Improving the Cleaning Cycle in Baghouse Collectors

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Scientific Dust Collectors

Improving the Cleaning Cycle in Baghouse Collectors

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Introduction

The dust collector has been around for many years. The generic pulse jet baghouse in particular has been around since 1963 and the cleaning cycle has not changed much in over 45 years. The cleaning cycle is the most important part of the dust collector. In a generic baghouse, an orifice and venturi system are used to induce air; whereas Scientific Dust Collectors uses a converging/diverging nozzle developed in the late 1970's. The converging/diverging nozzle allows for more cleaning air to be induced into the bag compared to the generic orifice and venturi system. It is because of this that Scientific Dust Collectors can operate at higher air-to-cloth ratios, clean more of the filter bag, and provide longer filter life.

The Orifice & Venturi

A typical venturi is approximately 6 inches long and has a throat diameter of 1 ¾" as shown (Figure 1),

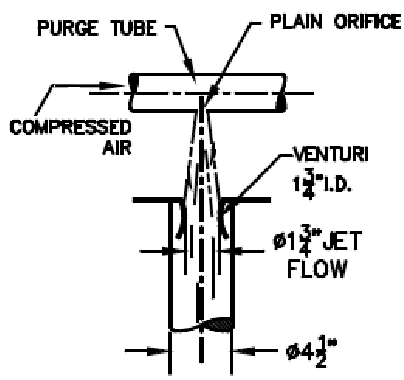

Figure 1. Orifice & Venturi System

and is placed approximately 2 to 3 inches away from the purge tube ("blow pipe"). A hole or orifice is put into the purge tube and aligned with the venturi. During the cleaning cycle, the compressed air at high pressure leaves the orifice as a jet of air at a speed of Mach 1.0 (1030 ft/s) that expands by the Law of Conservation of Momentum until the jet is the same diameter as the throat of the venturi. This seals off the flow of clean air out of the bag and reverses the direction of flow to clean or "back flush" the bag.

To effectively clean the entire bag, there is only 2 to 3 inches between the orifice and the bag so that the energy of the high pressure can be used to clean the bag. This has some shortcomings, given that this short distance is not nearly enough space to draw in the required amount of air necessary to clean the entire bag. Consequently, as the air passes through the venturi, a vacuum is created at the top of the bag, pulling in air from the dirty airside of the bag to compensate for the lack of air created from the short distance. Scientific Dust Collectors has recently conducted tests to observe this phenomenon.

Test Equipment Setup

A purge tube with 12 orifices evenly spaced was connected to a Goyen 1½" Diaphragm Valve with an on time of 100 milliseconds and connected to a 4 cubic ft. manifold tank. A 4½" 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 in four different locations: near the orifice on the purge tube, at 5 inches from the top of the bag and 1 inch from the side of the bag (to prevent interference with the venturi), the middle of the bag, and at the bottom of the bag (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 pilot tubes in the bag at the three locations. 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 system. To assure consistency in the data, the pressure in the purge tube was controlled to 74-77psig for 100psig in the manifold and 67-70psig for 90psig in the manifold. (Note: for the remainder of this paper, any references to air pressure unless otherwise noted will refer to pressure in the manifold).

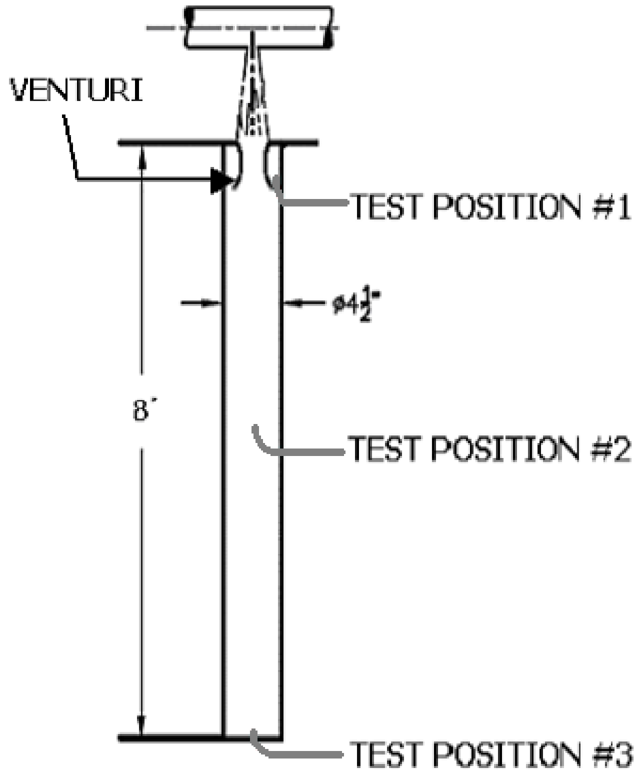

Figure 2. Testing Setup for Orifice & Venturi

First, we tested the flow at the top of the bag (Test Position #1). During testing at a minimum flow of –711CFM was seen at 90psig (See Figure 3) and an average flow of –742CFM was seen at 100psig (See Figure 4) at Test Position #1.

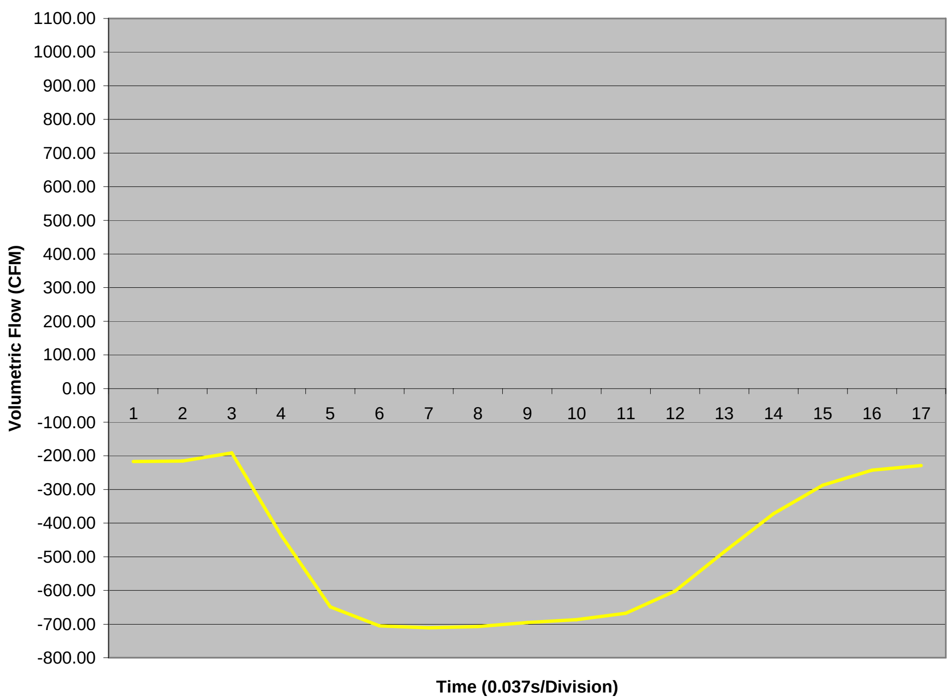

Figure 3. Volumetric Flow of a Venturi at <u>90psig</u> at the <u>Top</u> of the Bag

