COST EFFECTIVE DUST COLLECTION

FOR THE

COMPOSITE MANUFACTURING INDUSTRY

AUTHOR:
Kenneth E. Abbott
Managing Member

Envirosystems Manufacturing, LLC
2555 N. Coyote Dr., Ste. 118
Tucson, Arizona 85745, USA

I. INTRODUCTION

Dust collection is a necessary requirement in many industries and the Composite industry is no exception. Air borne dust, even that regarded only as nuisance dust, is not only a housekeeping expense but will also reduce worker productivity and contaminate the product.

Unfortunately, unlike high tech manufacturing equipment such as CNC Routers or Mills which reduce labor, increase productivity and increase profit; dust collection equipment is generally considered just a cost of doing business. The fact is nothing could be further from the truth. Proper dust collection equipment can add to the bottom line by reducing housekeeping and equipment maintenance costs while at the same time boosting worker productivity, not to mention the pride that comes from working in a clean manufacturing environment. Additionally, as we all know, the business of manufacturing with Composites, whether it be basic raw material manufacture or final fabrication, is very sensitive to both air borne and surface contamination. A small amount of contamination on a faying surface can easily ruin a complex assembly and sometimes this damage is not detected until very late in the process, resulting in the complete loss of many hours of labor not to mention scraped materials. The vast majority of these types of problems can be easily eliminated with the proper dust collection system. The question is: “what is the proper dust collection system?”

II. SYSTEM SIZE

The first question that comes to mind is: What size system is needed? The answer to this can be subjective unless you first establish a few basic parameters by answering the following questions:

1. What is generating the dust?
2. How big is the generating area?
3. Can the generating functions be grouped and/or isolated?

The answers to these questions will help to determine the size and type of equipment needed to do a proper job of collecting air borne contamination in your facility.

Whenever possible, all the dust generating activities should be grouped in one area. This is not always possible, and there are ways to deal with this problem if it exists, but to the extent possible, the most cost effective method of eliminating air borne contamination is to confine it to one area where it can be isolated and filtered using the least possible amount of air.

All air borne contamination is removed by directing it into a controlled air flow generated by a fan. This flow of air will pull the contamination through a filtration system made up of various types of filter media. The filter media type will be determined by the type of contamination involved, but the amount of air is solely determined by the size of the area that is being controlled. The larger the area, the more air required. The actual calculation used to determine the amount of air volume required for a particular application is very simple. The width of the room is multiplied by the height resulting in a room cross section value expressed in sq. ft. As an example a room that measures 40 ft. wide by 60 ft. long by 10 ft. high has a cross section of 400 sq. ft. (40 ft. wide x 10 ft. high), the length being unimportant for air flow volume calculations.

By multiplying this cross section by the required speed of the air movement through the room in feet per minute (FPM) a value will result expressed as cubic feet per minute (CFM). In our example room, if an airflow of 50 FPM is desired we would multiply the cross section of 400 sq. ft. by the desired flow of 50 FPM to arrive at the fan volume size of 20,000 CFM.

It is now easy to see why we would want to use the 40 ft. dimension of the room as our cross section and not the 60 ft. dimension. Had we decided to move the air across the width of the room instead of down the length, we would have been multiplying the 10 ft. height by 60 ft. with a resulting cross section of 600 sq. ft. and a fan volume requirement of 30,000 CFM, a 50% increase for the same room size.

There are times when the room size is so large that providing dust collection for the entire space is not practical. In these cases, there are some alternatives. If the dust generating activities can be grouped in one area, a simple three sided enclosure can be erected around the generating activities consisting of two side walls, a ceiling with lighting (an additional perk to this type of approach) and a dust collection unit in the rear wall. The front is left open with the dust isolation resulting from a relatively high air flow, typically in the 140 to 160 FPM range, flowing into the open front of the enclosure as the dust collection unit is pulling it out through the back wall. While this type of dust isolation requires a higher air flow, which consequently increases the fan volume requirement, the cross section reduction achieved more than off sets the additional air flow requirement. Additionally, the open and well lighted work area is very conducive to worker productivity.

