



Advantages of Cleaning without a Venturi In Pulse Jet Baghouse Collectors

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Scientific Dust Collectors

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Introduction

A venturi has been associated with reverse pulsejet baghouse dust collectors since the 1950's, and has become the industry standard design for the reverse-jet cleaning system of baghouse dust collectors. While the reverse-jet with venturi does provide some advantages when compared to other methods such as reverse-air or mechanical-shaker cleaning systems, the venturi itself has some disadvantages that are often overlooked. The reverse-jet cleaning system with venturi allows for continuous cleaning of the dust collector with almost no moving parts, compared to the reverse-air and mechanical-shaker, which have a significant amount of moving parts. The reverse-jet system utilizes compressed air traveling through an orifice. 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. The typical venturi is approximately 6 inches long, has a throat diameter of 1 3/4", and placed 2 to 3 inches away from the outside of the purge tube (blow pipe) as shown (Figure 1).

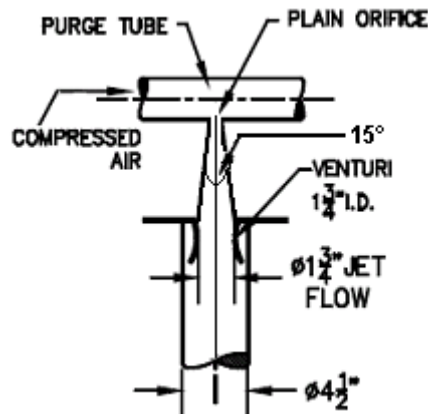


Figure 1. Orifice and Venturi Cleaning System

During normal operation of the dust collector, air is being pulled through the bag by means of a fan. During the cleaning cycle, the jet of air leaves the orifice and expands to the 1 3/4" throat diameter to seal off and stop the flow of that fan air only through the row of bags that is being cleaned. Once the fan air is stopped, the bag is back flushed with the remaining energy, which cleans the bag and reduces the filter cake. The venturi, however, also creates three undesired effects at the top of the bag. First, due to the short distance between the purge tube and the bag, not enough clean air is induced from the clean air plenum, 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 creates a "puffing" effect at the top of bag. Puffing is when dust on the filter cake is propelled at such a force that it imbeds into the surrounding media. 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) has recently conducted tests to observe this.

Test Equipment Setup

A purge tube with 12 orifices evenly spaced was connected to a Goyen 1 1/2" Diaphragm Valve with an on time of 100 milliseconds and connected to a 4 cubic ft. manifold tank. A 4 1/2" diameter by 8 ft. long singed polyester bag was aligned in front of the system at the second orifice from the manifold. Pressure monitors were placed along the length of the bag every inch from 3 inches to 25 inches from the top of the bag and 1 inch from the side of the bag (to prevent interference with the venturi and maintain consistency) (See Figure 2 for diagram). To measure the pressure in the purge tube, a Dwyer® Series 626 Pressure Transmitter (range: 0-300psig, accuracy: 0.25%) was used; and to measure flow in the bag, Ashcroft® RXLdp differential pressure transducers (range: ±25inWG, accuracy: 1.0%) were connected by pitot tubes in the bag. All of the transmitters were linked to a Hyperlogger™ by Logic Beach Inc. and during the cleaning cycle, measurements were taken every 37 milliseconds. A minimum of 20 samples was taken for each setup. To assure consistency in the data, the pressure in the purge tube was controlled to 74-77psig for 100psig in the manifold.

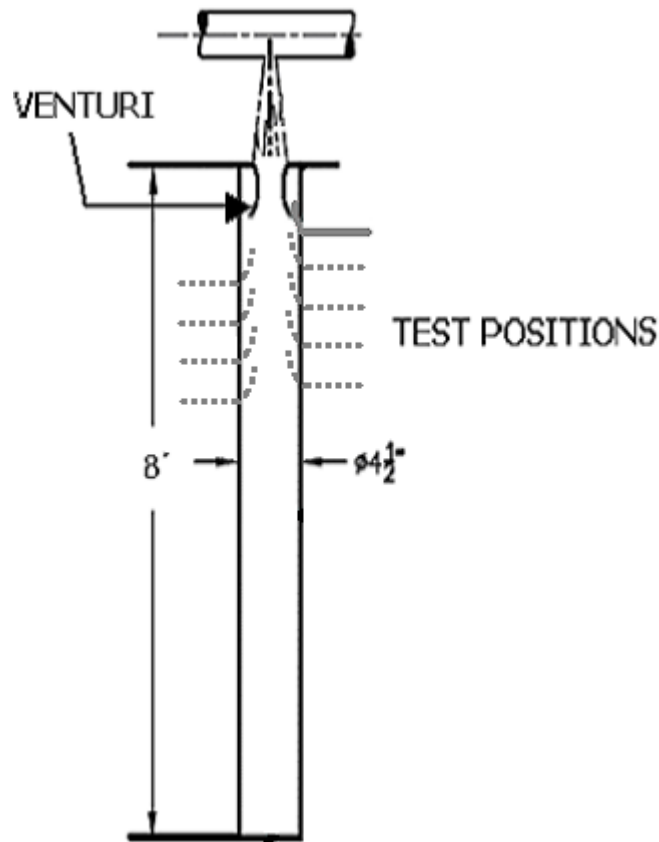


Figure 2. Testing Setup for Orifice and Venturi System

Test Results

During testing, the samples taken at every inch from 3 inches to 25 inches from the top of the bag showed four (4) distinct “zones” of airflow at the top of the bag as shown in Figure 3.

