

SSPC: The Society for Protective Coatings

Guide 16

Guide to Specifying and Selecting Dust Collectors

1. Scope

1.1 This guide will assist end-users in the selection of dust collectors to be used in conjunction with containment systems to control emissions to the environment, enhance visibility, and reduce worker exposures within the containment. It will discuss the purpose of dust collector use in painting projects; define dust collector terminology; describe the types of dust collectors and the mechanisms of collection; and discuss efficiency, operation, and maintenance of dust collectors.

2. Definitions

The definitions below do not appear in the SSPC Protective Coatings Glossary.

Aerosol: A system of small liquid or solid particles suspended in a gas, in this case air. The aerosol particle can be a single particle or an aggregate of connected smaller particles. The size of these particles can be in the range of 0.002 to 100 micrometers in diameter. Particles that are of the most significant health concern are between 0.2 and 5.0 micrometers in aerodynamic equivalent diameter.

Air to cloth ratio: A size or rating of the fabric filter media that is expressed in terms of air flow capacity versus fabric media area, in units of cubic feet per minute per square feet of fabric. The ratio represents the average velocity of the gas stream through the filter media and is sometimes referred to as the filtration velocity in feet per minute (ft/min).

Can Velocity: Also known as "Approach Velocity." The velocity of the dust-laden air as it passes upward between the filter media. The can velocity is calculated by dividing the volume of air of the system (cfm) by the effective cross-sectional area of the filter chamber. This

effective area is calculated by subtracting the area occupied by the filters (sum of the areas of the number of the bags) from the total cross sectional area of the filter chamber.

Dust Collectors: A subset of a larger group of gas cleaning devices. Dust collectors are used to remove large amounts of particulate matter (typically greater than 1 grain per cfm) from gas streams and come in a wide range of designs to meet various industrial applications. For the purpose of this document, the gas stream is assumed to be air at ambient temperatures.

Dust Load: The quantity of dust in the air stream. Usually expressed as grains of dust per cubic foot of air (grains/cfm).

ft/min: feet per minute, units of speed (velocity).

Grains: A measure of the mass of particles in the air. One pound contains 7,000 grains.

Inches of Water: Units of pressure equal to the pressure exerted by a column of liquid water an inch high at standard temperature. Typically expressed in inches w.c.

Inlet Loading: The amount of material going into the collector. Extremes of high or low loading might allow slightly higher can velocities.

Static pressure (SP): The flow potential force within a duct or device that acts in all directions and is measured relative to the surrounding atmospheric pressure. Static pressure can be positive or negative with respect to the external atmosphere.

Velocity pressure (VP): The pressure required to accelerate air from zero velocity to a given velocity, proportional to the kinetic energy of the air stream. Velocity pres

sure can only be exerted in the direction of airflow and is always positive.

Total pressure (TP): The algebraic sum of the static pressure (SP) and the velocity pressure (VP); typically in inches of water. TP can be positive or negative.

Velocity: The time rate of movement including the direction of movement; feet per minute (ft/min).

3. The Purpose of the Dust Collector

The purpose of a dust collector is to remove entrained particulate matter from air streams to maintain compliance with particulate emission laws and to reduce damage caused by dust to people, equipment, the finished product, or adjacent property. The concept is very simple; however, the process of separating particulate from air can be complex. The complexity arises from the extremely heterogeneous nature of the size and physical characteristics of particles and from the quality and quantity of the air stream that is to be cleaned. A thorough understanding of the purpose and intended use of the dust collector is needed before selection of a dust collector can be made.

The dust collector is a critical component of the containment system for the maintenance painting process. The exhaust fan attached to the dust collector draws contaminated air into the collector. This creates negative pressure inside the containment that draws clean air into the containment from the outside. The airflow through the containment helps to remove contaminants from the breathing zone of the workers. Airflow can also improve visibility inside the containment. The ability of the dust collector to provide both negative pressure and airflow within the containment is directly related to the design, construction, and maintenance of the containment system, dust collector, and supporting parts (e.g. duct work). To prevent contaminants from being released into the environment, all air leaving the containment should pass through the dust collector. The containment system is only as good as the weakest element that makes up the containment system.