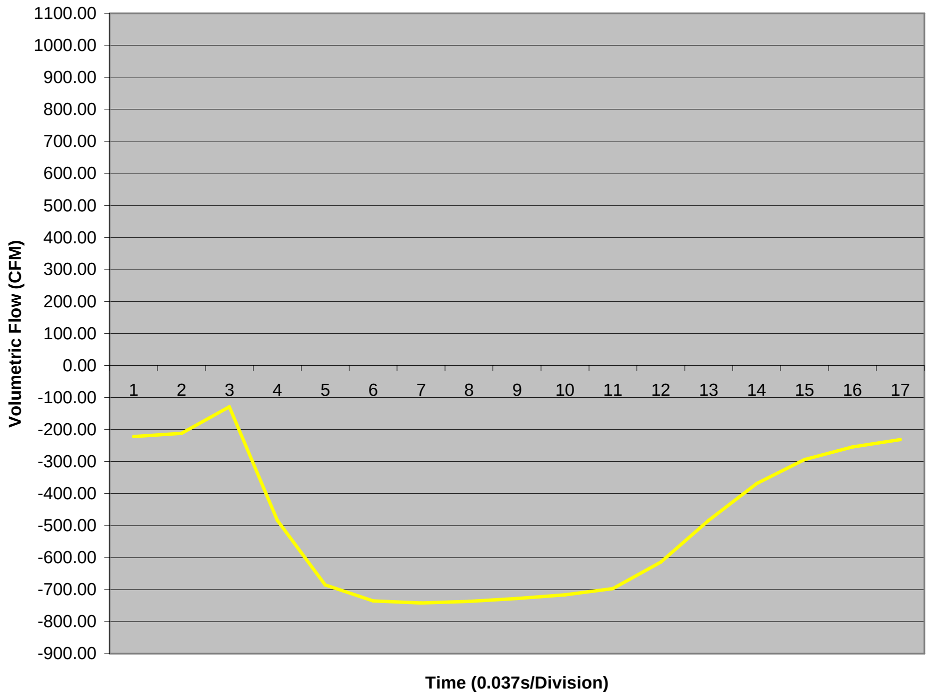

Figure 4. Volumetric Flow of a Venturi at <u>100psig</u> at the <u>Top</u> of the Bag

These results confirm the phenomenon of negative flow at the top of the bag for an orifice and venturi. Instead of a positive airflow during the cleaning cycle at the top of the bag, the cleaning flow is actually negative, drawing dirty air into the bag fibers. This negative flow leads to “puffing” when the bag fails, dust is actually pulled through the bag into the clean side and it can also reduce the filter life.

We then conducted tests at the middle of the bag (Test Position #2); a maximum flow of 648CFM was seen at 90psig (See Figure 5) and 671CFM at 100psig (See Figure 6).

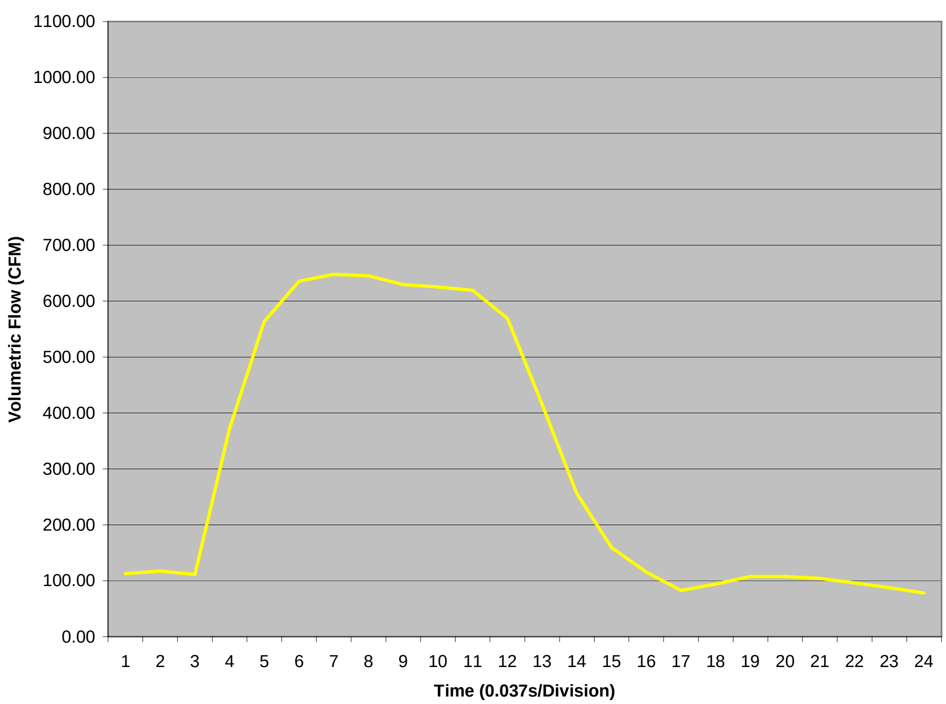

Figure 5. Volumetric Flow of a Venturi at <u>90psig</u> at the <u>Middle</u> of the Bag

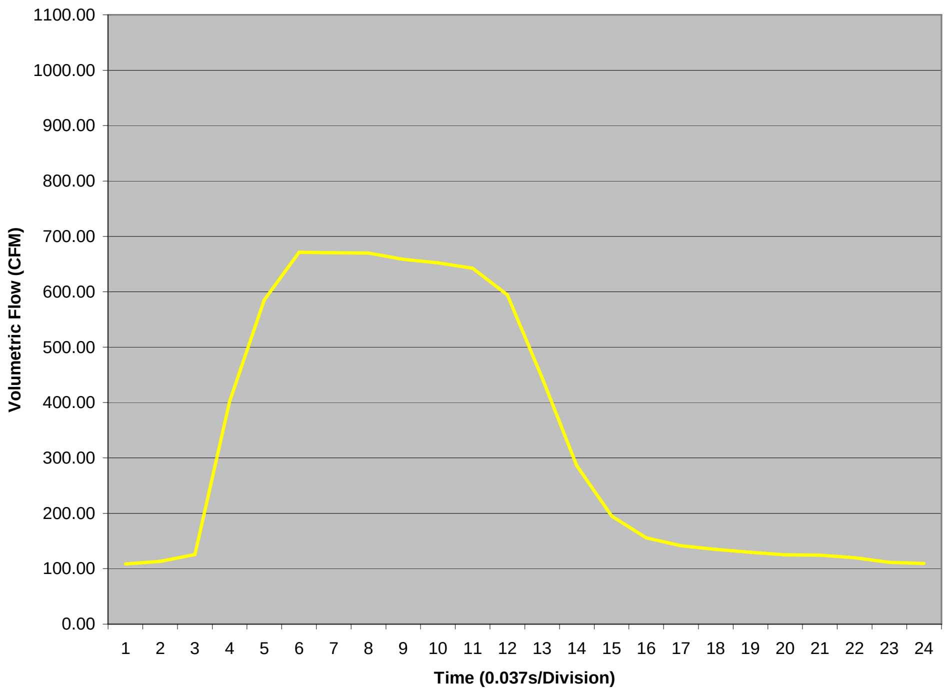

Figure 6. Volumetric Flow of a Venturi at <u>100psig</u> at the <u>Middle</u> of the Bag

Lastly, we tested at the bottom of the bag (Test Position #3), a maximum flow of 602CFM was seen at 90psig (See Figure 7) and 631CFM was seen at 100psig (See Figure 8).