As far as results are concerned, this approach, if sized properly, is 100% effective with absolutely no escape of transient dust into the adjoining work areas. We refer to these enclosures as Contamination Control Booths or CCB’s. They are typically fabricated of light sheet metal and can be quickly set up. A typical interior height would be 8 ft. but they can be easily fabricated in any size. The result is that now the ventilation requirement is sized based on the cross section of the CCB, not the building itself.

As an example, lets assume that the dust generating activities in the room above only took up an area of 20 ft. long by 10 ft. wide and was being generated by hand sanding of product surfaces on individual work tables. A CCB could be erected with floor dimensions of 10 ft. wide by 20 ft. long with an overall height of 8 ft. The cross section to be ventilated is now only 10ft. x 8 ft., or a cross section of only 80 sq. ft. Since the front of this CCB is open we would need to generate an airflow of 140 FPM to provide isolation of the dust inside the CCB, but even at this higher air flow rate, the CFM requirement is now only 11,200 CFM or roughly half the amount needed to accomplish the same task in the entire room.

III. SYSTEM TYPE

Now that we have a handle on sizing the system, the next question is; what type of system will be the most cost effective for a given operation? There are two variables which ultimately determine the cost of any dust collection system.

1. How much air volume is required?
2. How much energy (horsepower) will it take to achieve it?

The first step is to do everything possible to minimize the volume of air required to control the dust. This is where the grouping and, perhaps, the use of CCB type enclosures can dramatically reduce the ultimate cost of the system required. The next step is to configure the dust collection components to minimize the amount of energy required to provide the established air volume.

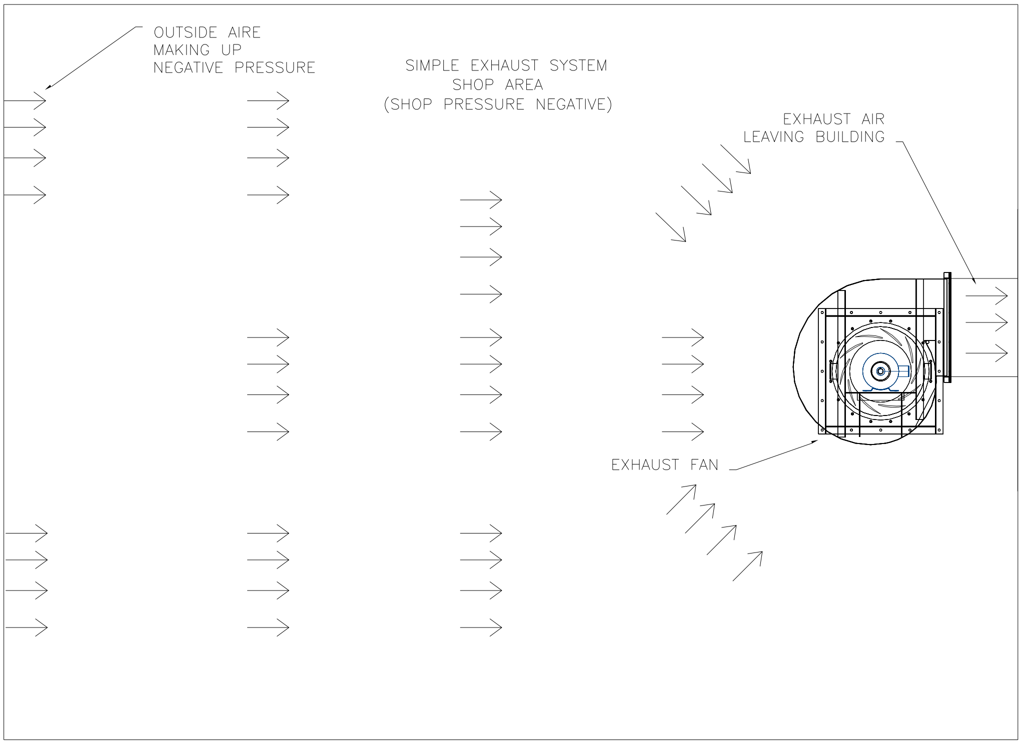
The cost of horsepower is significant. Assuming an average cost for industrial power is approximately 8 cents per kilowatt hour (KwH) and your facility operates a single shift, 5 days a week for 52 weeks, a 5 HP fan will cost $805 per year to operate. If that fan needs to be 30 HP to provide the same volume because of ducting or other installation considerations, the cost to move the same volume of air will be $4,238. It is easy to see how important it is to understand your particular dust collection problem and find the best way to control it.

