

CITY DUST CONTROL

ABSTRACT

Two types dust control systems are utilized in the mining industry. Most familiar is the high velocity design, where air velocities in the ductwork are in the range of 3,000 to 4,000 feet per minute (FPM). The other design is the low velocity system, where transport velocities are less than 1,800 FPM. There are significant advantages to the low velocity transport design.

A high velocity system carries all particles collected through ductwork to the dust collector. This system's disadvantages are that maintenance costs are higher, product is lost to the dust collector, and the system requires more energy to operate. The ductwork is subjected to highly abrasive blasting from the coarser dust particles. A single hole worn in a high velocity duct can imbalance the whole system, and dramatically reduce its effectiveness in controlling dust exposure.

The low velocity design is a dust containment system where only the fine, primarily respirable size particles are moved to the collection device. Coarser particles, which are contained, rather than conveyed, are returned to the process stream. It is important to remember that low velocity does not mean low airflow. Pickup air flows, capture velocities, hood design and static pressures at the pickup points are the same in either a low or high velocity transport system. The term low velocity only refers to that part of the ducting system downstream from the pickup point.

The advantages of the low velocity system are lower maintenance costs, lower energy consumption, and more reliable dust control. The system is less likely to lose effectiveness due to wear. Although the low velocity system has a higher initial capital cost, over the life of the system this is offset by lower energy and maintenance costs.

APPLICATION WITHIN UNIMIN

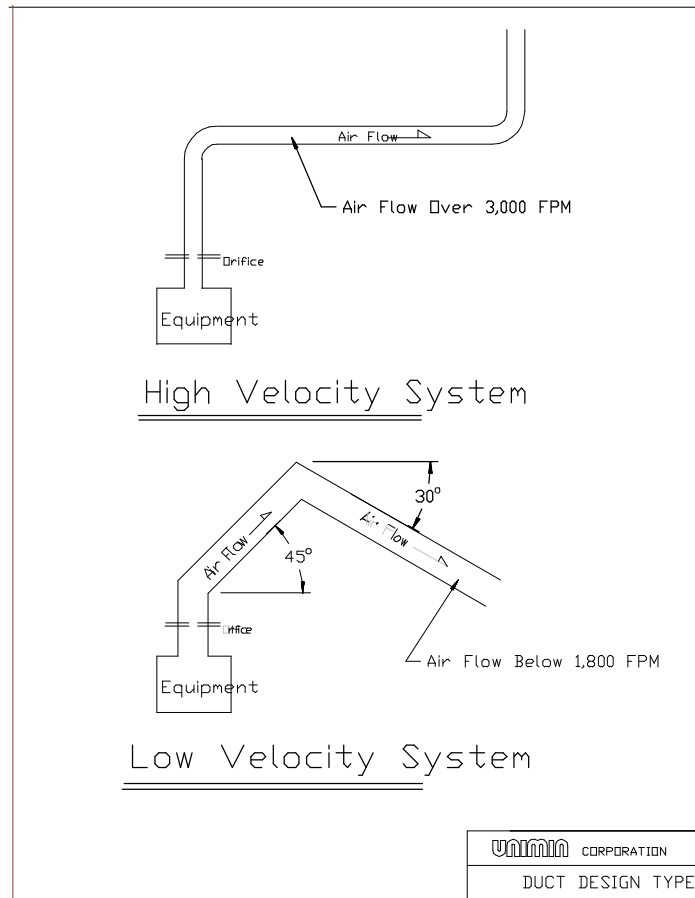
Unimin Corporation is a global mining company, extracting and processing industrial minerals at over 100 operations in 13 countries on four continents. Several of the minerals mined (including silica, feldspar, and nepheline syenite) are very abrasive, resulting in unacceptable wear and poor performance with high velocity dust collection systems. This has led to the development of low velocity dust control, which the company has been applying with excellent success for almost 30 years.

TYPES OF DUST CONTROL SYSTEMS

There are two basic types of dust control systems, characterized by the transport velocity of the dust from the pickup point to the dust collection device. (See Figure 1.)

utilizes velocities in the range of 3,000 to 4,000 feet per minute (FPM) to transport dust from one end of the system to the other. This is a true dust **collection** system. The second system, and the one adopted by Unimin as its standard design, is the low velocity system. As opposed to a dust **collection** system, this approach is better described as a dust **containment** system, with duct velocities always being less than 1,800 FPM. Low velocity systems are designed so that they will not transport coarse particulate, while still removing respirable dust (generally particles less than 10 microns in size).