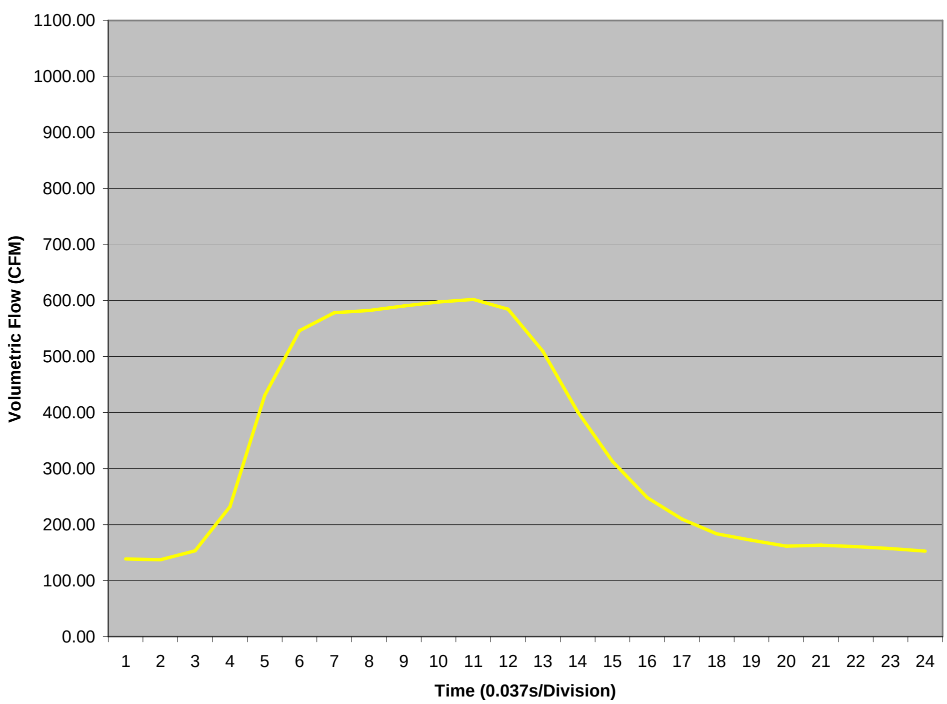

Figure 7. Volumetric Flow of a Venturi at <u>100psig</u> at the <u>Bottom</u> of the Bag

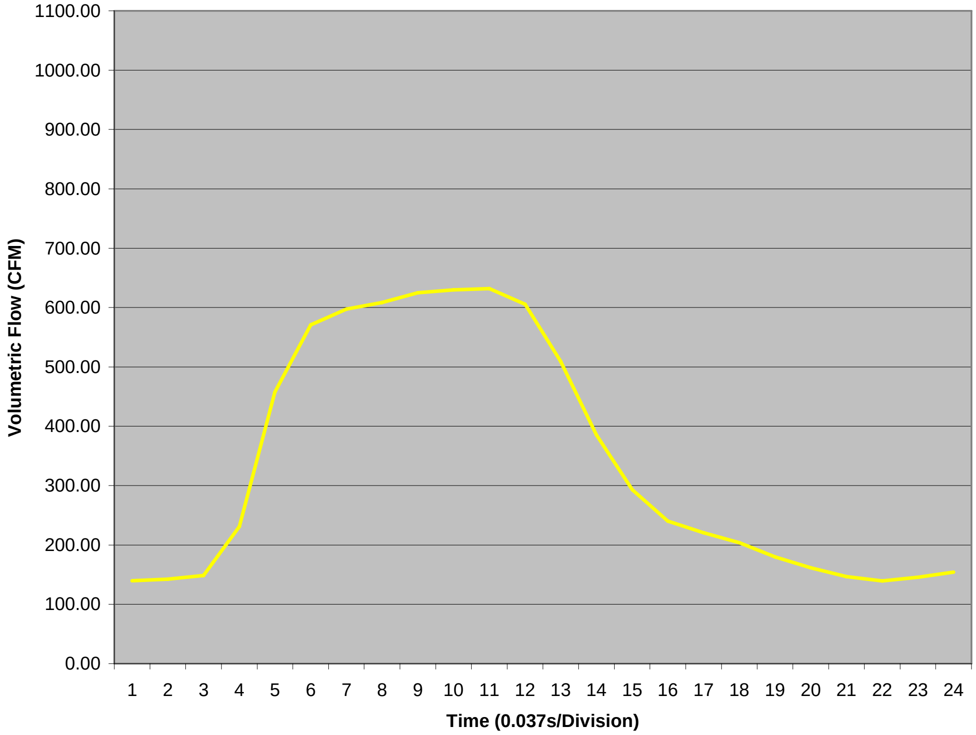

Figure 8. Volumetric Flow of a Venturi at <u>100psig</u> at the <u>Bottom</u> of the Bag

Looking at the results, it is clear that the orifice and venturi system has some cleaning deficiencies. At the top of the bag it is pulling in –711CFM and at the bottom of the bag it is pushing out 602CFM. The system is pulling in 18% more dirty-air at the top than it is pushing out cleaning-air at the bottom!

The Scientific Difference

The Scientific Dust Collector difference is in our patented nozzle technology. Over 27 years ago, we put a nozzle on the purge tube instead of the standard orifice. With this nozzle, we were able to generate supersonic flow at the exit of the nozzle at an ambient exit pressure (14.68psia, 0psig). We were able to operate without the venturi and place the purge tube a generous 17 inches away from the bag opening. In doing so, we have a significant area to induce cleaning air into the bag as the air jet has expands to the diameter of the bag. Also, this produces more positive flow throughout the entire bag over the generic orifice and venturi system. Under the same conditions as the orifice and venturi and a similar setup (See Figure 9), we conducted tests on our existing nozzle design.

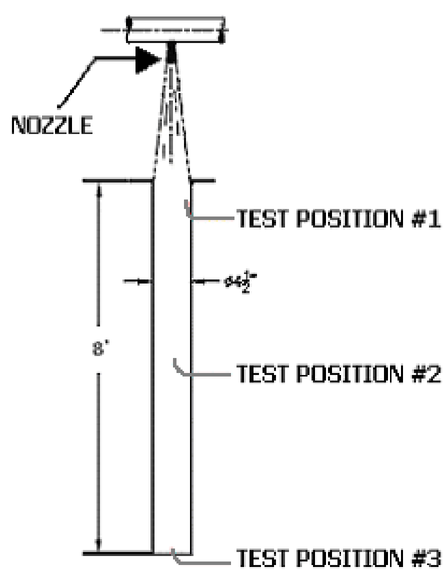

Figure 9. Testing Setup for SDC Nozzle

Beginning at the top of the bag, the Scientific nozzle attained a maximum flow of 644CFM at 90psig (See Figure 10) and 672CFM at 100psig (See Figure 11). It is significant to note that at this position the Scientific nozzle is pushing almost as much air out as the venturi is pulling in.

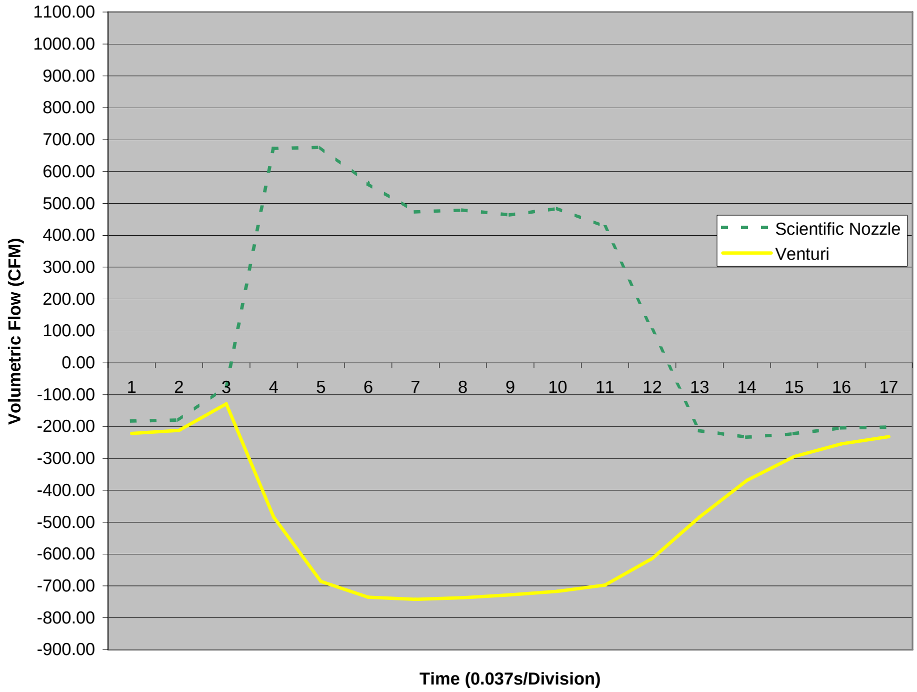

Figure 10. Volumetric Flow of the Scientific Nozzle vs. Venturi at <u>90psig</u> at the <u>Top</u> of the Bag

