Fabric Pulse Jet Collector Early Designs (Circa 1963)

To expand in the application area for process streams that operate at higher temperatures and corrosive conditions, an improved fabric pulse jet collector was developed. The early design is illustrated in Figure 7-2. The main changes in the collector include the collecting of dust on the outside of the bag, the grouping of bags into rows, and the cleaning of the bags by rows. Each bag was typically 4 to 6 inches in diameter, 6 feet long, and arranged with 6 to 10 bags in a row. The cleaning sequence was accomplished by cleaning each row of bags individually. The cleaning energy consisted of a compressed air powered eductor or reverse jet that ejected compressed air into each bag in the row. A pipe or purge tube was common to all of the bags in a given row and it was located over the center of each bag in the row. Orifice holes were positioned in the purge tube at the center of the bags which directed the compressed air jet into the throat of the bag.

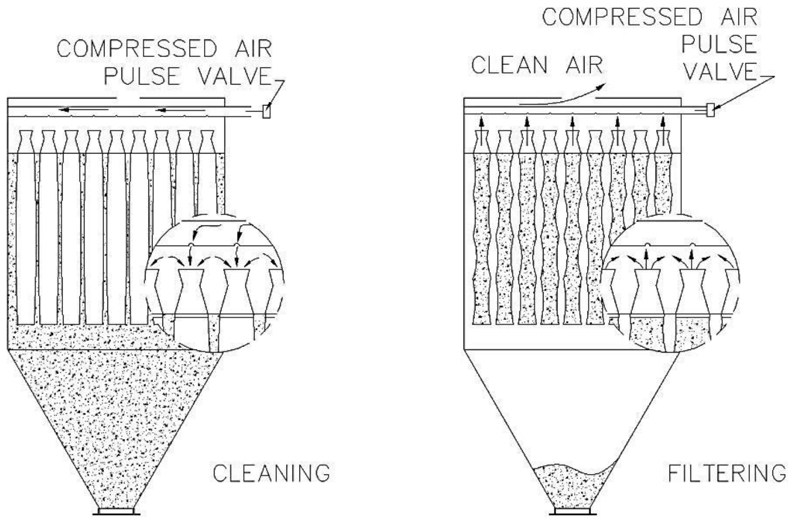

FIGURE 7-2

When the compressed air travels through the orifice, it becomes an air jet that expands by the Law of Conservation of Momentum until it is stopped by one of the following:

- The opening of the bag itself.
- A tube which is inserted into the center throat of the bag and the tube diameter is calculated to generate the proper jet velocity in relation to the size of the orifice in the purge tube.
- A so-called venturi, which serves the same purpose as the tube described above, is basically a tube with smooth transitions attempting to reduce the pressure drop as the fan air flows from the bag into the clean air chamber.
- An orifice plate that is centered in the throat at the top of the bag and it has the same purpose as the tubular insert or venturi.

The characteristics of these early cleaning jets were as follows:

Table 7-1

Average velocity at throat of the tube, venturi or orifice	15,000 feet per minute
(It should be noted that this was the same velocity as the blow ring outlet.)	
Venturi throat opening	1 7/8 inches diameter
Jet flow	290 CFM
Bag diameter and length	4½ inches x 72 inches
Bag area	7 sq. ft.
Filter flow rating per bag	100 CFM
Nominal filter ratio	14 FPM*
Average pressure drop	3 1/2 inches water column
Average Air Consumption	¾ SCFM/1000 CFM of filtered air
Average dust penetration at 10 gr./cu.ft. load	0.0005 gr./cu.ft.

* Actual filter ratio or filtering velocity was lowered by various dust and process characteristics, primarily because of the dust laden air entering into the hopper. Average filter ratios were approximately 10:1 or 10 FPM filtering velocity through the bags.

