Ineffective Cleaning in Generic Baghouses

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Scientific Dust Collectors

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Introduction

In a typical "generic" baghouse application, the cleaning is accomplished by back-flushing the filter with compressed air that travels through an orifice hole in a purge tube (blow pipe) and through a venturi. The typical venturi is approximately 6 inches long, has a throat diameter of 1 ¾", and placed 2 to 3 inches away from the outside of the purge tube (blow pipe). As the compressed air leaves the orifice, it becomes a jet of air traveling at the speed of sound, Mach 1.0. This jet of air expands under the Law of Conservation of Momentum at a cone angle of about 15° until it is stopped by the throat of the venturi as shown (Figure 1). This same concept holds true for both 4 ½" and 6" diameter bags.

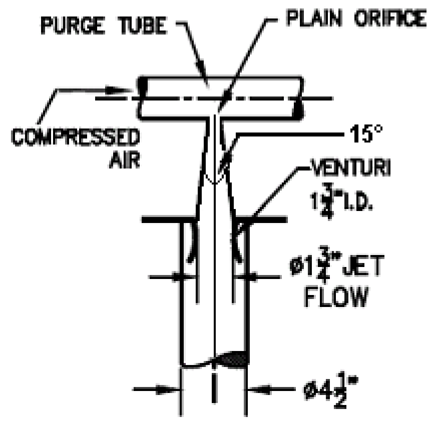

Figure 1. Orifice and Venturi Cleaning System

This cleaning system allows dust to be filtered at an air-to-cloth ratio of 5:1. That means for every 5 CFM of airflow, there is 1 square foot of media used to filter the air. This has been the industry standard for over 50 years. Just because this cleaning system has been standard, does not mean that it is flawless. There are several inherent problems with the orifice and venturi cleaning system. First, due to the proximity between the orifice and throat of the venturi, not enough clean air is induced during the cleaning cycle, and as a result, air is pulled in through the bag from the dirty air plenum to compensate. Second, due to the energy contained within the compressed air and the close proximity to the orifice, as the jet expands and passes through the venturi at high velocity, it overwhelms the surrounding media with air and can create a puffing effect. Lastly, due to the high velocity of air after the venturi, the induced air is forced out of the bag creating another vacuum further down the bag. As a result, there is a large section of the top of the bag that is unusable for repetitive cleaning of the dust.

Scientific Dust Collectors (SDC) on the other hand developed and patented a way of cleaning filter bags without using a venturi. Using a converging and diverging nozzle instead of a generic orifice and venturi, SDC found that the entire length of the bag could be cleaned fully, more effectively, and allow the dust to be filtered at an air-to-cloth of 10:1 or higher while maintaining a lower pressure drop. SDC has recently conducted additional tests to observe this and it is documented in "Advantages of Cleaning without a Venturi in Baghouse Collectors", a corresponding technical paper describing this difference between the generic baghouse cleaning and SDC's nozzle technology. After the completion of the previous technical paper, further analysis was completed to find out the effects of the overwhelming amount of cleaning air and find out how much cleaning air is too much. That is the subject of this technical paper.

Previous Results

Testing was conducted measuring the flow at every inch from the top of the bag from 3 inches to 25 inches. Results showed the consistency in cleaning that the nozzle provides versus the orifice and venturi system, which created four distinct zones. Zone 1 (3 inches to 7 inches) consists of negative flow, or a vacuum, which is required in the orifice and venturi system to compensate for the lack of induced air. Zone 2 (8 inches to 12 inches) consists of extremely high flow just below the venturi. Zone 3 (13 inches to 17 inches) is another region of negative flow that is due to the extremely high flow in Zone 2 pushing out too much air, Zone 3 must draw more air in to compensate for the loss. Zone 4 (18 inches to 25 inches) is where the flow finally stabilizes and continues to be positive flow throughout the rest of the bag. In contrast, SDC's nozzle has consistent positive flow through the entire tested range. The results as can be seen in the comparative table of flow Figure 2.