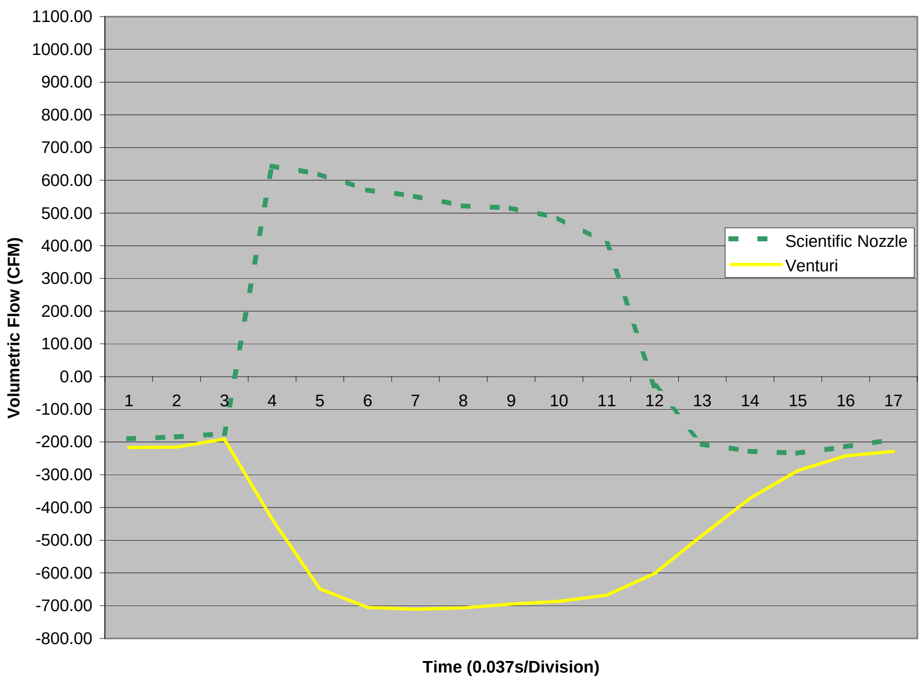

Figure 11. Volumetric Flow of the Scientific Nozzle vs. Venturi at <u>100psig</u> at the <u>Top</u> of the Bag

At the middle of the bag, the Scientific nozzle had a maximum flow of 894CFM at 90psig (See Figure 12) and 975CFM at 100psig (See Figure 13).

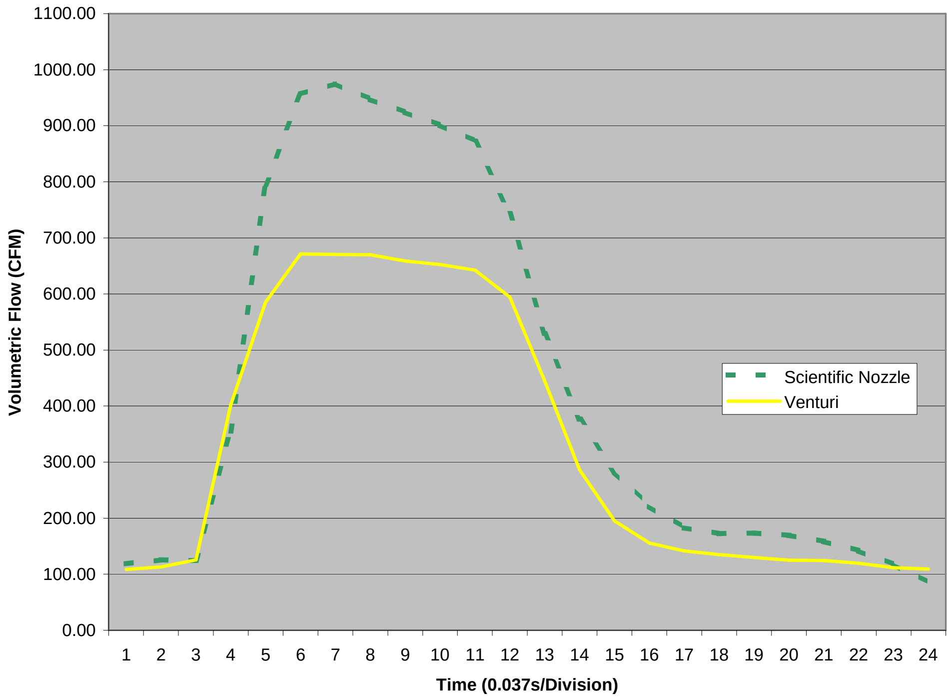

Figure 12. Volumetric Flow of the Scientific Nozzle vs. Venturi at <u>90psig</u> at the <u>Middle</u> of the Bag

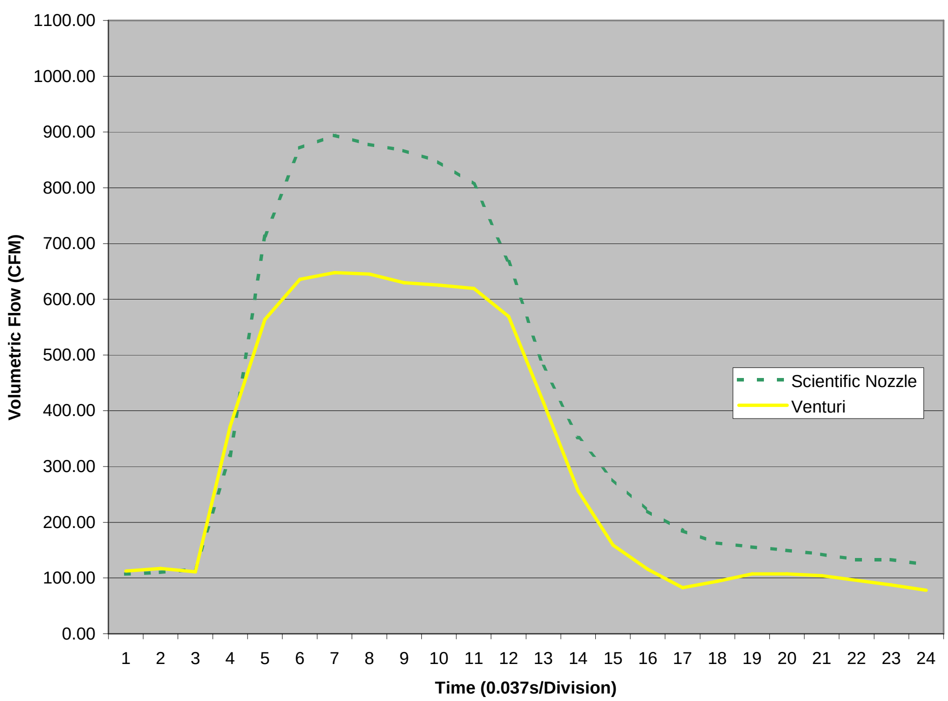

Figure 13. Volumetric Flow of the Scientific Nozzle vs. Venturi at <u>90psig</u> at the <u>Middle</u> of the Bag

The Scientific nozzle outperforms the generic venturi at the middle of the bag with an increase of 38% cleaning flow at 90psig and 45% increase in cleaning flow at 100psig.

At the bottom of the bag, the Scientific nozzle had a maximum flow of 836CFM at 90psig (See Figure 14) and 882CFM at 100psig (See Figure 15).