The primary purpose of the containment system is to contain debris and protect the environment. The primary purpose of the dust collector is to provide airflow through the containment to reduce worker exposure to airborne dust, improve visibility, and maintain an inward airflow (negative pressure).

Containment systems and methods of monitoring releases are discussed in detail in SSPC-Guide 6, "Guide for Containing Debris Generated During Paint Removal Operations." Knowledge of the containment structure is critical in

selecting the dust collector and will be discussed as needed to aid in the understanding of dust collector functions.

4. Types of Dust Collectors

There are four major types of dust collectors: centrifugal, wet, electrostatic, and fabric collectors. Each of these will be briefly discussed.

4.1 Centrifugal Collectors: These collectors separate particulates from air streams by gravitational, inertial, or centrifugal force. Collection efficiency is affected by particle size, particle velocity, collector design, and dust concentration. Centrifugal collectors can be designed to remove large particles effectively and economically; however, they are not generally suitable for the collection of fine particles. Most centrifugal collectors (e.g. cyclones) are used in stationary applications; however, some vacuum systems incorporate centrifugal collectors.

4.2 Wet Collectors: Wet collectors separate particulates from air streams by impacting the particles with water spray. They are commonly referred to as scrubbers. Wet collectors are typically used for high temperature and moisture-filled gas streams. Neither of these conditions typically exists in maintenance painting applications.

4.3 Electrostatic Precipitator Collectors (EPCs): EPCs separate particulates from the air by introducing a charge into the atmosphere and using a negatively charged plate to precipitate (attract) the charged particles. EPCs are primarily used for heavy-duty dust applications such as utility boilers and cement kilns. While they have the ability to effectively filter the concentration of interest to the industrial painting industry, they generally cannot handle the size range of dust typically generated by industrial painting operations.

4.4 Fabric or Cartridge Filter Collectors: This type of collector separates particulate from air streams by straining, impaction, interception, diffusion, and electrostatic charge. Air must pass through a specially designed fabric that retains the dust on the fabric but allows the cleaned air to pass through. Fabric dust collectors are the type of collector used most frequently in the industrial painting industry.

Fabric dust collectors (hereafter called dust collectors) are further broken down into two primary types based on the filter configuration (bag and cartridge dust collectors), both of which are used heavily in the painting industry. Both bag and cartridge systems can attain capture efficiencies of

99+% of particles over the entire size range of 0.1 to 100 micrometers. Fabric filtration systems are normally designed to collect dry particulate; therefore, their use with wet removal processes requires careful consideration.

4.4.1 Baghouses: Baghouses or bag collector's account for more than 80% of the fabric dust collection systems used in all dust collection applications today (primarily fixed plant facilities, although they are also used in abrasive recycling equipment). Baghouse dust collectors use vertically mounted tubes or bags of fabric media ranging from five to twelve feet in length to remove contaminants. They can filter a wide variety of materials (e.g. fibrous, particulate, moisture laden, and hygroscopic materials). They are used at temperatures up to 500 °F and can handle extremely heavy dust loads. Many abrasive recycling systems utilize baghouse collection systems due to the heavy to extremely heavy particulate loading (2 to greater than 10 grains per cubic feet of air per minute (gr/cfm), and varying particulate size (0.1 to 100 micrometers).

4.4.2 Cartridge Collectors: Cartridge dust collectors are used on dry dust applications or when high concentrations of small (less than 1 micrometer) particulate are likely, but are capable of filtering a broad range of particulate sizes (0.1 to 30 micrometers). Most mobile dust collectors utilize cartridge collector systems. While the abrasive blasting process generates particulate ranging from 3 to 100 micrometers in size, the dust collection system is primarily responsible for removing fine particulate suspended in the air (i.e., small particulate).