Locating the dust collector as close as possible to the area it is filtering is one way to reduce the ducting required and, consequently, the fan horsepower. Ducting produces friction or resistance to flow for any fan system and the only way to overcome that is to use a bigger motor. The more ducting needed for your fan, the more horsepower will be required.

Minimizing the area to be filtered is another great way to reduce fan size requirements. If the entire area can't be located inside a CCB type enclosure, the use of a dropped ceiling is the best method of greatly reducing the fan volume requirement since it reduces the cross section and therefore the total volume of air required. This is one of the easiest and best value facility modifications you can make to maximize dust collection efficiency and minimize energy consumption.
There are many types of basic and hybrid systems available for removal of air borne contamination, but for the purpose of this paper we will address four of the most common:

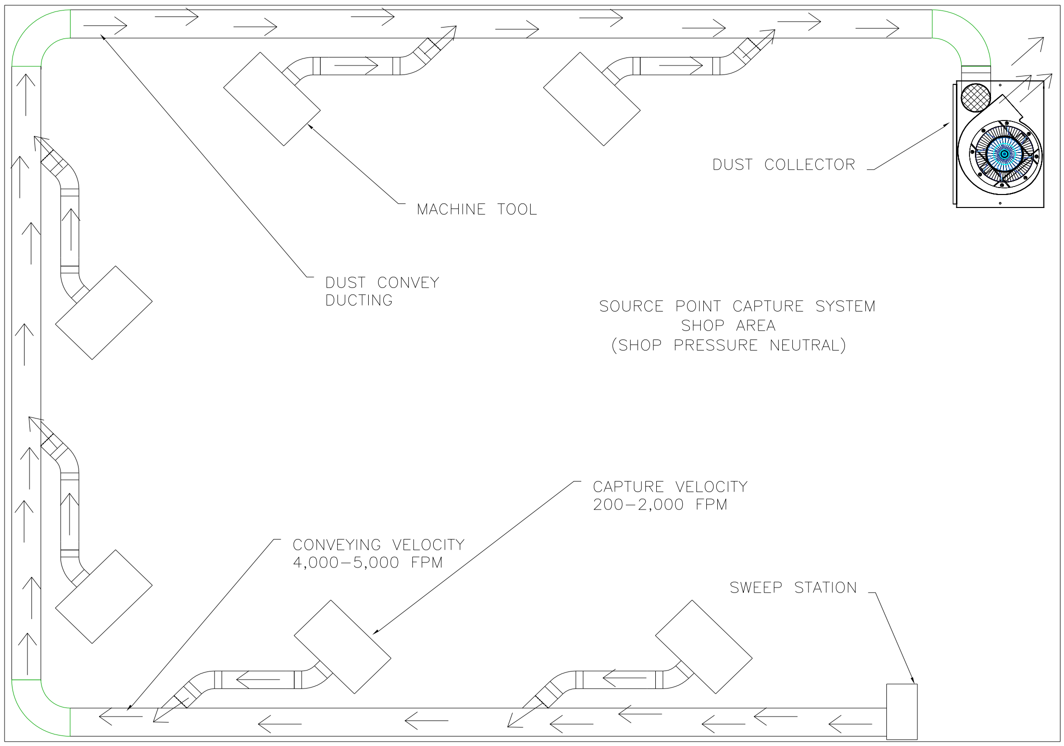
1. Simple Exhaust Units
2. Source Point Capture
3. Push-Pull Re-circulating
4. Negative Pressure Re-circulating