Zone 1	3 inches	4 inches	5 inches	6 inches	7 inches
	-569	-586	-680	-600	-652
Zone 2	8 inches	9 inches	10 inches	11 inches	12 inches
	3391	3138	1758	1309	1336
Zone 3	13 inches	14 inches	15 inches	16 inches	17 inches
	-451	-393	-443	-277	-245
Zone 4	18 inches	19 inches	20 inches	21 inches	22 inches
	880	1014	577	564	574
		23 inches	24 inches	25 inches	
		582	620	567	

Figure 3. Table of Volumetric Flow (in CFM) from 3 inches to 25 inches.

In “Zone 1” from 3 inches to 7 inches, the flow is actually negative. At 5 inches down, it reaches a minimum value of –680CFM. This negative flow or vacuum created is the result of the short distance from the purge tube not allowing enough air to be induced from the clean air plenum, and consequently must be drawn in from the dirty air plenum. In “Zone 2” from 8 to 12 inches, the flow is positive, but at 8 inches down, it reaches an extremely high value of 3391CFM. The high flow in this zone is a result of the venturi itself. As the air continues to expand at 15°, it reaches the diameter of the bag and since the bag is porous, the air flows out. Due to this high volume of air flowing out in this zone, the following zone, “Zone 3”, is affected. Here from 13 to 17 inches, the flow is negative again, reaching a minimum value of –451CFM. As the air is pushed out from Zone 2, another vacuum is created and must be compensated for by drawing in air again from the dirty air plenum in Zone 3. Finally, in “Zone 4” from 18 to 25 inches, the flow spikes positive and then stabilizes to maintain a constant flow of about 550CFM to 625CFM throughout the remainder of the bag. This can also be seen

graphically in Figure 4. It is also interesting to note that at 8 inches down from the top of the bag in Zone 2; as the flow reaches 3391 CFM, the velocity reaches a maximum of 511 feet per second (FPS) (Figure 5). To put it another way, 511 FPS is equivalent to 348 mph; which is faster than a Top Fuel dragster at the end of the quarter-mile at about 325mph.