Figure 1: High Versus Low Velocity Systems



HIGH VELOCITY SYSTEMS

The high velocity system is intended to carry dust laden air from the pickup points of the system to the dust collector, without having the particles settle out in the ducts. Because of the high air velocity and lack of material settling, the ductwork can be run horizontally or vertically. From a construction standpoint, this is a simpler installation

to install. Therefore, most companies use this type of success. This system can give satisfactory performance if properly designed and maintained. However, in the long term, a high price may be paid for this type of system.

Advantages of high velocity transport are:

Ease of Design and Installation: Since the ducting in a high velocity system can be installed horizontally as well as vertically, there are few restrictions on where the ducting can be run. Very neat ducting layouts can be easily designed, normally with a central horizontal duct and smaller collection ducts branching off to the equipment.

Lower Initial Capital Cost: The initial capital cost of the high velocity transport system is lower due to the simpler layout and smaller duct sizes required for the given air volume.

Disadvantages of the high velocity systems are:

Higher Wear and Maintenance Costs: Ductwork in this system is subjected to highly abrasive "blasting" by the dust particles moving at a high speed. The problem is more noticeable with very abrasive minerals such as silica. Due to changes in air direction, elbows and branch entries are particularly vulnerable to wear. Because of this wear, most ductwork and fittings are fabricated from heavier materials, and fittings have long radiuses. The high wear rate results in greater maintenance manhours and material costs.

Less Consistent Operation: A system which has holes in the ducting loses its effectiveness at the pickup point. A single hole in the duct has a much greater affect on a high velocity system than the same hole on a low velocity system since the static pressures are greater. Since high velocity systems are more likely to need maintenance, they will be operating at suboptimal efficiency for a higher proportion of the time.

Higher Electrical Cost: Higher velocity means higher pressure drops throughout the system. This equates to increased horsepower and higher power consumption.

Higher Lifetime Costs: Although the high velocity system is cheaper to install initially, the higher maintenance and operating costs lead to higher overall lifetime costs of the system.

LOW VELOCITY SYSTEMS

The low velocity system is not a dust **collection** system, but rather a dust **containment** system. The basis of this system is to create a negative static pressure in the area

oint, maintaining adequate air flow to prevent dust
The low velocity system relies on maintaining a
negative static pressure at the pickup points and within the enclosed equipment.

The transport velocity is designed to move only the finer particles, particularly those in the respirable size range, generally less than 10 microns. Ductwork in the low velocity system cannot be run horizontally. Respirable dust is removed by the low velocity air flow, while heavier particles, will not be transported. Therefore, the ductwork must be designed so that the larger particles will fall back into the process. A sloped, saw tooth design is used instead of long horizontal runs. In order to control the air flow, a fixed orifice is positioned in the duct segment, preferably on a downward run, so as not to trap material above the high velocity flow through the orifice (resulting in wear). A properly designed and balanced low velocity system will provide a plug free and virtually maintenance free dust control system.

Advantages of the low velocity system are:

Low Wear and Maintenance Costs: Because of the absence of larger particles, as well as the lower velocities involved, abrasion is very low even at points where the air changes direction. This allows for the use of short radius or mitered elbows without fear of extreme wear.

Lower Energy Costs: Dust control systems are designed for expected pressure losses within the system. These losses are due to air friction and pressure losses across the dust collection unit. By reducing the air velocity, frictional losses in the ductwork and fittings are reduced, lowering overall power requirements.

Higher System Availability and Reliability: Moderate orifice size changes can be made without completely upsetting the system. Even opening a branch completely will not drastically change the air flow in other branches because the change in pressure drop is small. Should one branch of the network fail or change flows dramatically, the system tends to stay in balance and other branches do not lose effectiveness. The air flow can vary substantially on two identical pieces of equipment while maintaining excellent dust containment.

Higher Product Recovery: The low velocity system does not transport product size particles to the dust collector, leaving them in the product. Losses through the dust collection system are therefore lower.

Disadvantages of the low velocity system include:

Higher Initial Capital Cost: The requirement to pass a certain volume of air (CFM) through the duct at a predetermined velocity (FPM) dictates the diameter of the duct. As a result, a low velocity system requires larger diameter ductwork than

al air flow. Secondly, because ductwork cannot be design is used which adds to the cost of installation. There is more length of ducting in a low velocity system, and it is more complicated to install. Visually, the saw tooth runs are not as neat as tight horizontal runs.

More Complicated Design: The design and layout for a low velocity system require more engineering. Since runs cannot be horizontal, it is sometimes difficult to find room for the required sawtooth design of the ducting.

DESIGN OF DUST CONTROL SYSTEMS

All systems, whether simple or complex, have in common the use of hoods, duct segments, special fittings and a collector that leads to the exhaust fan. In fact, a complex system is merely an arrangement of several simple exhaust systems, connected to a common duct.