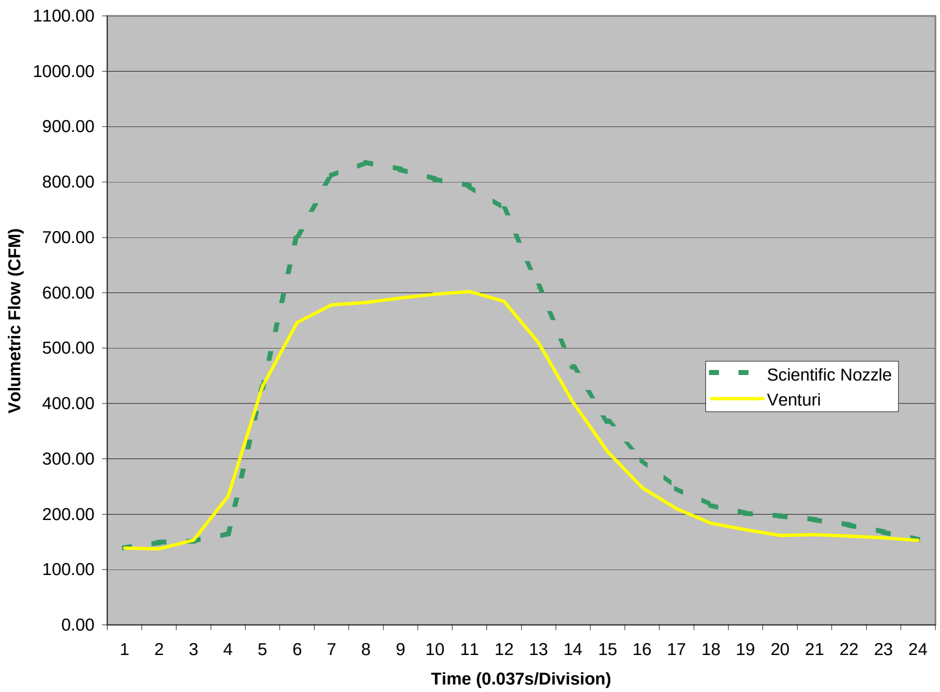

Figure 14. Volumetric Flow of the Scientific Nozzle vs. Venturi at 90psig at the Bottom of the Bag

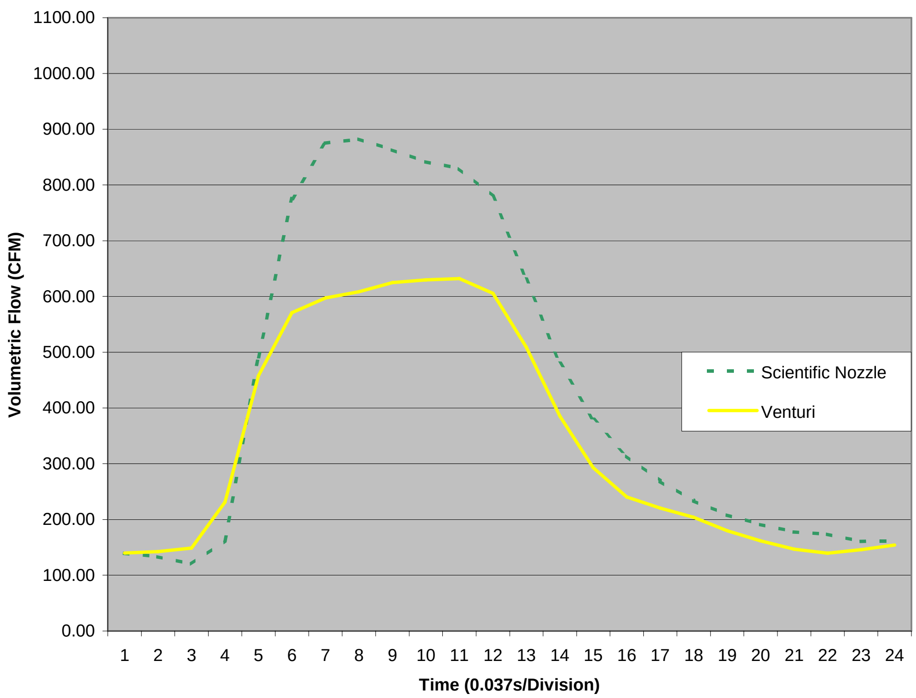

Figure 15. Volumetric Flow of the Scientific Nozzle vs. Venturi at 100psig at the Bottom of the Bag

Again, at the bottom of the bag, the Scientific nozzle outperforms the generic venturi system at the bottom of the bag; with a 39% increase in flow at 90psig and a 40% increase in flow at 100psig. For over 27 years, Scientific Dust Collectors has been outperforming the competition by providing better and complete bag cleaning. This allows us to operate efficiently and effectively at higher air-to-cloth ratios and provide longer filter life.

The Next Generation of Nozzle Technology

At Scientific Dust Collectors, we are committed to always advancing our cleaning technology. Over the last few years we have reviewed and improved upon our original nozzle design to produce the next generation nozzle. This new nozzle saves space as it placed 13 inches away from the purge tube while providing better cleaning then its predecessor and far superior cleaning over the generic orifice and venturi.

Under the same conditions as the original Scientific nozzle and the orifice and venturi, the new Scientific nozzle out performed the competition. At the top of the bag the next generation nozzle achieved a maximum of 914CFM at 90psig (Figure 16) and 901CFM at 100psig (Figure 17).

It should be noted that the next generation converging/diverging nozzle was designed to operate at 70psig at the nozzle (approximately 90psig in the manifold). When the pressure at the nozzle is 70psig, the nozzle is said to be "ideally expanded". In the nozzle, the 70psig is at the throat of the nozzle, and this is where the flow achieves Mach 1.0. As the flow continues to travel into the diverging section, the pressure decreases as the Mach number increases and at the exit of the nozzle; the pressure has decreased to the ambient pressure, while still traveling supersonic. When the pressure is above the designed pressure, the nozzle is "under-expanded"; which means that the flow could have expanded further and because of this, expansion waves are created at the exit. In this case, at 100psig, the nozzle is "under-expanded"; and the effect of the expansion waves at the exit of the nozzle are seen at the top of the bag. This is why the flow at 100psig is not greater than the flow at 90psig when compared to the original Scientific nozzle and orifice and venturi, which both increased as the pressure increased. As the flow continues to develop down the bag, the results at the middle and the bottom of the bag will reflect an increase in flow as the pressure increases.

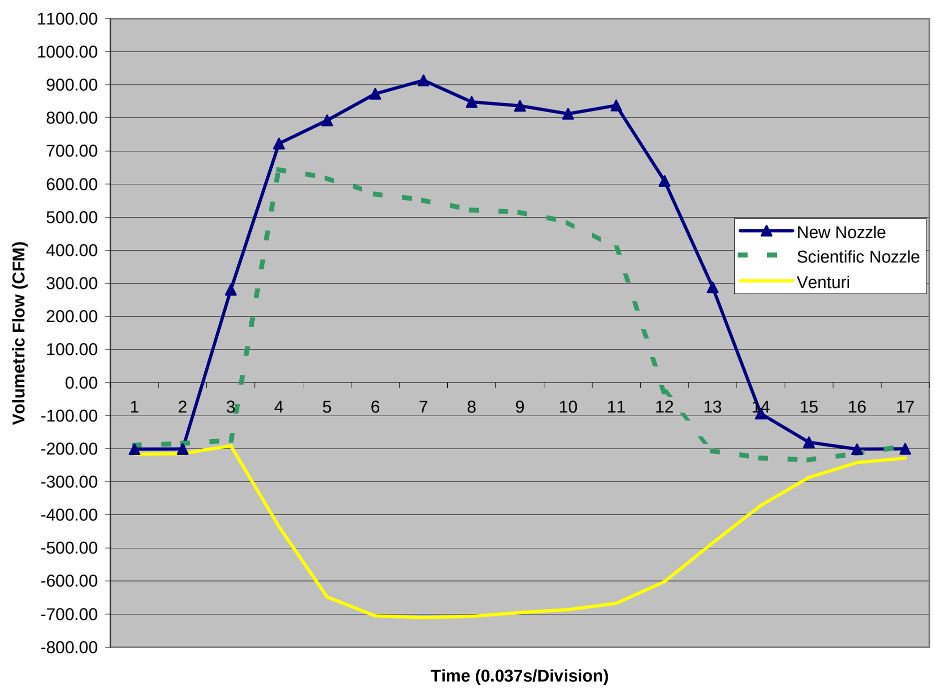

Figure 16. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at <u>90psig</u> at the <u>Top</u> of the Bag