Zone 1		**3 inches**	**4 inches**	**5 inches**	**6 inches**	**7 inches**
	Venturi	-569	-586	-680	-600	-652
	SDC Nozzle	1025	1221	1436	1057	1181
Zone 2		**8 inches**	**9 inches**	**10 inches**	**11 inches**	**12 inches**
	Venturi	3391	3138	1758	1309	1336
	SDC Nozzle	1118	1153	1208	1256	1128
Zone 3		**13 inches**	**14 inches**	**15 inches**	**16 inches**	**17 inches**
	Venturi	-451	-393	-443	-277	-245
	SDC Nozzle	1079	977	1236	1134	1048
Zone 4		**18 inches**	**19 inches**	**20 inches**	**21 inches**	**22 inches**
	Venturi	880	1014	577	564	574
	SDC Nozzle	1096	1095	1194	1182	1036
			23 inches	**24 inches**	**25 inches**	
	Venturi		582	620	567	
	SDC Nozzle		954	924	1061	

Figure 2. Table of Volumetric Flow (in CFM) from 3 inches to 25 inches for the Venturi and SDC Nozzle.

Further Calculations

To further understand the cleaning cycle, not only must the bag being cleaned be looked at, but also the surrounding bags must be evaluated. All filter media have permeability ratings, which is not the same number as the dust collector air-to-cloth ratio. This is the maximum amount of air (in CFM) that can permeate an area of media (typically in square feet). As a rule, the permeability rating of the media must be equal or greater than the air-to-cloth ratio of the dust collector. The most common form of filter media is singed polyester, because of its adequate filtering ability and relatively low cost. For singed polyester, the typical permeability is roughly 40 CFM per square foot of media. This means for one typical 4 ½" diameter by 8' long bag, taking the surface area of the bag, there is 9.46 ft^2 of available media, and therefore the maximum CFM that one filter bag can absorb would be 378CFM. Using the cross-sectional area (πr^2) of the bag and the formula $Q = V A$, the velocity through the bag is 3,426 FPM.

In a generic baghouse, the typical bag spacing is 1" between the diameters of the bags (or 5 ½" between the centers of the bags). To model the flow in the surrounding bags, the bag being cleaned would need to theoretically increase in size so that it is even with the neighboring bag, this is done by adding 1" to the radius, or 2" to the diameter as shown in Figure 3.

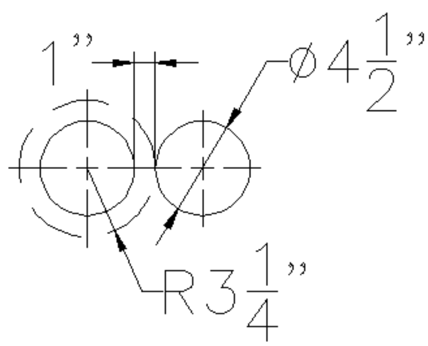

Figure 3. Generic Baghouse 1" bag spacing.

Here, the new bag radius will be **r = 3 ¼"**. Using the maximum velocity calculated earlier from the permeability and the new theoretical cross-sectional area, the maximum flow is 790 CFM. This means that once the flow in the bag being cleaned reaches 790CFM (or a velocity of 7,153 FPM), the air expands outward toward the neighboring bags. As the air expands, it slows down and once it reaches the neighboring bags, it will be traveling at the maximum velocity of 3,426 FPM. Once the air reaches the surrounding bags, it overwhelms them with air, and creates a blinding effect that hinders the overall cleaning performance and can damage the surrounding media. During the cleaning cycle of the orifice and venturi system, the cleaning flow overwhelms the surrounding media in several areas throughout the cleaning cycle as shown in Figure 4.

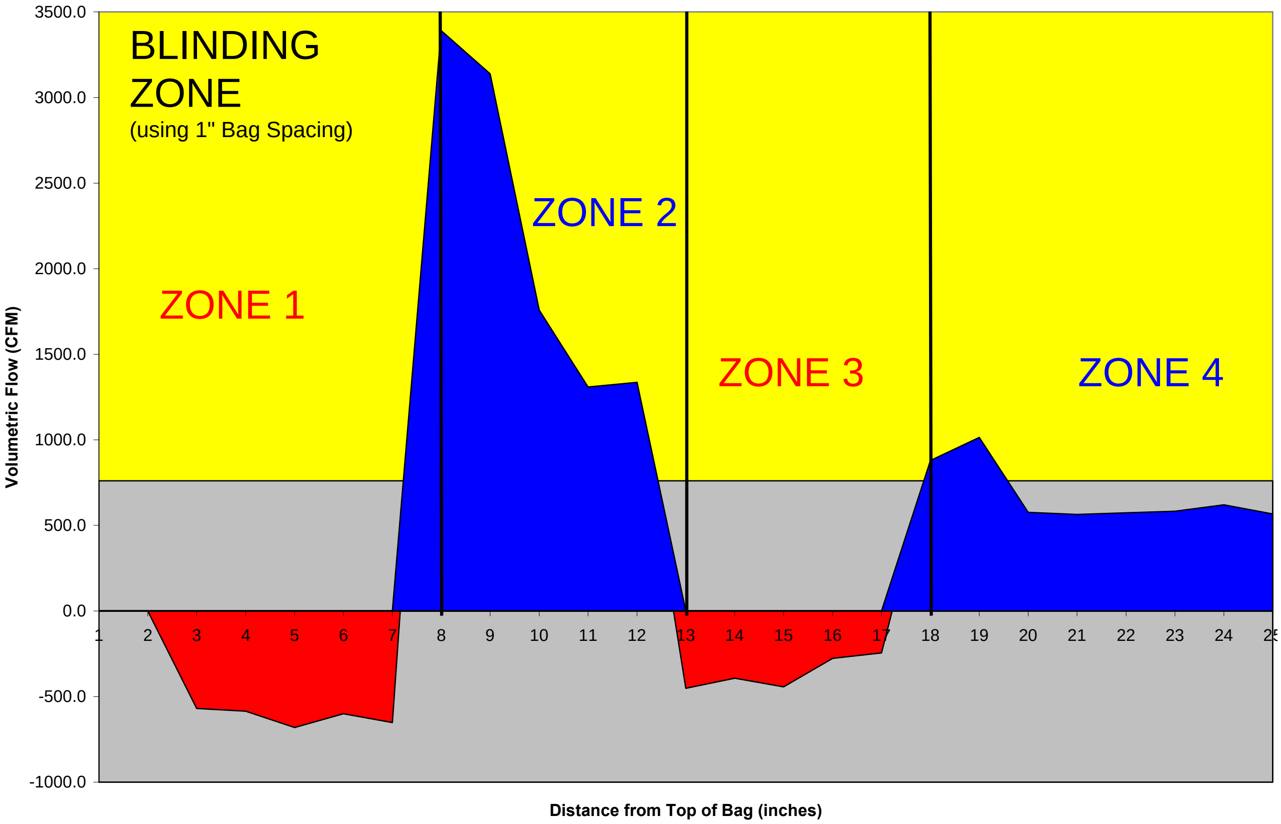

Figure 4. Blinding Zone with Generic Baghouse 1" bag spacing.

From the graph, it is clear that all of Zone 2 is providing excess flow, as well as a few inches in Zone 4 where the flow finally stabilizes.

The previous results shown in Figure 4 above were using 1" bag spacing, which is an industry standard. There are some dust collector manufactures that use wider bag spacing for larger dusts and applications where bridging can be a problem. Wider bag spacing can reach up to 3" between the diameters of the bags (or 7 ½" between the centers of the bags). Using a similar scenario as before, increasing size of the bag so that the new bag radius would be **r = 5 ¼"** as shown below in Figure 5.

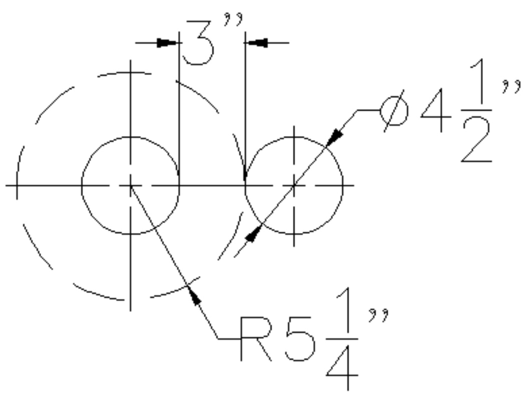

Figure 5. Scientific Dust Collectors 3" bag spacing.

With the maximum velocity calculated earlier, <u>3,426 FPM</u> and new theoretical cross-sectional area, the maximum flow is <u>2060 CFM</u>. Again, looking at this maximum flow allowed graphically the orifice and venturi cleaning system still overwhelms some of the media even at a wider bag spacing as shown in Figure 6.