Cartridges are composed of rigidly pleated elements providing a large amount of filter area in a comparatively small housing. Cartridges are typically mounted either horizontally or vertically within the filter housing. Cartridge systems should not be used when the loading is expected to exceed 3 gr/cfm.

5. Types of Cleaning Mechanisms

Dust collectors are typically classified by their cleaning mechanism. There are three common types: shaker, reverse pulse, and pulse jet. Baghouses utilize either shaker, reverse pulse, or pulse jet systems. Cartridge collectors utilize either reverse pulse or pulse jet systems. In the industrial painting industry, almost all current equipment uses pulse jet systems.

5.1 Shaker Systems: In shaker systems, dirty air enters at the center of the bag area and the dust cake

accumulates on the interior surface. Shaker systems rely on a vibrating mechanism to shake the filters. This creates a sine wave along the top of the bag that ripples down the length causing a portion of the dust cake to change shape and fall into the hopper. Pressure drops across the baghouse determine the shake interval. Typical shake intervals range from 10 to 30 seconds. Shaking speed and frequency are dependent upon the diameter and length of the bag. Multiple baghouse filters are packaged in separate compartments in the dust collector. During cleaning, one compartment at a time is shut down for the shaker process, while the remaining compartments remain in operation. This is called off-line cleaning. Shaker systems have a low air-to-cloth ratio (A/C). This means that the units are typically oversized (i.e., requiring high air volumes) and many bags are required in order to maintain filtration efficiency during the cleaning cycle. Additionally, because shaker baghouses have multiple bags per compartment, the time necessary for filter replacement is increased.

5.2 Reverse Pulse Systems: Reverse pulse systems have largely supplanted shaker systems and are currently being replaced by pulse jet systems. The design of the dust collector for reverse pulse systems allows the dust-laden air to enter at the top of the unit. The dust collects on the interior of the bags or cartridges. Heavy particles fall into the hopper, helping to extend bag life. The filtered air is then vented to the atmosphere. Reverse pulse systems are multi-compartment systems. Cleaning is accomplished by isolating one compartment at a time (while the others continue to operate). Pulses of compressed air enter through a venturi nozzle, which creates a shock wave. The wave causes the dust cake on the inside of the bags to fracture and fall into the hopper. Typical pulse durations range from 30 seconds to several minutes. Reverse pulse systems are considered the least aggressive cleaning method, but one which extends bag life.

5.3 Pulse Jet Systems: Pulse jet systems are considered to be the most aggressive and effective filter cleaning approach. An FHWA publication, Lead-Containing Paint Removal, Containment and Disposal (FHWA-RD-94-100)¹, published in February 1995, indicated that only those dust collectors using pulse jet cleaning mechanisms were effective over the duration of the study. Pulse jet systems are the only systems where cleaning occurs while contaminants are entering the compartment.

In pulse jet systems, the inlet air stream enters the unit and passes vertically between the bags or cartridges. Dust accumulates on the outside surfaces of the filters. Pulse jet

¹ Lloyd M Smith and Gary L. Tinklenberg, Lead-Containing Paint Removal, Containment and Disposal, FHWA RD 94-100, Federal Highway Administration, McLean, VA, February 1995.

systems continuously remove some dust from the bag or cartridge through an adjustable cleaning frequency dictated by a timer or differential pressure across the filters. When the differential pressure point is reached, a high-pressure jet of compressed air is directed inside the filter for 0.1 to 0.15 seconds at intervals ranging from 1 to 30 seconds. The pulse creates a shock wave similar to that used in the reverse pulse system, causing the dust cake to fracture and fall into the hopper. Proper adjustment of the cleaning frequency in these systems is necessary for optimal particulate removal efficiency. If the duration of the pulse is too short, cleaning is inefficient. If the duration of pulsing is too long, the bag life is reduced. For optimal operation, the frequency of cleaning should be adjusted so that differential pressure across the collector ranges from 3 to 6 inches water column (w.c.). Some manufactures employ timers rather than differential pressure drops to determine the cleaning sequence.