The basic sequence of designing the control system is to start at the equipment and describe each branch in terms of necessary airflow, velocity, duct size, and fittings. Using the velocity pressure method, pressure losses are calculated by branch. In a complex system, the branches must be balanced by the use of orifice plates. The overall flow rate and pressure loss determine the size of exhaust fan that is needed.

The design is normally completed using a spreadsheet which includes the necessary formulas and makes balancing the various branches easy. (Such a spreadsheet is included in the Unimin Engineering Standard referenced at the end of this paper.)

It is important to keep in mind that low velocity transport does not mean low airflow. Capture velocities and hood airflows are based on the Industrial Ventilation Manual published by the American Conference of Governmental Industrial Hygienists, and are the same in either system.

PRACTICAL DESIGN TIPS FOR LOW VELOCITY DUST CONTROL SYSTEMS

It has been said that "Experience is the best teacher". This is especially true as related to the design of an efficient, reliable, and trouble free dust control system. The following points are based on Unimin's experience in installing and maintaining these systems at our plants.

1. Airflow Target of 1,800 FPM

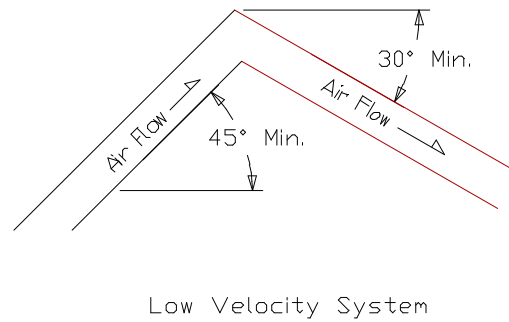
Because of the nature of a low velocity system, it is not necessary to maintain a specific air velocity within the ductwork. No flow should be greater than 1,800 FPM to keep abrasion low. The normal velocity target for individual equipment branch lines is 1,800

ductwork should be designed for less than 1,800 FPM in order to

2. Avoid Running Ductwork Horizontal

As a result of the system's low velocity, ductwork cannot be run horizontally. Larger dust particles that are drawn into the airstream would drop out in the duct, and would build up in a horizontal duct. Therefore, ductwork should be designed for a minimum upflow angle of 45° and a minimum downflow angle of 30°. (See Figure 2.) This will allow any particles that are drawn into the airstream to slide back to the source. A dropout point must be located at the low point of all duct runs, to allow any trapped particles to fall out. In most cases, there is likely to be a convenient process point at which to deposit particulate.

Figure 2: Angled Ductwork in Low Velocity System



3. Use of Main Duct Trunk Lines

The system design should use one or more main trunk lines, running from the air filter to a central location in relation to the dust control points. Smaller branch duct lines are then run from the main to the individual pieces of equipment. These trunk lines can be rectangular as well as round. In areas where space is a problem, rectangular duct cross-sections that are shallow in depth and wide are easier to install. These trunk lines can be run vertically up the side of an existing column or bucket elevator. Remember to allow a dropout point at the bottom, possibly into the bucket elevator.

4. Minimize Field Fits and Welds

New ductwork and fittings should be shop fabricated and be as complete as possible before it is sent to the field for erection. Any time a torch is lit or a welding machine is started in the field, it becomes time consuming, costly, and most likely will result in a



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t. Extra time spent at the design stage, preplanning and duct segments, will pay big dividends later during installation.

5. Use of Rolled Angle Ring Flanges

Flanged connections are an efficient and easy means to install ductwork in the field. Rolled angle ring flanges are readily available, inexpensive, and easy to install. These flanges should normally be used on all shop fabricated fittings, hoods, and duct segments.

6. Predetermine Required Field Fits

There are occasions when field fits must be made. Many times we can anticipate where these fits will be required before the material is sent to the field. It is best to make field cuts and welds at the flange point of the ductwork. The ductwork can be intentionally shop fabricated longer than needed. A rolled angle ring should be shop installed at the end of the duct, and tack welded only. This will keep the ductwork from becoming distorted during handling and transit. The tack weld can then be cut in the field, the duct shortened, and the flange moved, rotated and welded as required.

7. Avoid Mitered Elbows Greater Than 90

Pressure losses in ductwork increase rapidly with abrupt directional changes greater than 90 . Since duct pressure losses are a function of the velocity squared, the low velocity system still results in lower pressure losses compared to a high velocity system. However, you may want to consider using a segmented elbow in areas of unusually abrupt change in air direction.

8. Size Orifice Plate for 2" Minimum Pressure Drop

An orifice plate, sized for a minimum pressure loss of 2", should be installed in each individual branch line. This is to allow the flexibility to easily expand the system in the future. As additional branch lines are added to the main trunk line, the orifice plate can be re-sized for a larger orifice opening (giving less restriction).

