Advanced Dust Collector Technology Applied to the Venting of Shot Peener and Blasting Operations

When fabric media and pleated media cartridge dust collectors are applied to venting operations from shot peening equipment, conventional generic designs and operating parameters have been generally been applied.

There are two essential elements that must be considered for safe operation with a shot peening application:

1. Prevention of fires in the dust collector.
2. The efficiency and maintenance of operating the dust collector itself.

Fire Prevention

There is a definite potential for a spark to be generated and carried through the ductwork right into the dust collector. Another source of ignition is electrostatic charge where these combustible and explosive dusts are involved. In an article on "Explosions and Fires in Dust Collectors" (copy available upon request), it is pointed out that continuous cleaning pulse-jet dust collectors are safer to operate than mechanical cleaning shaker style collectors. It is strongly recommended that a highly efficient spark arrestor/cooler be installed in the ductwork leading to the inlet of the dust collector. QAM supplies probably the most effective spark arrestor called the QUENCHER. It transforms laminar flow in the ducts, which carry sparks hundreds of feet to set fire to the dust collector, to turbulent flow which extinguishes the spark and protect the dust collector from igniting a fire. Ask for our comprehensive documentation on this essential product.

Another important issue can be maintenance of the shot peening equipment. When the shot peener goes out of adjustment and/or alignment, it will produce excessive flame. Spark arrestors are design to stop sparks and embers but a flame front will go straight through the device.

Dust Collection Equipment and Engineering

The abrasive generated dusts have some unique properties that need to be addressed to accomplish the following by application of advanced technology dust collector designs:

1) Lowering the dust penetration through the filter cake filtering mechanism will protect the environment and employees.
2) Recirculation of the vented air can reduce energy consumption.
3) Further economic savings, by lowering energy consumption, for operating the vent system at lower pressure drops and reducing pulsing air consumption.
4) Filter life can be increased by 3 to 4 times.

History

For many years, abrasive blast operations were vented from the blast cabinets through mechanical shaker dust collectors. Originally it was thought that the filtering was accomplished by a sieve action where the holes in the media were smaller than the dust particle size in the gas stream. In these units the initial collection efficiency was relatively low. As the dust collected on the filter media (usually a tightly woven sateen cloth) and the filters became heavier, the particulate collection efficiency increased dramatically to the point that cleaned gas could be returned to the plant. As the cake became thicker, the pressure drop increased. It would eventually increase so high that the flow through the system would be choked.

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The next step in the development was to remove the dust and maintain a low average pressure drop by disposing of the dust collected on the surface of the media. Several mechanical arrangements to remove excess dust were development. During the process of removing the dust, a portion of the dust remained on the media. This residual dust had formed a filter cake and even after cleaning the collection efficiency was high enough to allow recirculation. These were some of the first renewable filter elements.
Typically the average dust collector outlet dust emissions coming through the collector was approximately **0.2 milligrams per cubic meter**. This met the requirements for re-circulating into the workplace until the more recent OSHA emission regulations.

Refer to Figure 1, an illustration of mechanical shaking filter in its most elemental form. The dust laden vent stream enters the cylindrical filter element through the fan into the inside of a relatively tall cylindrical filter element constructed of cotton sateen cloth. The top the filter is supported through a pulley to a cord. The dust collects on the inside of the cylindrical element where to forms a filter cake. The cleaned air is returned to the work area through the filter. As the dust accumulates the pressure drop increases and the filtering efficiency also goes up.

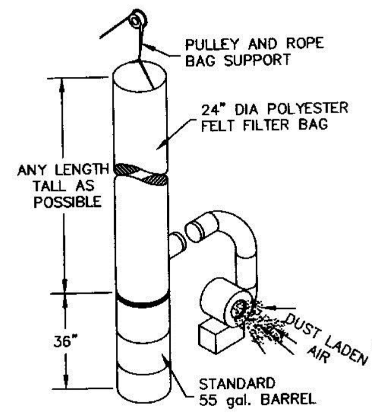

FIGURE 1

Typically the bag is 24 inches in diameter and 72 to 120 inches high. The pressure drop across this filter element is designed to start at 0.50 inchWC and is cleaned at between 2 ½ to 3 inchesWC. If the collector is not cleaned the dust will wedge in the cloth and become partially clogged. When operated correctly the pressure drop will fall back to less than one inch. The filter media should be replaced when the average pressure drop is less than 1 ½ inches. As the filter cloth fails it will require shorter cleaning intervals. The flow in the vent system would need to be shut own for 3 to 4 minutes for cleaning. When continuous cleaning was required, more than one shaker collector was installed in parallel. These were large and had dampers to allow each compartment to clean off line