<u>Fabric Pulse Jet Collector Later Designs (Circa 1971)</u>

The original design was later modified by the original patent holder and the characteristics of the cleaning jet were altered, presumably to accommodate ten foot long bags. This "generic" cleaning design was then copied by the whole industry. The new characteristics were:

Table 7-2

Average jet velocity at the throat	25,000 feet per minute
Venturi throat opening	1 7/8 inches diameter
Jet flow	500 CFM
Bag diameter and length**	4½ inches x 120 inches
Bag area	12 sq. ft.
Filter flow rating per bag	90 CFM
Nominal filter ratio	8 FPM
Average pressure drop	6 inches water column
Average Air Consumption	1 ¼ SCFM/1000 CFM air flow
Average dust penetration at 10 gr./cu.ft. load	0.008 gr./cu.ft.

** Over time there were a variety of bag diameters and lengths introduced by different suppliers. However, the jet characteristics and performance were similar.

The new design was expected to operate at the same nominal filter ratio as the early designs. However, field experience showed that the nominal filter rate actually dropped from the designed 14:1 ratio to an actual ratio of 10:1. The true reason for this reduction in performance will not be understood until much later. In reality, the nominal filter ratio for the new design was 8:1, however, most collectors actually operated between 5:1 to 6:1 ratios.

In the new 8:1 ratio design, the air consumption and pressure drop increased dramatically. Unfortunately, in the general selection of dust collectors, the air-to-cloth ratio became the dominant specification in selecting the pulse jet collectors. In time it was generally accepted that the pressure drop, air consumption, and dust penetration would be at the new higher levels. In addition, the average bag life went from 5 to 6 years for the 1963 design to 2 to 3 years for the 1971 design. In the rapidly expanding market of the early 70's, this deterioration of performance was accepted by the engineers. In fact, to solve any operational or application problems, the cure was to lower the filter ratios even further.

It is important to understand the reason for this deterioration of performance. There were two main factors: 1) upward velocity of dust entering the filter compartment from the prevalent hopper inlets (sometimes referred to as "can" velocity), and 2) the change in the velocity characteristics of the cleaning jet.

<u>Changes in Jet Characteristics ("Generic" Baghouses)</u>

The obvious change was that the jet velocity for cleaning had increased from 15,000 FPM to 25,000 FPM. It has been well documented that on the 1971 design, the bag inflated and formed a cylindrical shape during cleaning. This change from a concave shape between the vertical wires on the cage during cleaning has led many to believe that the primary cleaning mechanism was this flexing of the bag during the cleaning cycle. Like all engineering determinations, there was a certain underlying truth to these studies. The fact was that when the collectors were compartmentalized and cleaned off line, this so-called "flexing" of the bag allowed the application of the pulse jet collectors to be used in many processes where no other collector, including the continuous cleaning pulse jet, was effective. However, with the development of the cartridge collector, this type of flexing could not happen during the cleaning of the media; therefore, these theories seemed to be discarded with the passing of time.

It is important to note that if the aggregate open area in the filter cake is larger than the venturi or jet area, suitable pressure will not develop and the bag will not leave the wires. Therefore, no flexing of the bag or media will develop from the velocity of the cleaning air. Typically, when collectors are running below 2 inches water column, whether cartridge or fabric, this indicates that the effective area of the cake and media combination is very large and the flexing of the bag does not occur. When the pressure drop is over 3-1/2 inches water column, the flexing of the bags will occur on generic venturi-based fabric collectors. After the cleaning cycle, the aggregate area of the opening in the bag/cake is increased. It is in this newly opened area that the dust collects and the pressure drop is lowered until an overall pressure balance is reached.

Velocity of Dust Ejected During the Cleaning Mode

It can be concluded that the dust leaves the bag during the cleaning cycle at the velocity of the cleaning jet. The change from the 1963 design increased from 15,000 fpm to 25,000 fpm. If these velocities are converted to velocity pressure, we get 14 inches w.c., and 38 inches w.c. respectively. This indicates that the propelling force of dust from the bag has increased by 2.7 times during the cleaning mode. Refer to Figure 7-3. At the higher velocity, the dust is thrown from one row of bags in the cleaning mode towards the adjoining row of bags.

