Aerodyne®

Airflow Through a Dust Collection System

When you are dealing with dust collection system, the most important component is having the correct airflow going through your system so that the dust collection is properly done. While this initially appears to be simple it is the most complex part of a dust collection system. To put it simply, every component from the pickup hoods to the exhaust stack affect the airflow going through the system. And any changes, whether deliberate (ex. changing filters) or accidental (filters plugging) the airflow in the system will be affected. The following explains the different components in the dust collection system and how they affect the airflow.

Pickup Points/ Hoods

Most dust collection system have pickup points/hoods that are used to collect the dust by pulling the air around the location into the dust collection system. The amount of air and the profile of the airflow is based on the hood design. Some hoods are located close to the dust source while other hoods are used to pickup dust across a large areas. Using the correct hood is very important when you are designing the dust collector. If you are using a hood designed for pinpoint collection but need to collect over a wide area you will not get the dust collection you are looking for. If you use a wide area hood for pinpoint collection you will be collecting more airflow that is required, thereby increasing the size of you dust collection system.

The air velocity going through the hoods is extremely important for the proper operation of hoods. If you are not getting a high enough air velocity through the hood, dust will escape the area and settle on the ground or equipment or be breathed by workers. The proper air velocity is based on the process that is generating the dust. If the dust is coming off at high velocities like a grinder, you will need a higher air velocity. While, if the dust is drifting upwards slowly from a system a lower velocity would be required.

The final consideration on hoods is how close they are to the point of dust generation. The farther they are away the larger the hood and greater the velocity of air (thereby more airflow) is required to capture the dust. So when trying to design a system, you should always try to place the hood as close to the point of dust generation as possible. This will keep the airflow as small as possible, allowing a smaller dust collection system to be used. For additional information about hood design the Industrial Ventilation Handbook is a good guide.

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Ductwork

Now that we have captured the dust in our hoods, we must transport the dust from the hoods to the dust collector. Sometimes you located the dust collector right next to the area you are collecting the dust and sometimes it is located all the way on the other side of the facility. Some dust collectors are dedicated to a single area or process while others handle multiple areas (hoods). All of this requires ductwork to transport the air from one place to another.

When you are designing your ductwork, you have to keep two things in mind. The larger the ductwork the less friction (pressure drop) is required for a certain amount of air to travel in it. However, in order to keep dust particles from dropping out in the ductwork a minimum velocity is required. What this means is that while a larger diameter ductwork decreases the resistance to moving the air through the ductwork, it could also allow dust to buildup in the ductwork.

Dust buildup in the ductwork can cause maintenance issues and could even be an explosive hazard, so it should be avoided. The ductwork should be designed as to have a high enough velocity to keep the dust from falling out of the airflow. Basically this means pick the largest duct size that will still achieve the velocity required to keep the dust in the airflow without it falling out. The velocity is based on the dust characteristics, but generally a velocity of 3500 FPM or greater is required to keep dust from settling in the ductwork.

Another recommendation when designing the ductwork is to keep elbows to a minimum. Elbows add significant amount of resistance to the ductwork systems, and the areas before and after elbows cause a disruption of the airflow pattern. This can lead to dust falling out near an elbow causing further disruption of the airflow. So to keep the air flowing easily, try to make the ductwork as straight as possible.

One other thing to keep in mind, flexible ductwork is very handy, but this comes with a price. Flexible ductwork has a very high friction factor. Flexible ductwork has around 2.5 times more pressure drop (per 100' of ductwork) than standard metal ductwork. So while using flexible ductwork can make the installation and connection of equipment easy, always try to keep the amount of flexible ductwork you used to the barest minimal.

Dust Collectors

There are many different types of dust collectors that you can use in the system. Each of them have certain strengths and weaknesses. The most common are baghouses, cartridge collectors and wet scrubbers.

Baghouses and cartridge collectors use a filter media that builds up dust and prevents the dust from passing. The filters will be periodically cleaned (by shaking or with compressed air). Over time the dust layer will increase, causing the pressure drop across the filters to increase. Usually a dust collection system allows for 6" W.C. for the baghouse / cartridge collector. Once the pressure drop increases above this, the airflow in the system will decrease. It is therefore very important to monitor the pressure drop in the baghouse and cartridge collectors. As when the pressure drop increases above the maximum pressure drop in your design, your airflow will go down. And this will cause dust to escape you system at the pickup points.