Pulse-Jet Cleaning Dust Collectors

In the early 1960's continuous cleaning pulse jet collectors were introduced. These collectors were much smaller than the mechanical cleaning collectors and reduced the complexity of the venting ductwork. The typical collector was 15-25% of the size of the compartmented mechanical cleaning collector. The diaphragm valves that powered the cleaning system were simple and would run for 500,000 cycles compared to about 5,000 cycles for the typical dampers in a mechanical cleaning collector before maintenance was required. In general, this meant maintenance was required every 6 months for the compartmented filters and 3 years for the pulse-jet fabric filters.

Figure 2 illustrates the typical arrangement of a pulse-jet dust collector. However, the average particulate load penetrating through the collector was about 2.5 milligrams per cubic meter, which could not be re-circulated into the working environment. Referring to figure 3, the reason for this radical change in dust penetration was due to the inherent nature of the cleaning system. The velocity of the cleaning jet propelled the ejected dust at an angle perpendicular to the surface of the cylindrical filter element. Dust is propelled at a velocity proportional to the velocity of the cleaning jet as it enters the bag. Typically cleaning jet velocities were 24,000 feet per minute. As illustrated in figure 3, this ejected dust would be driven toward adjoining filter bags in the filtering mode and some of the dust would be driven through the bag and its associated filter cake. This caused the much larger penetration of dust through this type collector. It was easily verified by observing the "puff" of dust noticed from the outlet stack of many collectors. This puff would last for one to three seconds after each cleaning pulse.

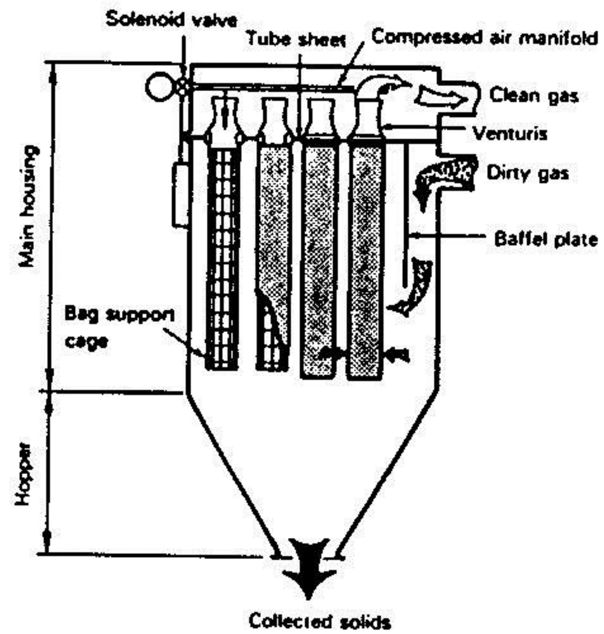

Figure 2

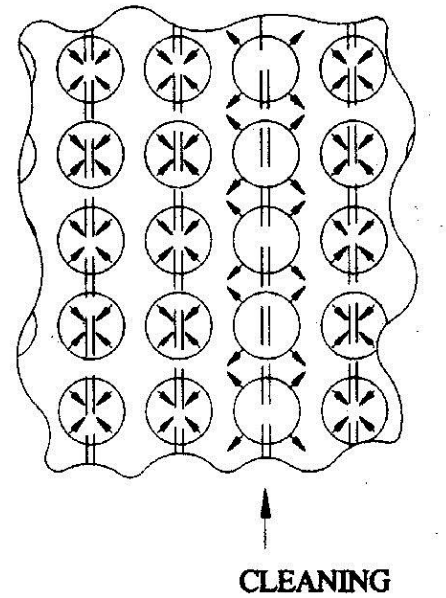

Figure 3

In 1973, pleated filter elements were introduced into the dust collection market. This introduction coincided with rapid increases in energy costs. Figure 4 is a cross section of a pleated filter element, which was better known as a cartridge filter element. It was believed that pulse jet collectors would be more efficient if they were pleated because of low velocities through the filter element. Initial tests by the American Foundry Society seemed to verify this concept. On dust coming from foundry sand systems and abrasive blast operations, the dust at the outlet from a pleated cartridge was measured at 0.03-0.04 milligrams per cubic meter.