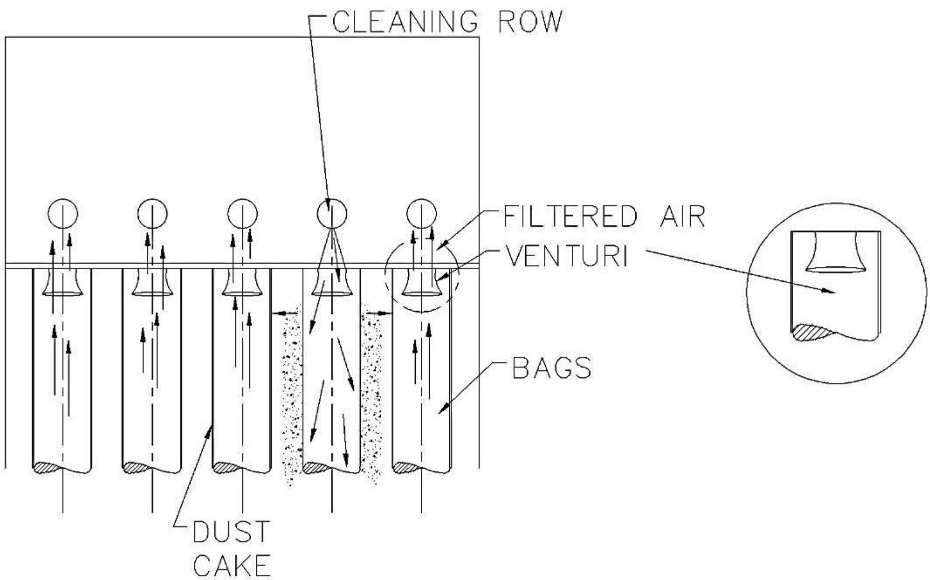

FIGURE 7-3

This dust at the higher velocity drives itself through the adjoining bag and its cake. The dust cake becomes increasingly denser and develops a more resistant barrier until equilibrium conditions are reached.

When examining the dust collected from the clean side of the collector during performance testing, a wide range of dust particles are noted which includes those that are in the 20 micron range and smaller.

On many applications, “puffing” can be observed from the exhaust of collectors immediately after the pulsing of each cleaning valve. This phenomenon is dependent on the effective density of the dust. The lower density dusts tend to penetrate the adjoining bags more than the higher density dusts. Very low density dust such as paper and many fibrous dusts can also operate at low pressure drops, low air consumption, and extremely low penetrations.

Effect on Media Selection

The phenomenon of driving dust through adjoining bags has led bag suppliers to offer a wide array of bag media formulations. If we ignore the requirements imposed by temperature and chemical attack, the main consideration in selecting filter media is its ability to resist the penetration of the propelled dust that traveled through the bag and its associated cake. There are several approaches.

The most effective approach is to use bags with laminated construction where PTFE media is laminated to the felted or woven bag. This laminate has such fine openings that the coating can hold water, yet allows air to pass through the laminate freely. Its original application was to make waterproof fabrics that prevent water from entering the fabrics yet allows the vapor and air to pass through unimpeded. Unfortunately, PTFE bags are expensive when compared to the standard media and therefore are usually used only in special applications.

Another approach is to fabricate the filter cloth with finer threads, especially near the filter surface, to provide a more complex serpentine path so that the dust penetration is reduced. Dual dernier felts and woven felts are examples of materials that have a layer of fine threads on the filter surface and coarser threads below the surface.

Bag Modifications

Use pleated filter elements. When a pleated filter is cleaned, the dust can be driven against adjoining elements at high jet velocities, but since the dust is directed at another dust collecting surface that is also blowing dust in the opposite direction, penetration does not occur. This will be explained further in later chapters. There are some limitations and principles that must be applied to selecting and applying pleated filter elements that are beyond the scope of this discussion.

Insert bag diffusers. These proprietary inserts reduce the velocity of the jet cleaning forces as the bags are cleaned. The inserts consist of perforated cylinders that fit into the cage but around the outside of the venturi.

Baffles. Baffles have been inserted between the rows of bags to prevent the dust from impacting the adjoining rows.

Pulse Jet Collector Technological Breakthrough (1979) by Scientific Dust Collectors Company

Noting that the blow ring collector was able to operate at very low pressure drops and filter ratios of 18 to 22:1, the engineers at Scientific Dust Collectors launched a research and development effort to determine if they could develop a pulse jet collector that had the same characteristics. They made some important discoveries and a number of patents were issued.

