How to protect your dust collection system from system effect loss

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If you don’t consider system effect loss (pressure loss) as you’re designing your dust collection system, the actual airflow through the system at startup can be surprisingly lower than the design airflow. This can reduce the system’s dust collection efficiency to a point that affects your workers’ health and your product’s quality. Read this article for tips on how to protect your system from the system effect loss caused by some fan inlet and outlet connections.

The consequences can be serious when a newly installed dust collection system’s total airflow is dramatically lower than that called for in the system design documents. The system’s reduced airflow can result in hazardous conditions for workers because the airflow through capture hoods is too low. System ductwork can plug because the low airflow slows dust transport, causing dust to settle out of the airstream. Too little airflow can prevent the system from capturing fugitive dust, which can re-enter the process and contaminate product. Reduced airflow can also prevent cyclones and scrubbers from efficiently collecting dust, resulting in excessive stack emissions.

If you notice that the performance data published for your exhaust fan doesn’t match your system’s actual airflow, try to eliminate simple causes first. Check whether the system’s components, including capture hoods, dampers, ductwork, dust collectors, cyclones, scrubbers, and the exhaust fan, are working properly. Also review your static pressure calculations to be sure you haven’t made any obvious design miscalculations.

The frequently overlooked cause

If your system’s components and your design calculations aren’t at fault, the significant airflow reduction is most likely caused by a less-than-ideal (nonstraight) ductwork connection at the inlet or outlet of the exhaust fan (which is typically a centrifugal fan). The pressure loss, called system effect loss, at such a connection is usually greater than the connection’s friction pressure losses, which are caused by the flowing air’s contact with the duct walls.

What is a less-than-ideal connection? An example is a duct elbow rather than a straight duct section attached to or near the fan’s inlet or outlet. Straight duct attached to the fan inlet promotes uniform air velocity into the fan, but an elbow at or near the inlet produces a turbulent airflow pattern for some distance downstream from the elbow. This turbulence produces a nonuniform fan inlet airflow pattern that will affect the fan’s performance. The extent of the resulting system effect loss depends on whether the elbow is attached directly to the inlet or is located some distance away from it. Other less-than-ideal inlet and outlet connections, such as box plenums and offset flexible connections, can also create nonuniform airflow patterns.

When you select a fan for your dust collection system, your choice is based on the fan maker’s published performance data (called a performance curve or pressure-volume curve). Based on these fan ratings, you can select a fan that will provide the airflow your system requires. But here’s where the problem arises: Many of us don’t realize that the fan maker’s performance data is based on tests using only straight duct sections attached to the fan inlet and outlet.

More about fan performance tests

Most fan makers rate fan performance based on tests established by the Air Movement and Control Association International (AMCA) Standard 210, Laboratory Methods of Testing Fans for Rating. The standard establishes uniform lab performance-testing methods for fans and other air movers. The standardized test arrangement it calls for — straight duct sections attached to the fan inlet and outlet — isn’t intended
to exactly reproduce any field installation. In fact, the multitude of possible inlet and outlet connections found in actual fan installations is impossible to simulate in a lab. But the standardized tests allow you to reasonably compare fan ratings by different fan makers.

Of course, unlike a fan in the AMCA test arrangement, your fan will be installed in a real plant where you can't always use straight duct at the fan inlet or outlet. In the tight space left by equipment, floors, and walls in your plant, often no room is left to install straight duct at the inlet and outlet. Using a less-than-ideal connection—a duct elbow or other connection without straight duct—can be the only option you have.

So if you choose a fan based on published performance data without considering the system effect loss caused by your actual fan inlet and outlet connections, the fan's performance won't match the published performance data and your dust collection system won't operate with the airflow you need. Once your system is installed, it's extremely difficult to solve these problems. Avoid them by considering system effect loss before selecting your fan.

**How the SEF is used to select the right fan**

Take a closer look at how system effect loss reduces fan performance by examining Figure 1. [Editor's note: Information in this section and the next has been adapted from information in AMCA publications. To contact the organization or obtain copies of the publications, see reference 1.] Figure 1 graphically represents the system effect loss in a dust collection system with a less-than-ideal fan connection of some type. You can assume that the system's designer accurately calculated the system pressure losses shown in curve A and selected a suitable fan for the system's desired operation at point 1. However, you can see that curve A makes no allowance for the effect of the nonstraight fan inlet and outlet connections on the fan's performance. To compensate for this effect, the system designer should have added a system effect factor (SEF) to the calculated system pressure losses shown in curve A and, from this, determined the system's actual performance curve (curve B).

Point 4 is the intersection point between the fan's performance curve (called "Fan catalog pressure-volume curve" on the figure), as published in the fan maker's catalog, and the system's actual performance curve (curve B). So the system's actual airflow will be deficient by the difference between points 1 and 4.

To achieve the system's design airflow, the system designer should have added an SEF equal to the pressure difference between points 1 and 2 to the calculated system pressure losses (curve A). Had the designer done this, the fan would have been selected to operate at point 2, and the dust collection system would have operated at the design airflow.

**Determining the SEF for your system**

When you design your dust collection system's exhaust system, determine the SEF for the fan inlet and outlet connections from a system effect curve chart, such as the one shown in Figure 2. This system effect curve chart has been published for a range of typical fan inlet and outlet connection configurations in AMCA Publication 201-90, Fans and Systems. In the chart, curves for various connection configurations are labeled with letters F through X; the letter corresponding with a particular connection configuration is identified in text accompanying the chart (not shown in Figure 2).
By entering the chart on the curve for your particular connection configuration at the fan’s inlet or outlet velocity, you can read across the curve to find the correct SEF. Add this SEF, given in inches of water gauge, to your total calculated system pressure losses as you make your system design calculations. This will enable your dust collection system to operate at your design airflow.

Some installation tips
Once you’ve determined the SEF and selected the proper fan, follow these steps to successfully install your dust collection system:

1. Have the engineer who designs your dust collection system produce detailed design documents that specify the exact fan inlet and outlet connection configurations. This will ensure that the sheet metal contractor who installs the system isn’t left to guess which configurations to use.

2. Ensure that the sheet metal contractor follows the engineer’s design documents by having the engineer review and approve the contractor’s shop drawings of the connection configurations before system construction begins.

3. Allow no changes to the connection configurations during construction unless the engineer in charge approves them.

The detailed design documents will also allow sheet metal contractors to produce more accurate bids and help you avoid awarding your system’s construction to an unusually low bidder who later delivers a bill for several cost extras. The documents will speed up the construction phase, help you and the contractor communicate more clearly, and result in a smoother system startup.

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Reference
1. AMCA, 30 West University Drive, Arlington Heights, IL 60004-1893; 847/394-0150, fax 847/253-0088 (e-mail: amca@amca.org).

For further reading
Find more information on dust collection in articles listed under “Dust Collection and Dust Control” in Powder and Bulk Engineering’s comprehensive “Index to articles” (in the December 1998 issue and on PBE’s Web site, www.powderbulk.com).