It is important to understand the reason for this much lower dust penetration in applying cartridge dust collectors for abrasive blast and shot peening processes. It can be noted that the velocity of the cleaning jet and the high velocity ejection of dust toward the adjoining filter element is neutralized. The dust is hurled toward a filter media segment that is also pressurized. No penetration from this ejected dust occurs and therefore no "puffing" as was the case with conventional design pulse-jet collectors

Figure 5 shows details on some of the limitations of the process. Most dust collector manufacturers and designers packed too many pleats in the cartridge filter element. Also, the cleaning system was undersized for the amount of media at that must be cleaned. The result is dust bridging on the inner pleat. In many cases, we can lose up to 80% of the eight workable area of filter media. This led to short filter life and high maintenance cost.

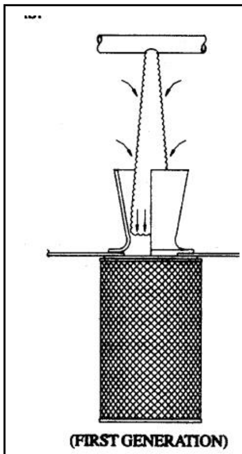

Figure 4A

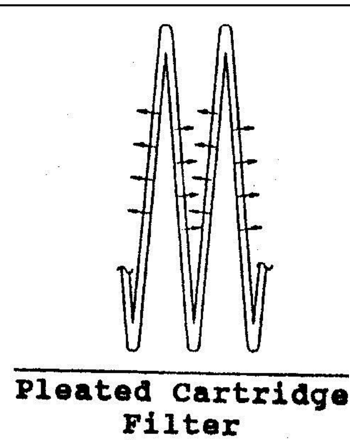

Figure 4B

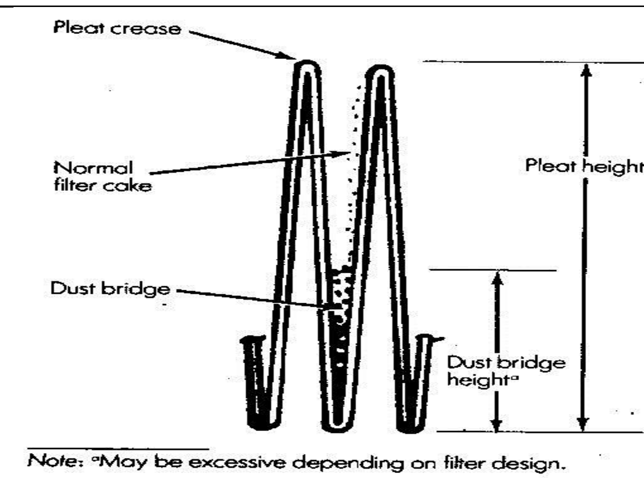

Figure 5

Compare Collector Sizes

For a 10,000 cfm Venting Process, the differences in foot print size for the various collector types were as follows:

Mechanical collector shaker collector with three compartments	225 square foot
Conventional pulse jet with membrane coating on bags 6fpm filtering	75 square feet
Conventional pulse jet collector with felted media with 6 fpm_	75 square feett
Cartridge collector at 2 fpm filtering velocity	45 square feet

Advanced Technology Applied to the Various Designs

Advanced technology modifications have improved the operations of each of these types of collectors, reducing the foot print, lowering pressure drop (with lower power consumption) and reducing penetration of dust through the collectors. Figure 3 showed how the reverse jet cleaning propelled the dust toward adjoining rows of filter elements, causing higher pressure drops and high power consumption. The pleated cartridge element eliminated this defect. However the pleats were crowded together based on the mistaken premise that a lower filter velocity would increase efficiency and lower pressure drop. In figure 5 the crowding of the pleats resulted in the dust bridging in the valley of the pleats. Because the reverse flow air stream follows the path of least resistance, no air flows beneath the dust bridge in the valley making this filter media useless. With 2 inch deep pleats and 14 to 16 pleats per inch, operated at pressure drops over 3 inches WC, the bridge is such that 75 to 85 per cent of the filter media is rendered useless. This action places high velocity cleaning air through the filter cake and reduces the filtering effectiveness after each cleaning cycle until the filter cake repairs itself. The advanced technology designs are those in which the bridging effect is reduced by limiting the square feet of media in each element and by spreading the pleats as illustrated in figure 6.