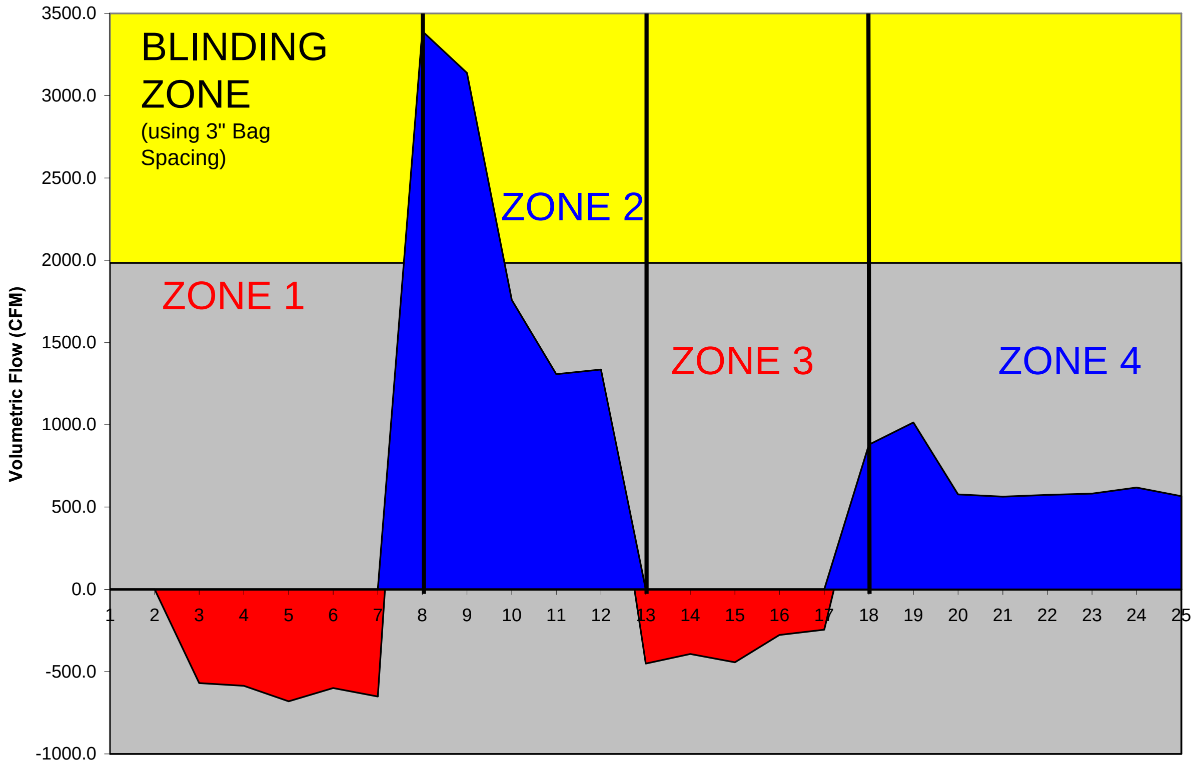

Figure 6. Blinding Zone with Generic Baghouse 3" bag spacing.

At Scientific Dust Collectors, <u>we utilize 3" spacing between bag diameters as our standard compared to the generic baghouse that only uses 1" bag spacing</u>. With the 3" spacing between the bags, our cleaning does not overwhelm the bags, rather it is just the right amount of cleaning as shown in Figure 7.