SIMPLE EXHAUST SYSTEM



<u>Simple Exhaust Unit</u>: The simplest and by far the least expensive, from an equipment standpoint, is a simple exhaust system. This type of system provides only the very lowest of filtration efficiencies if it provides any at all and is not a viable option in many parts of the Country due to State and Federal air pollution regulations. When it is a viable option, its use will be restricted to those applications where only a small amount of non-listed dust is generated and only in areas where the exhausted contamination will not affect surrounding neighbors. These types of situations are very rare. This type of collection only makes use of very course filtration media and is utilized more for air movement in the workplace than actual dust collection. The course nature of the filtration media, if any is used at all, results in the ability to generate relatively high CFM volumes with very low horsepower, but the lack of proper filtration leaves the operator open to possible litigation if other than non-restricted dust is passed through the system. The fact that the equipment is relatively low cost, is usually negated by the fact that this type of system must exhaust all the air outside the building, resulting in loss of heated or cooled air. Exacerbating this situation is the further fact that the air exhausted must be replaced from outside air which must then again be heated or cooled. This type of system has limited applications and is not recommended as a method for serious consideration but is only mentioned for the purpose of explanation.

SOURCE POINT CAPTURE SYSTEM



<u>Source Point Capture:</u> A very common type of dust collection uses what is termed source point capture. This type of system can take several forms but usually consists of a central dust collection unit which is connected through a series of ducting to various remote locations. The ducting can be attached to stationary dust generating equipment such as saws, grinders, routers or mills or it can simply be connected to a collection hood mounted on a work table. The dust generating point on a piece of equipment is usually enclosed by some form of a hood, which connects to the duct. As the machine operates and dust is generated, the dust collector pulls air through the hood, capturing the dust before it can be dispersed into the air around the equipment. It then filters the dust and exhausts the filtered air, either back into the workspace or outside the building depending on the installation type.

When this type of system is connected to a hood on a work table, a worker will generally be performing some type of hand work in front of the collection hood or capture zone, allowing the contaminate generated to be pulled into the hood and into the dust collector. These are commonly used for such things as soldering or light cleaning of dust generating products. Capture zones, or the area within which the capture velocity exists, is usually very small. A typical capture zone will lose over 90% of its capture velocity within the distance of one conveying duct diameter from the face of the hood. This greatly limits the effectiveness of this type of system, especially when they are utilized for operations where an operator is moving parts back and forth in front of the hood. Once outside the capture zone, dust will simply migrate as fugitive dust throughout a room.

A typical effective capture velocity for a soldering operation, where smoke is simply drifting from the tip of the soldering iron, is in the 200 to 300 FPM range. When grinding or sanding, however, the contamination is being thrown off the tool head at such a high speed that a capture velocity of up to 2,000 FPM may be required. This greatly increases the volume and, consequently, the size of the fan required to generate this flow. Of even more concern is the resistance to flow this type of system encounters due to the friction of air flow through the ducting. This equates directly to the horsepower required for the fan.

The source point capture system offers advantages for operations where there are many different machines operating in a large space with no way to effectively group and enclose them for effective dust control. While they are not 100% effective, they can greatly reduce the amount of fugitive dust thrown into the air which, in the case of high speed automated tooling, can be significant. A secondary dust collection system for surrounding air is generally also required but can be significantly reduced in size with volumes calculated on air changes in a room per hour rather than on air flow velocities in FPM.

