



# WHAT A *DRAG*

**CHRIS POLIZZI, WL GORE & ASSOCIATES,  
USA, ADDRESSES THE BENEFITS THAT CAN  
BE GAINED BY INSTALLING FILTER BAGS WITH  
THE LOWEST POSSIBLE DRAG.**

## **Introduction**

Filter bags are a drag! Literally, they are a drag! It doesn't matter whether they are filter bags or pleated filter cartridges. Nor does it matter if they are conventional filter bags or ePTFE membrane filter bags. It also does not matter whether they are reverse air bags or pulse jet bags. Webster's dictionary states the meaning of drag as 'something that retards motion, action, or advancement.' In other words, drag can be viewed as the resistance something experiences. So filter drag is the total resistance of the filter media and the dust. The combination of the media and the dust in and on the media are a significant resistance in the process ventilation system. The higher the resistance,

the higher the energy consumption and therefore the higher the cost to move the necessary process airflow across the filter media. This article will first introduce the concept of Filter Drag and explain how it is measured. Secondly, we will discuss how filter drag can be used by cement producers to better evaluate different filter media and ultimately how to maximise performance of the process or decrease costs of the baghouse.

## **Filter drag in baghouses**

In a baghouse, filter drag is defined as the relationship between operating Differential Pressure and the actual air to cloth ratio at which the baghouse operates.





$$\text{Filter Drag} = \frac{\text{Differential Pressure}}{\text{Air to Cloth Ratio}} = \frac{dP}{A/C} = \frac{\text{"mm}}{\text{m}^3/\text{min}/\text{m}^2}$$

As baghouse operators embrace the concept of filter drag, they will be able to quantify and reap the benefits of choosing a filter bag with a low filter drag over the entire bag life. Having a filter bag which starts with a low filter drag but increases in filter drag over time negates the benefits we will discuss, as well as adding risk to the overall performance of the baghouse operation. Filter drag of the filter media is important since it affects the environmental performance, maintenance activities and production of a cement plant. Taking a closer look at the filter drag equation, certain components of it are reasonably straight forward, such as the air to cloth ratio. The air is the actual airflow with which the baghouse operates and is typically stated in terms of actual m<sup>3</sup>/minute. The cloth is the area of the filter bags installed in the baghouse stated in terms of square meters of filtration media. The ratio air to cloth gives the denominator of the filter drag equation. The numerator of the equation is the baghouse operating differential pressure in millimetres water gauge. This is the tubesheet differential pressure and not the flange-to-flange differential pressure. Let us take a look at what parameters affect differential pressure along with the differential pressure equation.

$$\Delta P = K_1 v + K_2 C v^2 t$$

K <sub>1</sub>	=	Resistance of the filter media
v	=	Face velocity
K <sub>2</sub>	=	Resistance of the dust cake
C	=	Dust concentration
t	=	Time

Figure 2 is the filtration equation that defines differential pressure and the units of differential pressure are millimetres water gauge. Note this differential pressure equation only calculates the differential pressure across the filter bags (and does not include the differential pressure across the tubesheet or the exit loss through a cage's venturi in a pulse jet baghouse). Let us first take a closer look at the second part of the equation. The second term is referred to as the K<sub>2</sub> term. This is the resistance associated with the dust cake as it forms on the surface of the filter bag in between cleaning cycles. This will vary based on the process dust (shape, size, agglomerating properties, packing density, etc.) and how the baghouse is designed and operated. You can change the impact of K<sub>2</sub>, by cleaning differently, for instance changing the cleaning frequency. The first part of the equation is referred to as the K<sub>1</sub> term. This is the resistance associated with the filter media. The K<sub>1</sub> resistance of both depth filters and membrane surface filters increases over time as the filter seasons or partially blinds in use. An optimal low filter drag filter bag starts with a lower K<sub>1</sub> term and maintains this lower level over the life of the filter bags.

Now you have a clear understanding of which parameters go into the calculation of filter drag and the units of filter drag are mm water gauge/m<sup>3</sup>/min.

Additionally since you know how to calculate filter drag, you may ask yourself, why should I care? By using a filter media that performs at the lowest possible filter drag, cement plants have the operational flexibility to do several things.

### A few examples

Let's look at some examples if a cement plant installed filter bags with a lower operating filter drag. For the sake of the examples, let's consider the benefits of a 15% lower filter drag media.

#### Fan energy savings example

On many of the process baghouses in a cement plant (kilns, clinker coolers, finish mills, coal mills, and raw mills), the fan motors are equipped with a variable frequency drive, VFD. Therefore, by using a set of filters with a 15% lower filter drag, the process could be operated at the same airflow and use the same number of filter bags but operate at a 15% lower differential pressure. By operating with this lower pressure drop, the fan motor could be operated at lower rpms, resulting in savings on the utility cost. For a cement kiln baghouse operating with an airflow of 850 000 m<sup>3</sup>/hr and a baghouse differential pressure of 150 mm water gauge and a typical electric utility rate, a 15% decrease in differential pressure would result in fan energy savings of approximately US\$45 000 a year. Over the life of the filter media, these savings continue each year.

#### Increased airflow example

By utilising a filter media which operates at a 15% lower filter drag, plants wanting to operate at the same differential pressure and using the same number of filter bags could operate at a 15% higher airflow. If a plant has raw mill capacity, cooler capacity and the kiln baghouse as the largest bottleneck to production, this could potentially allow the plant to increase clinker production. Although this is likely a rare scenario, in these plants there would be a huge value. In a high demand or sold out cement market, this would obviously be very attractive to cement plant operators. Understanding how rare it is for the kiln baghouse to truly be the most production limiting bottleneck, cement operators have confirmed more airflow is still of value to plants where alternative fuels are used. This is due to the additional airflow volumes necessary for combustion. The amount of an alternative fuel combusted is often limited by the amount of O<sub>2</sub> available. More available airflow would enable more alternative fuel utilisation which would be a lower cost fuel option relative to coal.

#### Longer filter bag life

For plants desiring longer filter bag life, by operating the process with the same amount of airflow, the same differential pressure and the same number of filter bags, longer life can be reliably accomplished. Because lower filter drag filters will clean down more effectively to a



lower residual differential pressure, the bags will clean less often over time and will therefore last longer.

### Decreased amount of filter bags

For the plant or process that might have a direct drive motor on their baghouse fan and also could not benefit from increased airflow, there would still be a benefit of using a lower filter drag media. These plants could install 15% fewer bags in the baghouse. This decreases the out of pocket costs of filter bags and filter change out labour cost. Additionally, installing fewer filter bags in the baghouse would make the baghouse run better due to lower can/lift velocity for a pulse jet baghouse as well as remove filter bags which may have experienced velocity abrasion in the past.

### Drag performance

Now that we have learned what filter drag means and the benefits of choosing a filter media with a low filter drag over the life of the filter, there may be a question of how to better understand the relative performance of your current filter bag's filter drag relative to potential alternative filter bags. Most cement plant operators have direct experience confirming ePTFE membrane filter bags operating at a much lower filter drag than conventional depth filtration filter bags. What may be interesting to learn is that there is also a fairly sizable range of filter drag performance among the various ePTFE membrane filter bags commercially available.

A reasonable first property to consider might be the permeability of the filter media. However, as we learned earlier, the permeability of a filter media changes drastically whether it is a conventional filter which operates on the principle of depth filtration or an ePTFE membrane filter media which operates on the principle of surface filtration. Even though membrane filters have been termed surface filters, all of the commercially available membrane filters have some level of seasoning or decrease in permeability of the filter media as fine process dust particulate find its way into the structure of the membrane.

Another parameter that might be of interest is the efficiency of the filter media. The rationale may be: the more efficient a filter media is, the more consistent its filter drag will be over time. The data does not support this. Some of the most efficient filters do not provide low filter drag.

Knowing the filter drag from another industry is not a great help either. Filter drag is influenced by the dust characteristics and the dust loading in the application. Recalling that filters season once exposed to dust, the type of dust being filtered affects filter drag. Because of this, filter drag data from one industry will rarely predict performance in a different industry.

For the cement industry and specifically kiln baghouse applications, a parameter found to be a great indicator for the filter drag of a filter is a residual differential pressure curve derived from a filtration performance test similar to the testing used previously as part of the EPA's Environmental Technology Verification Program. See Figure 1.

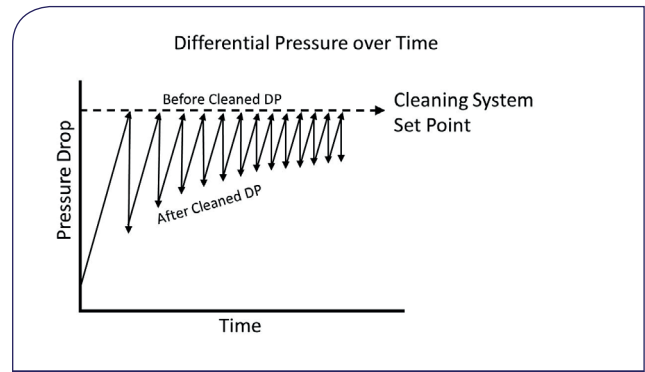


Figure 1. Differential pressure over time.

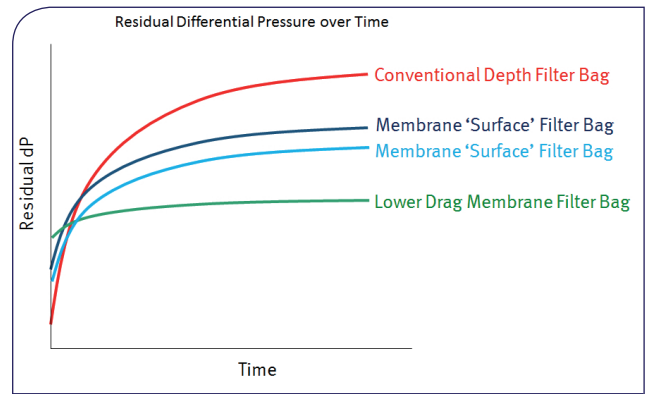


Figure 2. Residual differential pressure over time.

### Conclusion

Correlation performance testing has shown that filter media with low residual differential pressure in the VDI 3926, part 2 testing protocol, have delivered low filter drag performance in cement kiln baghouses. Residual differential pressure is essentially the  $K_1$  term of the differential pressure equation showing what level the seasoned filter media is capable of cleaning down to over the course of the test. W. L. Gore & Associates operate two of the filtration testing devices for both product innovation as well as benchmark testing. Independently, ETSI Environmental Services located in Roanoke, VA operates a filtration laboratory and performs filtration performance testing. They were the laboratory who performed all of the testing for the US EPA's Environmental Technology Verification Program. Archived filtration testing reports for 25 different types of filter media can be found on the EPA's website.<sup>1</sup>

It is valuable for cement producers to know the filter drag of the filter bags used in their baghouse. As you have learned, different types of filter bags have very different filter drag performance over time. See Figure 2.

By installing filter bags with the lowest possible filter drag, cement producers will be able to choose their desired benefit of either 1) fan energy savings, 2) increased airflow, 3) longer filter bag life, or 4) decreased number of installed filter bags. The benefit the cement producer may want at any given time may change based on market conditions, however a low filter drag filter bag will offer them this flexibility. 🌐

### References

1. <http://archive.epa.gov/nrmrl/archive-etv/web/html/exp-apc.html>.