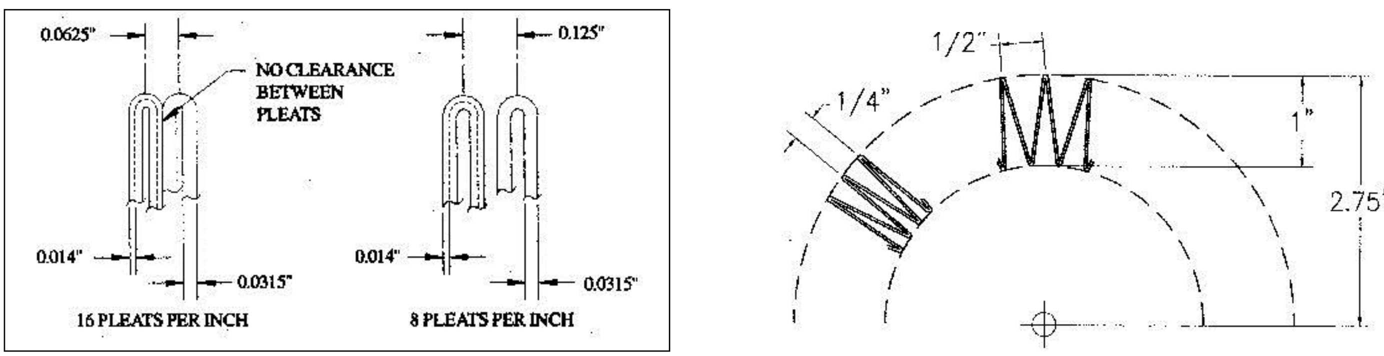

Figure 6

The filter element with the full filter media being cleaned can allow twice as much air in each filter element allowing a reduction in footprint by 50%. The next breakthrough in the **advanced technology** reverse pulse jet designs came in the realization that the capacity of a filter element depended on the reverse air volume of the cleaning jet. In fact the rating of a filter element was 20-30 per cent of the reverse air volume. The venturies in the designs of conventional collectors limited the reverse flow by 60 to 70%. By eliminating the venturi and lowering the velocity of the jet, dust ejected to adjoining bags and thus the emissions through the collector were reduced by 90% This allowed 70% lower pressure drop operation and 50% lower cleaning frequency. More volume could be applied per filter element and the footprint reduced drastically. The new foot prints for the **advanced technology designs were:**

1) Cartridge Collector with wide pleat spacing and collector, 10,000 ACFM at 0.035 mg per cubic meter emissions is **only 25 square feet**
2) Fabric collector with high volume, low jet velocity, 10,000 ACFM at 0.085 mg/cubic meter emissions is also **only 25 square feet**

Other important aspects of applying advanced Technology Collectors

Cartridge filter elements are offered in many configurations design and construction. Originally the only filter media were cellulose. This was because they were an adoption of truck intake replaceable filters and were assembled with plastisol which has poor adhesion. The cellulose would be impregnated by the plastisol. All pulse jet dust collector cartridges should use a good adhesive to seal the pleats against the caps on the cartridges. The adhesives recommended will not crumble or deform when an awl is manually pressed down between the pleats. Although cellulose media are often applied to pulse jet units, the media has a tendency to expand and contract with changes in humidity. This instability will promote bridging. The advanced technology cartridge collectors use spun bond fabrics which are stiffened so that they have the rigidity to keep the pleats from "pinching" or deforming. These new advanced spun bond media have the potential to become permanent filters in that they can be laundered to bring the media back to like new conditions. Fabric Filter elements are usually either polypropylene or Dacron felt.