9. Orifice Plate Location

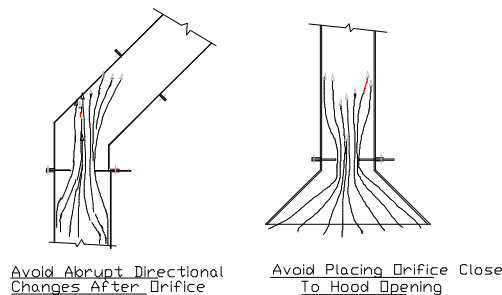
Install orifice plates a minimum of four to five duct diameters upstream and four diameters downstream from air directional changes. (See Figure 3.) This is to allow

to re-establish normal velocity. If an orifice plate is installed in a duct with a sharp directional change, the higher velocities encountered through the orifice opening will produce a sandblasting effect on the far side wall. Orifice plates should be installed in the downflow branch leg whenever possible. This will help to avoid having a buildup of heavier dust particles above the orifice plate.

10. Avoid Placing Orifice Plates near Hood Opening

Orifice plates should not be installed near hood inlet openings (as in Figure 3). Higher velocities near the orifice tend to capture unwanted material. Hood capture velocities below 500 FPM should be maintained. On fine grind materials, a target capture velocity of 200 FPM is desired.

Figure 3: Orifice Plate Locations to Avoid



CASE STUDY

In order to confirm that low velocity dust control can be justified, not only in terms of reduced employee exposure, but also on an economic basis, both low velocity and high velocity designs were prepared for a simple dust control system. This system provides 7,000 ACFM of ventilation for four vibrating screens and two belt conveyors. (Recall that the airflow is the same for both the low and high velocity designs.)

The capital costs for the each design are as shown in Table 1. The hoods are the same in each case. However, ducting is more expensive in the low velocity design due to the additional length and diameter. The dust collector is the same in each case (since the airflow is the same). A fan capable of generating greater static pressure, along with a larger motor is required for the high velocity system. Engineering and installation are more complex with the low velocity design, resulting in increased costs.

Overall, the capital cost for the low velocity system is \$13,600 greater compared to the high velocity system.

Table 1: Capital Costs

	High Velocity	Low Velocity	Difference
	\$12,500	\$19,500	(\$7,000)
Dust Collector	\$25,200	\$25,200	\$0
Fan & motor	\$6,100	\$5,200	\$900
Stack	\$6,000	\$6,000	\$0
Installation	\$24,900	\$28,000	(\$3,100)
Engineering	\$5,200	\$8,400	(\$3,200)
Contingency	\$8,000	\$9,200	(\$1,200)
Total	\$87,900	\$101,500	(\$13,600)

Operating costs are shown in Table 2. Due to the increased pressure drop in the high velocity system, the horsepower drawn by the fan is significantly greater. Based on a power cost of \$0.07 per kWh, the annual savings in electricity for the low velocity system is \$3,100. A further \$2,000 savings in reduced duct repair is also to be expected with abrasive particulate. The total annual savings is then \$5,100, leading to a payback of 2.7 years on the incremental \$13,600 investment in the low velocity design. Therefore, although the primary reason for the low velocity design is to ensure that worker exposure is minimized over the long term, there is, in fact, a financial justification as well.

Table 2: Operating Costs

	High Velocity	Low Velocity	Difference
Flow (ACFM)	7,000	7,000	0
P (%w.c.)	16	10.6	5.4
Fan horsepower	29.4	19.4	10
Power Cost (@ \$0.07/kWh; 60% fan efficiency; 90% power factor; 5,400 hrs/yr)	\$9,200 /yr	\$6,100 /yr	\$3,100 /yr
Maintenance Cost (Duct repairs only)	\$2,000 /yr	\$0 /yr	\$2,000 /yr
Total Operating Cost	\$11,200 /yr	\$6,100 /yr	\$5,100 /yr

Table 3: Payback Calculation

	High Velocity	Low Velocity	Difference
Operating Cost	\$11,200 /yr	\$6,100 /yr	\$5,100 /yr

	\$87,900	\$101,5000	(\$13,600)
	-	-	2.7 years
Incremental Capital Cost			

CONCLUSIONS

From the experience Unimin has had in operating both high velocity and low velocity systems, we have found that the low velocity transport design offers significant advantages over the high velocity design. Maintenance and power requirements are lower. The system is more reliable, and therefore, functions properly for a higher proportion of the time. The higher initial cost is offset by longer life and lower operating costs. Most importantly, the low velocity design results in lower, long term dust exposure to our employees.

Unimin Corporation makes its internal Engineering Standard for Dust Control Systems available to anyone who is interested in receiving a copy. This standard includes a more detailed discussion of the information in this paper. There are additional sections on the principles of airflow, and the methodology of airflow computations using the velocity-pressure method is described with examples. Copies of this standard may be obtained by contacting:

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