considered experimental, has proven itself a very viable alternative for some difficult particulate. As with scrubbers, water waste treatment is a significant issue and wastewater treatability should be a consideration for every application.

8.3.2 Fabric Collectors. Fabric collectors remove particulate by straining, impingement, interception, diffusion, and electrostatic charge. The fabric may be constructed of any fibrous material, either natural or man-made, and may be spun into a yarn and woven or felted by needling, impacting, or bonding. Woven fabrics are identified by thread count and weight of fabric per unit area. Non-woven (felts) are identified by thickness and weight per unit area. Regardless of construction, the fabric represents a porous mass through which the gas is passed unidirectionally so that dust particles are retained on the dirty side and the cleaned gas passes through.

8.3.2.1 Fabric Filter Efficiencies. Figure 8-15 shows typical filtration efficiency expectations for wet scrubbers, cyclone collectors and electrostatic precipitators. Note that reverse-pulse collectors, shakers, and cartridge-style collectors are not included on the chart. Such media collectors tend to achieve very high and very similar levels of "seasoned" efficiency because their efficiency is enhanced by the development of a "dust cake" on the surface of their filter media.

During steady-state operation a dust cake deposits and enhances efficiency of the filter media until increased flow restriction requires disruption and removal of the 'plugged' dust cake. Once the dust cake is dislodged there is a brief period of time as a fresh dust cake re-deposits when the media itself must provide filtration efficiency. The efficiency performance of a dust cake is similar for any collector handling a similar dust, so the overall efficiency of a collector is impacted more significantly by other variables such as the frequency at which cleaning is required, the rate that the dust cake develops, the filter media used, and/or the mechanical integrity of the collector including the integrity of the seal between filter media and the collector.

Properly maintained and conditioned filter media collectors achieve average efficiencies well in excess of the 99% mass efficiency across various particle sizes suggested for collection methods in Figure 8-15. As an example: the total particulate emissions for the media collector shall average no more than 0.002 grains per dscf (less than 5 mg/m^3) over the effective life of the filters. Improperly maintained media filters, unfortunately, are commonplace and efficiencies may vary directly with the care the collector receives.

Because media based collectors develop dust cakes on the surface of the media, the concentrations of dust present at the media when the dust cake is disrupted will be much higher than concentrations of dust in the inlet duct to the collector. As a consequence, filtration efficiency expectations based on dust concentrations in the inlet duct can be very misleading when stating actual collector filtration performance. A more accurate method of establishing performance expectations for media collectors is to state an acceptable outlet mass emission level rather than an efficiency for the collector. While collectors and media selections can achieve very low outlet emissions, it is important to confirm that there are field test methods available to verify such performance before establishing low emission expectations.[8.15]

The ability of the fabric to pass air is defined as permeability and is measured by the cubic feet of air that pass through one square foot of fabric each minute at a pressure drop of 0.5 "wg [125 Pa]. Permeability values for commonly used fabrics range from 25 to 40 acfm [0.012 to 0.019 am^3/s].

A non-woven (felted) fabric is initially more efficient than a