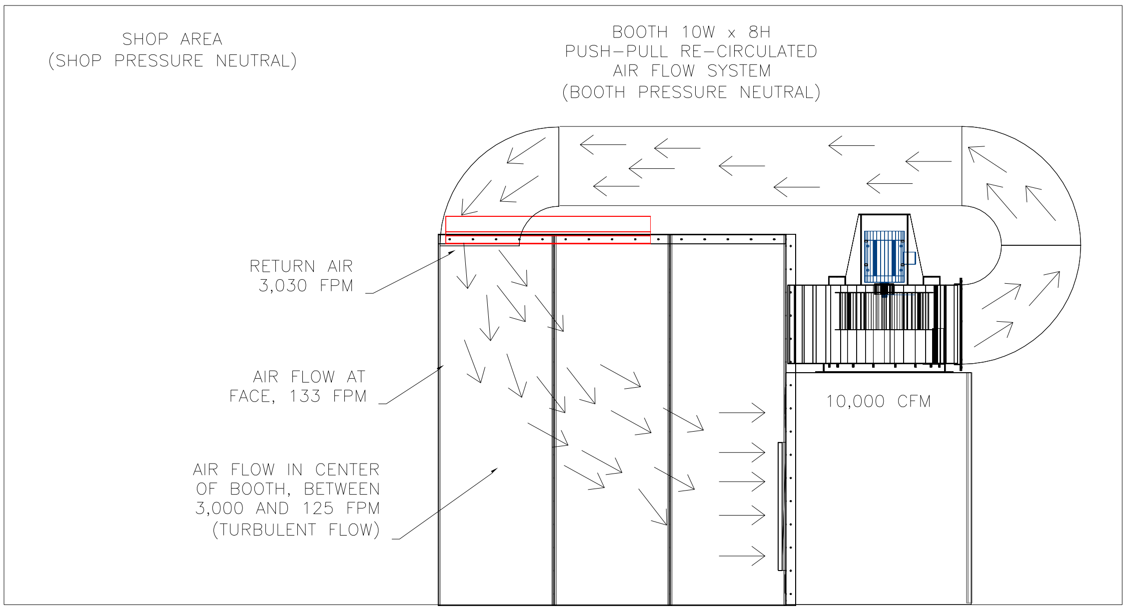
Another form of source point capture system is known as a down draft table. In this system, the dust collector and inlet hood are built into the work table with the table top being the inlet hood opening. The table is usually covered with a grating or mesh material which allows the air to be pulled through the table surface where it is directed into the filter system with the filtered air being exhausted back into the work area.

Down draft tables, while very effective for operations such as soldering or light sanding, are not commonly used for heavy grinding or sanding operations. This is due to the need for relatively high capture velocities or the velocity of the air as it enters the capture hood or table top opening when dealing with grinding or sanding operations. A down draft table system can be very effective for a variety of applications but, as with other types of source point capture systems, it will not capture 100% of the transient dust. If the purpose is to significantly reduce air borne dust contamination they will be of value but if absolute control is necessary this type of system will require a secondary dust collection system to collect dust which will inevitably escape the table capture zone.

Re-Circulating:

The most cost effective dust collection system for areas that can be enclosed is what is known as a re-circulating system. In this type of system the dust collector, whether located outside the building or inside, will pull air from a work area into an inlet device where the air will then be directed through filter media. The contamination will be trapped in the filter media and the clean air will be exhausted back into the work area. This results in no pressure balance issues within the room and does not result in the loss of heated or cooled air. The contaminated air is simply circulated through a filter system and then back into the room. The re-circulating method of dust collection generally take one of two forms:

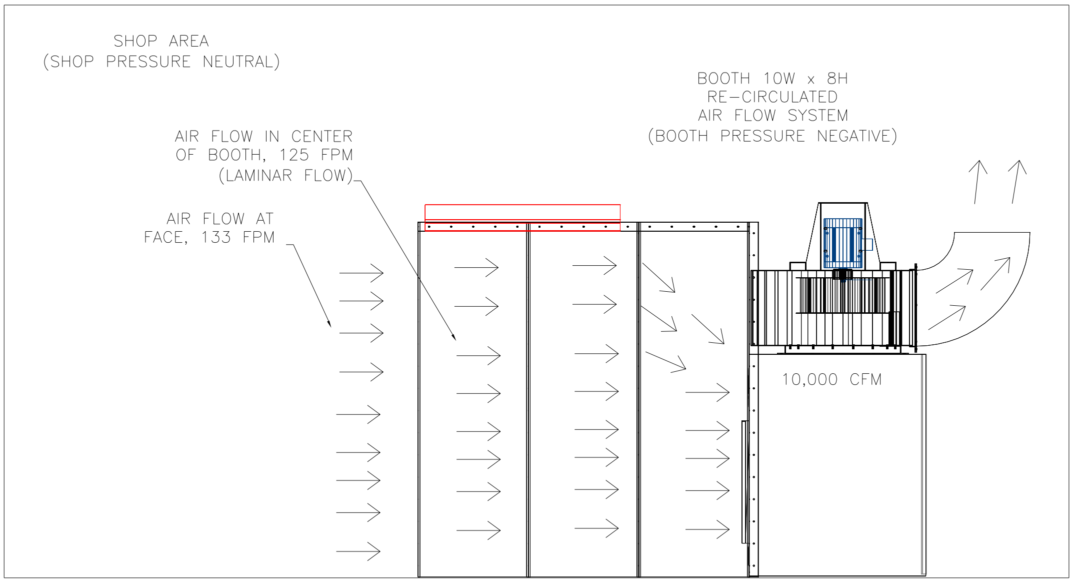
PUSH-PULL RE-CIRCULATING



1. <u>Push-Pull:</u> A method where the air is pulled into the dust collector at one end of a room or enclosure and the filtered air is channeled through ducting to the far end of the room or enclosure where it is then exhausted. This results in a Push Pull effect since the air is being pushed by the clean exhausted air toward the dust collector inlet while it is at the same time being pulled out of the work area and through the filters. This type of system is best suited to large rooms where it is not cost effective to erect smaller enclosures or CCB 's and the room size makes it un-economical to ventilate in its entirety. Let's use for an example a large room with dimensions of 200 ft. long by 100 ft. wide and a ceiling height of 25 ft. Let's further postulate that a conveyer system is moving parts along a route and at various points, some activity is taking place that will create some sort of air borne contamination. While the contamination may not be heavy in any one location if left uncontrolled a dust film would soon form over everything in the building. In this situation, the most economical solution might be to try to keep the contamination in the air until such time as it eventually drifts into the capture zone of one the dust collectors space along one wall. The exhausts from these dust collectors are ducted to the far side of the building where the exhaust streams will essentially blow the contaminated air toward the back wall where the dust collectors are located. While this is not a strictly controlled air flow, it is quite effective and, assuming the total dust load is not too great, it will

prove to me much more economical than attempting to move the air across this distance at a velocity that would ensure capture without the push effect.

NEGATIVE PRESSURE, RE-CIRCULATING



2. Negative Pressure: This method is similar to the push-pull in that it re-circulates all the air back into the work area. The major difference is that the air flow is generated entirely by the air being pulled into the collector with no assistance from the collector exhaust. This system is used when a small enclosure can be erected inside the work area. The air flow generated need only be calculated for the opening of the CCB, not the entire work area. As the collector pulls air through the open side of the CCB it creates a negative pressure within the CCB, eliminating the possibility of any dust escaping the open front of the enclosure. This is true even when a compressed air nozzle may inadvertently be directed toward the opening, thereby blowing dust outside the enclosure. When this happens, the high inflow of air into the enclosure captures this fugitive dust and pulls it back into the enclosure. Air movement is fast enough that there is little to no settling of dust to the floor. The clean air is then exhausted back into the work area where it will eventually circulate around and come through the open front of the CCB once again. This is very cost effective when dealing with a high dust load process or where there is no tolerance for any transient dust escaping the capture zone. In effect, if the work is accomplished inside the enclosure, no matter how high the dust load, there will be zero dust escaping the enclosure. The added advantage to this method is that along with 100% capture, the air volume and thus the fan size required for this system is much smaller than one used for the entire work area. The fact is, however, that besides

isolating dust generated inside the enclosure, the entire building air volume is pulled through in due course and so benefits from the filtration.

Both of these re-circulating systems have their uses and both can be cost effective if selected correctly. A push-pull system incorrectly applied can be less effective and actually cost more than a negative pressure system due to the in-efficiencies of capturing air within a CCB type enclosure. A negative pressure system, on the other hand, can be entirely in-effective at collecting dust from within a large room due to the lack of air flow control which is needed to direct contaminated air into the filter system. Both have their place and when used correctly both will result in a very cost effective system.