The pressure of the compressed air at the delivery tube can severely affect bag life. Too high a pressure or a misdirected jet of air due to misalignment of the delivery tube can damage the top several feet of the bag or cartridge. Average compressed air pressures range from 40 to 90 pounds per square inch (psi).

One of the popular features of pulse jet systems is the on-line cleaning feature, which allows work to continue without interruption of project operations. However, if high can velocities are present, on-line cleaning can have negative impacts due to gravity settling problems and re-entrainment of fine dust on the adjacent row of filters. During on-line cleaning, particles may stay suspended in the air due to the continuous upward movement of air. This can affect filter efficiency and overstress the system, because particulates are not removed from the air stream. Solutions to these potential problems would be to conduct off-line cleaning or to utilize a pulse-jet system equipped with multiple compartments (usually in a row).

6. Background on Dust

6.1 Dust Characteristics: Dust particles are generated by many maintenance painting processes. Of particular concern are those particles generated during the removal of potentially toxic paint (e.g. lead-based paint) from structures. It is important to understand the process that creates the particles to obtain an estimate of resulting particle size. In general, the majority of particles generated from mechanical action ranges from 3 to 100 micrometers. The larger particles will not stay in the air long enough to cause any great concern. Smaller particles are generated as well, but in smaller quantities. Very small particles (for example, fumes generated during the burning of paints) are

so small (0.001 to 0.1 micrometer in diameter) that they will pass right through a typical dust collector filter. A special air-cleaning device is needed for such operations. Specialty air cleaning devices will not be covered in this guide.

6.2 Dust Particle Size and Health: The size of particles is important for three reasons: health, settling velocity, and filtration. The dust collector user should be aware that particle size determines the deposition site within the respiratory tract. Smaller particles will travel further and be deposited deeper within the lung. Air coming from the dust collector may contain aerosols that are hazardous to health.

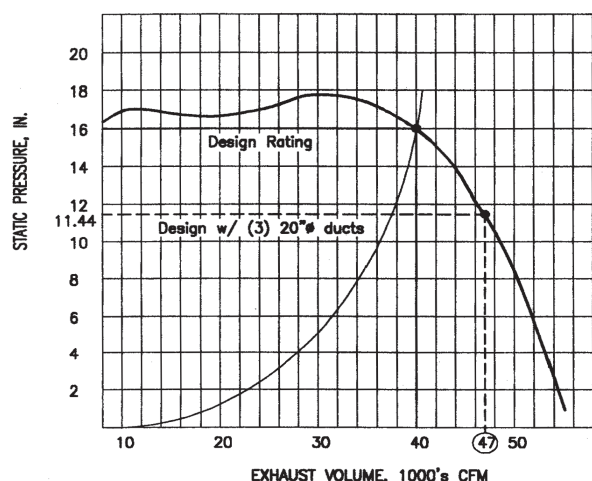
6.3 Dust Settling Velocity: Size will affect the rate at which the particle falls through the air. The smaller the particle, the longer it will stay airborne. For all practical purposes, the extremely small particle will behave more like a gas, staying airborne indefinitely. A particle with an aerodynamic equivalent diameter (AED) of one micrometer will fall at a rate of 0.04 feet per minute. It would take 200 minutes for a 1-micrometer particle to drop 8 feet. If the dust collector is working properly and removing the air from the containment system, the aerosols inside the containment will be removed within minutes after the paint removal has occurred. However, high concentrations of small AED aerosols may remain inside the containment for hours if the ventilation system is improperly designed, operated, or maintained.

7. Dust Collector Selection Criteria

7.1 Fan Performance: Fan performance is dependent on the design of the fan blades. Different fan designs will yield different characteristic performance curves. However, the performance of a fan can be generalized and discussed in relatively simple terms. The performance of a fan can be described by a graph of the airflow capacity (x-axis, abscissa) and the resistance to airflow or static pressure (y-axis, ordinate), as illustrated in Figure 1.