A key principle was identified to be that filter flow of air depends on the cleaning capability which in turn depends on the flow of reverse air in the cleaning jet, whether the filter element is a bag, cylindrical, pleated or envelope configuration. In other words, the better the media can be cleaned, the more airflow can be tolerated.

By reducing the jet velocity, the operating pressure drop is reduced even to the equivalent of the blow ring collector. This is actually 50 percent below the old technology designs. In addition, the reduction of the jet velocity reduces the dust penetration by over 80 percent and accomplishes a gain in bag life in the 200 percent range.

Since its introduction, a great many "high ratio" collectors of this design have been installed with the following operating characteristics:

Table 7-3

Average velocity at bag opening	10,000 feet per minute
Bag opening (no venturi)	4½" diameter
Jet flow	740 CFM
Bag diameter and length	4½ inches x 96 inches
Bag area	10 sq. ft.
Filter flow rating per bag	190 CFM
Nominal filter ratio	20 FPM
Average pressure drop	2½ inches water column
Average air consumption	½ SCFM/1000 CFM of flow
Average dust penetration at 10 gr./cu.ft. load	0.0005 gr./cu.ft.

In achieving the high performance of these "High Ratio" collectors (see Figure 7-4), there were some additional modifications that had to be developed:

Special Inlet Configurations. The inlets were moved from the hoppers to the upper section of the baghouse. This "high side inlet" created a naturally downward air flow pattern. The new cleaning system can now collect very fine dust that previously was driven out of the exhaust. Typically, these fine dust particles do not agglomerate as well and will not fall into the collection hopper, especially if high upward air flows are present which is usually the case with the use of hopper inlets. These inlets also changed the direction of the airflow which caused larger particulate to simply drop out of the airstream.

Special Baffles. The use of perforated vertical baffles directs the horizontal air and dust distribution into predetermined dust flow patterns in the filter compartment. In addition, a wider bag spacing was introduced.

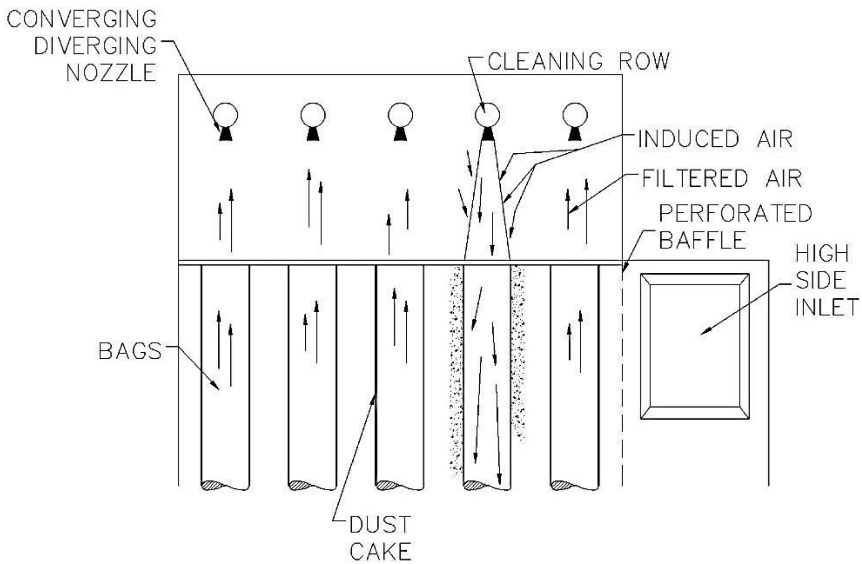

FIGURE 7-4

Applications. These fabric collectors can be applied everywhere other old technology collector designs were applied whether it consisted of fabric or cartridge filters. This includes the collection of submicron fume dusts such as in smelting, welding, or combustion processes.

Advantages of Scientific's High Technology ("High Ratio") Fabric Collectors

- Most compact collector available. Normal operation at 14 to 18:1 filter ratios or typically twice the filter ratio of "generic" baghouses.
- Bag life increased by over 200% using fewer bags.
- Compressed air usage decreased by at least 50%.