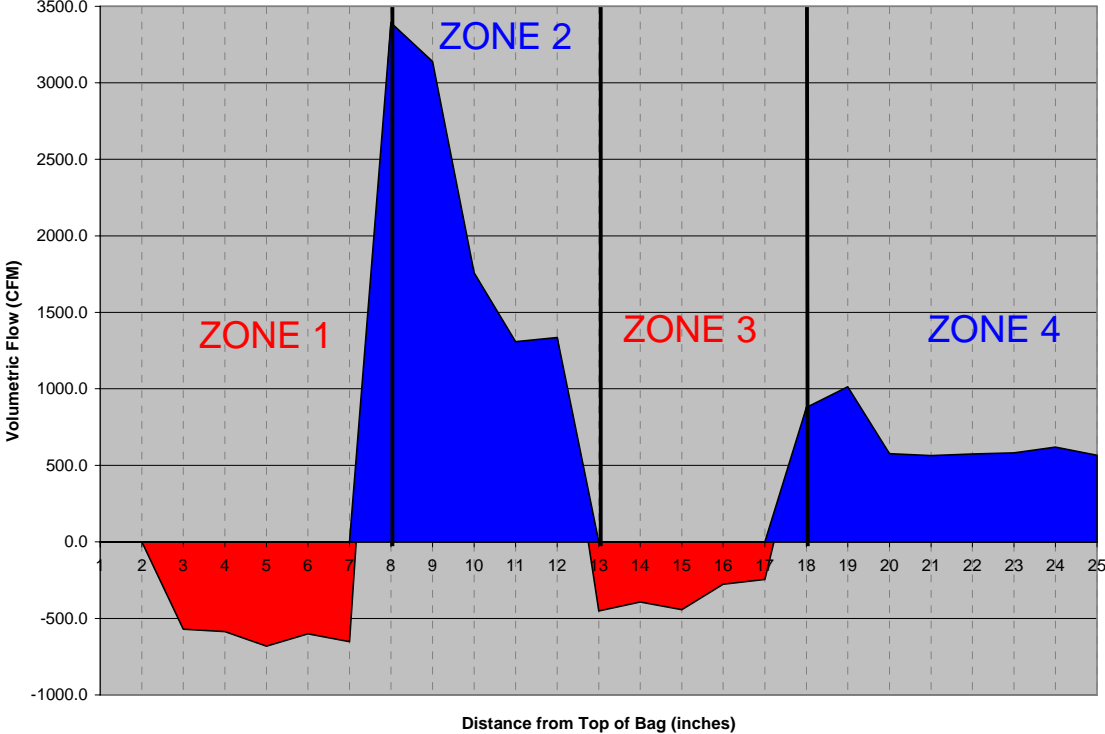


Figure 4. Volumetric Flow at the Top of the Bag from 3 inches to 25 inches (CFM)

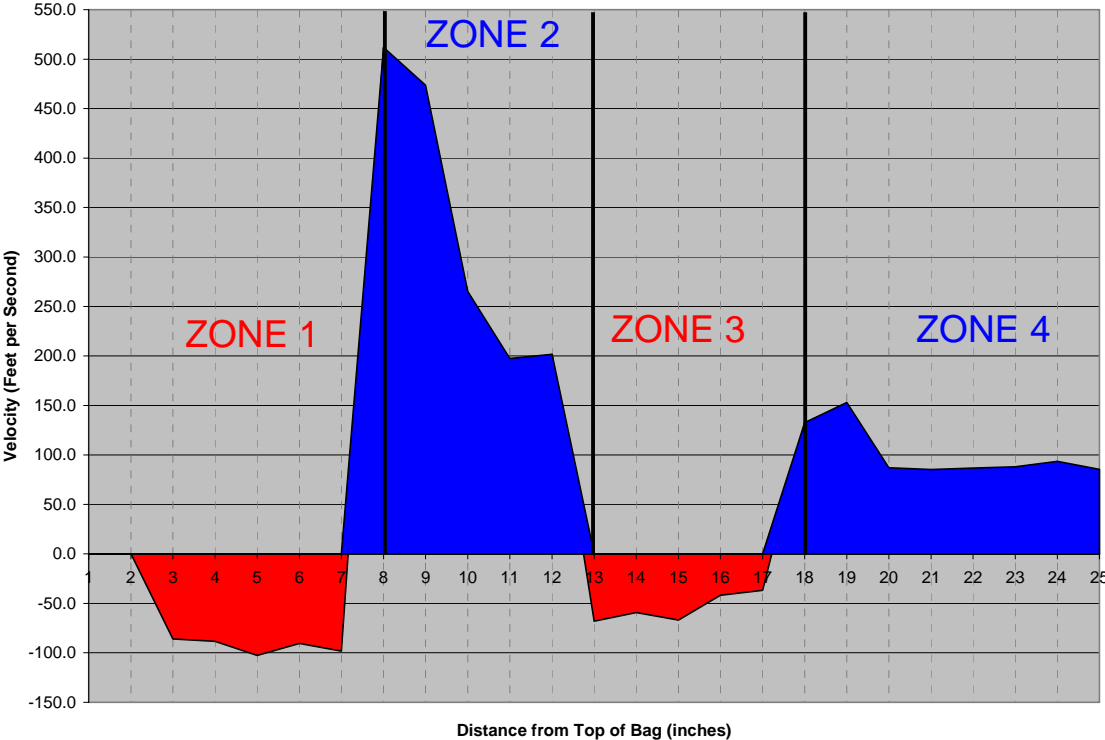


Figure 5. Velocity at the Top of the Bag from 3 inches to 25 inches (Feet per Second)

A visual representation of the airflow inside the bag is shown in Figure 6. From this representation, it becomes clearer as to exactly what is happening. As the flow enters through the venturi, there is so much energy contained within the flow and not enough air has been induced so it is pulled in from above creating a vacuum in Zone 1. As the flow moves through Zone 2, a significant amount of air is pushed out, so much so that it creates another vacuum in Zone 3. After the required air has been induced, the flow finally stabilizes in Zone 4. So in essence, the first 18 inches of the bag are unusable to repeatedly collect and clean dust due to the instability of the flow caused by the venturi.

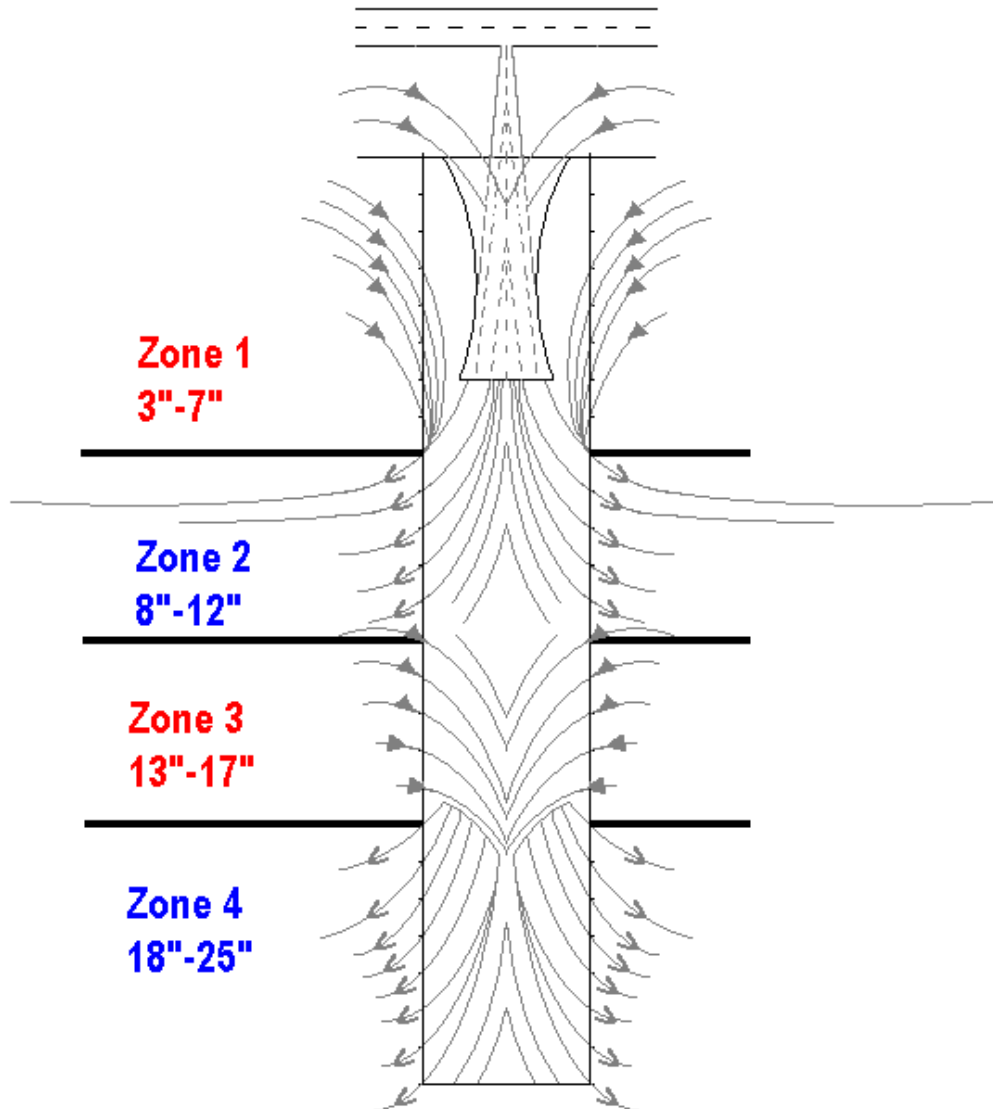


Figure 6. Visual representation of the flow at the Top of the Bag.

Comparison to the SDC Nozzle Technology

In the late 1970's, Scientific Dust Collectors developed and patented a new 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 and more effectively. By generating a supersonic flow of air that left the nozzle at ambient pressure, a generous supply of air was induced to clean the filter bag. The flow of air also decelerates before reaching the bag to provide a more gentle cleaning action as shown in Figure 7. Recently, Scientific Dust Collectors created and tested its next generation of nozzle that performs even better than the original design. In the tests conducted by SDC, the results showed that consistent flow has been achieved at the top, middle, and bottom of the bag for both the new Scientific nozzle and original Scientific nozzle; however, the orifice and venturi showed inconsistent flow (Figure 8).

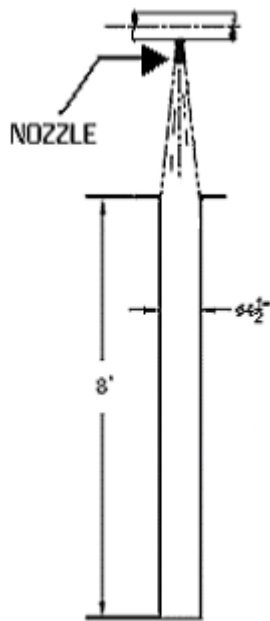


Figure 7. SDC Nozzle Cleaning System.

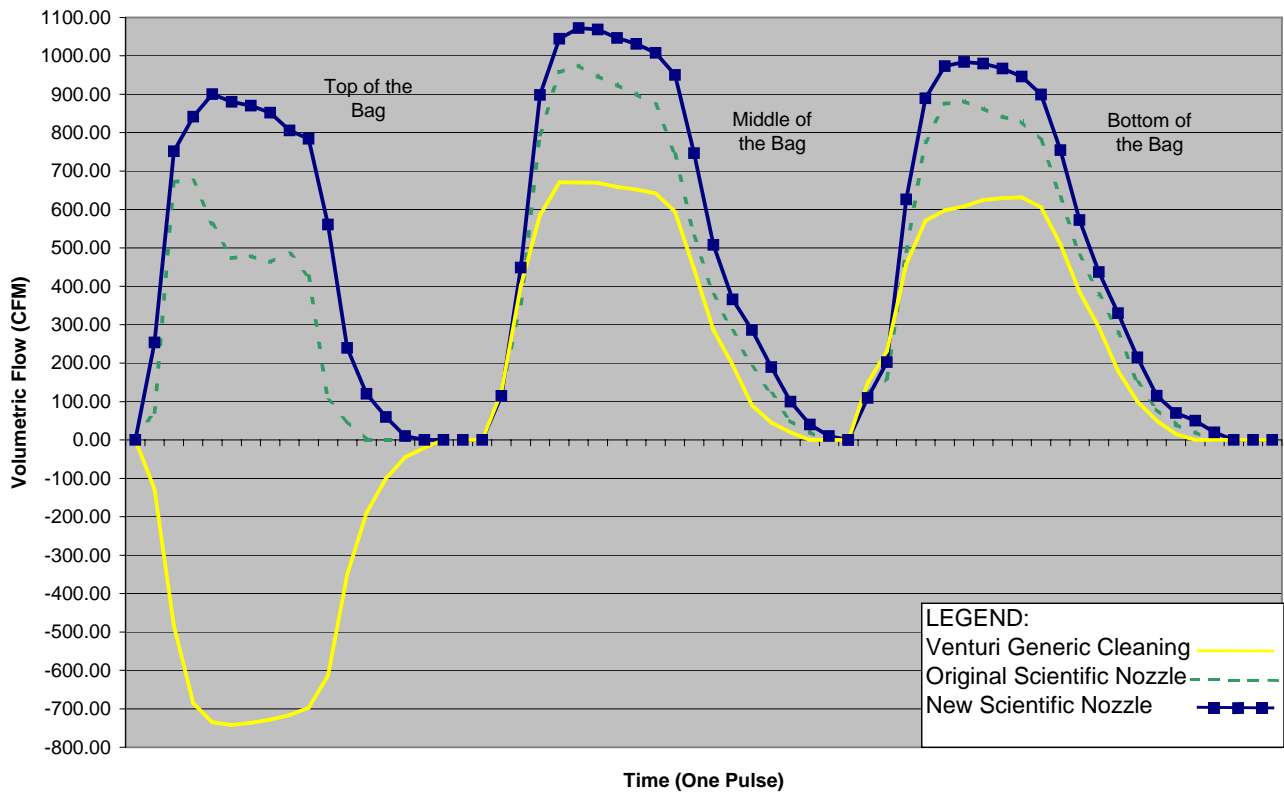


Figure 8. Volumetric Flow throughout the Entire Bag for all systems at 100psig

The Scientific nozzles clearly outperform the orifice and venturi system at the top of the bag due to the vacuum created. Moving further down the bag at the middle, the next generation Scientific nozzle outperforms the original Scientific nozzle by 14% and the venturi by 60%. At the bottom of the bag, still the next generation Scientific nozzle outperforms the original nozzle by 12% and the venturi by 56%.

Test Results

Similar testing of the next generation Scientific nozzle from 3 to 25 inches down from the top of the bag was also conducted. The consistency in cleaning that the nozzle provides is confirmed in the results as can be seen in the comparative table of flow Figure 9, graphically in Figure 10, as well as a comparison of velocity in Figure 11. It is also interesting to note that while the Scientific nozzle reaches a maximum of 10.5inWG, the orifice and venturi reaches a maximum velocity pressure of 58.8inWG (Figure 12); almost 6 times greater than the maximum pressure observed for the Scientific nozzle! This significant pressure will contribute to bag problems during operation of the generic baghouse collector.

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

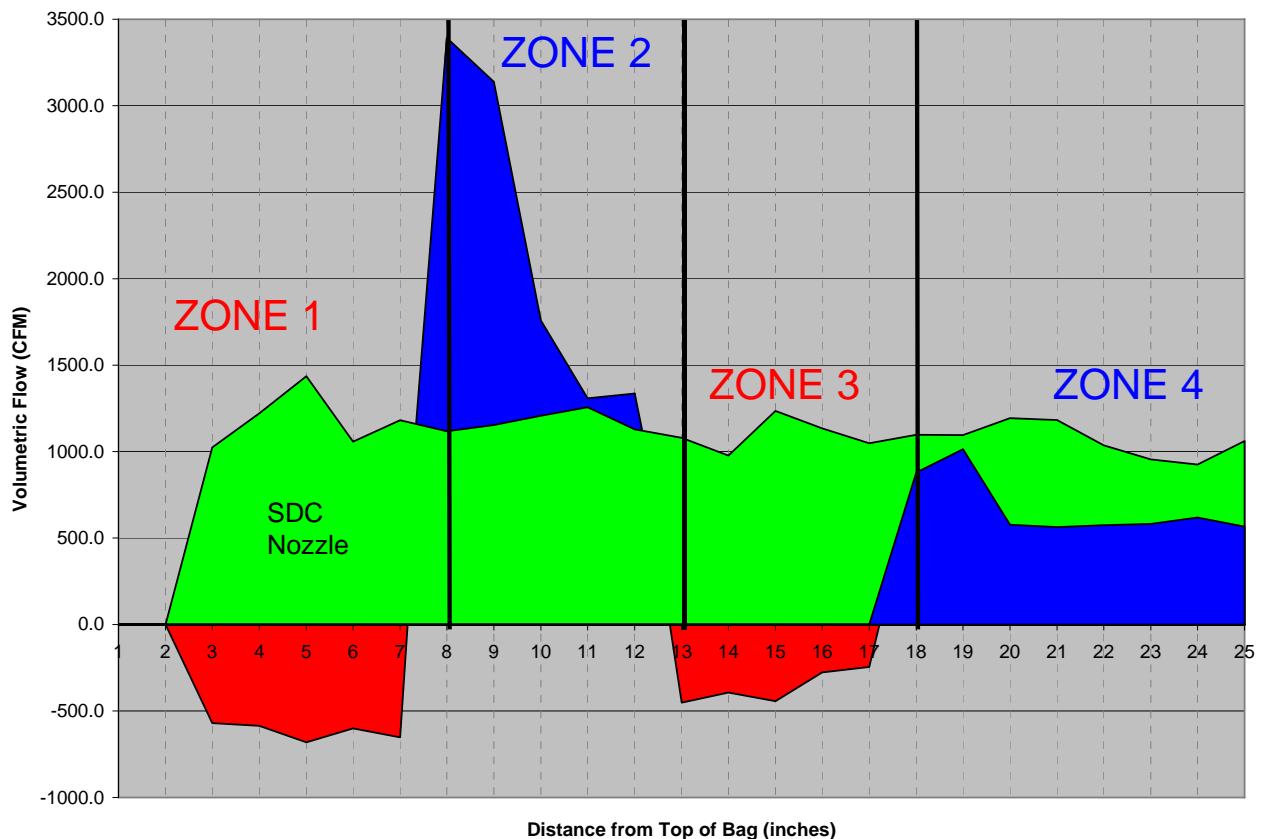


Figure 10. Volumetric Flow Comparison of SDC Nozzle and Venturi

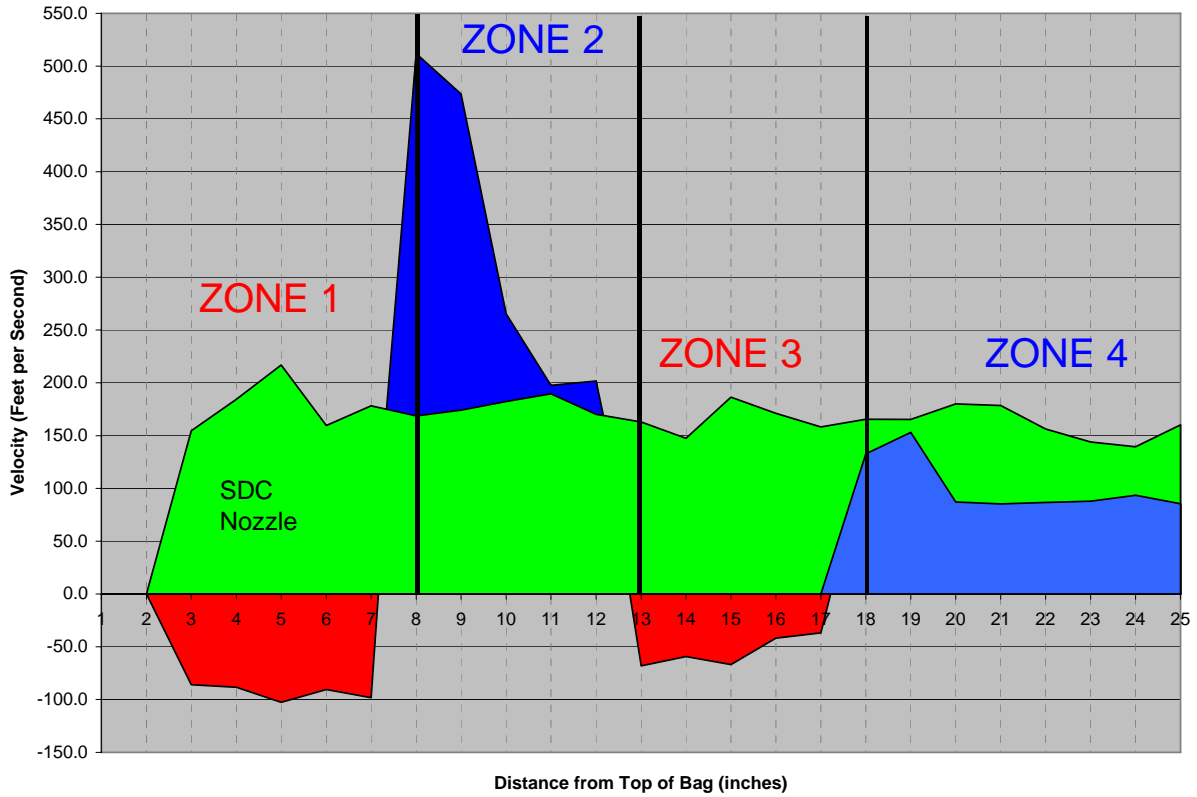


Figure 11. Velocity Comparison of SDC Nozzle and Venturi

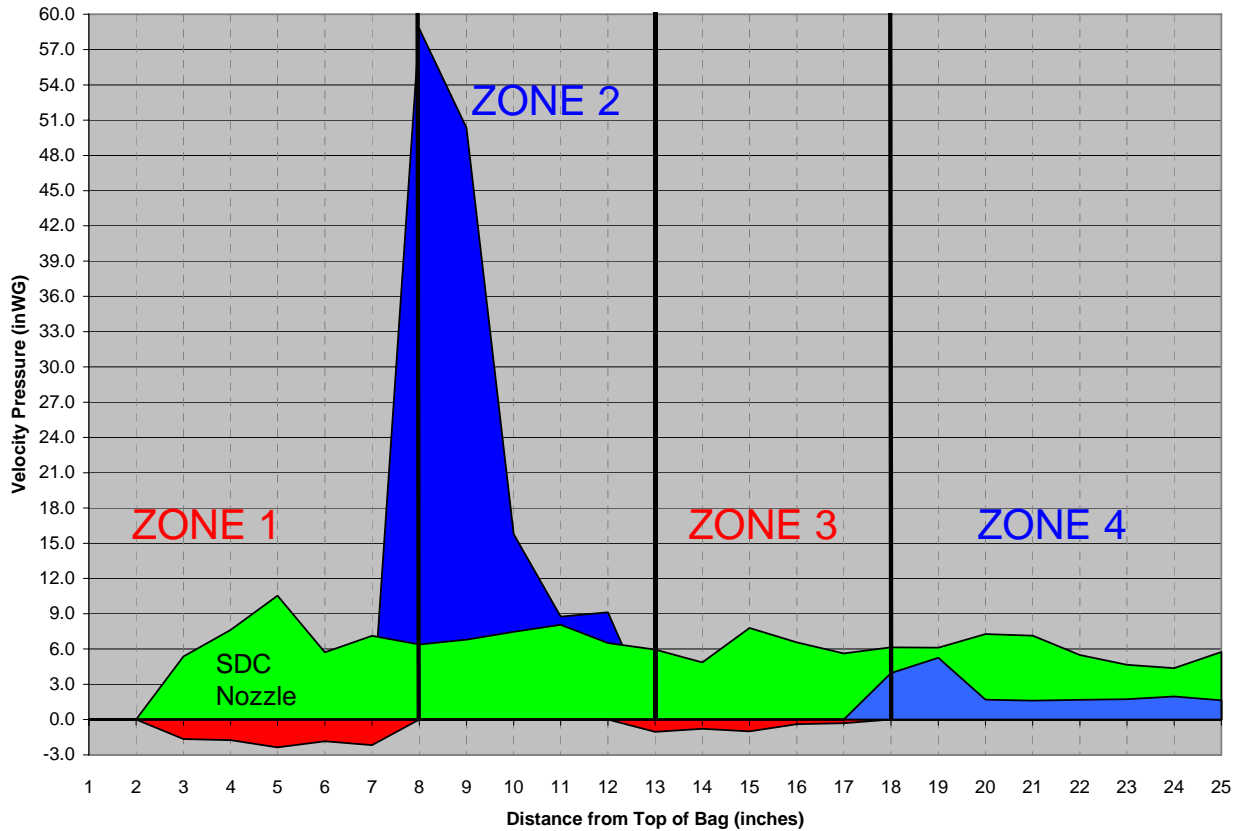


Figure 12. Velocity Pressure Comparison of SDC Nozzle and Venturi

Conclusion

Over the last five decades, the venturi has been an integral part of the cleaning cycle for the reverse-pulse jet baghouse dust collectors. While there are advantages to using a reverse-pulse jet system compared to other methods of cleaning such as a mechanical-shaker or a reverse-air system, the disadvantages of the venturi itself far outweigh its advantages. During the cleaning cycle, the venturi creates four distinct zones. The first zone from 3 inches to 7 inches is under negative flow, or a vacuum; pulling in the necessary air to compensate for the small area available to induce air before the flow enters the venturi. The second zone from 8 inches to 12 inches, just below the end of the venturi, is under very high positive flow. This is due to the exit conditions of the orifice: a high air pressure, a high flow velocity, and the close proximity to the bag. Also, a significant amount of air is being forced out of the bag creating a "puffing" effect, which can affect the surrounding media. The third zone from 13 inches to 17 inches is also under negative flow and more air must be pulled in to compensate for the amount of air forced out in the second zone. Finally, in the fourth zone from 18 inches to 25 inches, the system finally reaches a stabilized positive flow. Once the flow has finally stabilized, it is able to clean the entire bag; however, the cleaning is dependent on the state of the media. Over time, as the dust affects the pores of the media and clogs them, the amount of air able to pass through the media will decrease. This will cause the performance of the venturi system to decrease, as it is dependent upon inducing air through the bag from the dirty air plenum, and can eventually lead to bag failure. As can be seen in Figure 13, with the generic baghouse system with venturi, the first 18 inches of the bag are unusable media for repetitive cleaning; over an 8-foot bag for example, that comes to almost 20% of unusable media per bag.

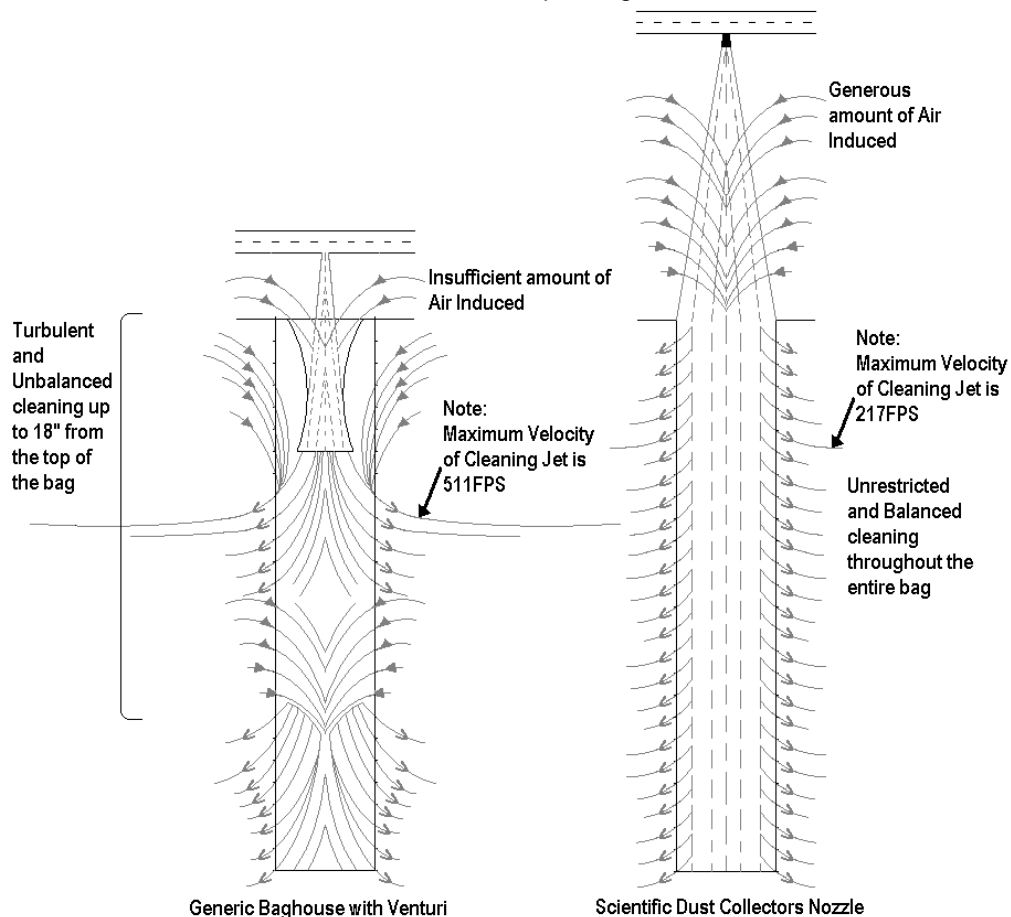


Figure 13. Cleaning system comparison of Generic Baghouse with Venturi to SDC Nozzle.

On the other hand, gaining the advantages of a reverse-pulse jet cleaning system without a venturi offers the best solution in dust collection. At Scientific Dust Collectors the patented converging and diverging nozzles cleaning system is able to induce enough air to effectively and consistently clean the entire bag. Also, over time, the cleaning performance will not decrease as the media becomes clogged. Due to the nozzle 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.

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