Cleaning System Designs must be sufficiently sized to develop the required volume to vent the process. The most volume that can be filtered depends on the number and size (or equivalent size) and number of valves. The advanced technology uses a proprietary supersonic nozzle design which increases the reverse jet flow by 70 per cent over a conventional orifice by getting a more efficient pressure to velocity conversion. For typical pulse pipe orifices or nozzles these are listed in the table below. It also decreases the compressed air requirements for the cleaning system by 40 per cent. To determine the maximum filtering capacity of any pulse jet cleaning collector, whether fabric or cartridge, you must determine the number of valves or equivalent size valves from table 9 below. As another more precise determination is to find the orifice sizes in the pulse pipes and multiply by the capacity of each orifice or advanced technology proprietary nozzle.

TABLE 9: Maximum flow per pulse pipe orifice or supersonic nozzle:

0.25 in. dia.	orifice	85 cfm	.500 in. dia	orifice	340 cfm
0.25 in. dia.	**nozzle**	**145 cfm**	**0.500 in. dia.**	**Nozzle**	**575 cfm**
0.312 in. dia	orifice	135 cfm	0.563 in. dia	orifice	430 cfm
0.312 in. dia	**nozzle**	**230cfm**	**0.563 in. dia.**	**Nozzle**	**730 cfm**
0.375 in. dia.	orifice	190 cfm	0.623 in. dia	orifice	530 sfm
0.375 in. dia.	**Nozzle**	**325 cfm**	**0.633 in. dia.**	**nozzle**	**900 cfm**
0.437 in. dia.	orifice	260 cfm	0.687 in. dia	orifice	615 cfm
0.437 in. dia.	**Nozzle**	**440 cfm**	**0.687 in. dia.**	**nozzle**	**1045 cfm**

For instance if, two collectors have 100 bags one with 0.25 orifices and the other with supersonic nozzles in the pulse pipes, the volume of the collectors will be:

With 0.25 orifices: 85 cfm x 100cfm/orifice = 8500 cubic feet pe minute
With 0.25 nozzles: 145 cfm x 145 cfm/nozzle = 14,500 cubic feet per minute

Maximum Flow determination by valve analysis.
Often when the orifice sizes are not specified in a supplier quotation, the maximum flow rating can be determined by referring to the valve size and whether orifices or nozzles are installed in the pulse pipes. If nozzles are installed it will be stated in the specifications.

TABLE 10: List of maximum filtering capacities of a collector for each diaphragm valve size:

1/2 iin. valve w orifices	340 cfm	1 inch valve with orifices	1360 cfm
1/2 in. valve with nozzles	**580 cfm**	**1 inch valve with nozzles**	**2310 cfm**
3/4 in. valve with orifices	765 cfm	1 ½ in. valve with orifices	3060 cfm
3/4 in. valve with nozzles	**1300 cfm**	**1 1/2 in. valve with nozzles**	**5200 cfm**

For instance if, two collectors have 100 bags one with twelve ¾ inch valves and orifices, the other with twelve valves with nozzles in the pulse pipes, the volume of the collectors will be:

With 0.25 orifices and 12 pcs ¾ valves: 765cfm x 12 valves = 9180 cubic feet pe minute

With 0.25 nozzles and 12 pcs ¾ valves: 1300cfm x 12 valves = 15,600 cubic feet per minute

It is noted that the rated volume of the collectors vary in that using the cleaning capacity of the valve is slightly higher than that listed in figure 9, which means the full capacity of the valve is not incorporated into the pulse pipe designs.

Safety and reliability

For safety, there are several considerations. The following are important.
1**) Measuring and guarding against leakage**. HEPA safety filters are mostly applied to re-circulating systems. These have a very limited dust holding capacity and can get filled up in a few minutes from a blasting system. Once they are filled up the vent system is choked and dust will be emitted at the hood. Another approach is to apply a dust measuring system at the outlet to sound an alarm in case of a failure of a filter element. A better advanced technology approach is to use no cleaning cartridge filter element as an after (safety filter). Monitoring the pressure drop is an accurate indication of either a slow leak or a catastrophic collector failure. The safety filter with an efficiency approaching a HEPA filter has 50 to 100 times the dust holding capacity to allow sufficient time to shut the system down and repair the failure.
2)**Reliability** is achieved by ensuring the collector is sized for the required vent volume as determined above.

Applying the data above the engineer can specify, select and evaluate the offerings from suppliers to obtain a venting system that will provide performance, safety, least space, less power requirements and reliability in his system.