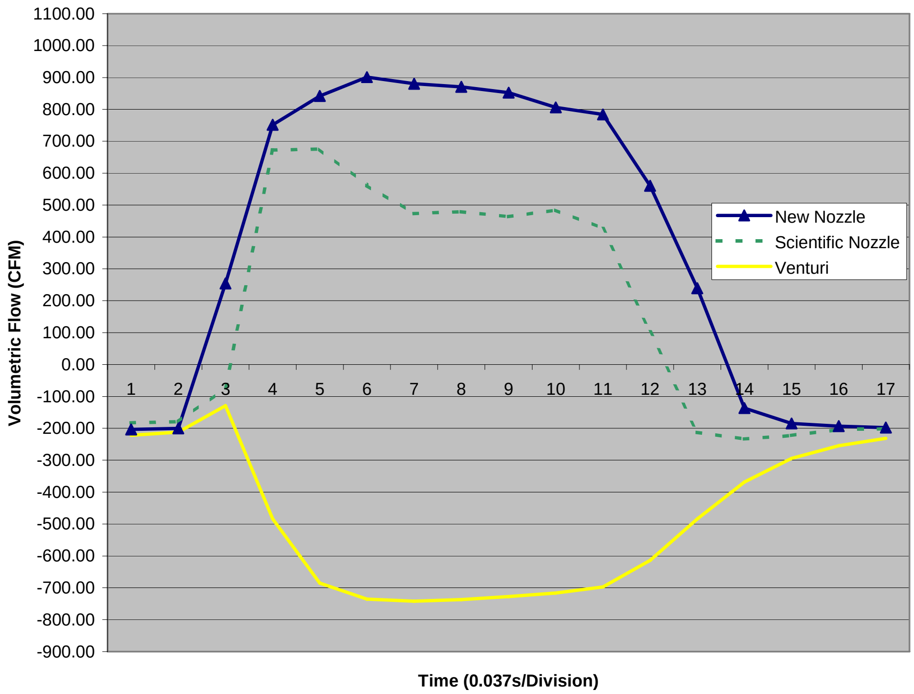

Figure 17. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at __100psig__ at the __Top__ of the Bag

As the graphs above show, the new Scientific nozzle out performs the original Scientific nozzle by 42% at 90psig and 34% at 100psig. Also, and of significant importance is the fact that the orifice and venturi arrangement is under negative flow at this position in the bag.

At the middle of the bag, the new Scientific nozzle achieved 1023CFM at 90psig (Figure 18) and 1072CFM at 100psig (Figure 19).

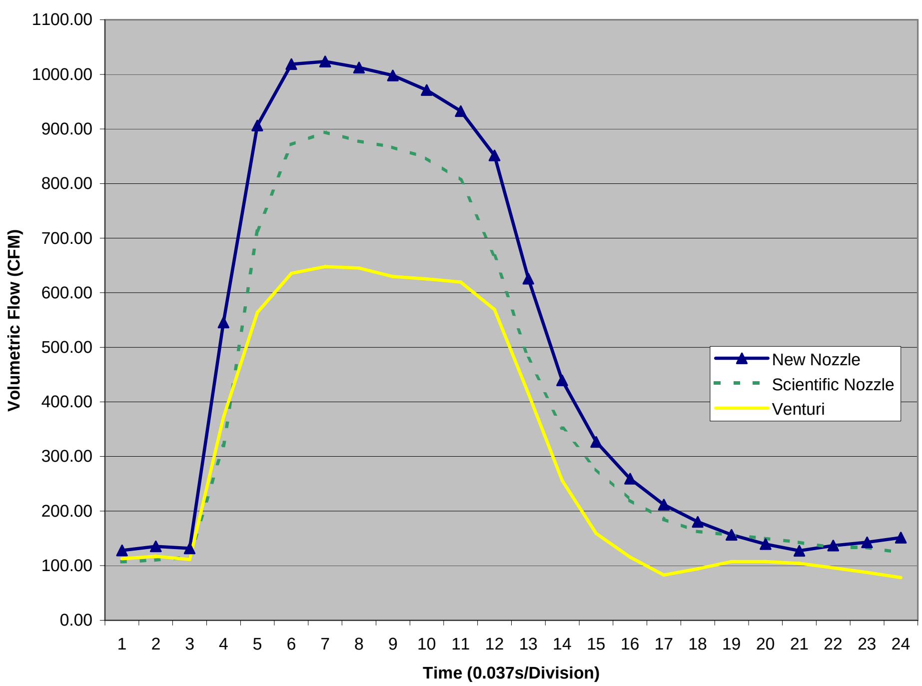

Figure 18. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at __90psig__ at the __Middle__ of the Bag

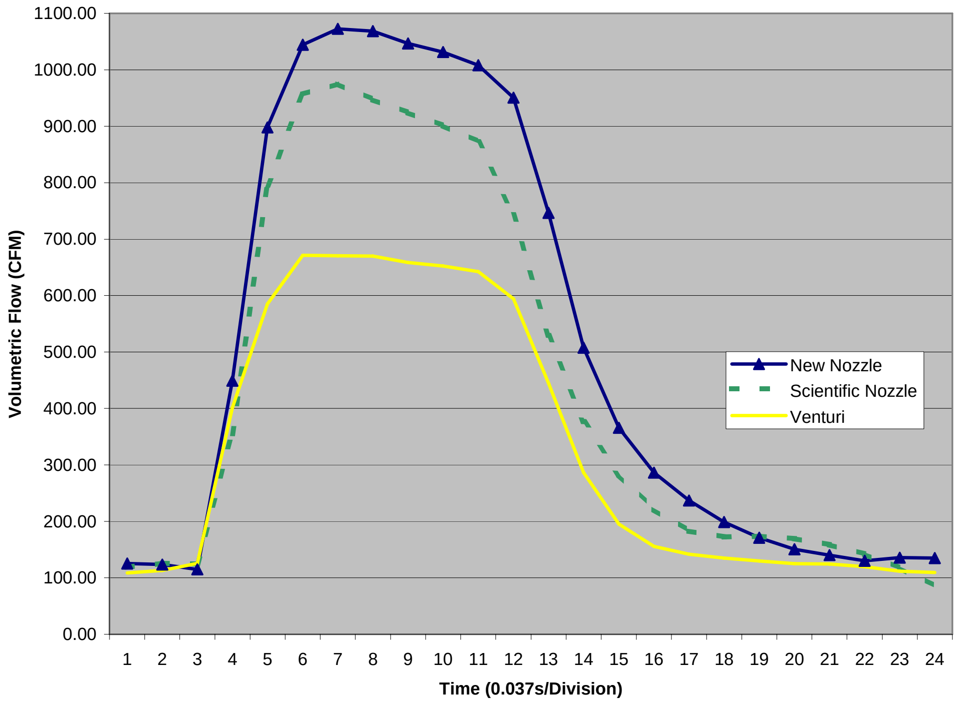

Figure 19. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at <u>100psig</u> at the <u>Middle</u> of the Bag

The new Scientific nozzle out performs the original Scientific nozzle at the middle of the bag by 14% at 90psig and 10% at 100psig. Likewise, it also out performs the orifice and venturi by 58% at 90psig and 60% at 100psig.