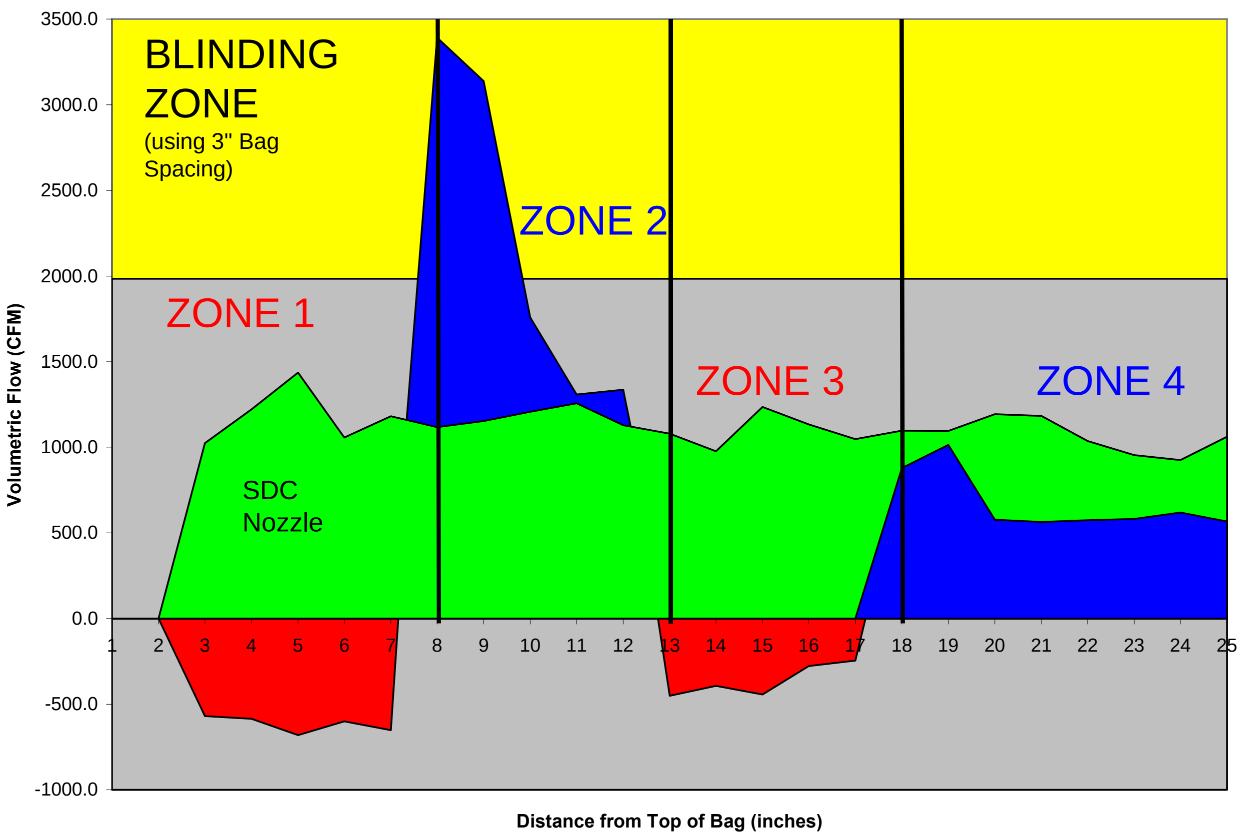

Figure 7. Blinding Zone comparison between SDC Nozzle Cleaning and Generic Baghouse.

Conclusion

For over 50 years, the orifice and venturi have been an integral part of the cleaning system for the reverse-pulse jet baghouse dust collectors. The venturi-based cleaning system allows dust to be filtered at a nominal air-to-cloth ratio of 5:1. This cleaning system also has inherent problems that cause a significant decrease in efficiency over time. Not only is the cleaning system unstable in cleaning of a single bag, the cleaning of the single bag affects the neighboring bags. During the cleaning cycle, not only is a vacuum created at the top of the bag, but a region of excessive flow. This excessive flow is so substantial that as it expands beyond the limits of the bag, and hinders the filters within a close proximity. In a generic baghouse, the nominal bag spacing is 1" between the filters (or 5 ½" between centers). At this spacing, once the flow is above 790 CFM the surrounding bags are affected. Looking back at the results, the peak flow of 3391 CFM is over four times the amount air allowed by the surrounding media!

On the other hand, Scientific Dust Collectors' patented converging and diverging nozzles cleaning system allows for dust to be filtered at a nominal air-to-cloth ratio of 10:1. Scientific Dust Collectors also utilizes a wider bag spacing of 3" between the filters (or 7 ½" between centers). If the generic baghouse were to utilize a similar spacing of 3" between filters, once the flow is above 2060 CFM the surrounding bags are affected. Looking at the results, the generic baghouse is still almost one-and-a-half times greater than the maximum flow allowed by the surrounding media. In fact, for the generic baghouse cleaning system not to affect the neighboring bags, the bag spacing would have to be 9 ½" (or 14" between centers)! The nozzle based cleaning only reaches 1436 CFM, well under the maximum flow. This wider spacing promotes dust release while also protecting the surrounding media from blinding. As a result of efficient dust collector design and patented nozzle cleaning technology, Scientific Dust Collectors is able to operate at higher air-to-cloth ratios, provide better and more complete cleaning of the filter, and longer filter life.

As a recommendation, when quoting baghouse, either buying or selling, remember to ask for wide bag spacing. It is the correct thing to do.

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