Fan characteristics can be evaluated experimentally for different fan revolutions per minute (rpm). For the present discussion, assume the fan and motor have been matched and sold as a unit. In the extreme, when running the fan with the outlet closed off, and reducing the flow rate to zero, the pressure developed inside the duct would, for all practical purposes, be the maximum that the fan could deliver. This pressure is called the static no delivery (SND) pressure. At the other extreme, if the fan were running without any obstructions, at zero resistance, with minimal connecting ductwork, the fan would be operating at maximum air movement. This is called the free delivery or wide-open operating condition. The SND and the wide-open

Figure 1
Fan Curve



points would be the two limits of the fan performance curve. The intermediate points on the airflow versus pressure graph describe the slippage characteristics of the fan. This graph is a universal way of describing fan performance, however, this information can also be given in tables.

7.2 Fan Power: Power considerations for driving the fan's propeller are usually addressed by the fan manufacturer. An end-user will normally purchase the fan and engine (or motor) in combination. Increasing the number of fan rpm increases the capacity of the fan to move air or overcome static pressure. However, there are limits to the rpm at which each fan is rated to operate. Exceeding the rpm rating can reduce the life of the fan and may become a safety hazard. The fan and motor should be matched to meet the needs of the operations.

7.3 Fan Selection: The selection of a fan for a given application is best done by a professional. In most cases, the fan is located downstream from the filtration housing, protecting it from air streams that are heavily loaded with dust. In order for the dust to be transported to the dust collector, duct velocities (called transport velocity) of 4,000 ft/min or higher are needed. The high transport velocities are needed to keep the dust airborne so that it does not settle out in the duct. The higher the duct velocity, the higher the resistance to airflow. High velocities commonly result in large losses of static pressure, 5 inches w.c. or more. Thus, the fan must be rugged and have the capacity to overcome high static pressure losses. A backward-

curved fan is typically used in dust collectors for this industry. It is intended to move air after filtration. For moving air laden with dust, a more rugged fan design, such as a radial tip wheel, should be considered. Other fan types include: propeller fans, tube-axial fans, vane-axial fans, centrifugal fans, multiple-blade fans, forward-curved multivane fan, paddle-wheel fans, and airfoil fans.

7.4 Can Velocity: Can velocity is generally described as the upward velocity of the air through the entire body of a dust collector including the open area between the filters.

Can velocity is an important factor in the proper design and functioning of a dust collector. If the can velocity is too high the dust pulsed off of the filters during the cleaning cycle will not fall downward into the hopper area. Rather the dust will be held suspended in the air stream and reattach to the filters. This will result in a greater drop in pressure (reduced air flow), excessive use of compressed air, and shortened filter life. High can velocity can be almost impossible to correct on an existing collector.

Can velocities are an important consideration when deciding the location of the inlets on the collector body. If the inlets are placed low on the collector and dust-laden air is introduced into the hopper area, the velocities will be highest at the very bottom of the filters. If the can velocities are too high, this could form a barrier for the dust falling from the filters. High velocities in the hopper area could also cause dust already settled in the hopper to be reintroduced into the air stream. This could be further exaggerated if the hopper is not emptied on a regular basis.

To optimize can velocity within the collector, the designer must consider the size of the collector body and the spacing between filters. The designer must also consider such variables as inlet loading, bulk density, particle size, and particle characteristics.

7.5 Off-line versus On-line Cleaning (Pulse Jet):

One of the reasons that pulse jet systems are so popular in the industrial painting industry is the ability for the filters to be cleaned on-line without interrupting production. If the system is equipped with only one compartment, on-line cleaning can have high suspended dust levels and ineffective cleaning that ultimately increases static pressure. In a single compartment design, the on-line cleaning process can prevent effective gravity settling of the particulate due to the continuous upward movement of air (can velocity). It also fosters the re-entrainment of smaller dust particles (less than 10 micrometers) into the air and onto adjacent or recently cleaned filter media. As a result, the overall filter efficiency and filter life may be reduced. Consideration should be given to specifying multi-compartment pulse jet systems to maintain the benefits of on-line cleaning (i.e.,