At the bottom of the bag, the new Scientific nozzle achieved 940CFM at 90psig (Figure 20) and 985CFM at 100psig (Figure 19).

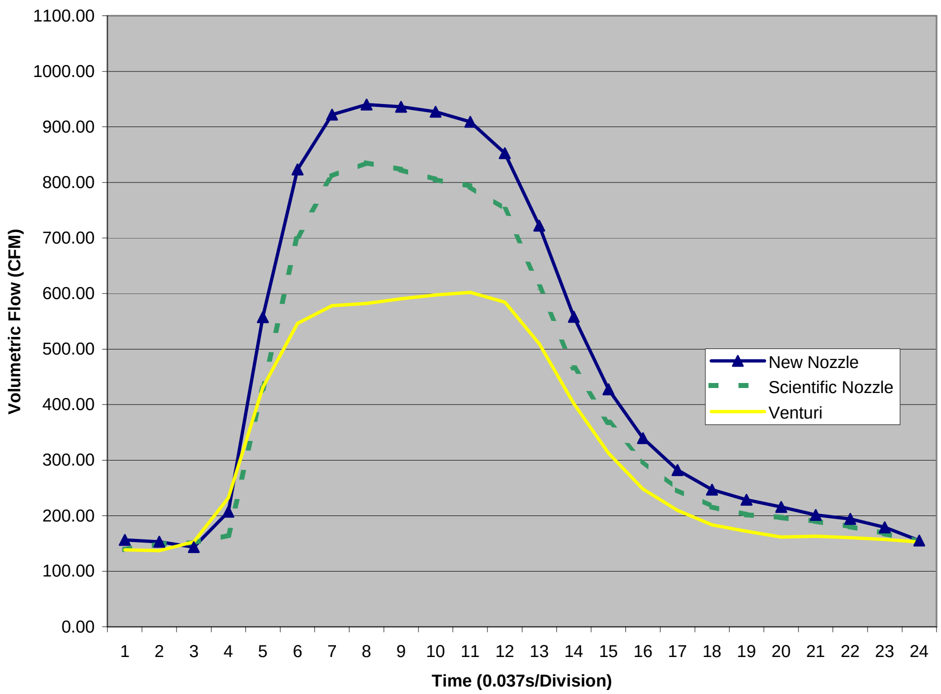

Figure 20. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at <u>90psig</u> at the <u>Bottom</u> of the Bag

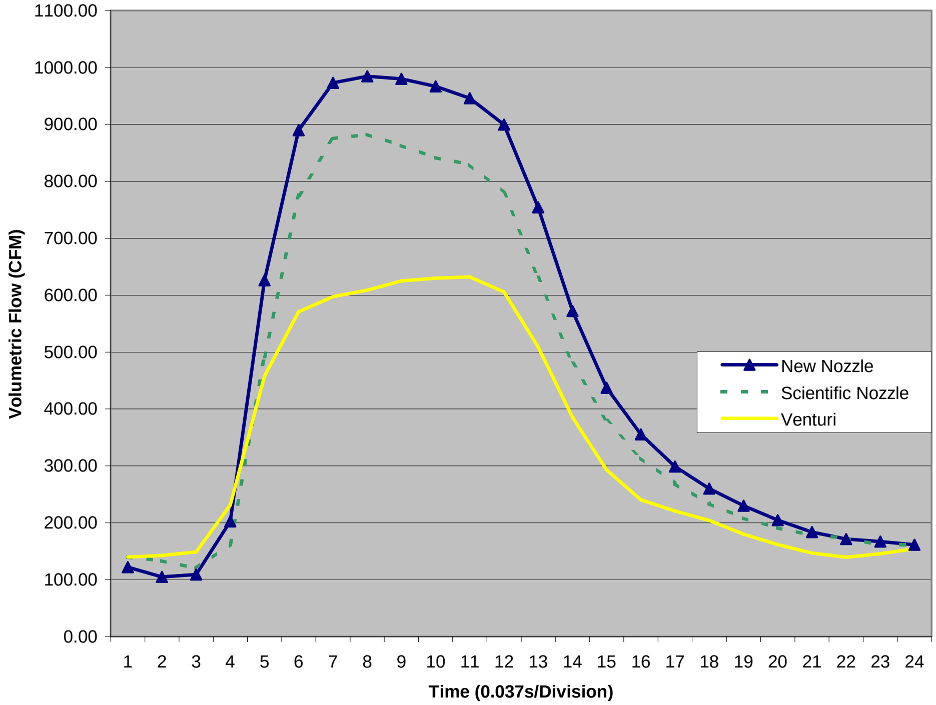

Figure 21. Volumetric Flow of the New Scientific Nozzle vs. The Original Scientific Nozzle vs. Venturi at <u>100psig</u> at the <u>Bottom</u> of the Bag

Here again, the new Scientific nozzle out performs the original Scientific nozzle by 12% at 90psig and 100psig; as well as outperforming the standard orifice and venturi by 56% at 90psig and 100psig.

Overall, both Scientific Dust Collectors nozzles (new and old) outperform the generic baghouse cleaning system of an orifice and venturi. The following figures provide a summarized glimpse at the whole cleaning cycle over the entire bag at both 90psig (Figure 22) and 100psig (Figure 23). As the graphs show, the orifice and venturi are not able to provide sufficient cleaning at the top of the bag because the system is attempting to clean with dirty air. These tests were conducted using a brand new filter bag. Over the life of the filter, one can expect that as the filter pores clog up with dust, the amount of air able to travel though it will decrease. For the orifice and venturi, as the amount of air pulled in through the top of the bag decreases, the flow throughout the bag will decrease. On the other hand, the Scientific nozzles are cleaning with all clean air; which means that even as the pores clog over the filter life, it will still provide the same amount of cleaning flow inside the bag, which means the filter will last longer.