There are multiple types of wet scrubbers used for dust collection. The most common are venturi scrubbers and what can described as cloud chambers. Cloud chambers use high pressure nozzles to create very small particles to make contact with the dust. While venturi scrubbers force the airflow and water through a small diameter section, forcing the water and dust to contact. Afterward both units have mist eliminators and/or packed towers to collect the water droplet.

The venturi's pressure drop is based on the airflow going through the unit. As the airflow increases, so does the pressure drop. So if for some reason the ductwork or hood is blocked the pressure drop through the venturi will fall rapidly. The venturi's dust removal efficiency is very much dependent on the pressure drop through the venturi. For example pressure drops as high as 50" W.C. maybe required to remove submicron particles.

Whereas a cloud chamber may only have a pressure drop of a few inches of water. (They both use high levels of energy for dust collection, the main difference is that it much more efficient to transfer energy to a liquid (cloud chamber) than air (venturi)). Cloud chambers, packed beds, etc. are dependent on both the airflow and the packing / internals in the vessel. Therefore partially blocked hoods/ ductwork won't drop the airflow as quickly. However, plugging of packing will cause a decrease in the airflow. The main thing to remember is that as the dust collectors internals get dirty, the airflow through the dust collector will decrease unless the system fan compensates. This will mean that the airflow being collected (and dust) will decrease, which will allow dust to escape the system and settle on equipment, floors, etc.

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Auxiliary Equipment and Accessories

The dust collection system might have auxiliary equipment such as pre-filters, HEPA filters, isolation valves, manifolds and control dampers which could affect the airflow in the system. They all could have pressure drops associated with them, which would need to be added to the system total static pressure for the proper airflow to be achieved by the system.

Pre-filters such as cyclones and drop out boxes collect the larger dust particles allowing the smaller ones to pass through to the main dust collector. This lowers the loading going into the main dust collectors allowing filters to last longer and decrease utilities such as compressed air and makeup water. A cyclone uses centrifugal force, while a drop out box uses a sudden change in direction, to remove the larger dust particles in the airstream. The cyclone pressure drop is based on the airflow going into the cyclone and much like the venturi scrubber described above, it will increase / decrease directly proportionally to the airflow going through it.

HEPA filters are used after a dust collectors to collect any fine dust that manages to get pass the main dust collectors. HEPA filters are usually used when the airflow is being recycled back into the facility. The dust collector system should be designed to allow up to a certain pressure drop across the HEPA filters. And once they reach that amount the HEPA should be replaced or cleaned. Like the filters in the dust collectors, once the dust builds up and the pressure drop increases greater than the design amount, the airflow throughout the system will decrease to compensate.

Isolation valves are used to protect the rest of the system from a dust explosion in the dust collector. The isolation valve is open during normal operation allowing airflow through it. It will then close during a dust explosion, isolating the dust collector from the rest of the system, thereby preventing the explosion from doing additional damage. During normal operation there is usually a small pressure drop across the valve. This pressure drop is usually under 2" W.C. If the dust collection system is recycling the air back into the facility (ex. using HEPA filters) then there needs to be a second isolation valve on the return ductwork.

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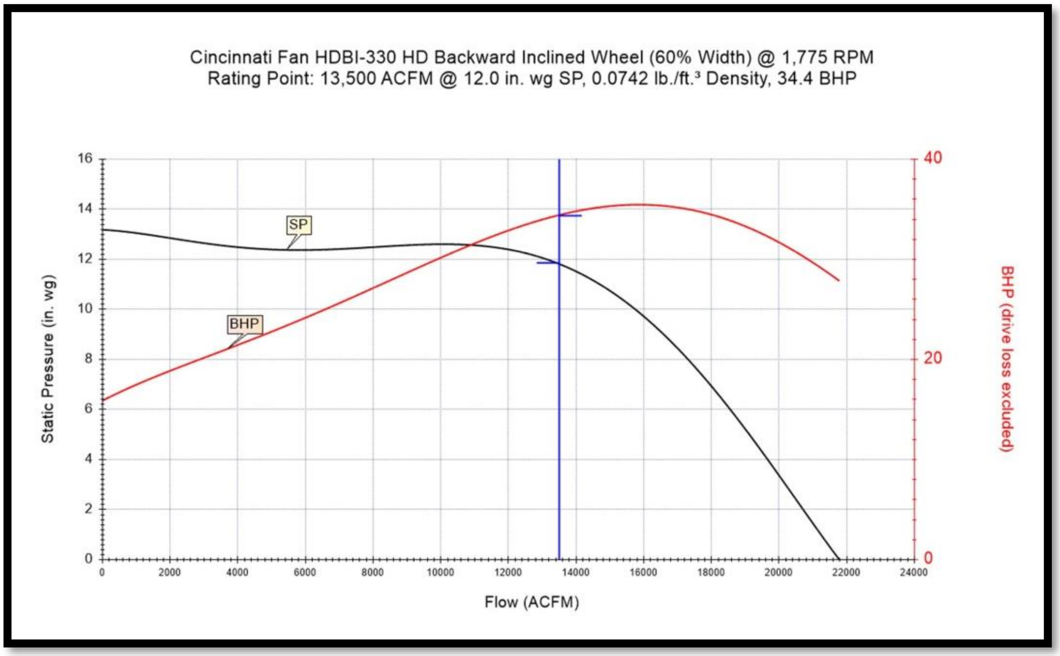
Manifolds are used to in dust collections systems to combine airflows. A manifold can combine as few as three (3) airstream or many more. The main thing to remember is as you combine multiple airflows the airstreams will mix and there will be additional pressure drop caused by the mixing of the airstreams. Be sure to take into account the pressure drop of the manifold(s) when sizing your dust collection system.

Control dampers are used to balance the dust collection system. They are often used to make sure air is pulled in the correct proportions throughout the system. Control dampers should be used on any system modifications to help keep the system operating at the right airflow. Some systems are designed without control dampers. These systems use the ductwork design to get the correct airflow, but any changes to the system could cause unbalanced flow, thereby affecting your pickup points. If you are changing your system, control dampers may be required for balanced flow. One thing to be careful about is that if a control damper is left open or closed wrongly, the whole system can be thrown off.

Exhaust Fan

The exhaust fan is usually the motive power behind the dust collection system. And usually the exhaust fan is a centrifugal blower. One of the characteristics of the centrifugal blower is that the airflow produced by the fan is directly tied to the static pressure produced by the fan at a specific speed. Each centrifugal blower has a performance curve which shows what the airflow and static pressure will be. (see attached sample fan curve)



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Exhaust fan also have multiple impeller designs to consider. Some impellers are very good in handling dusty air (radial), but they usually require a lot of energy to provide the same process performance. While other impellers provide the process performance very efficiently (ex. backwards inclined), but will have issues in dusty air, so therefore the location of the fan and efficiency of the dust collector can affect the fan selection. Backward inclined impellers are limited in their static pressure, so at higher static conditions, you might not have an option besides a radial impeller.

The proper way to size the exhaust fan is as follows:

1) Calculate the airflow required at each of the pickup points based on the hood design and location and add them all together to get a total airflow.
2) Calculate the pressure drop in the system by
    a. Adding the pressure drop through the ductwork
    b. Adding the pressure drops in the hoods, auxiliary equipment and accessories
    c. Adding the pressure drop of the dust collector(s)
    d. Adding the pressure drop of the stack or ductwork after the fan
3) Once you have the airflow and pressure drop required, add a little safety factor to the static pressure and select the fan.

The main thing to remember is that if for some reason the pressure drop in the system increases, the airflow through the system will decrease according to the fan performance curve. Often times it is a good idea to install a variable frequency drive (VFD) on the fan so that you can adjust the speed of the fan allotting for changes in filter conditions and other process upsets.

So to summarize, the dust collection system is sized and designed based on the total airflow going through it. Each of the components has an effect on the whole system, which often times are cumulative. Any modification of the system could affect every other piece of equipment, thereby affecting the total effectiveness of the system. As described above, the dust collection at the pickup points are entirely dependent on the airflow going through them. Any upset, modification, maintenance issue, etc. could affect that airflow, thereby causing the dust collector system not to provide the performance it was designed to do. Therefore constant monitoring of the airflow in the system is the best way to monitor the dust collection system.