IV. THE COST OF ENERGY

There are two major considerations when determining how cost effective a proposed system will be. One is the capture and filtration efficiency inherent in the systems as described above and the other is the energy required to operate that system. While the type of system will dictate what the initial capital cost will be for the equipment, the energy required to operate it will ultimately determine how cost effective the system is.

Energy costs are currently climbing faster than at any time in our recent history and this has a much greater impact on the actual cost of a specific type of system than any other factor. Two identical systems in terms of size, volume and filtration efficiency can have widely different costs of operation. Considering the size of most industrial dust collection systems, the operating cost savings, in a matter of only a year or two, can pay back the entire cost of a well designed system over the cost of a less energy efficient one.

It may help to identify the reasons for the difference in power requirements and costs associated with those differences.

Fan Size: All dust collectors require some type of motive power, usually in the form of a fan or blower. These fans are all rated for size using two points of reference:

1. CFM – Cubic Feet per Minutes or the volume this fan will generate when running full speed at sea level under standard day conditions.

2. S.P. (w.g.) – Static Pressure in inches of water gage. This is a reference to how much resistance to flow a given fan can overcome and still achieve the CFM rating given.

Of these two, only the CFM rating is generally given much consideration. This is unfortunate since it is the S.P. requirement that will determine whether or not the fan will perform the function it was chosen for. As an example, a fan with a rating of 10,000 CFM at 0.75" S.P. may only use a 5 HP motor and will do a fine job of moving air at that static pressure through a paint booth or other type of low resistance system. A 10,000 CFM fan suitable for a typical dust collection system on the other hand, will need to achieve its full rated volume at a resistance of closer to 3.0" or higher to be effective and that type of fan will require 10 HP or more. Both fans have the same CFM but they are vastly different in terms of what they can do.

Using a fan with the incorrect S.P. rating will result in a system that will cost more than it should have at best, and at worst will not do the job. This, unfortunately, is a common occurrence and is only recognized long after the equipment is installed and paid for. This type of problem can be avoided by working closely with your dust collection equipment supplier and ensuring that they know exactly what you want to accomplish. After that; take their advice. Explore the various ways of achieving the collection of your particular dust and then choose the one which is the most cost effective for you.

Things you can do to reduce the total energy requirement are:

1. Minimize the area to be controlled by grouping dust creating processes in one area if possible.

2. Enclose dust creating activities in CCB type enclosures if possible to provide controlled work areas and eliminate transient dust in the remaining work area using a negative pressure re-circulating system.

3. Use Down Draft tables for small, low dust load activities.

All of the methods above will achieve the intended purpose with a minimum use of energy. If these options are not possible then the next steps, in order of efficiency, would be:

1. A push-pull system to achieve a positive air flow across the work area. This will require higher horsepower fans due to the ducting requirements, but the air is being re-circulated which will provide some energy savings while achieving a generally satisfactory level of dust collection. This method assumes some tolerance for transient dust but will provide a much improved environment over the same area without benefit of this type of system.

2. A source point capture system to collect as much of the high dust load as possible at the source with a secondary system of lower volume to collect transient dust over a longer time period. Once again, this system assumes some level of dust tolerance in the work area. The degree of tolerance will determine the size necessary for the secondary system.

   This is the most expensive system to operate from a volume of air to horsepower ratio since these systems typically operate at static pressures of 8 to 10 inches or more and even at relatively low volumes in the 4,000 to 6,000 CFM range can require fans in the 50 to 75 horsepower range or higher. Annual cost to operate a 75 hp fan using the assumptions given in Section III above is approximately $9,534.

V. CONCLUSION

No matter what type of system you may decide to use, it is important to know the factors that determine not only the efficiency of the system but also the cost of operation. You don't necessarily want the least expensive and you certainly don't want the most expensive. What you want is the most COST EFFECTIVE.

By working with a knowledgeable professional, whether that be an air quality engineering consultant, or a trusted manufacturers representative or distributor, determine what type of system will best suit your needs. Once that has been accomplished you will be ready to help design the system you require. Done properly you will be rewarded with a piece of equipment that will greatly improve your workplace and worker pride while also improving your bottom line.