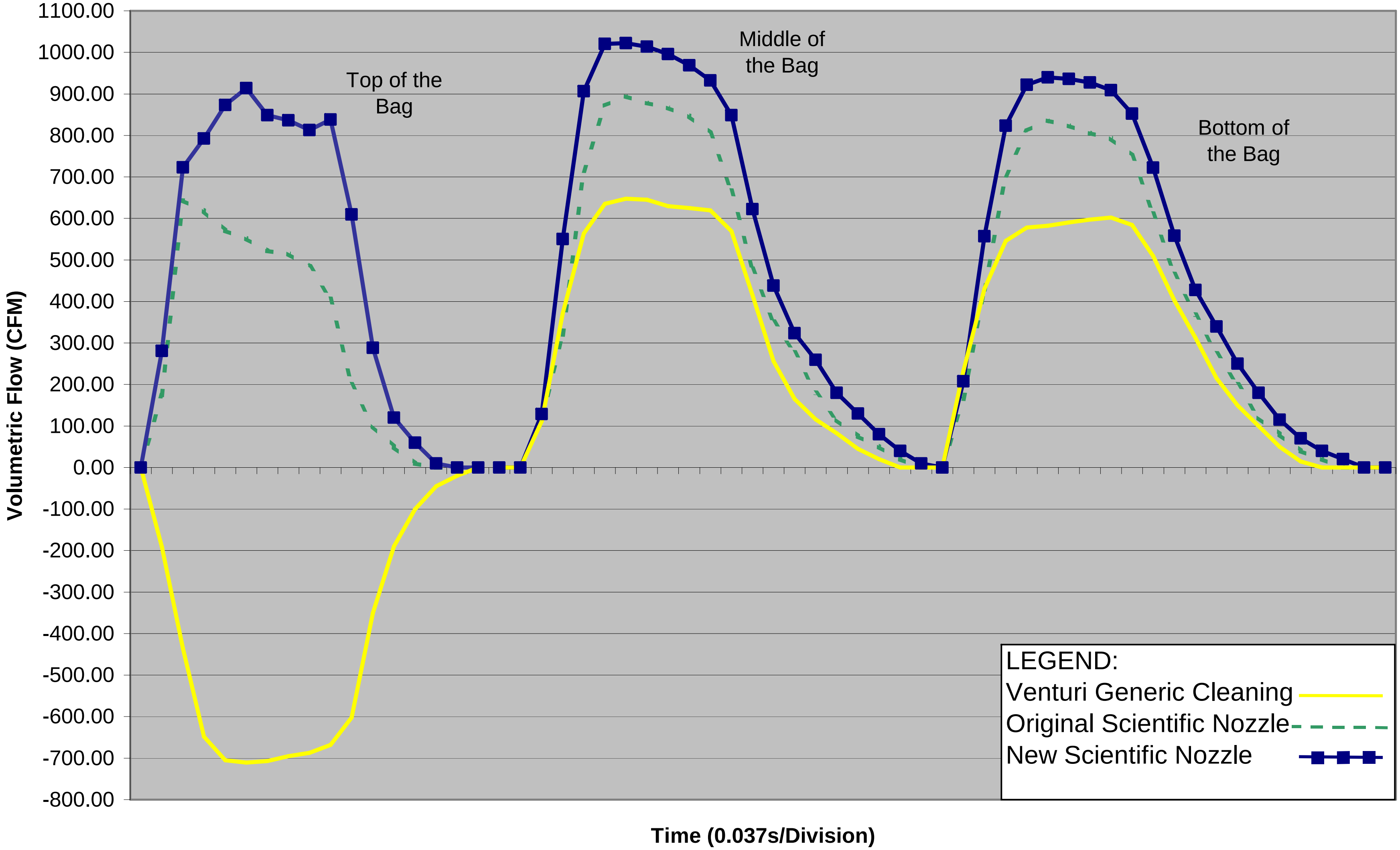

Figure 22: Volumetric Flow throughout the <u>Entire Bag</u> for all systems at <u>90psig</u>

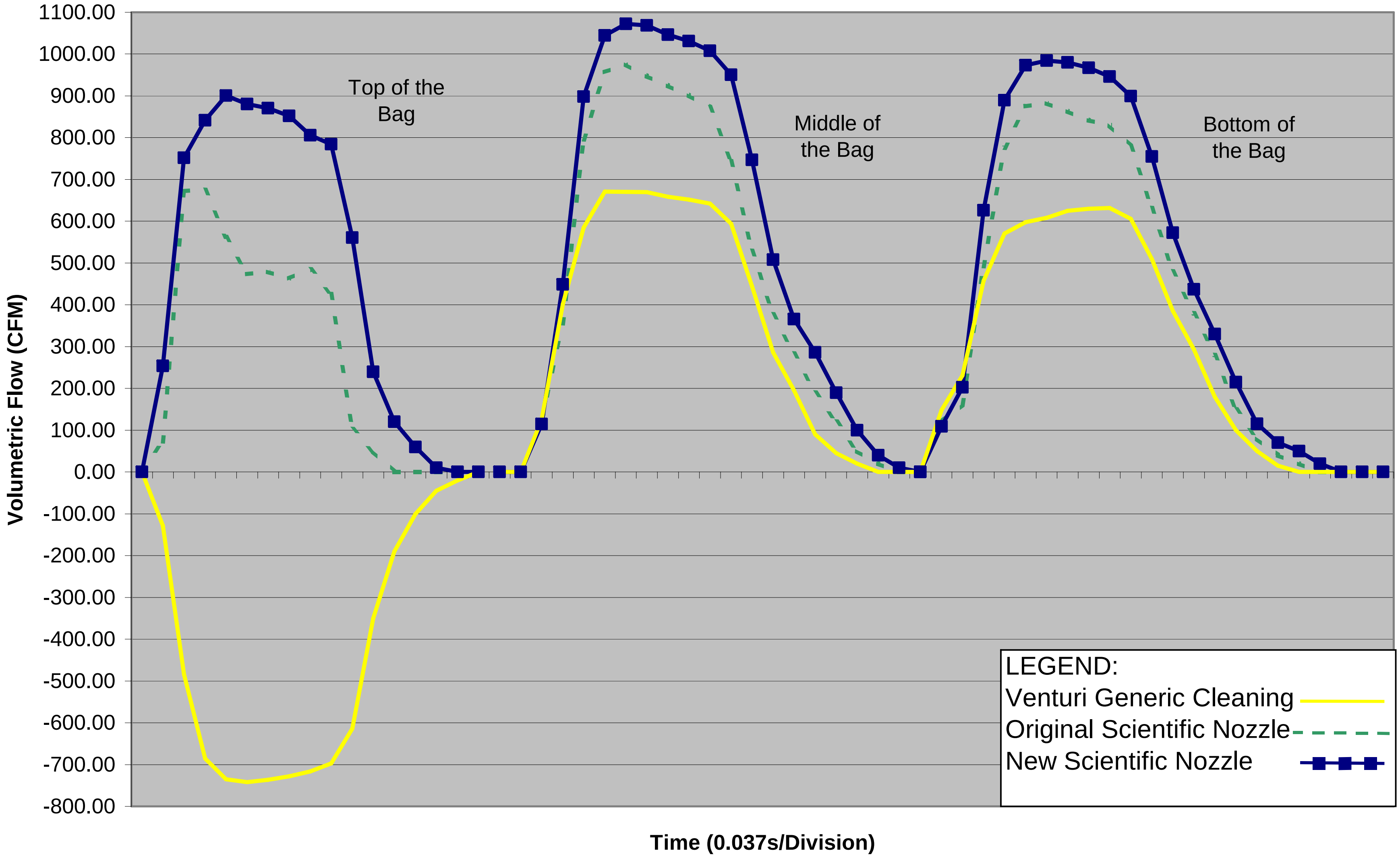

Figure 23: Volumetric Flow throughout the <u>Entire Bag</u> for all systems at <u>100psig</u>

Conclusion

The cleaning system is truly the most important aspect of a dust collector. Without an effective cleaning system, there will not be an effective dust collecting system. The trend presently is to place a focus on the number of bags, specifically how much cloth area or what “air-to-cloth ratio” to use. One would assume that more is better; the more bags or lower the air-to-cloth ratio, the better the cleaning will be. This is incorrect, and it has been the industry standard for over 45 years. The reason that more bags are needed is because as the dust becomes more difficult to clean, or remove from the media, more filter area is needed to suffice for the lack of good cleaning. The top of the bag, explained in previous pages, is not cleaning. In fact, the flow is actually negative during the cleaning cycle. In addition, not enough cleaning air is provided to the bottom of the bag. This is the reason that lower air-to-cloth ratios are used. If the bags could be cleaned better, then fewer bags could be used. It is our belief that it is not important as to the number of bags; rather it is important how well the bags are cleaned. This is the core principle at Scientific Dust Collectors and what sets us apart from everyone else. With our unique nozzle technology, we are able to clean the bag more effectively. With our original Scientific nozzle, we provided 40% more cleaning throughout the entire bag than the generic baghouse that employs an orifice and venturi. Also, we do not create a vacuum effect, pulling in dirty air at the top of the bag. For over 27 years, we have provided more effective cleaning systems, higher air-to-cloth ratios, and longer filter life than generic baghouses. Now, with the next generation Scientific nozzles, we are able to provide an even better cleaning system, and ultimately a better dust collector.

Figure Index: