Worldwide Pollution Control Association

WPCA-Duke Energy

FF/HAPS Seminar

October 12-13, 2011

Visit our website at www.wpca.info

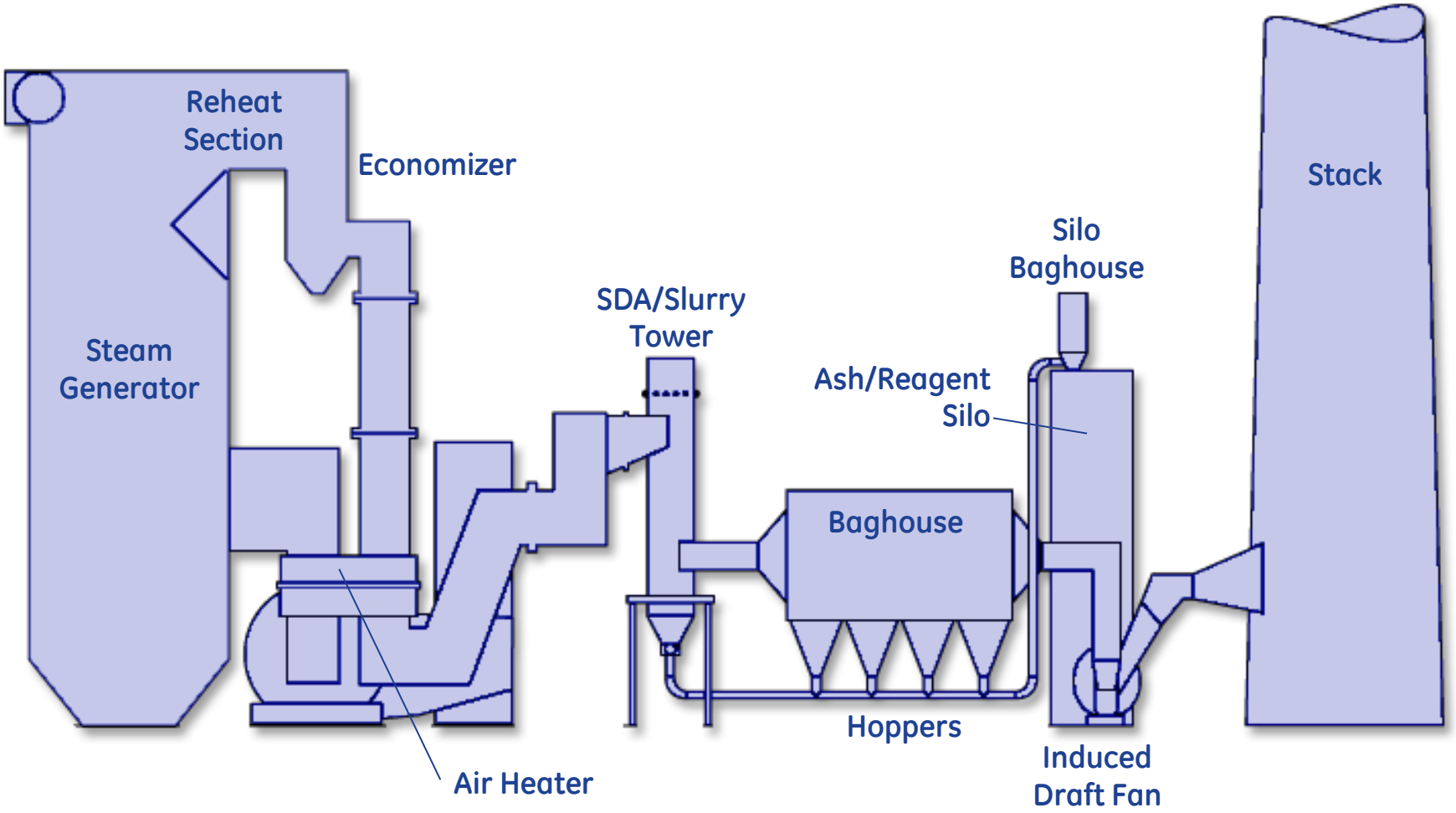
WPCA-Duke Energy Pulse-Jet Fabric Filter Training

Robert Brinkley
Babcock & Wilcox

Tim Stark
GE-Fabric Filter

imagination at work

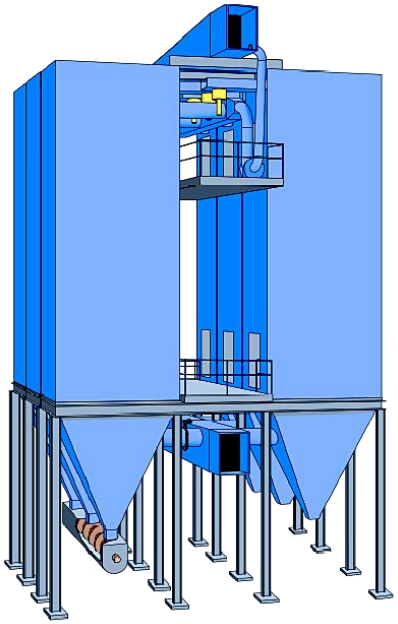
Typical SDA System Schematic

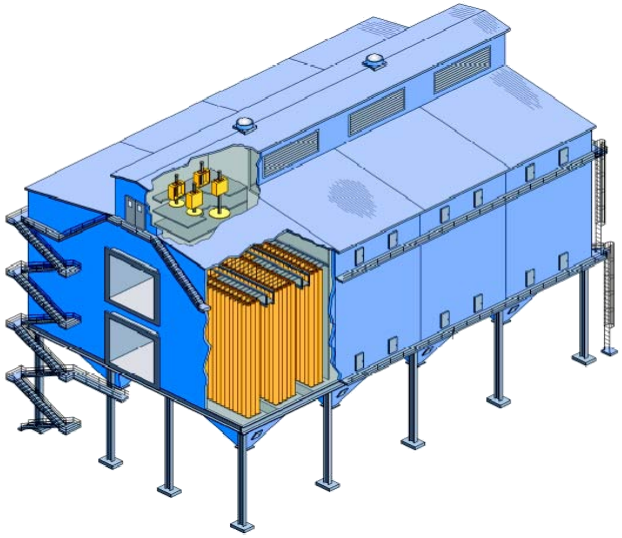


Hot Gas Market APC Trends

Historically, 95% of applications utilized Reverse Air collector designs:

- Woven Fiberglass bags
- Woven Fiberglass with PTFE
- 2:1 air-to-cloth ratio
- 11.5" x 30' filters (29cm x 9m)
- 4 – 8 year filter life
- Large footprint housing





Hot Gas Market APC Trends

In the past 10 years, the trend is moving to Pulse Jet collectors (approximately 80% of applications):

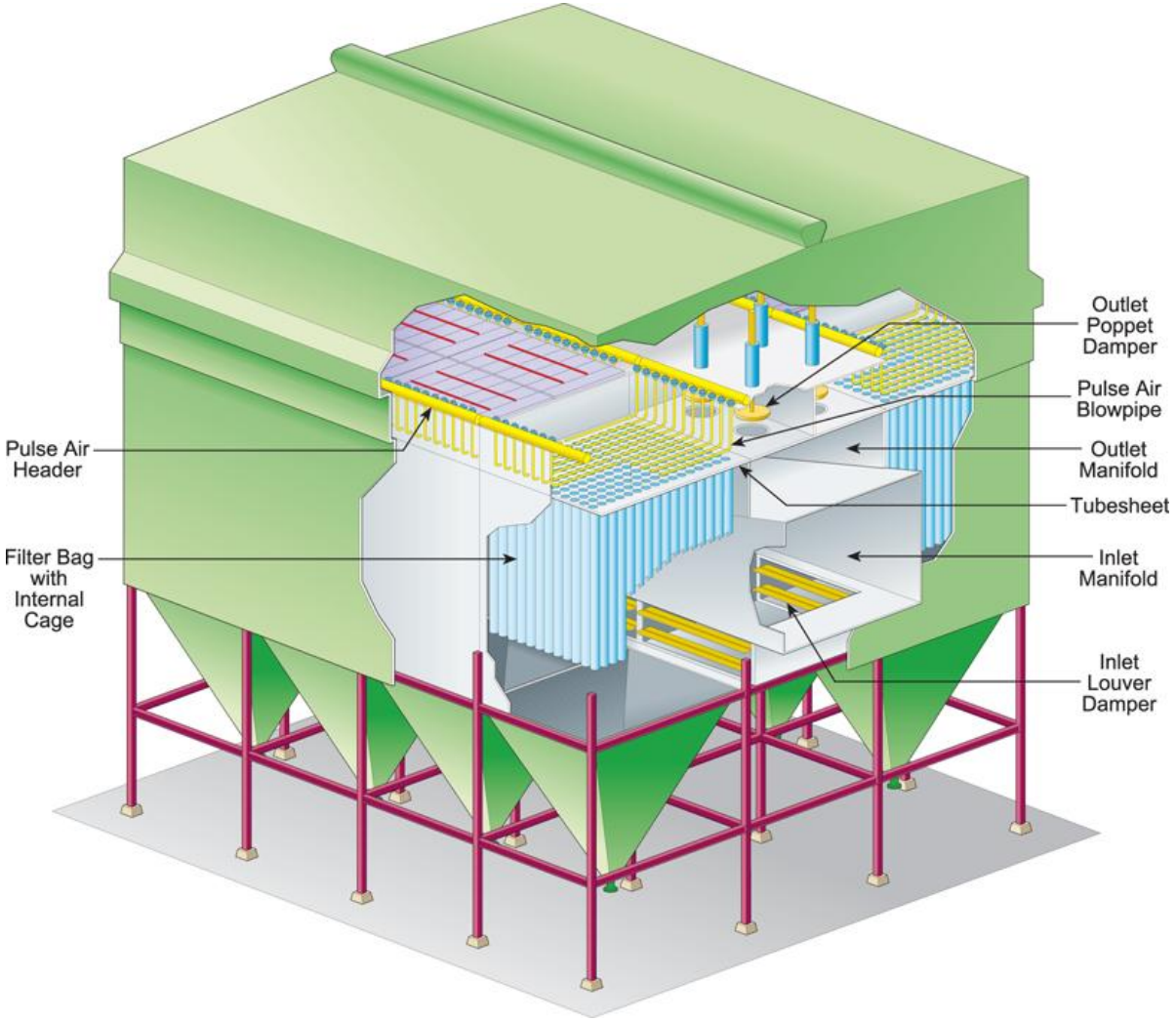
- Felt used for under 375°F (190°C)
- 2.5-3.5:1 Air-to-Cloth ratio
- 3 – 6 year filter life
- Smaller housing footprint

Municipal Solid Waste Incineration
16 MW – 65,000 ACFM

Coal-fired Industrial Boiler
110,000 ACFM

Utility Boiler
500,000+ ACFM

Pulse-Jet Baghouse



Three Types of Cleaning Systems

- High Pressure/Low Volume
  - 8-7bar (80-100psi)
- Medium Pressure/High Volume
  - 2-3bar (30-45psi)
- Low Pressure/High Volume
  - 1bar (15psi)

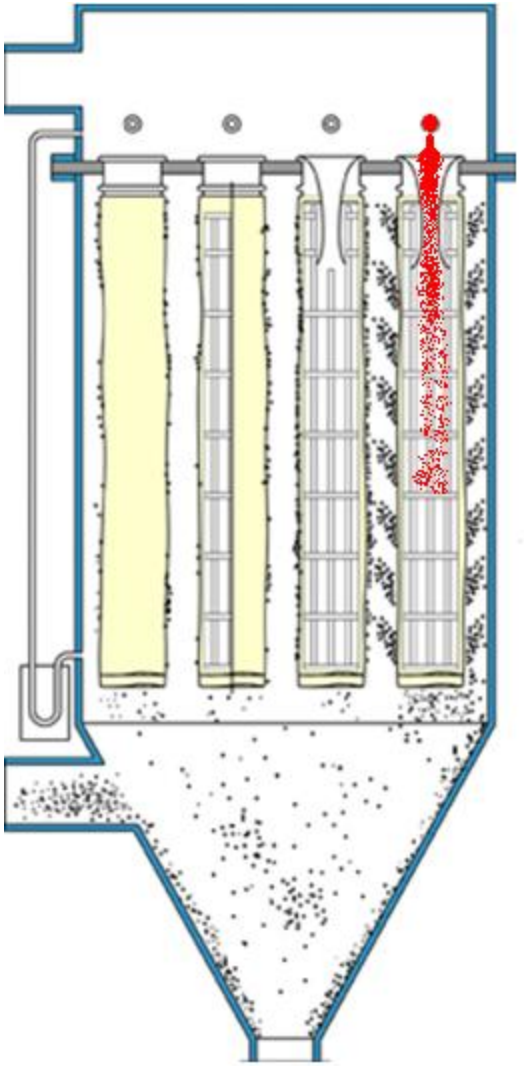
Medium Pressure/High Volume

- 2.5" to 3" pulse valves
- Typically round filters with cages
- Do not use traditional venturis
- Filters: 125-159mm x 3000-6000mm
  5"-6.25" x 10'-20‘
- Requires an air compressor

Pulse Jet Baghouse

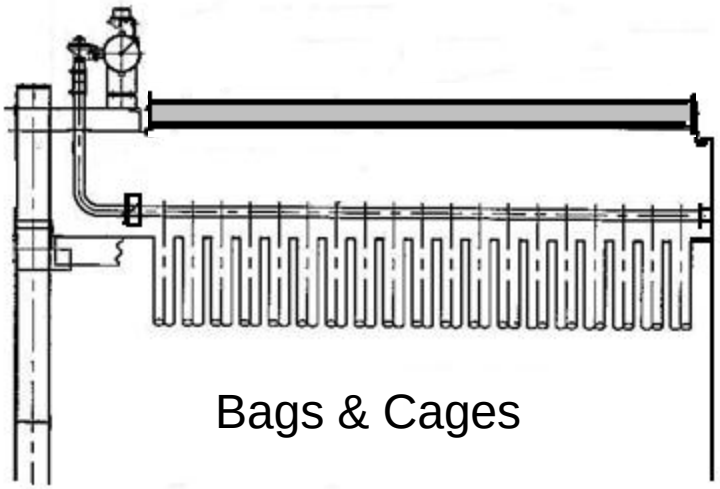
Clean
Gas Outlet

Dirty
Gas Inlet

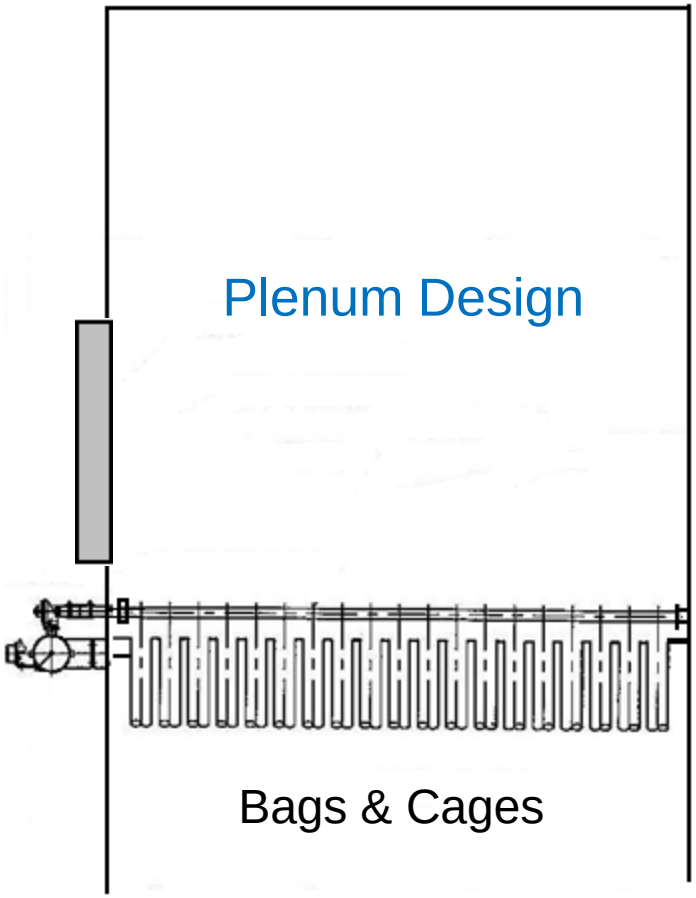


Pulse-Jet Designs

Hatch Design

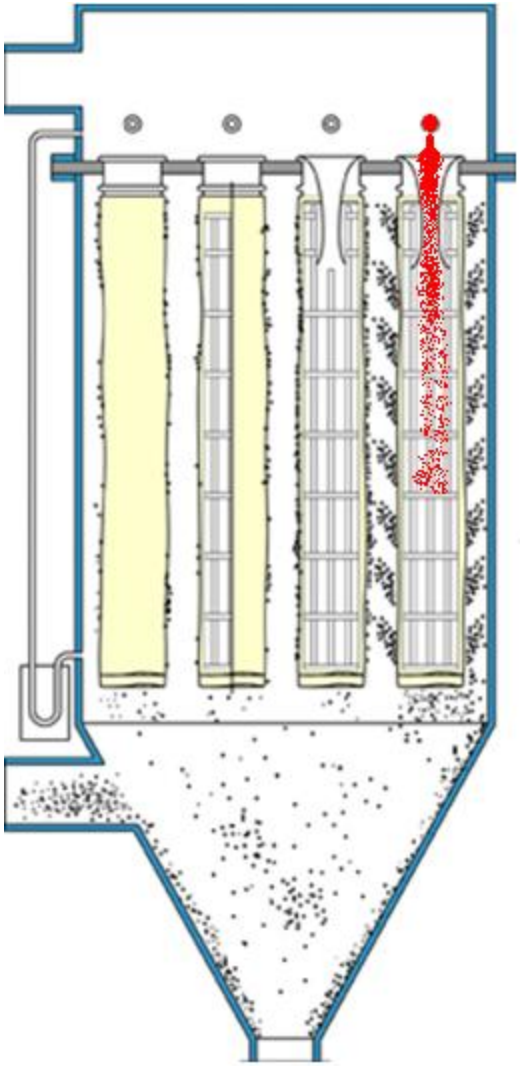


Plenum Design



Pulse Jet Fabric Filter

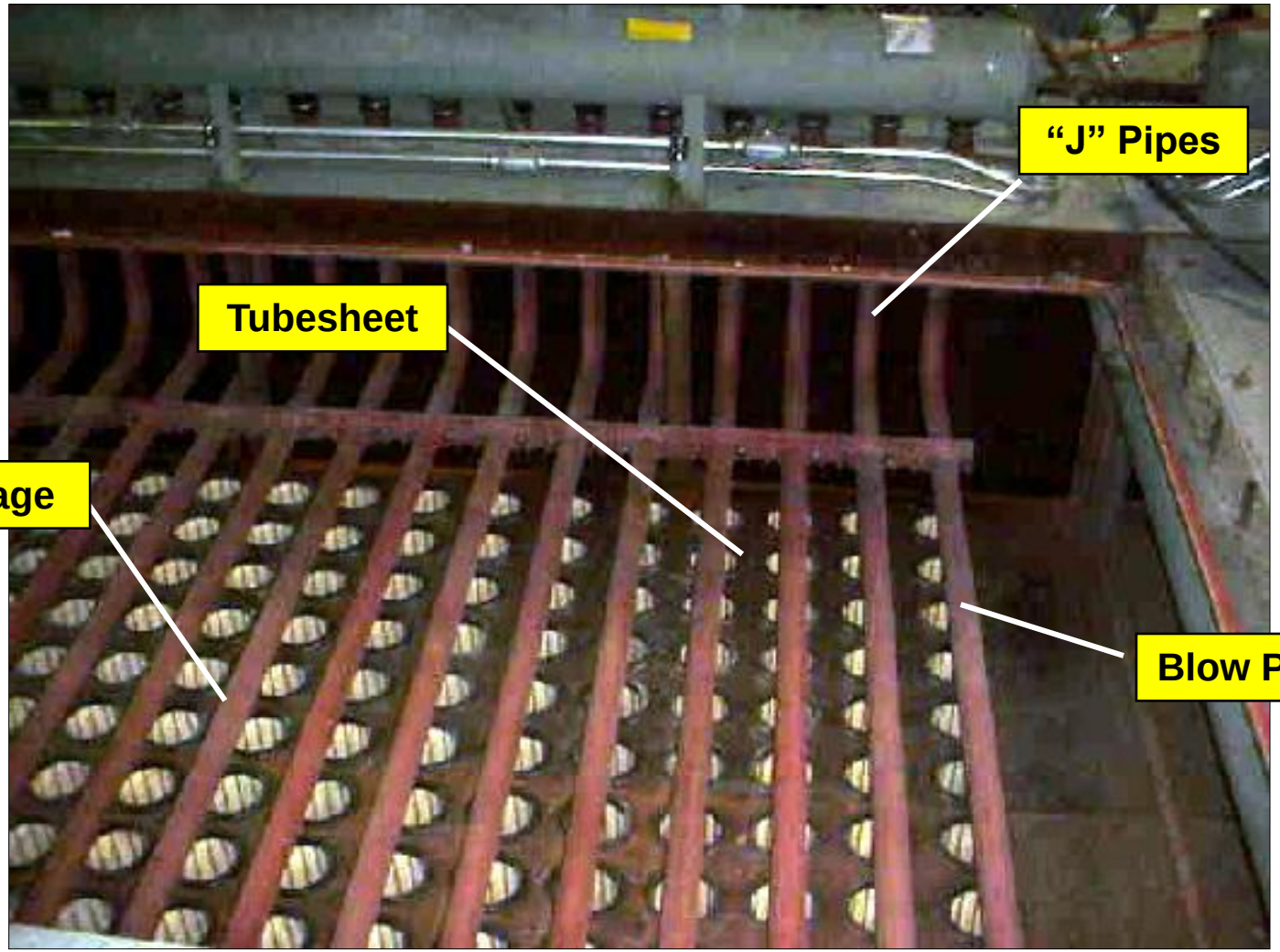
Clean
Gas Outlet



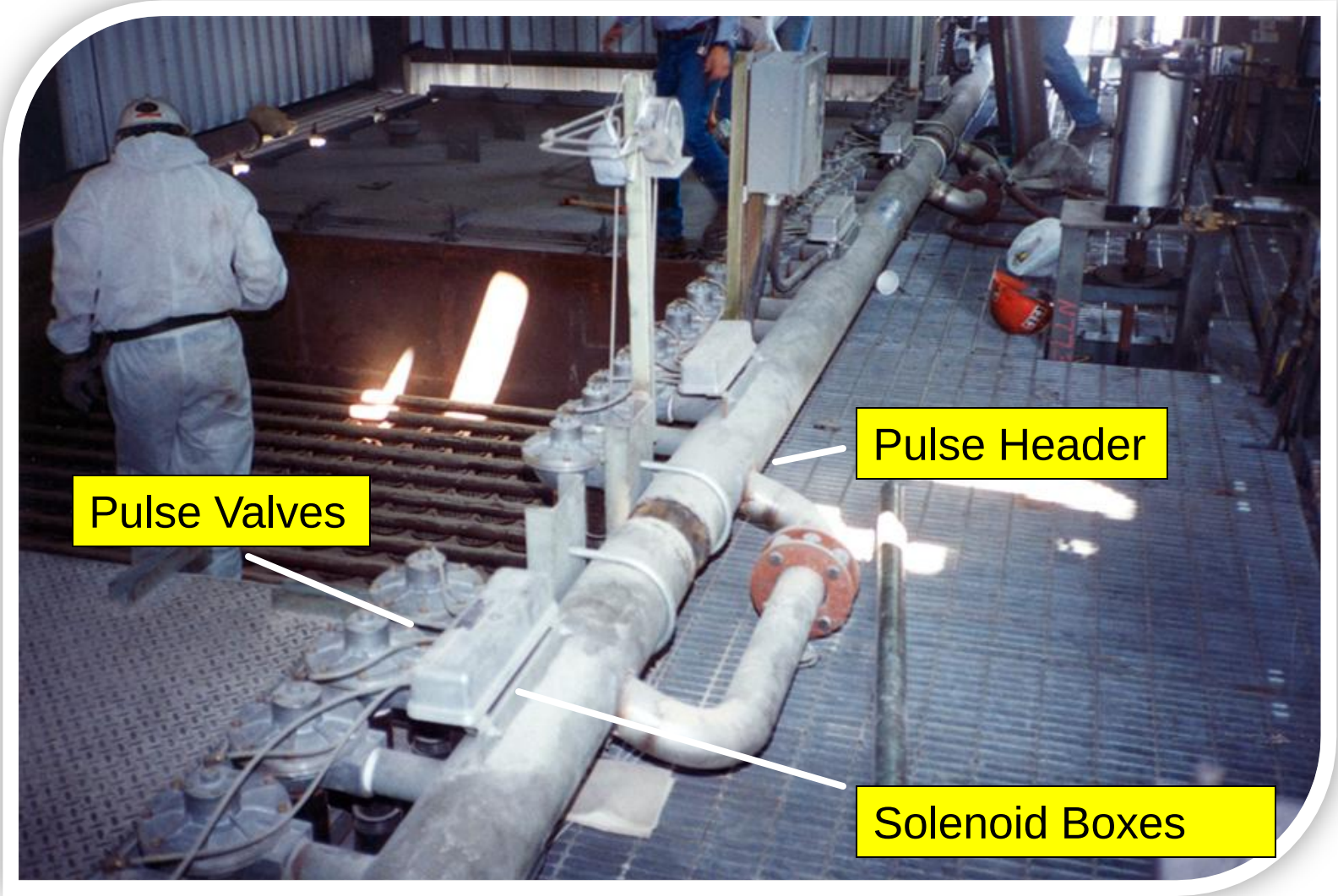
Flue
Gas Inlet

8 and 10 m bags

Pulse Air System



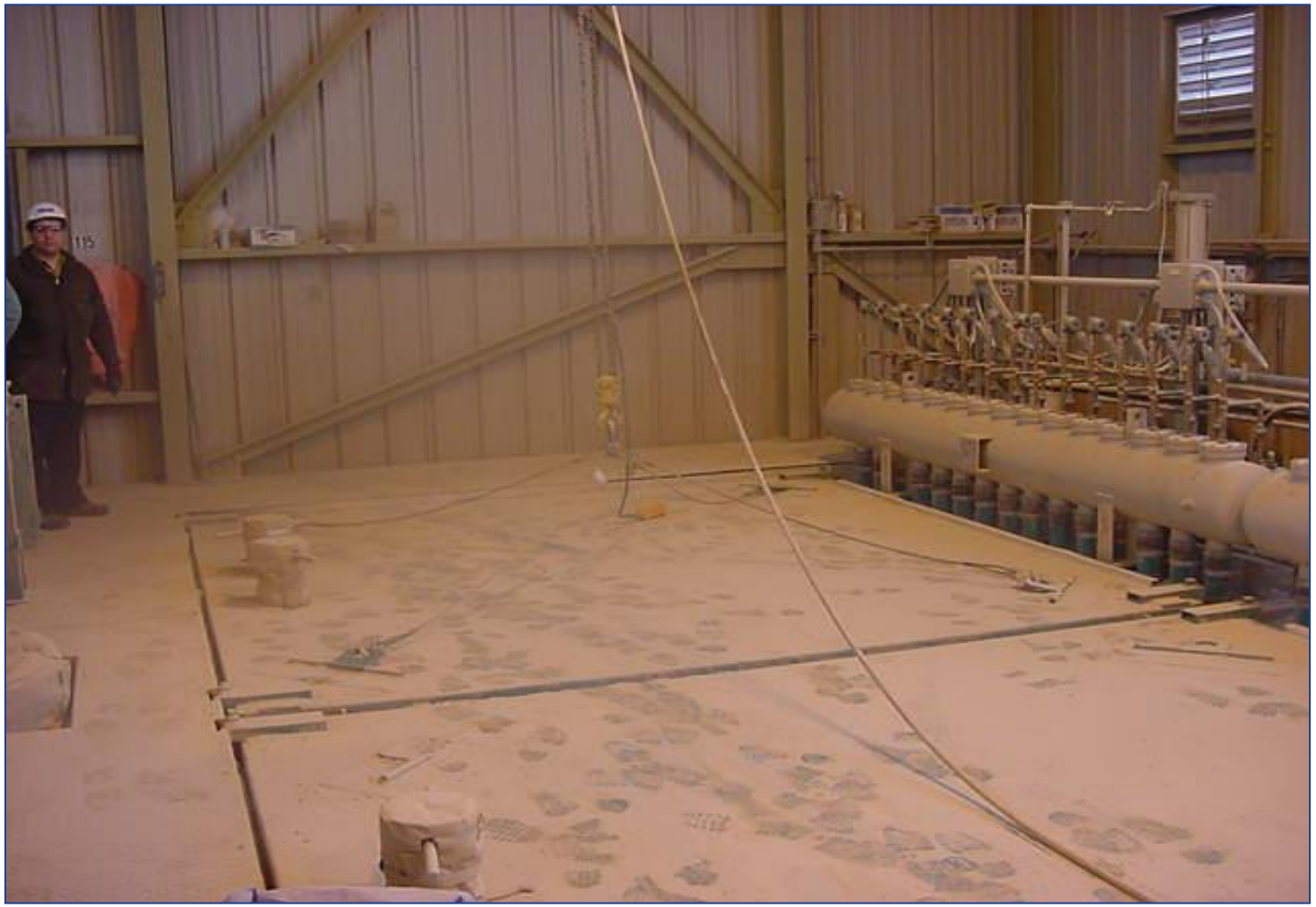
Pulse Jet Baghouse



Medium Pressure Cleaning System

Cleaning Systems

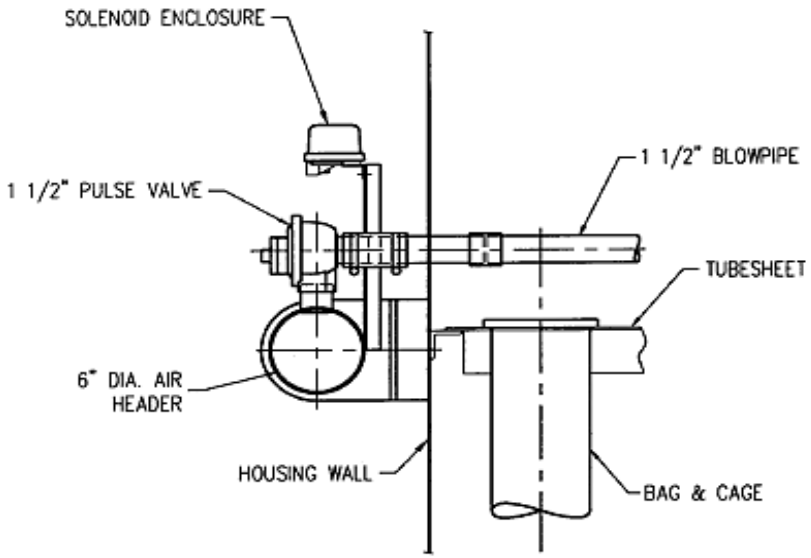
Cleaning Systems



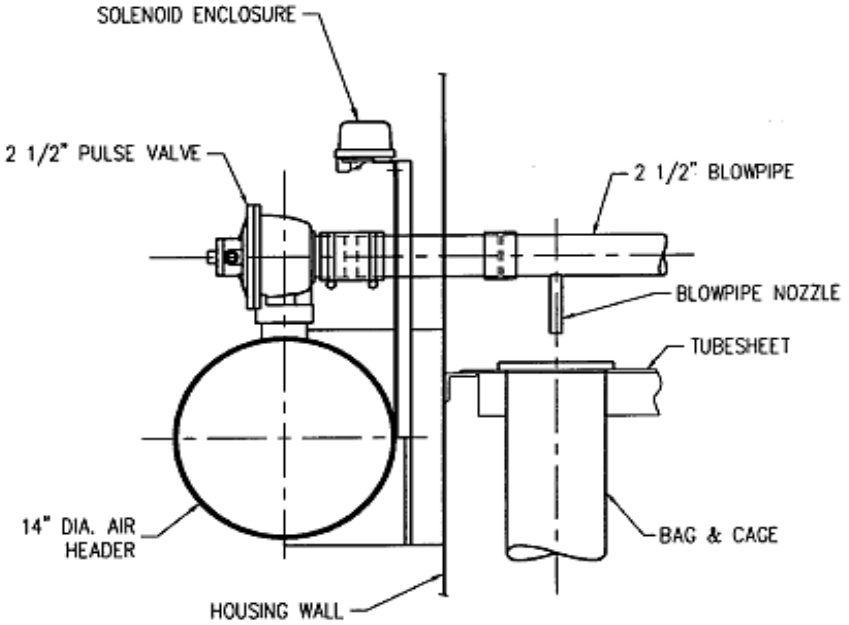
Medium Pressure / High Volume Pulsing

- Standard pulsing system
- 14" nominal diameter compressed air header
- 3" diameter pulse valve & blowpipe
- Blowpipes typically include nozzle extensions at each blow hole
- 3" diameter pulse valve @ 30 psi consumes 140 scfm max.
  pulse interval: 6 seconds
  duration: 230ms
  volume: 14.03 scfm/pulse
- Horsepower required to compress air to 30 psi:
  15.26 Hp = 11.38 Kwh
- Formula:
  HP = 0.2267Q [[PSI/14.7+1] 0.283 –1] + 30% safety factor

Cleaning Systems



LOW VOLUME
HIGH PRESSURE
PULSING ARRANGEMENT



HIGH VOLUME
LOW PRESSURE
PULSING ARRANGEMENT

ACFM

Actual Cubic Feet of gas per Minute

The volume of the gas flowing per unit of time at the operating temperature, pressure and composition.

(also measured in cubic meters per hour)

Air-to-Cloth calculations

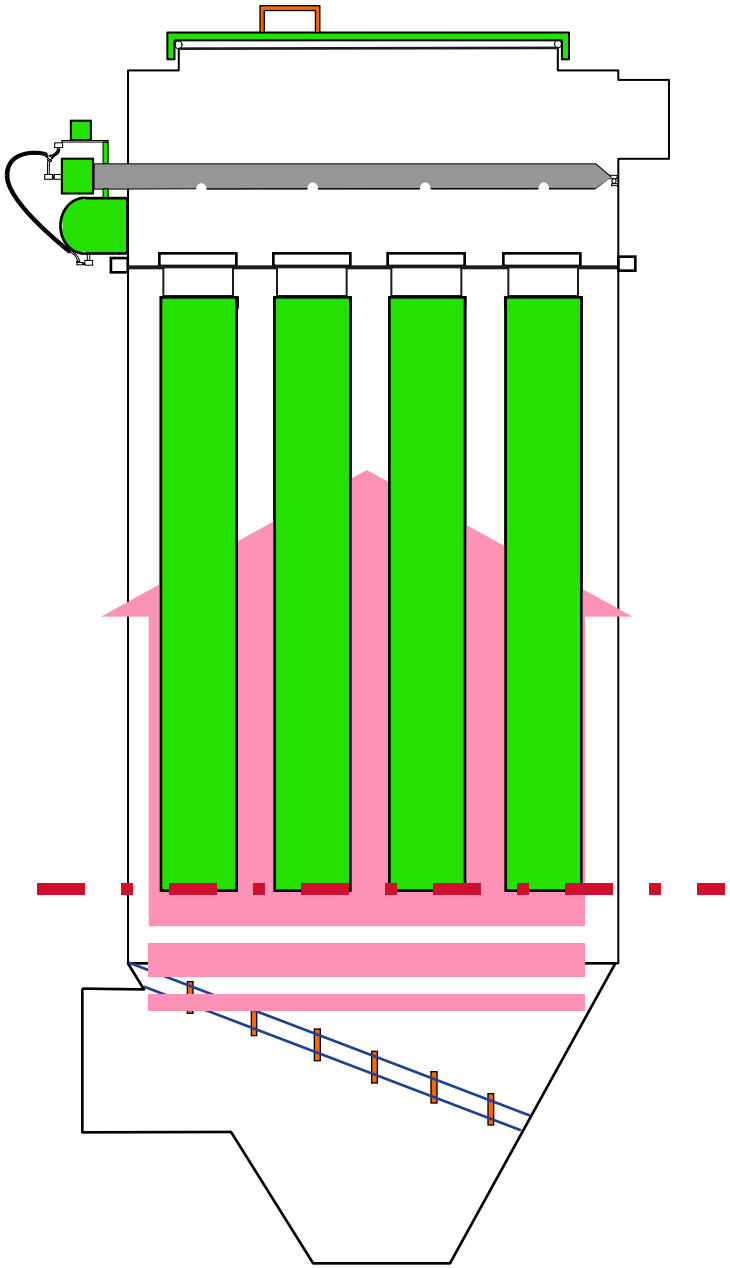
Air-to-cloth ratio = acfm ÷ total filter area

(Filter dia. X length x 3.14) = filter area

Total # filters x filter area = total filter area

Air-to-Cloth ratio (filter rate)

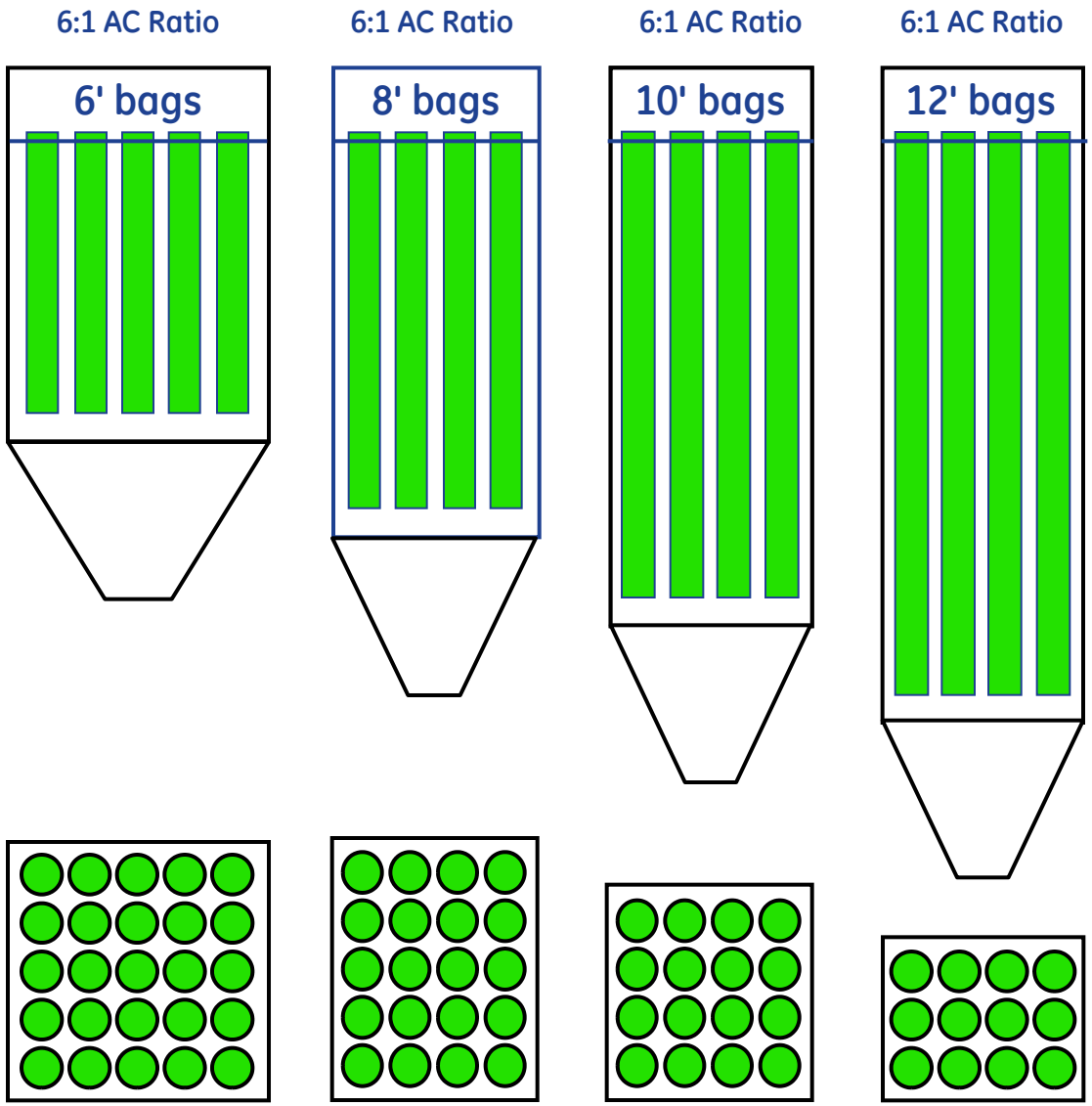
Type of Filter Cleaning System	Maximum Recommended Air-to-Cloth Ratio	
	Imperial	Metric
Shaker	**3.0**	**0.91**
Reverse Air	**2.5**	**0.76**
Pulse-Jet:		
A. Cylindrical Filter Bags:		
-For elevated temp	**2.5-4**	**.76-1.22**
B. Pleated Filters (Non-Paper Media)	**3.5**	**1.07**
C. Pleated Filters (Paper Media)	**2.0**	**0.67**



Can velocity

In a pulse jet dust collector with the filter elements suspended from the tubesheet and a hopper level inlet, Can Velocity is the upward air stream speed passing between the filters calculated at the horizontal cross-sectional plane of the collector housing at the bottom of the filters.

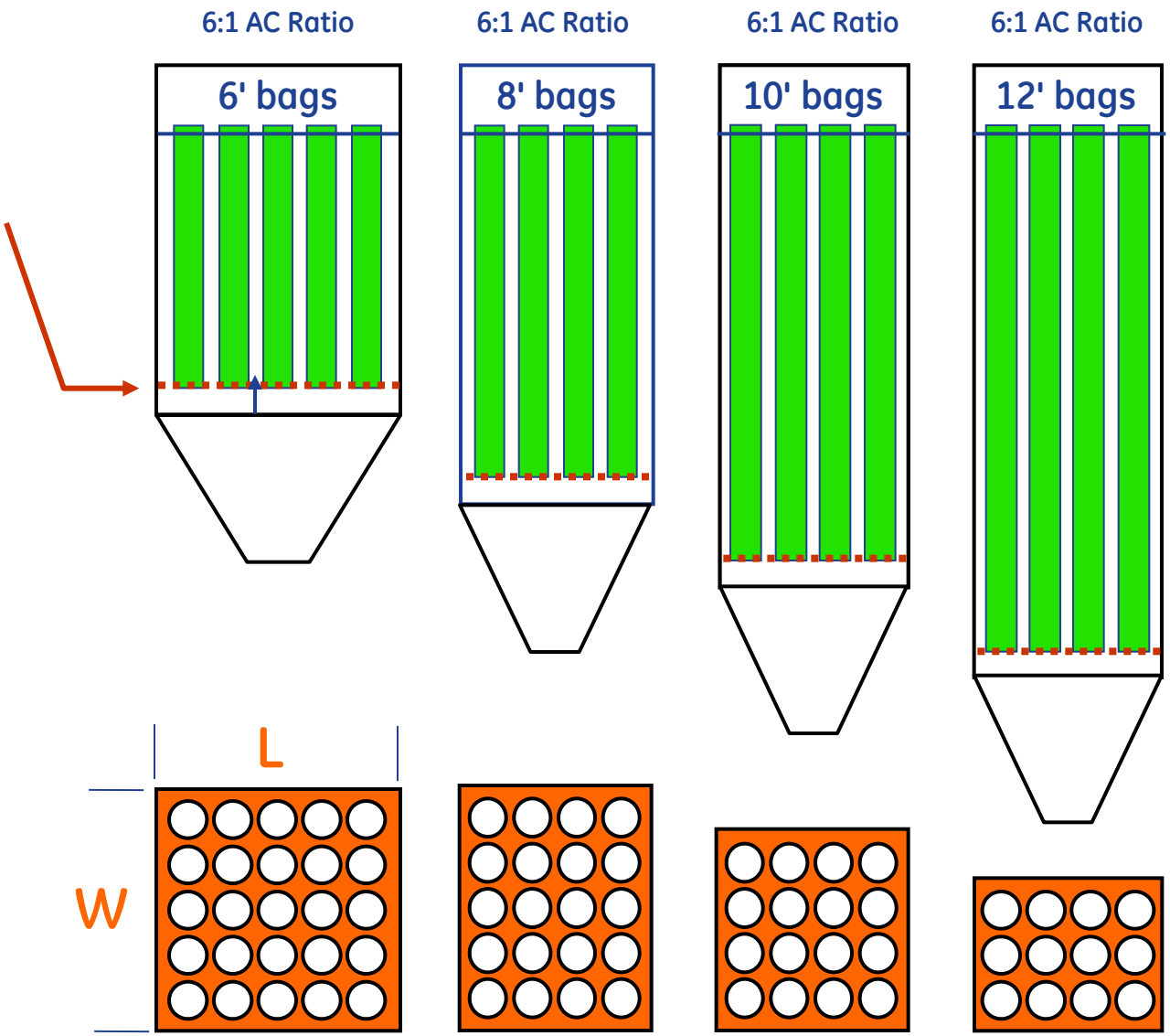
Can velocity

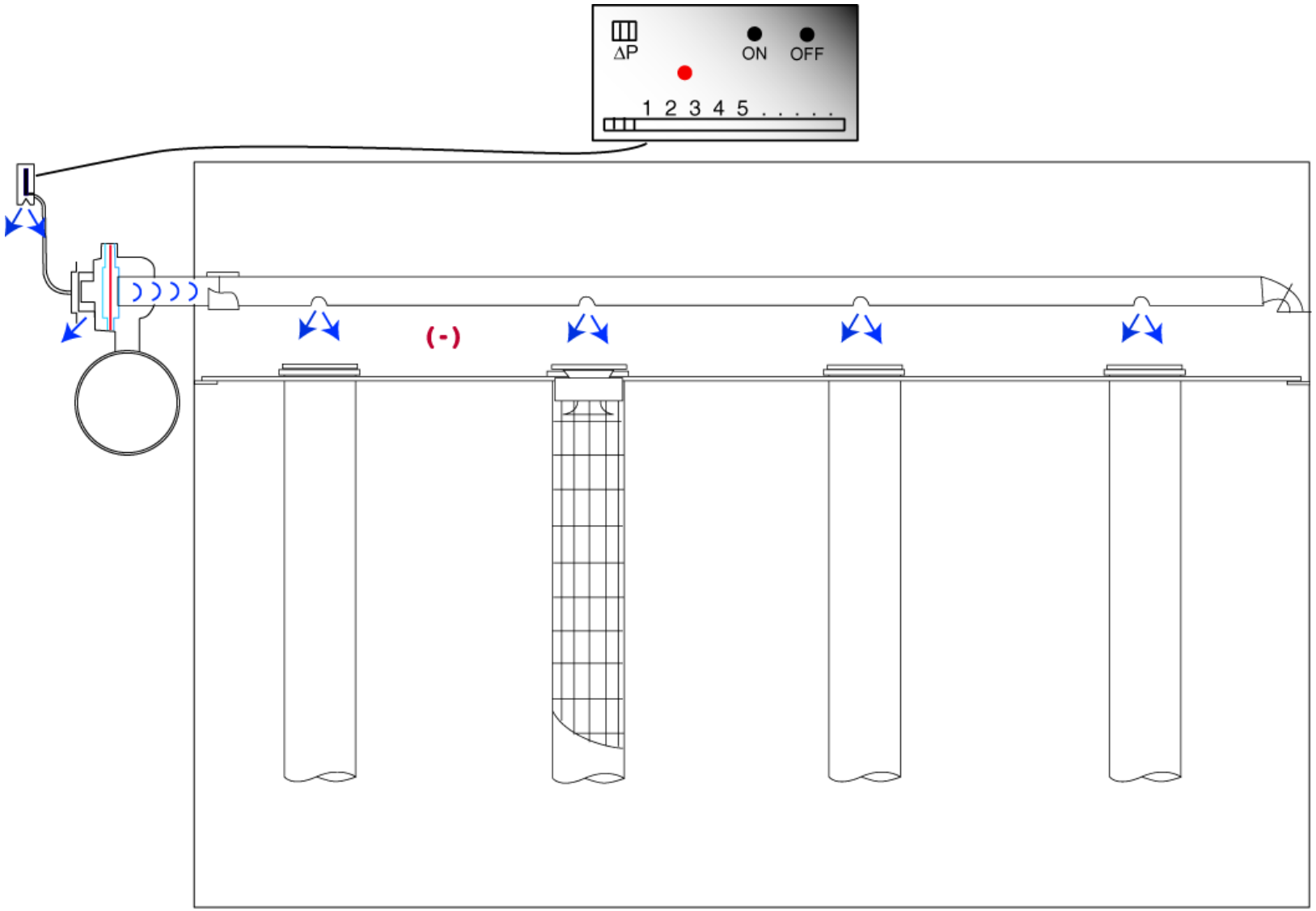


Can velocity

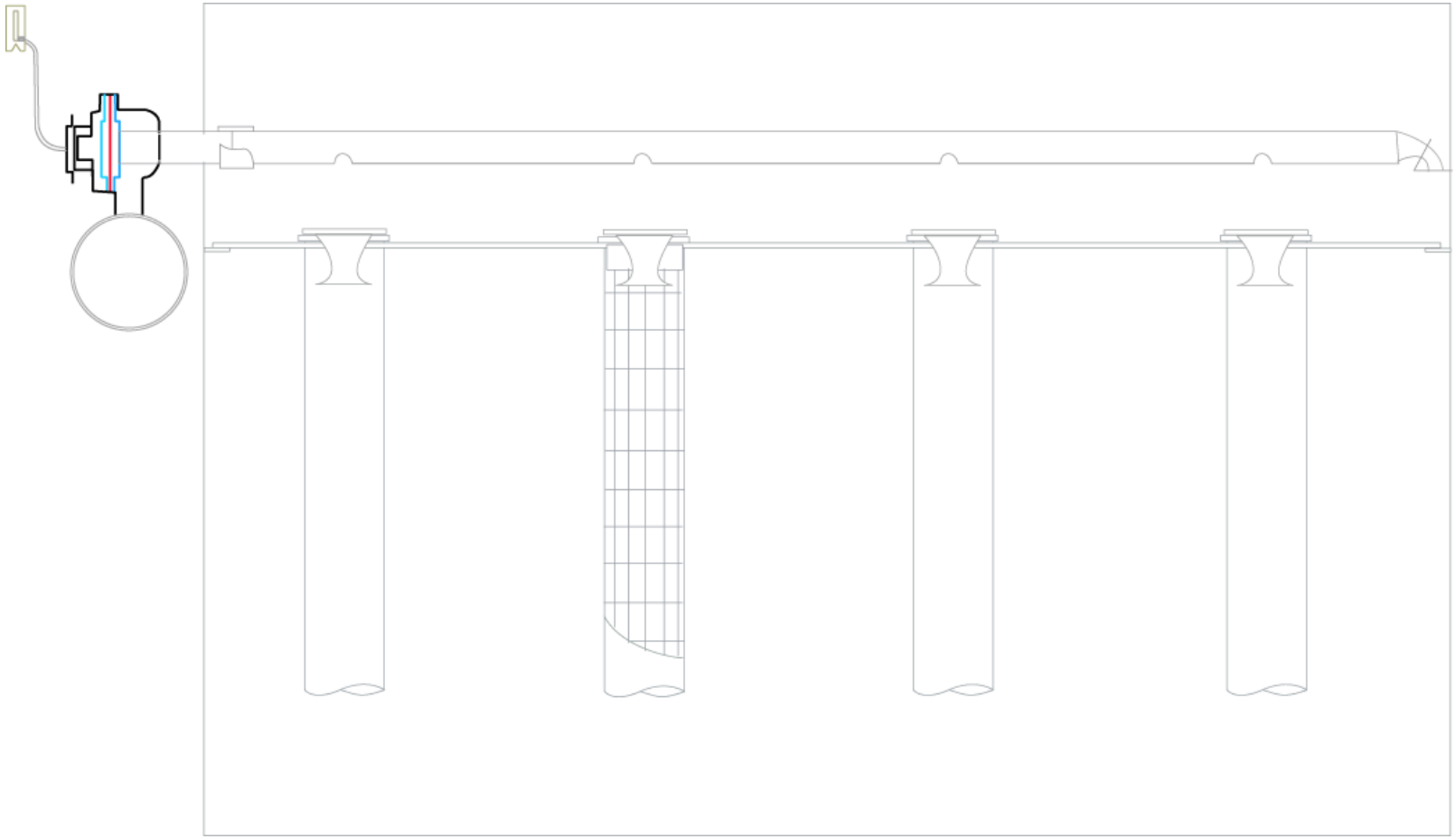
Industry Standard with hopper inlet: <300 fpm

Point of measuring can velocity (bag bottom)

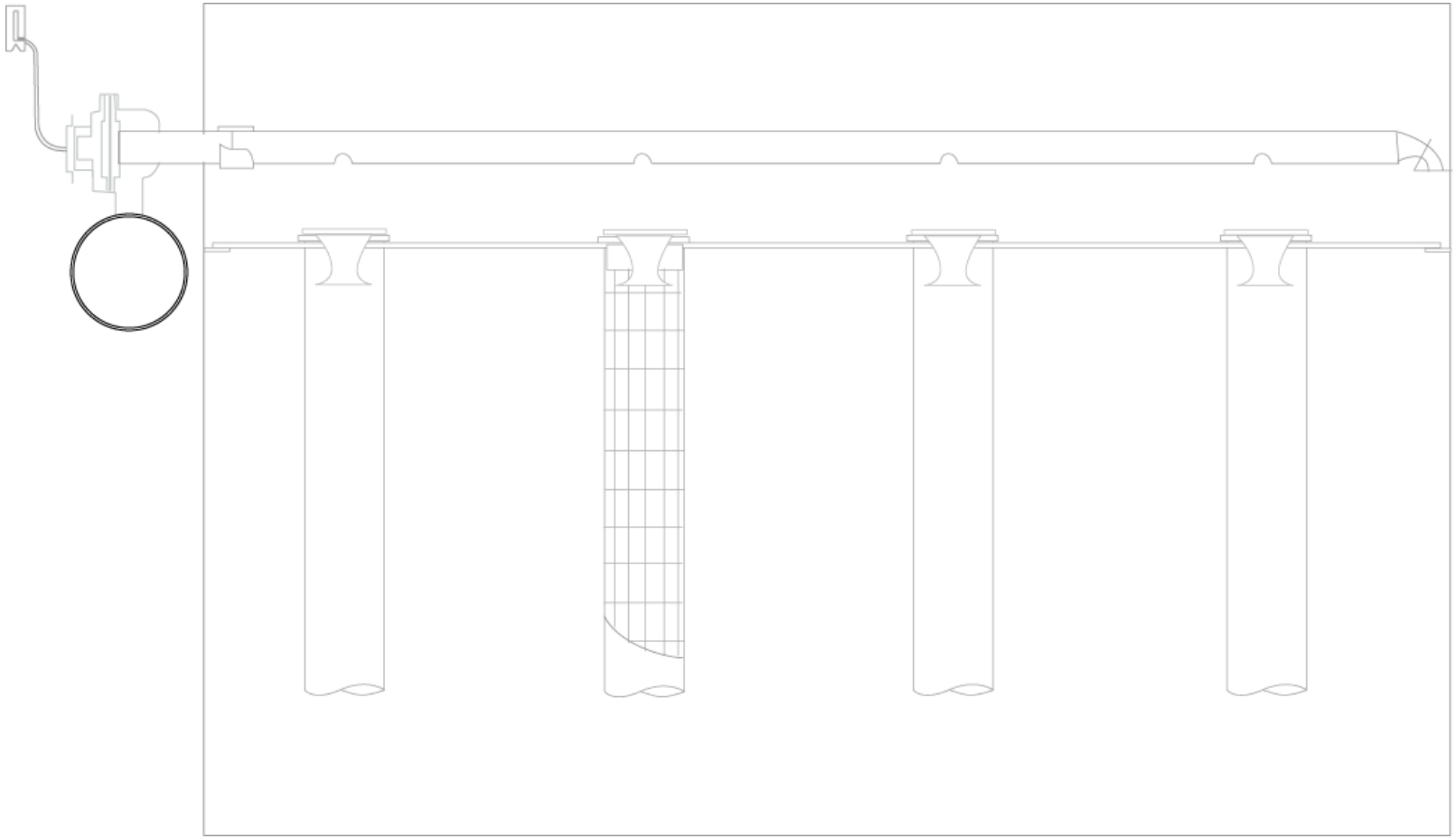



ΔP
ON
OFF
1 2 3 4 5 . . . . .
(-)

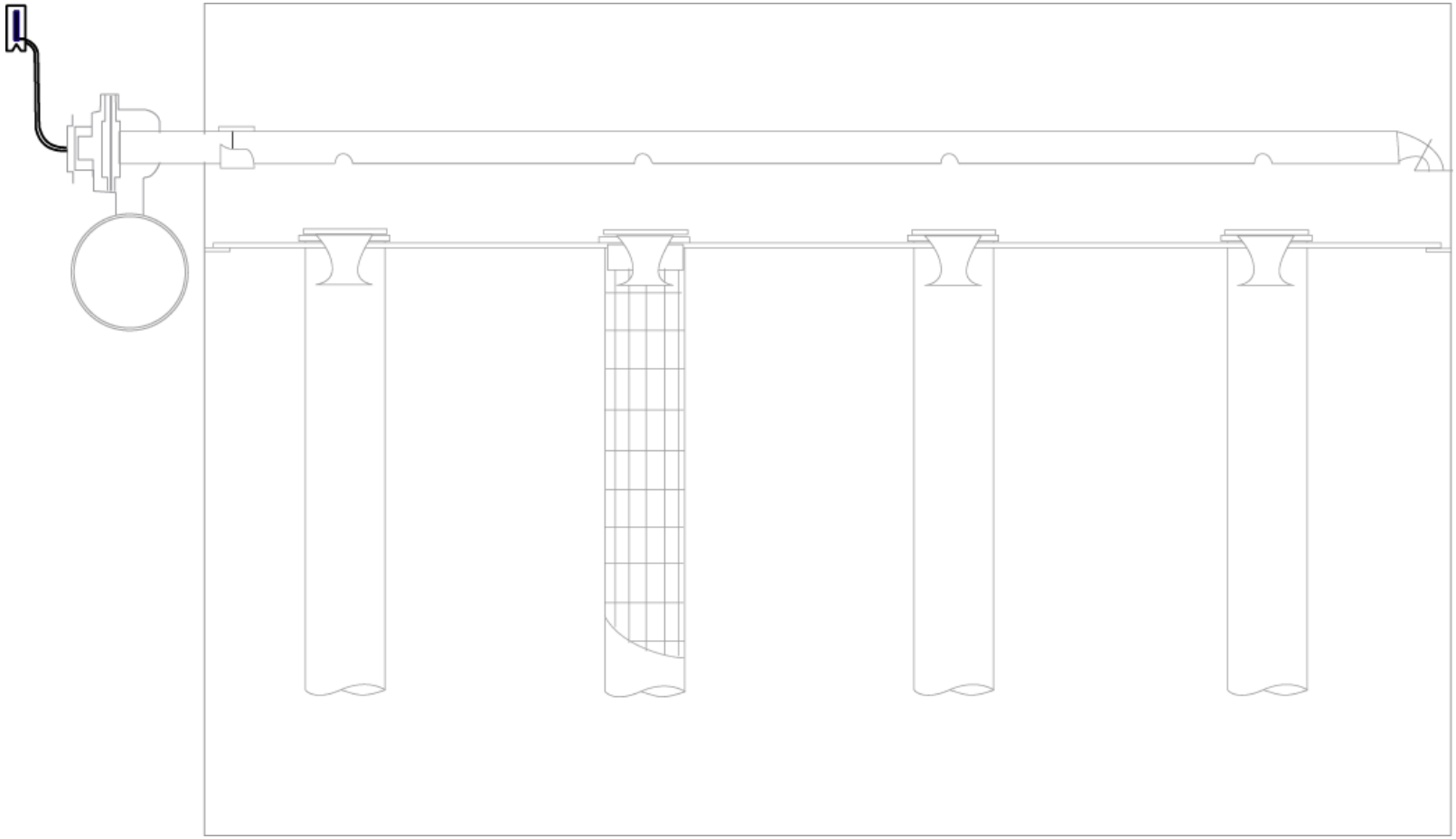
Diaphragm valve



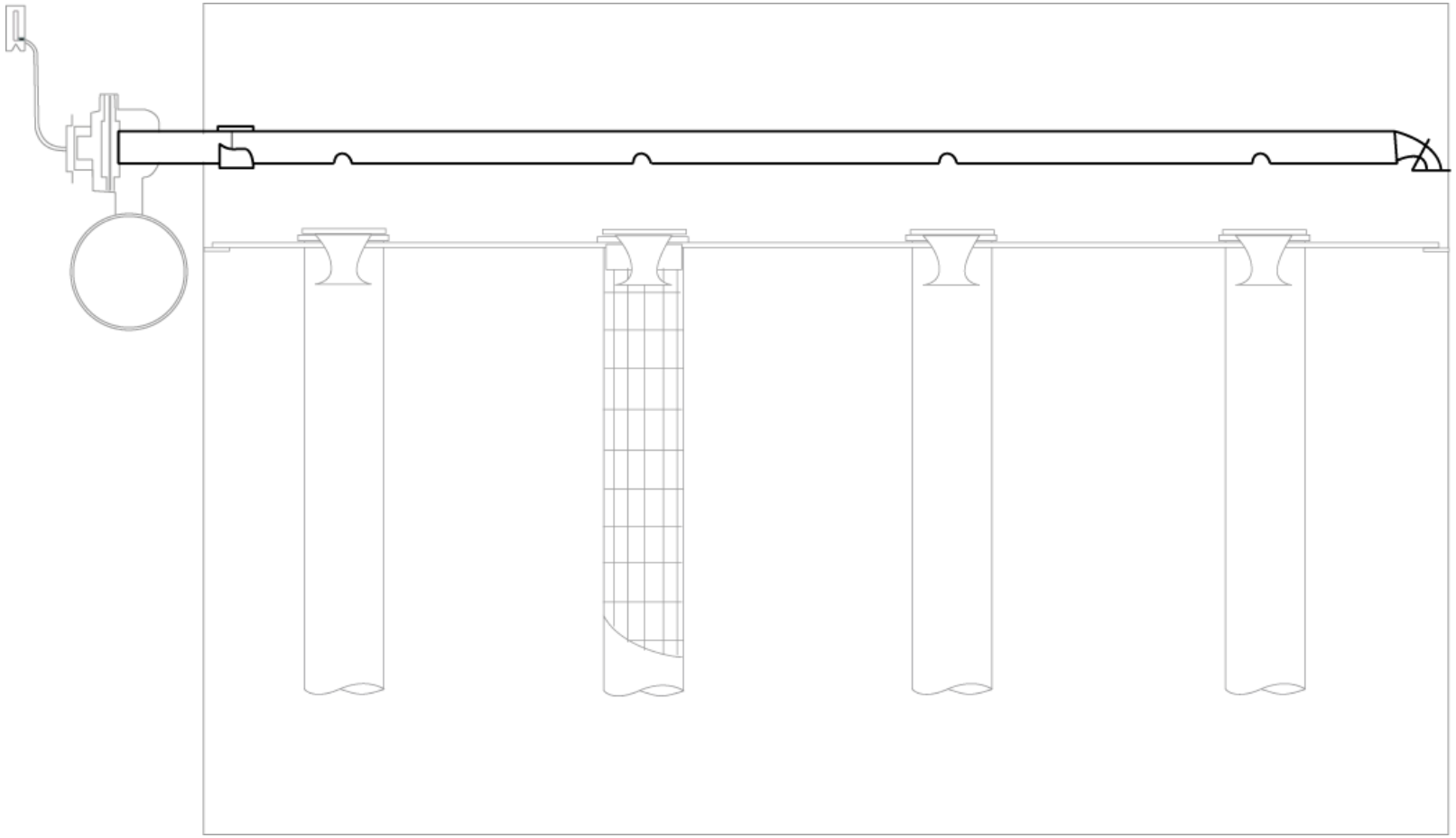
Manifold



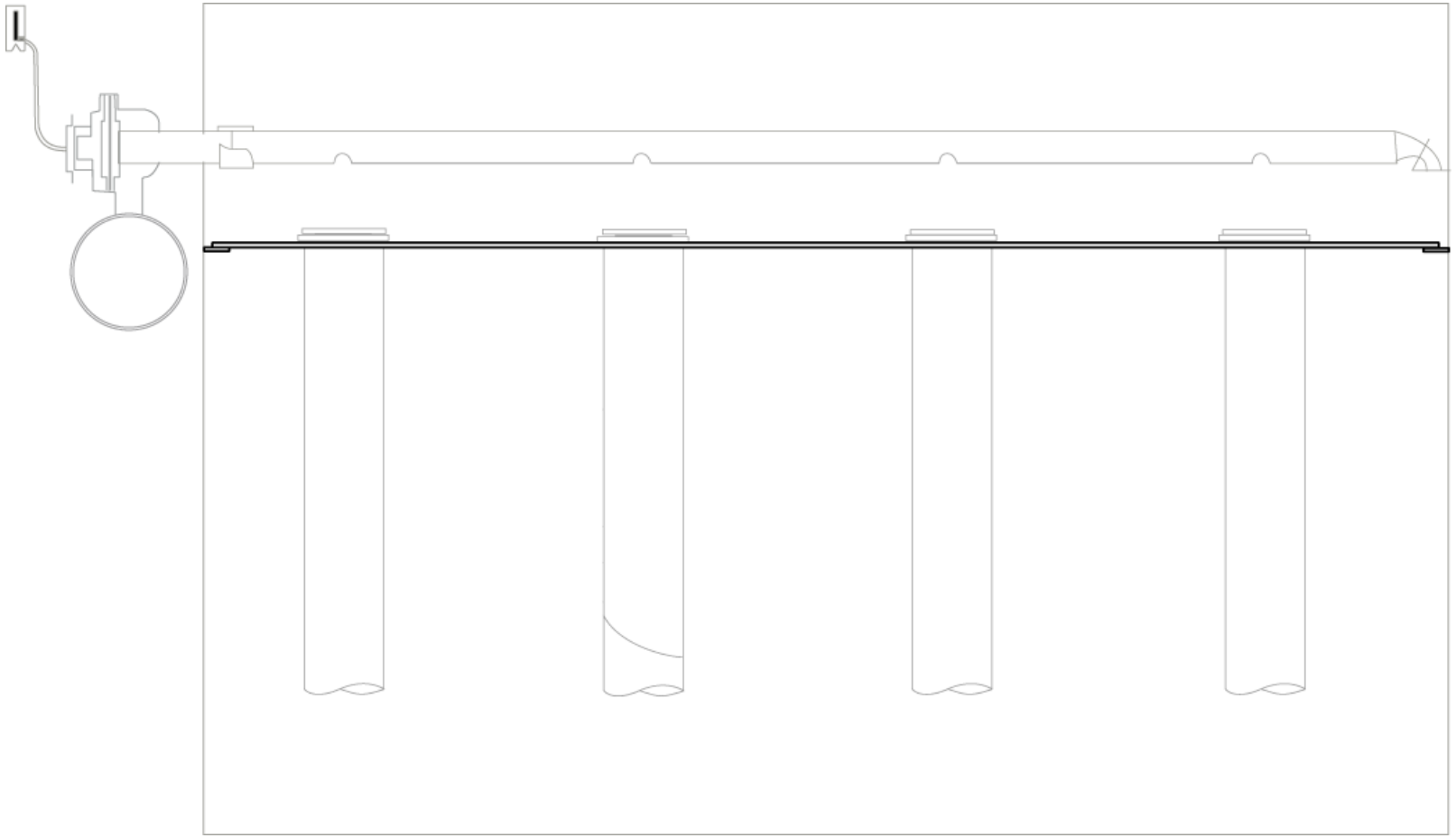
Solenoid valve with bleeder tube or integral to valve



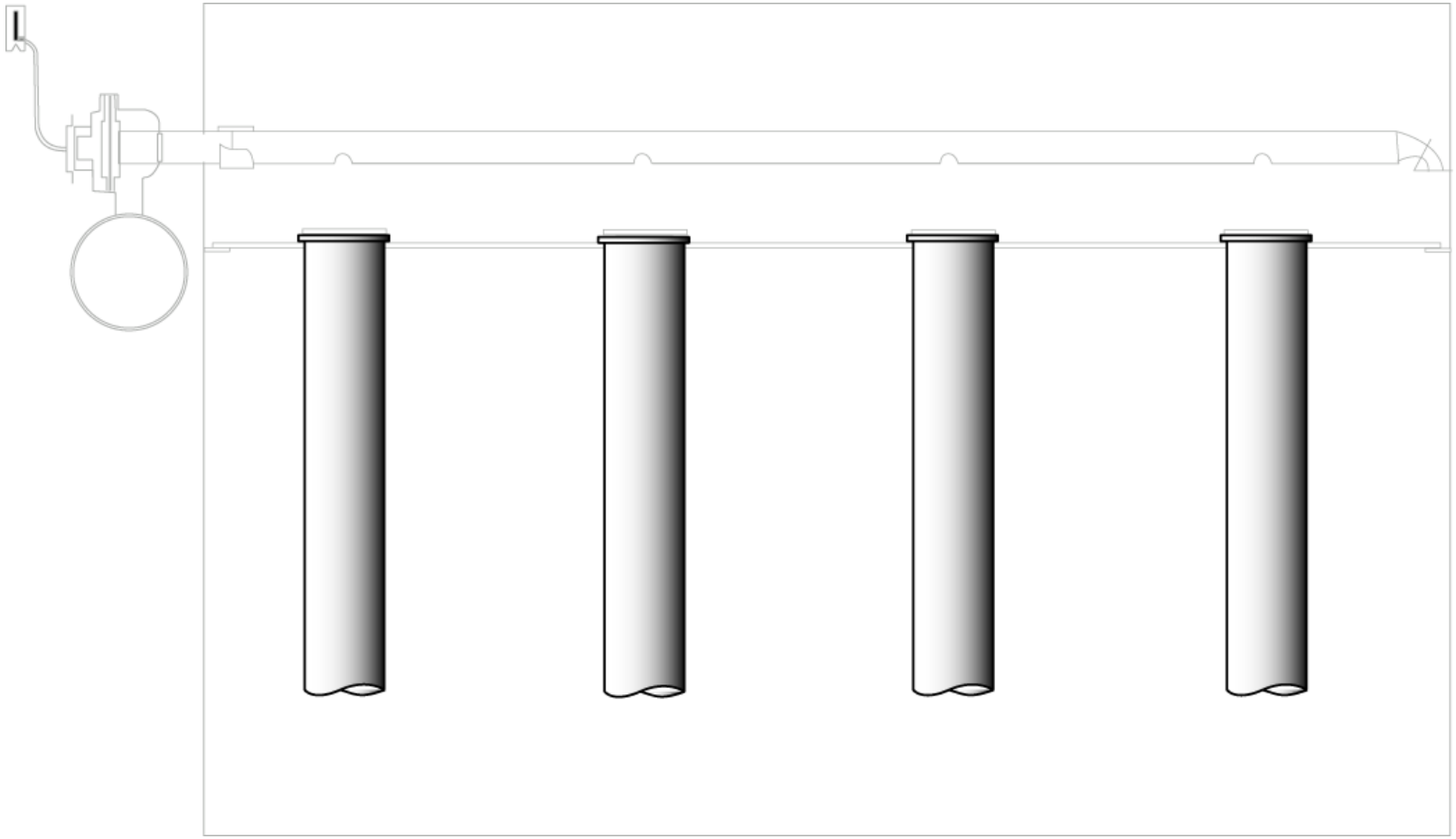
Blowpipe



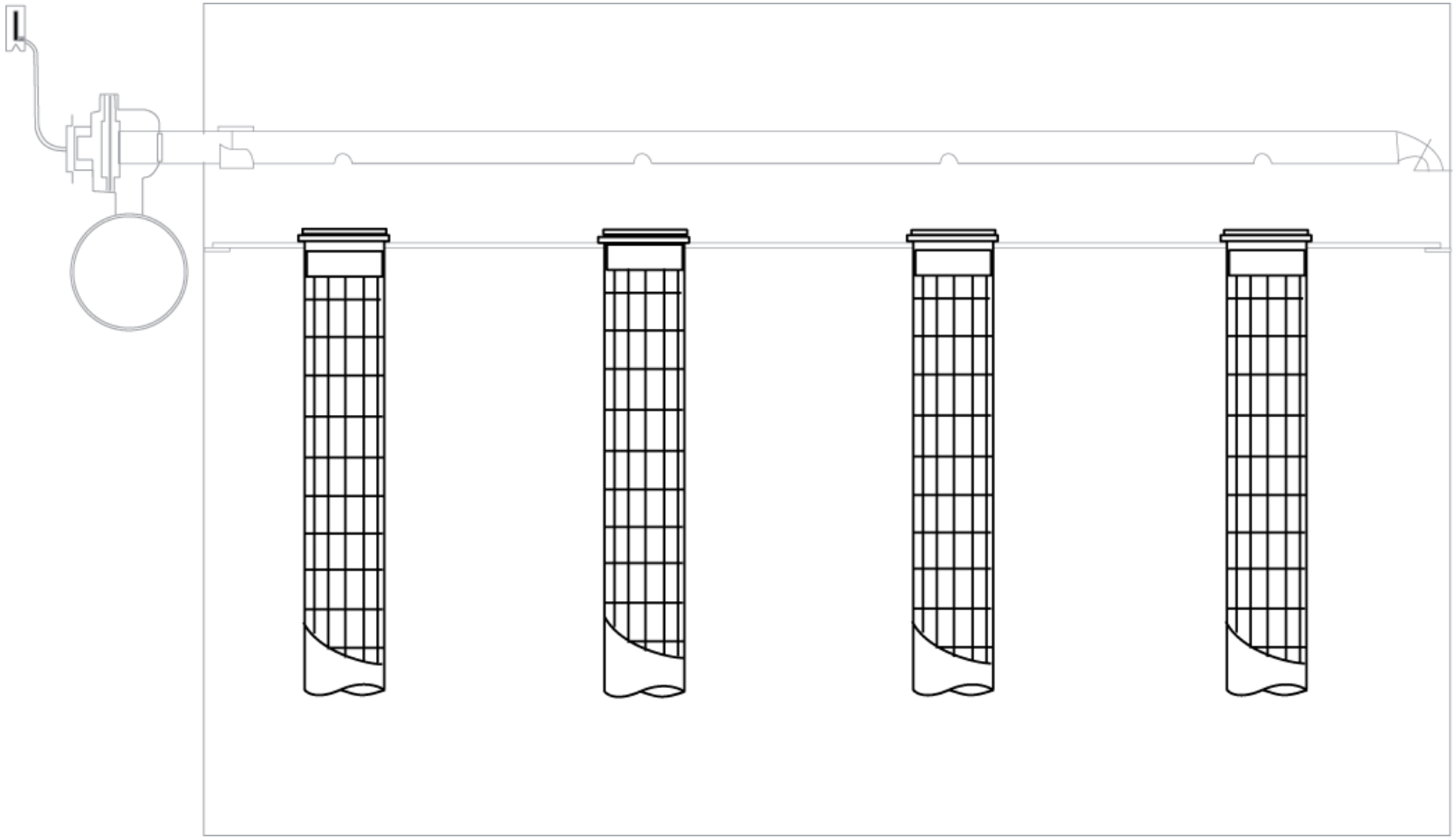
Tubesheet (cell plate)

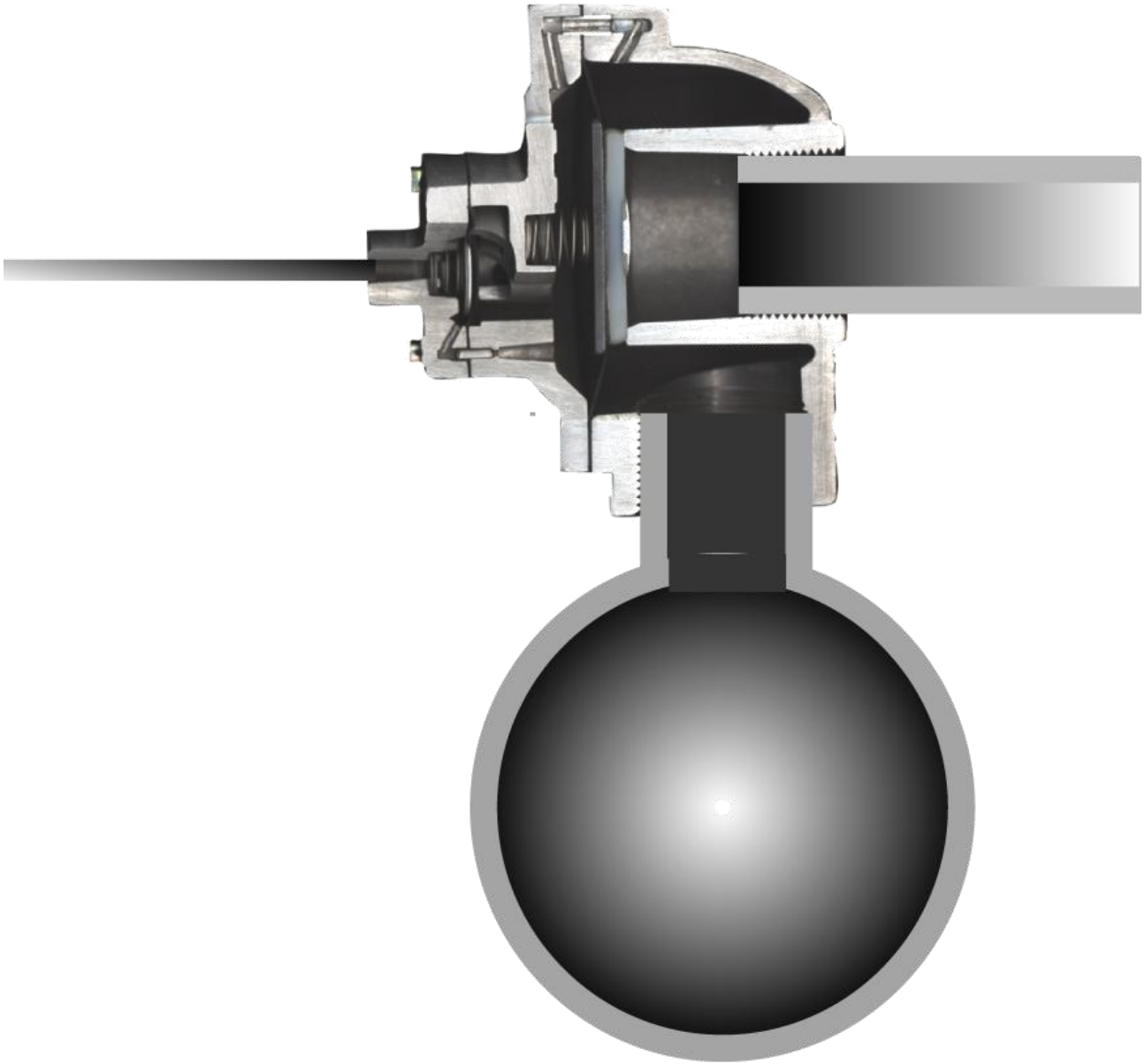


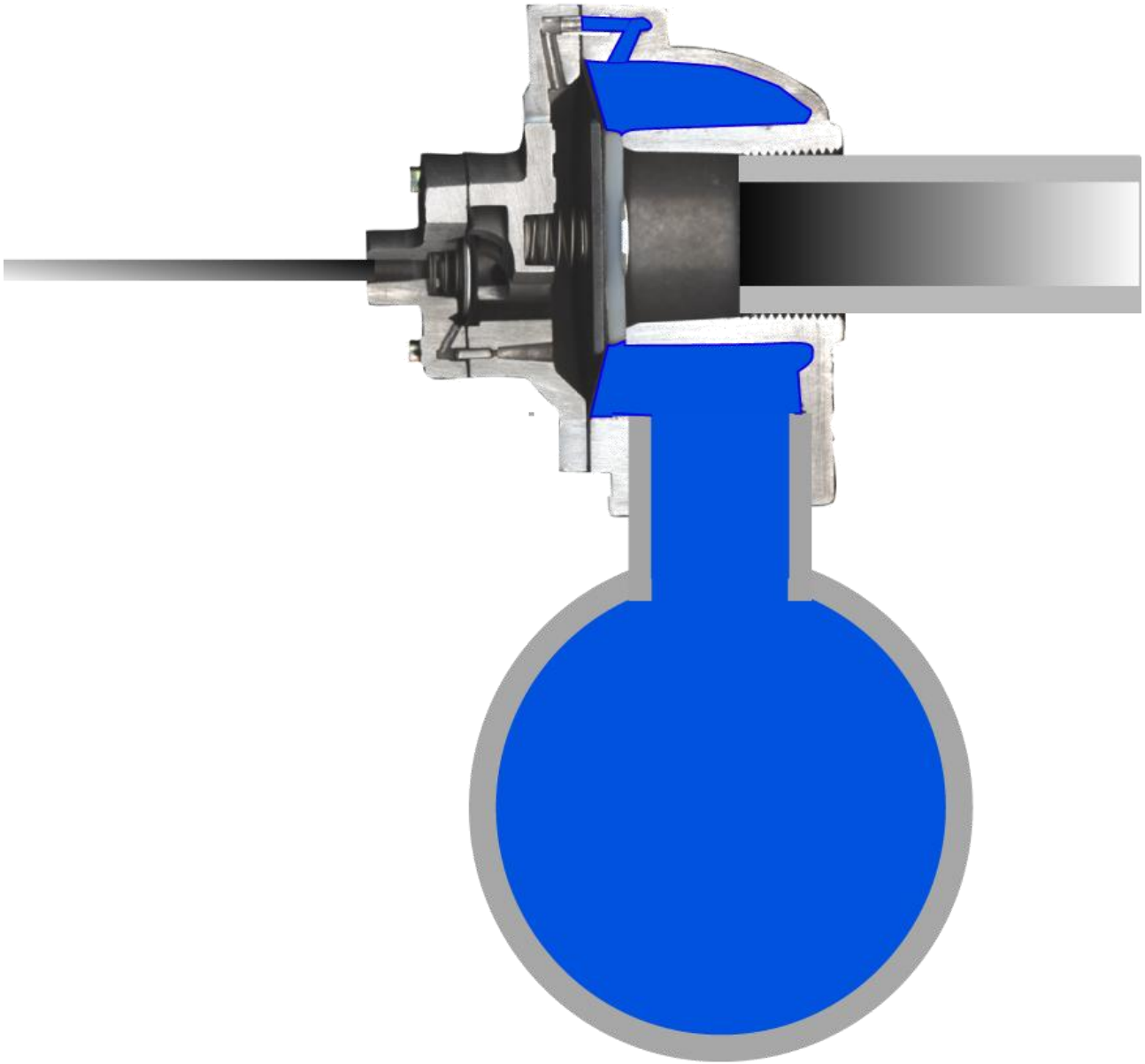
Bags

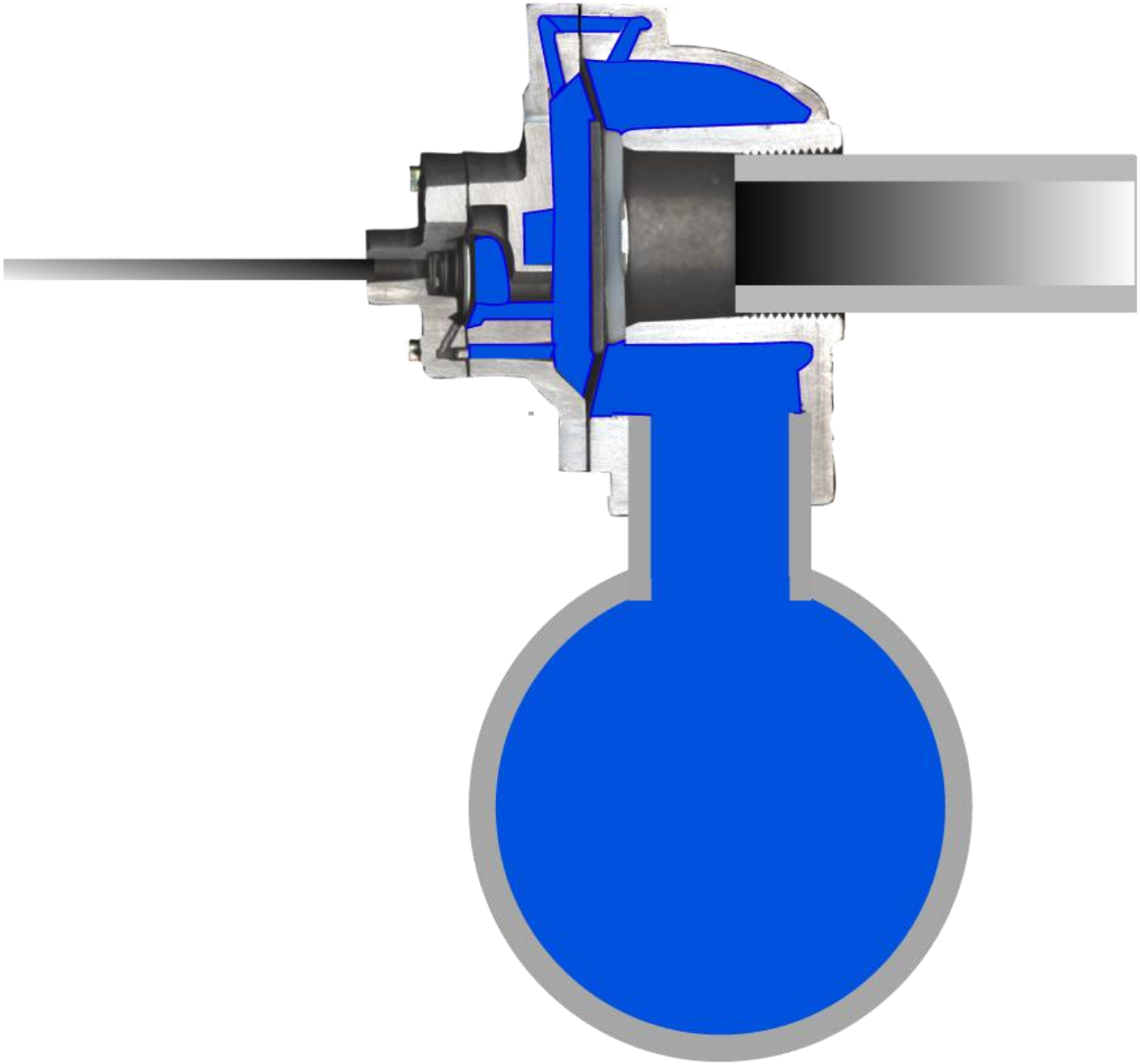


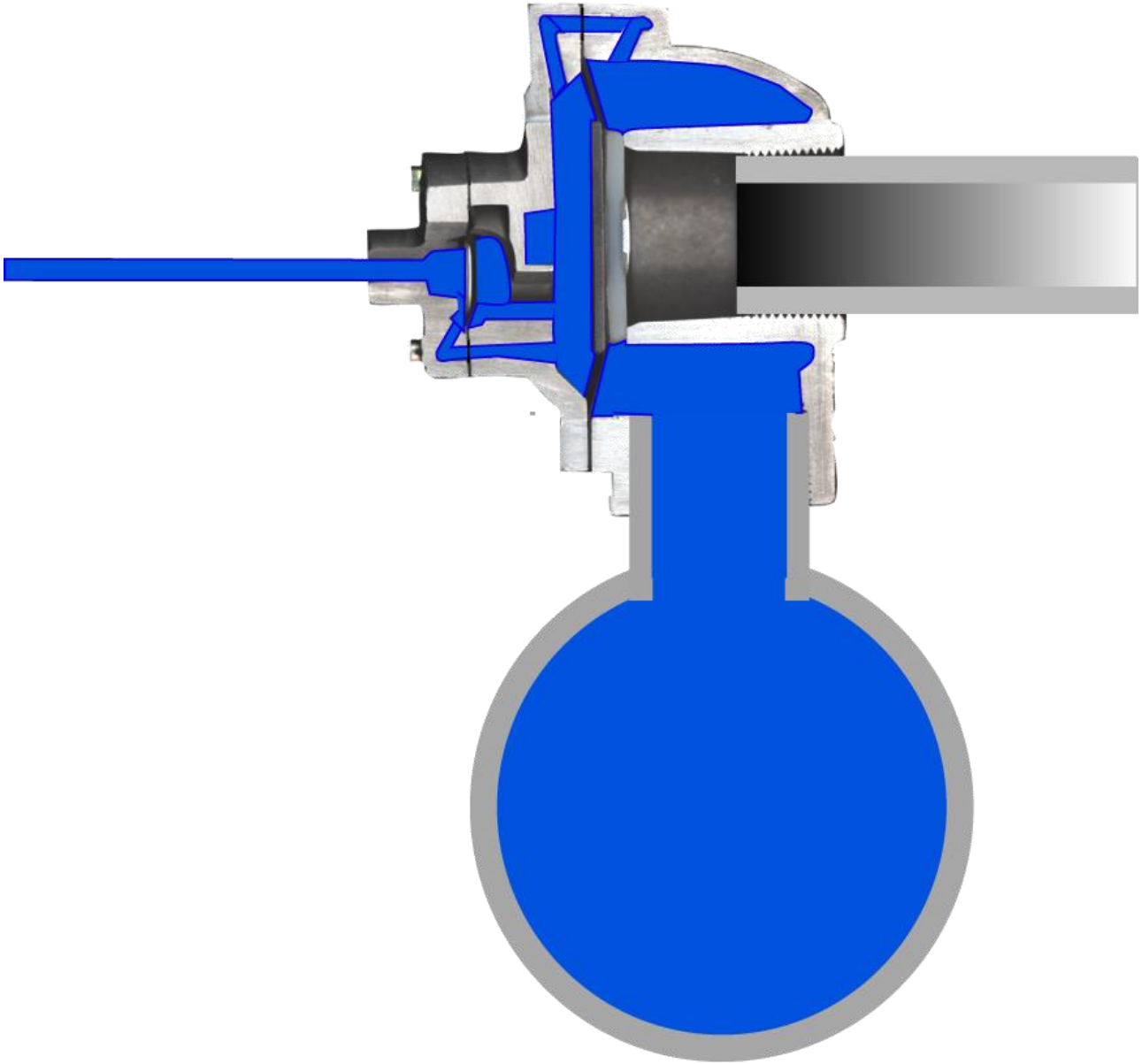
Cages



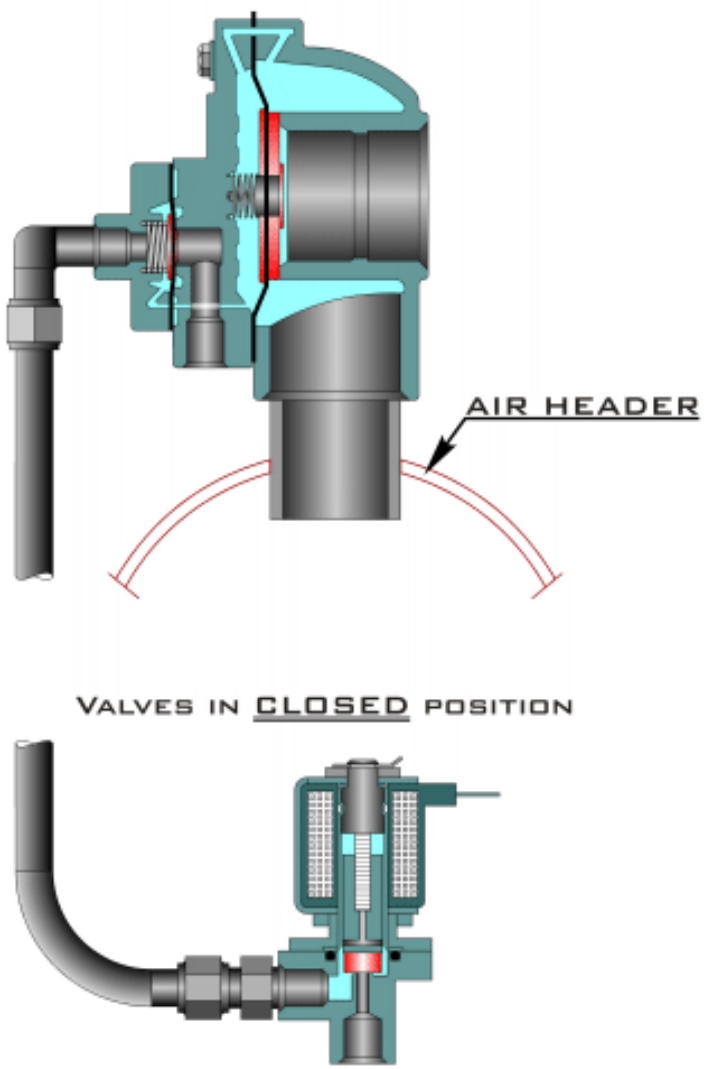


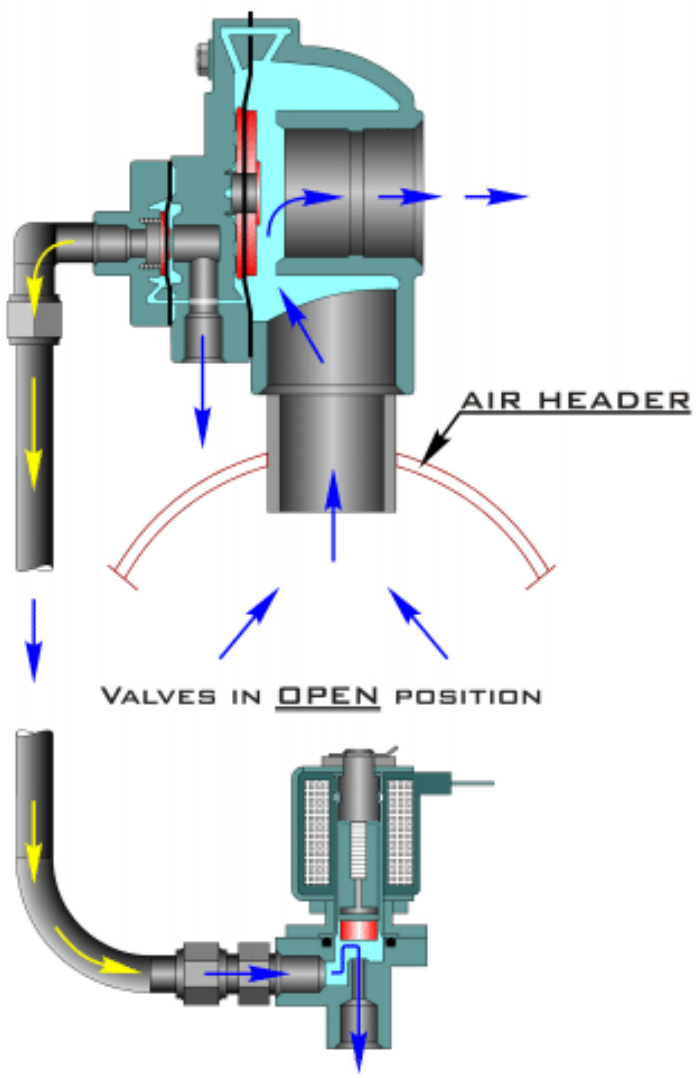




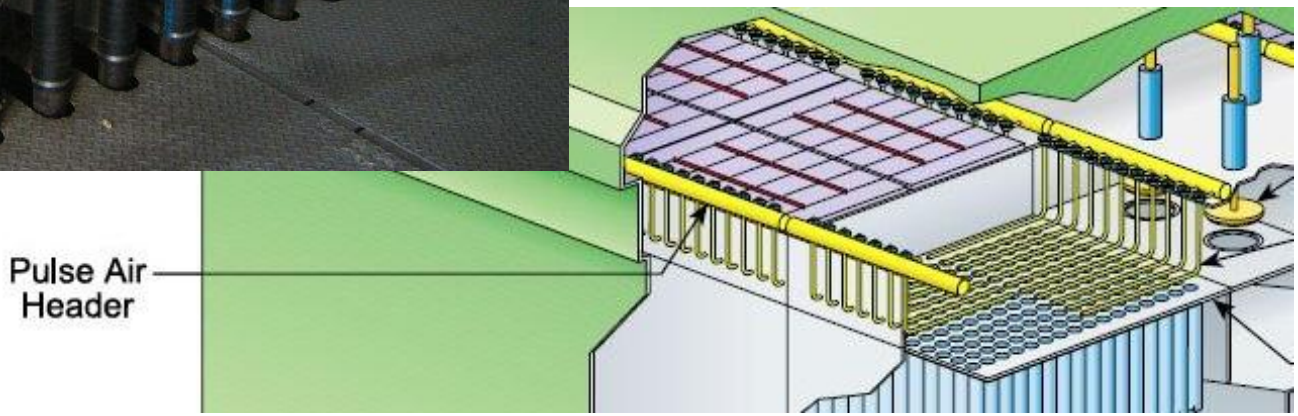


Valve / solenoid operation

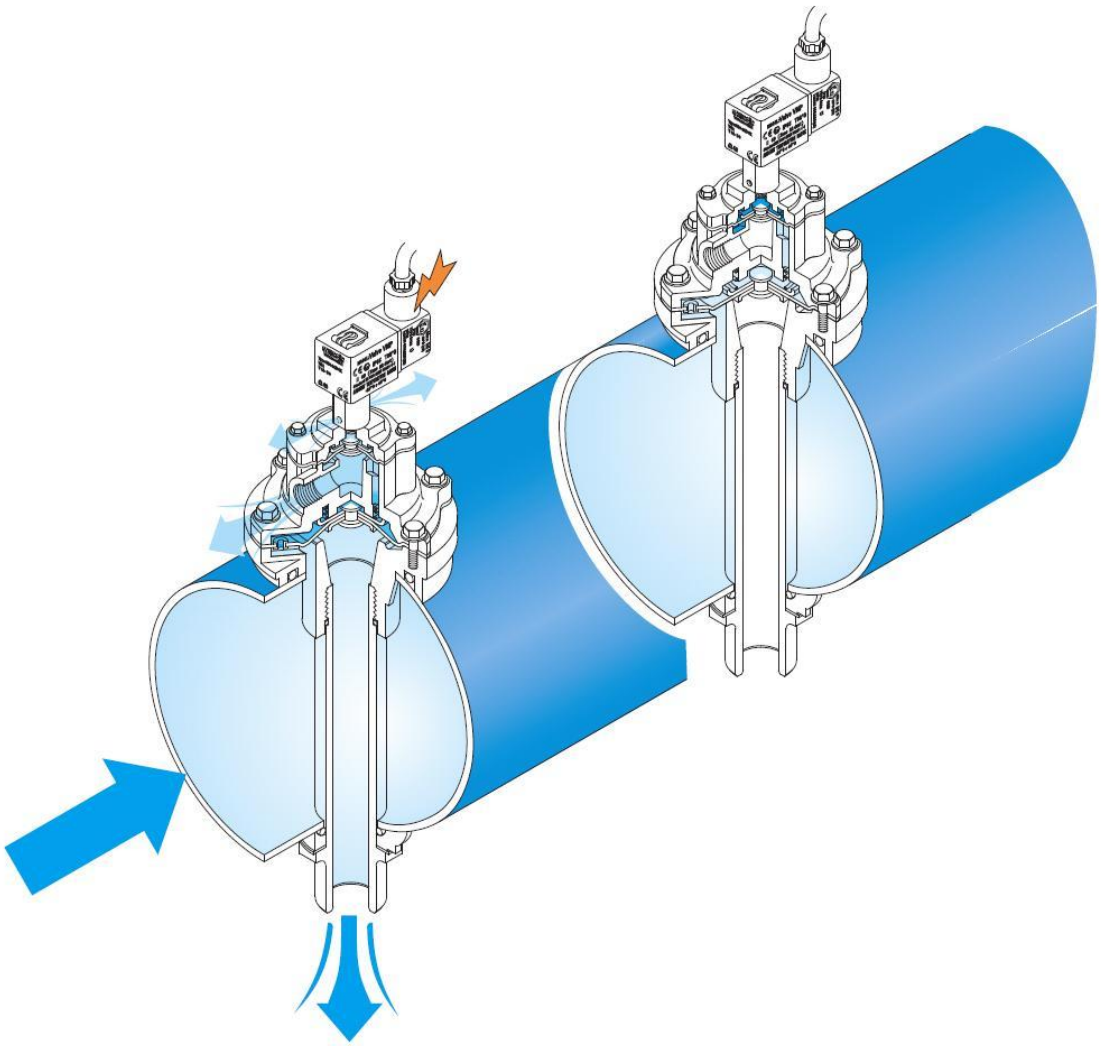




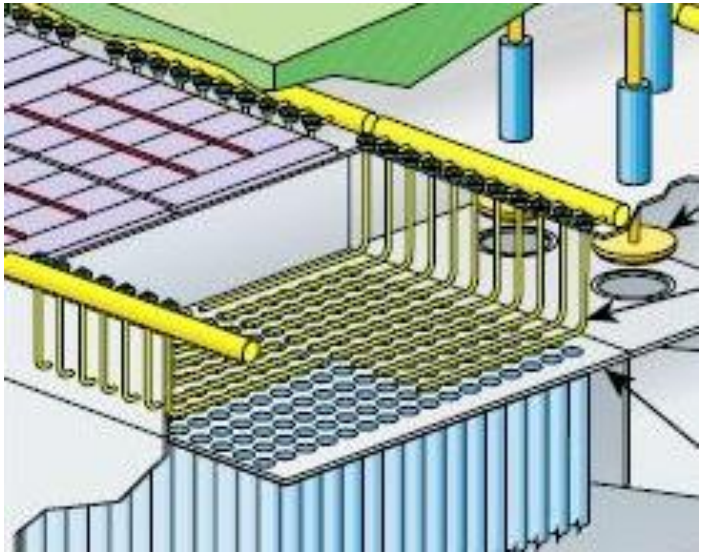
Pulse Air Headers



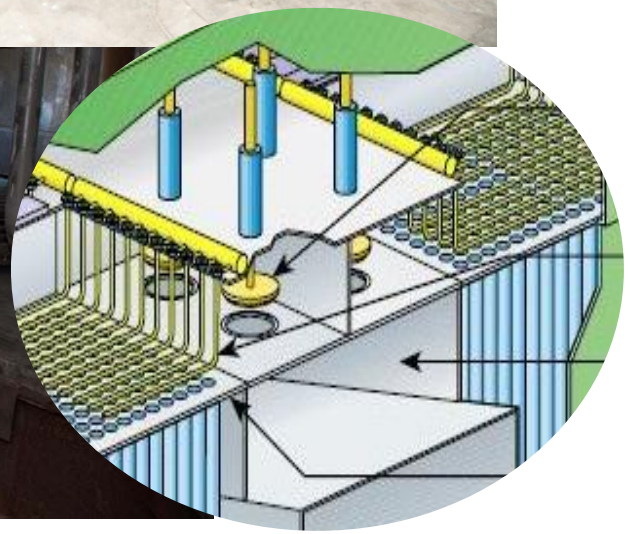
Pulse Jet Valves



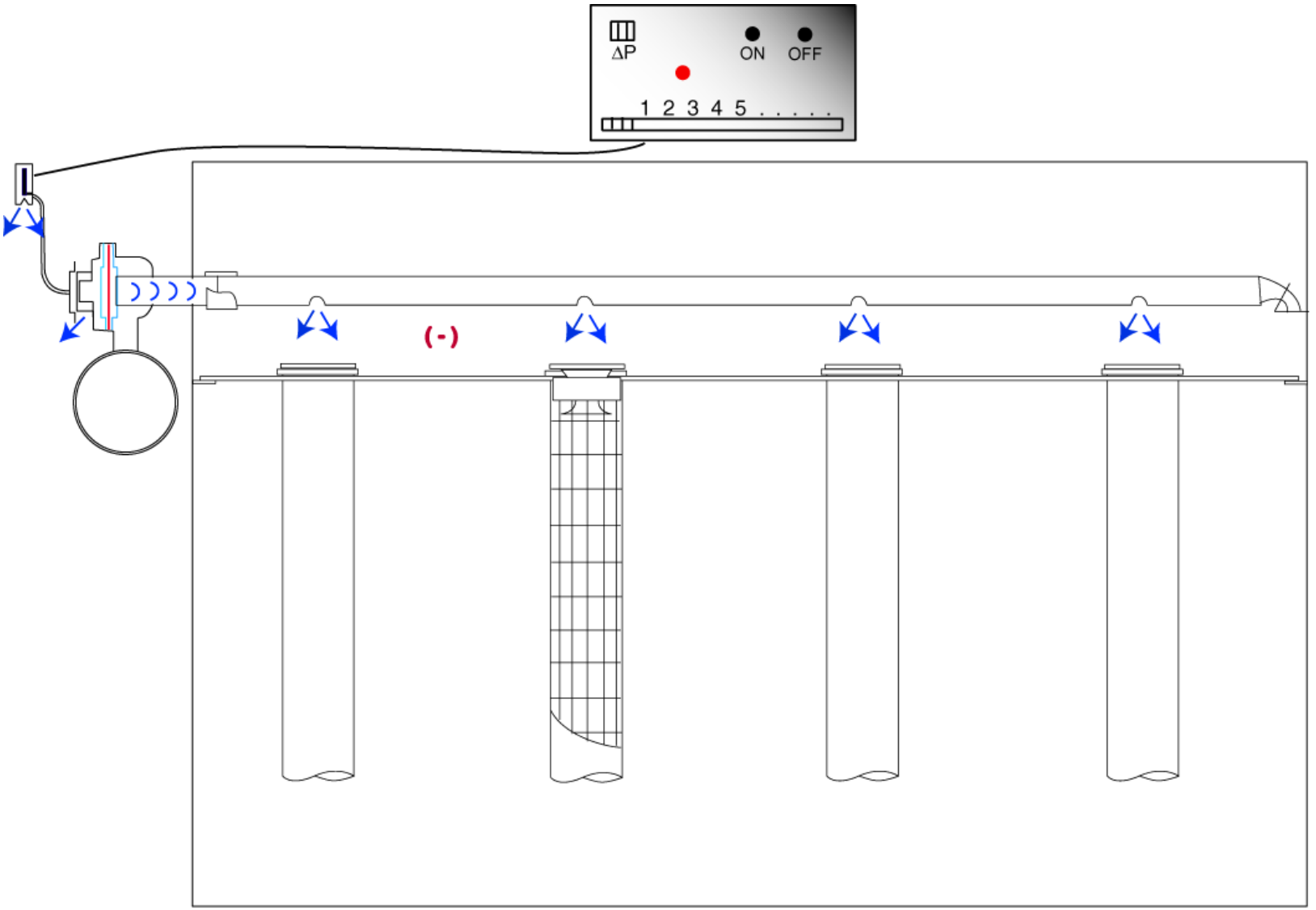
Inside a Compartment



Compartment Outlet Dampers



Bypass Dampers


ΔP
ON
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1 2 3 4 5 . . . . .
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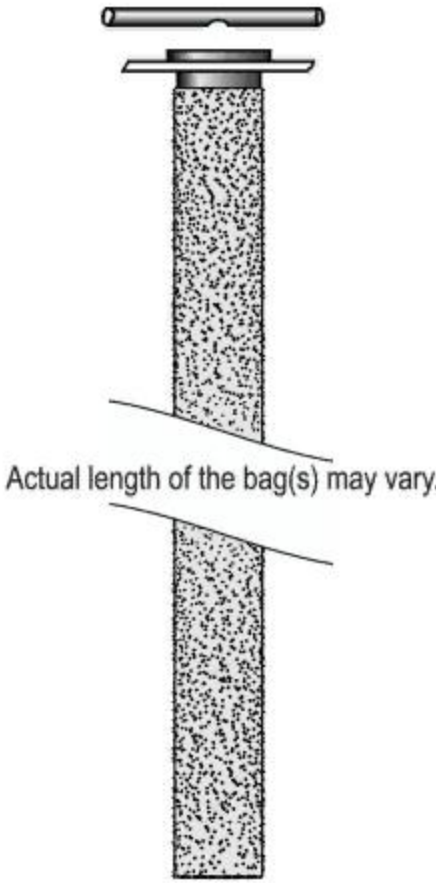
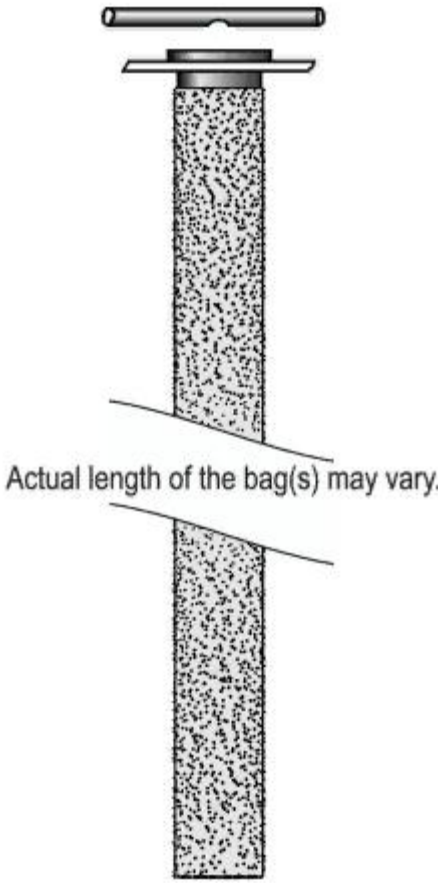
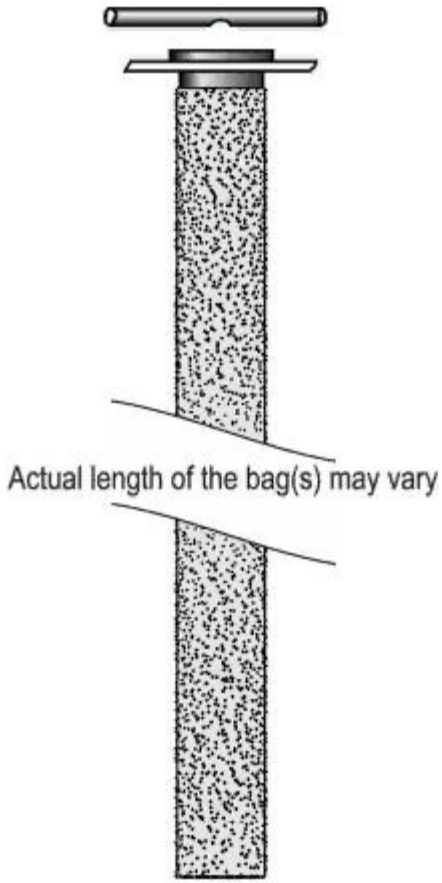
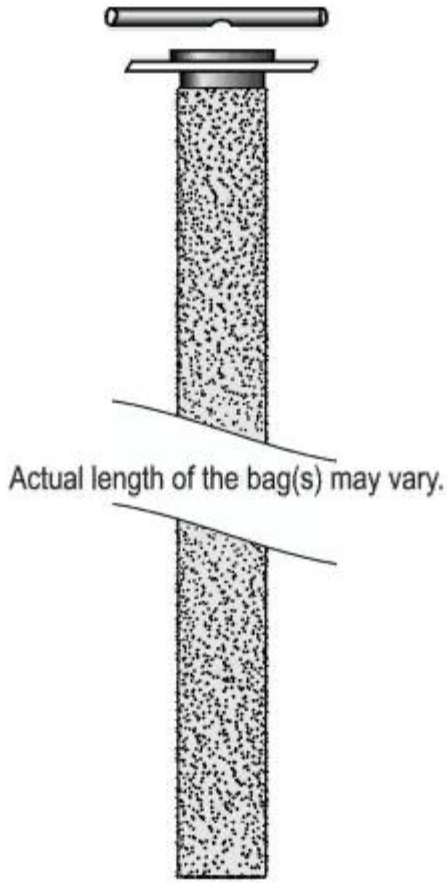

Actual length of the bag(s) may vary.


Actual length of the bag(s) may vary.


Actual length of the bag(s) may vary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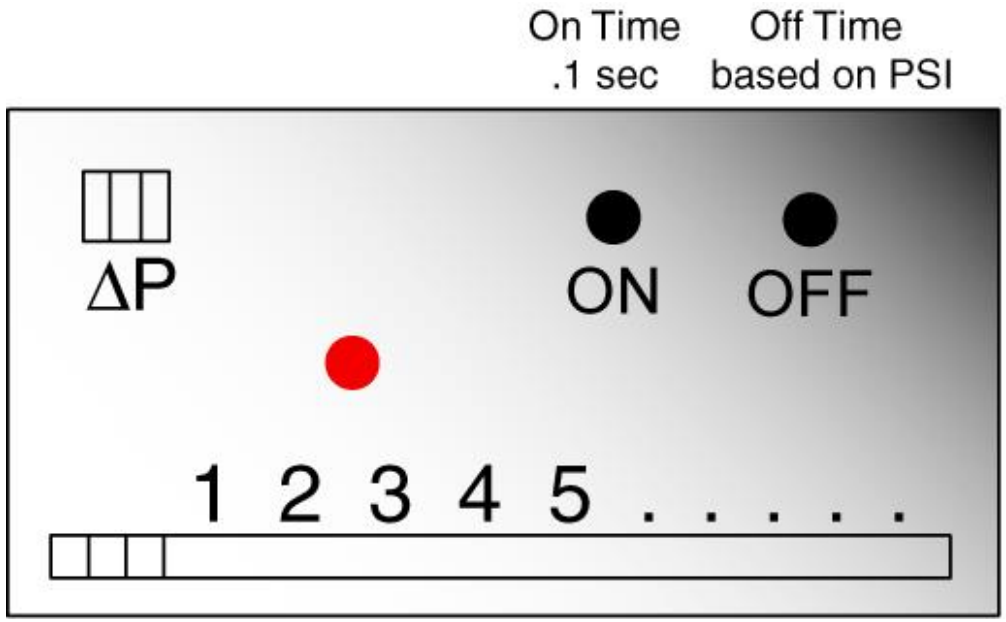
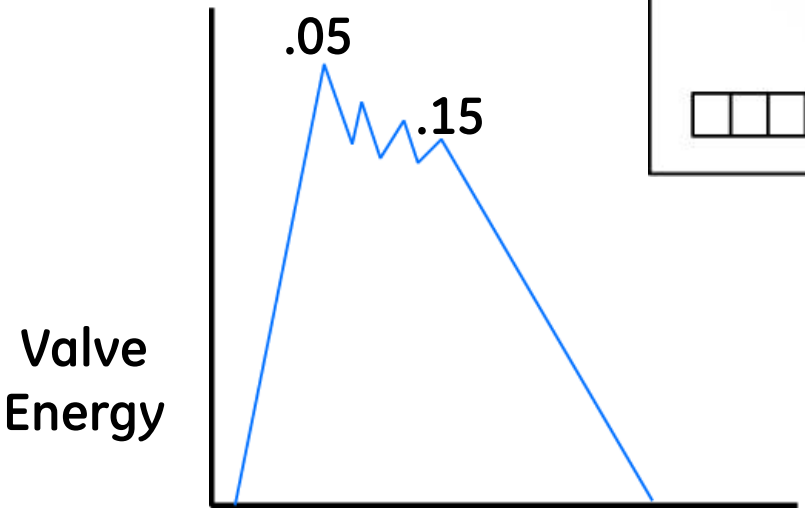
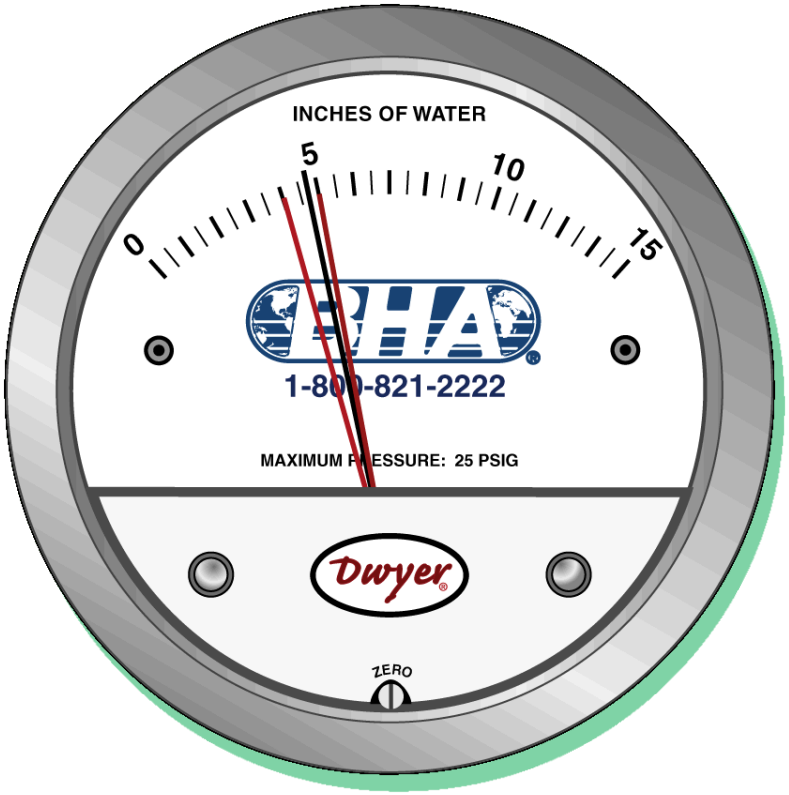


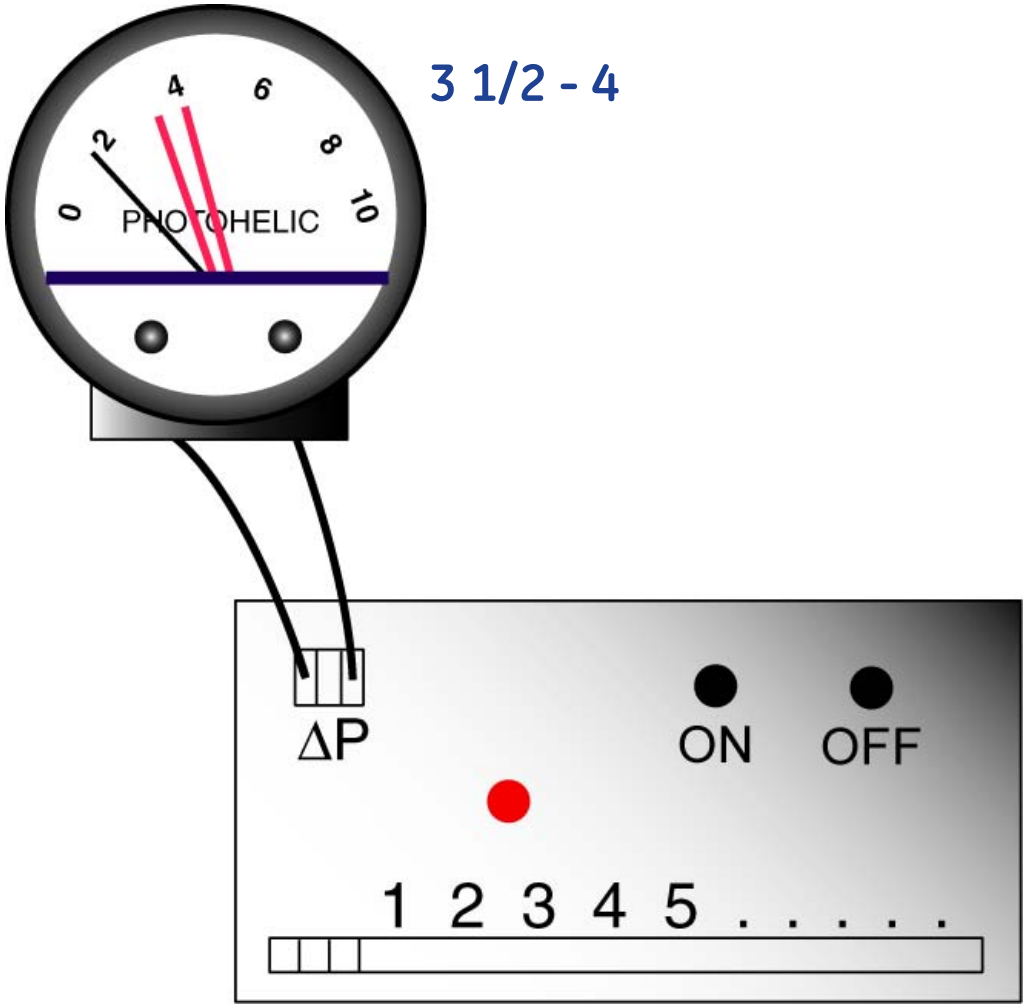


Time (standard for 1.5" DD valve, .250 sec target for 3" valve)

Clean-on-Demand system



High-Low set points at no greater than 1" apart…
Ideal is no more than 0.5"


3 1/2 - 4
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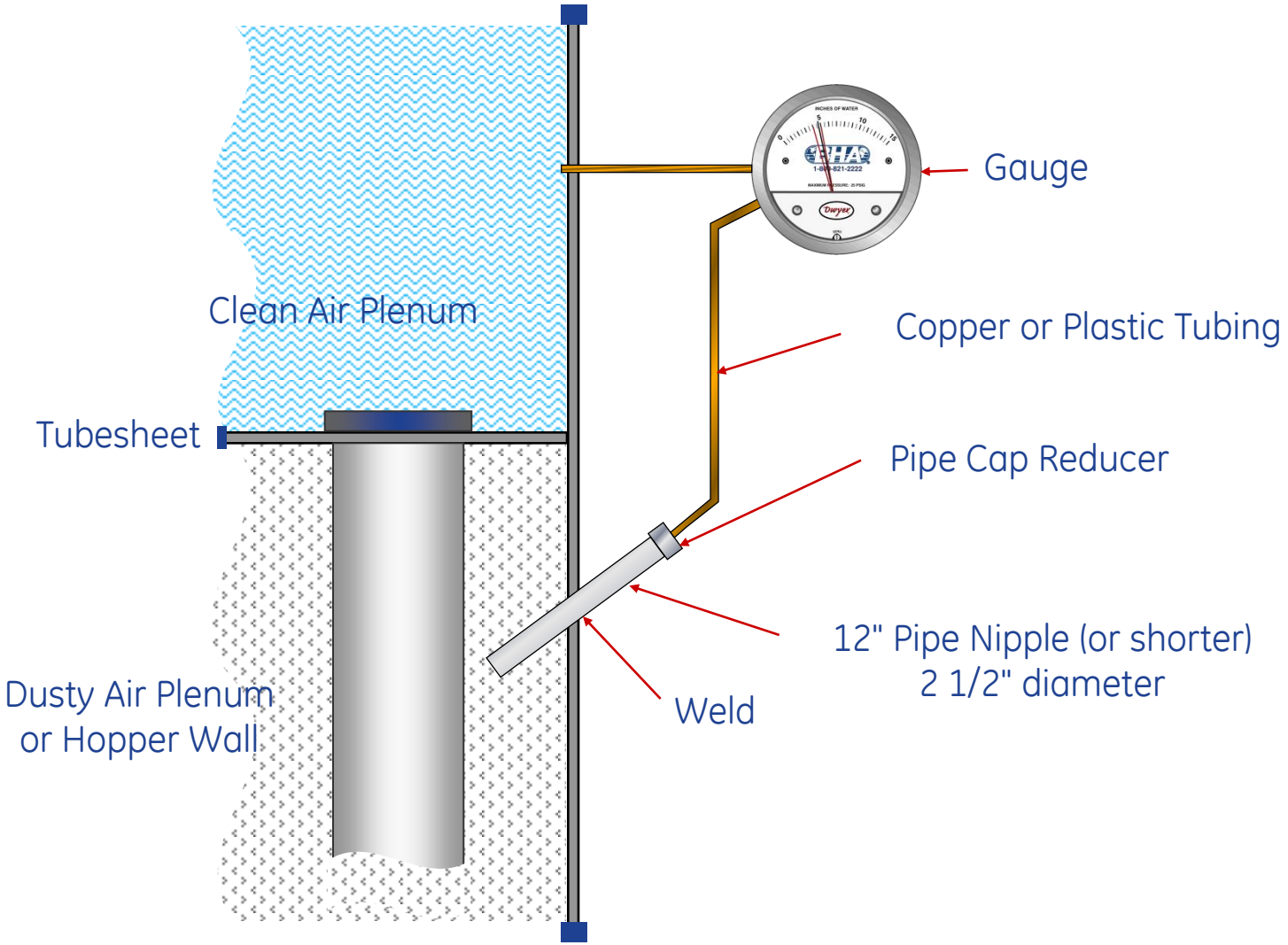
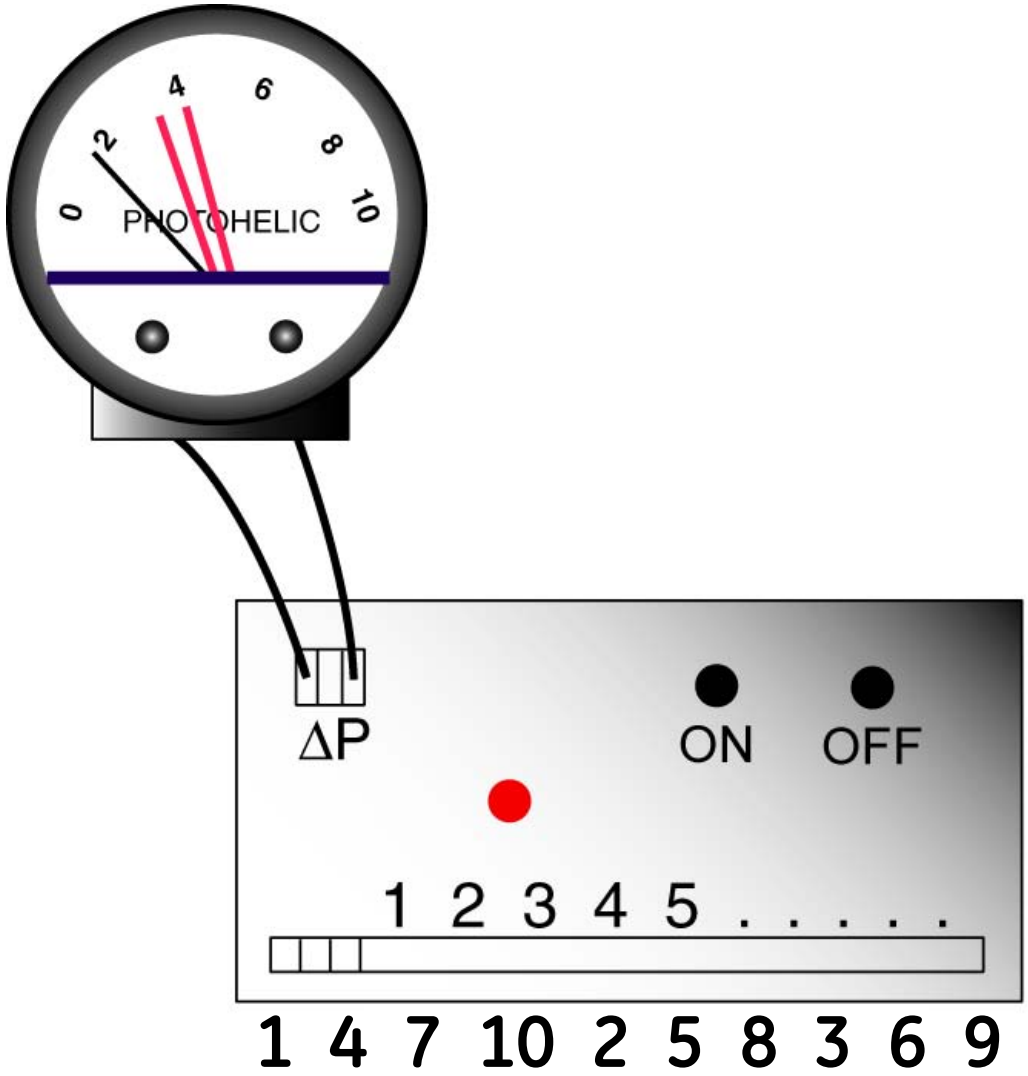
1 2 3 4 5 . . . . .

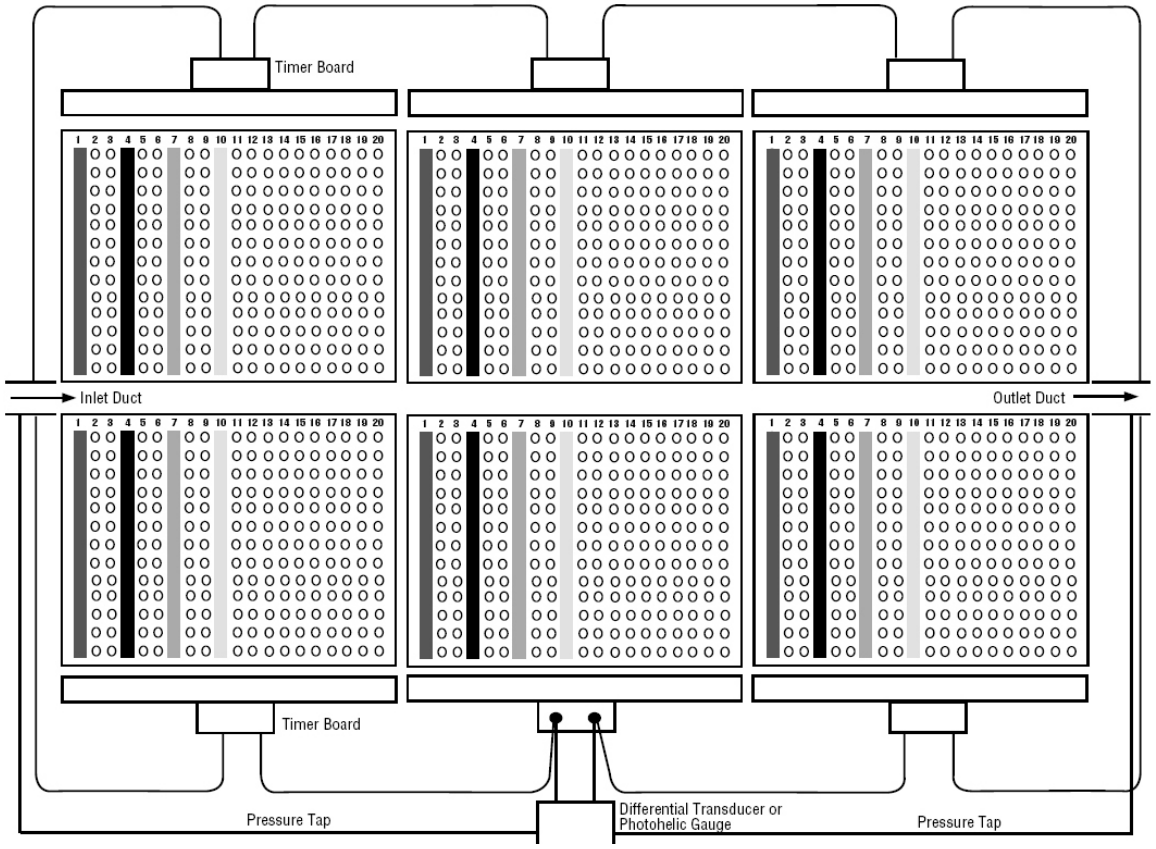
Gauge Connection Modification

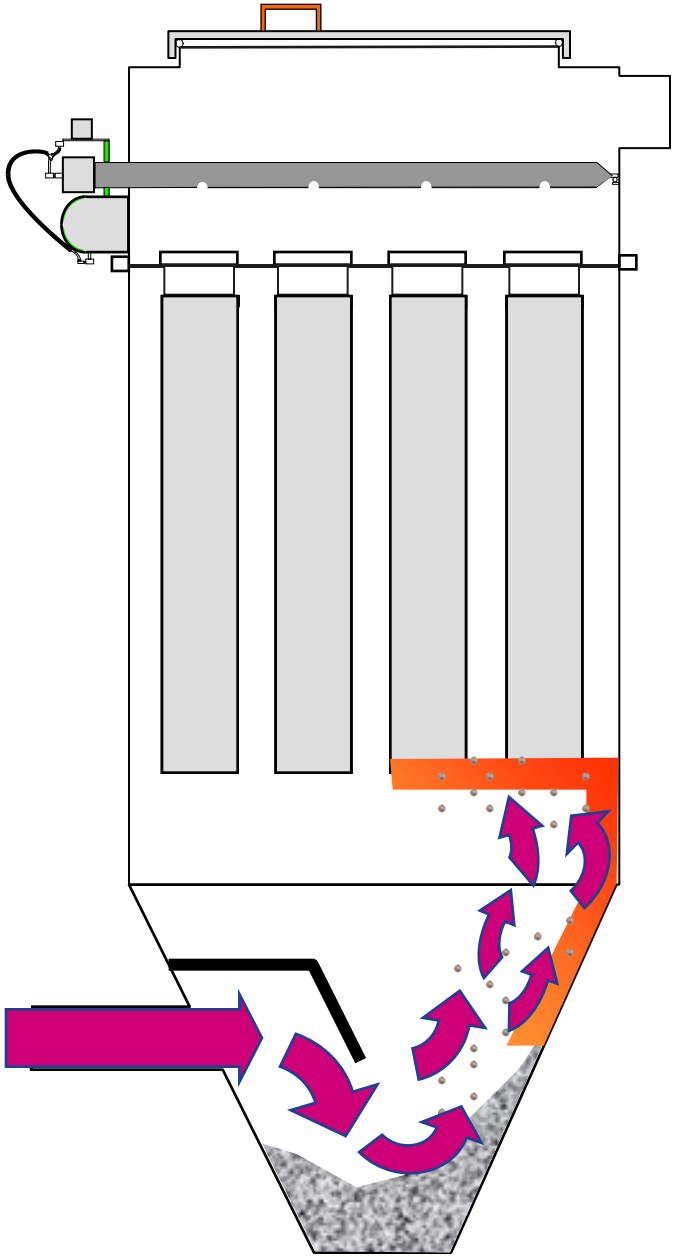




Cleaning sequence

Multi-Compartment Cleaning





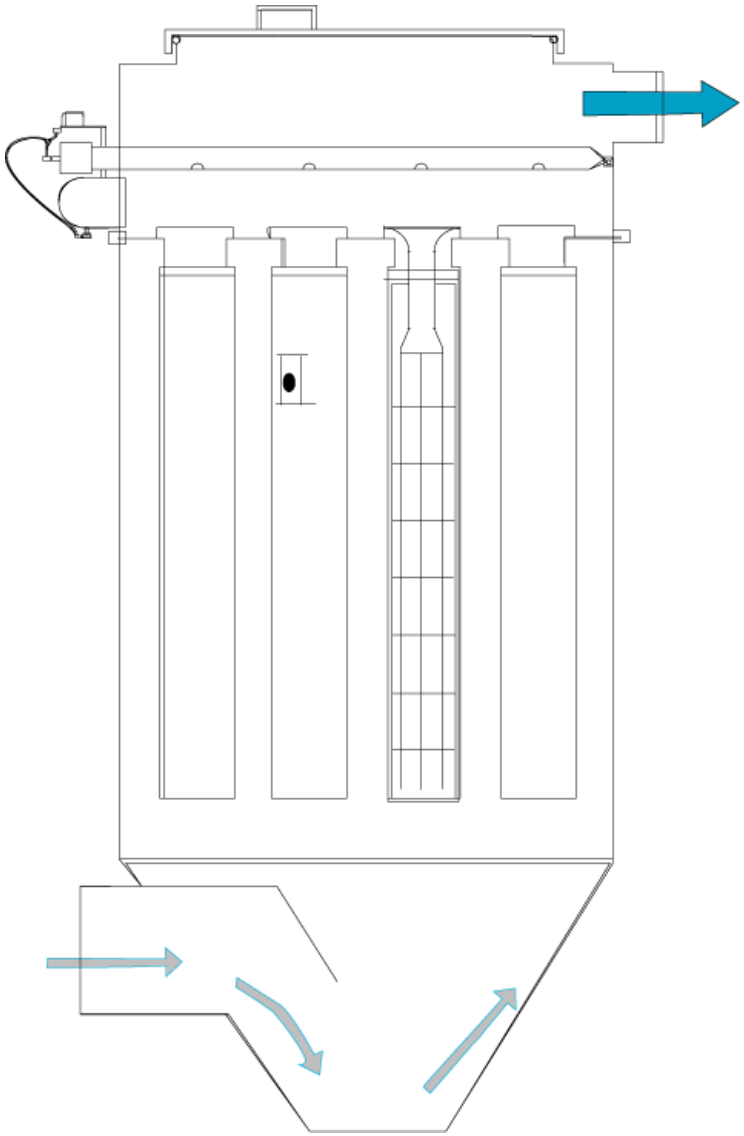
Common Inlet Design

- Inlet baffle directs airflow down into hopper.
- Collected material can swirl upward, causing heavier than design grain-loading.
- Narrow hoppers and nearby bag bottoms may experience abrasion damage.

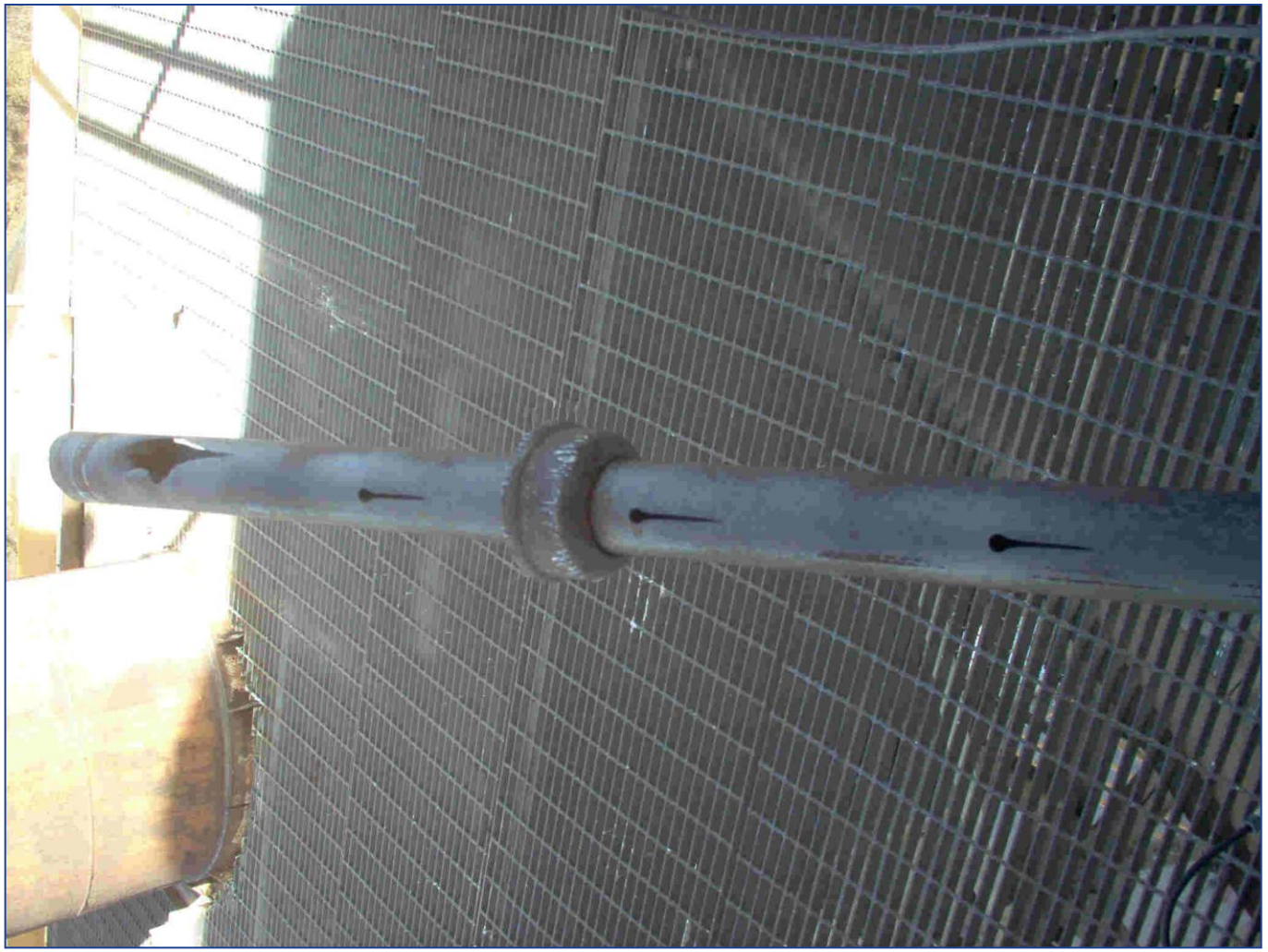
Photo of Bags as Viewed from the Hopper

1352 Bags
Per Compartment

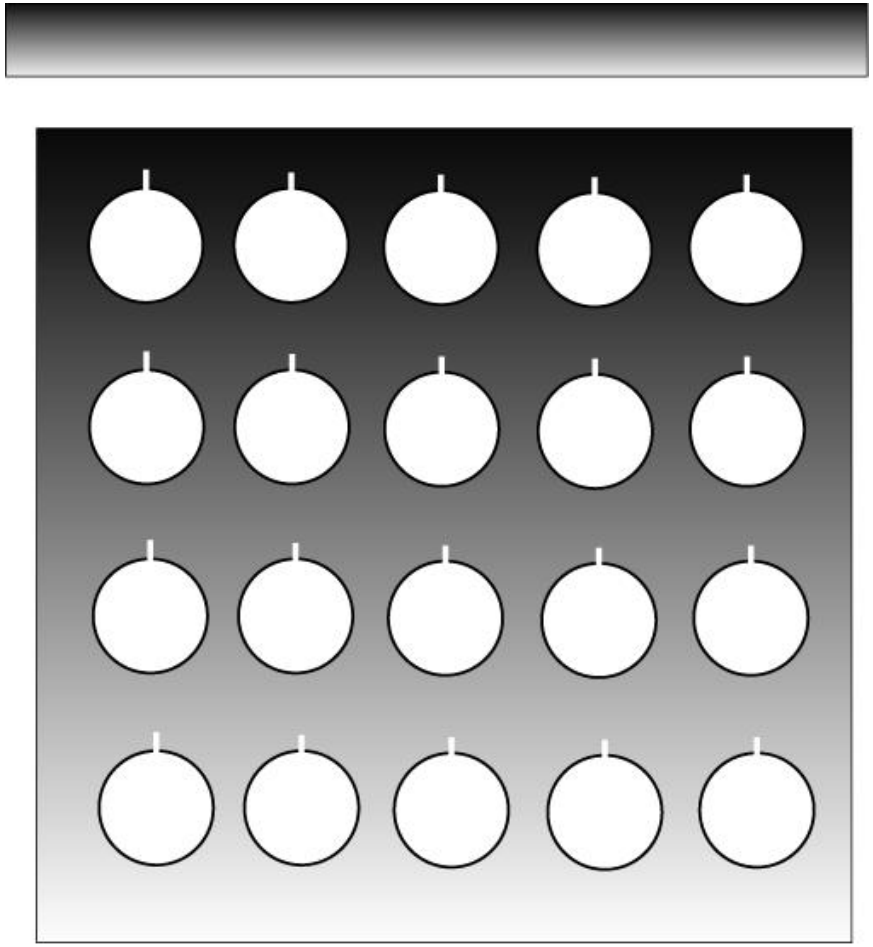
Abrasion failure: Bottom of filter bags located directly in line with inlet gas stream
Excessive movement of filters causing bag-to-bag abrasion

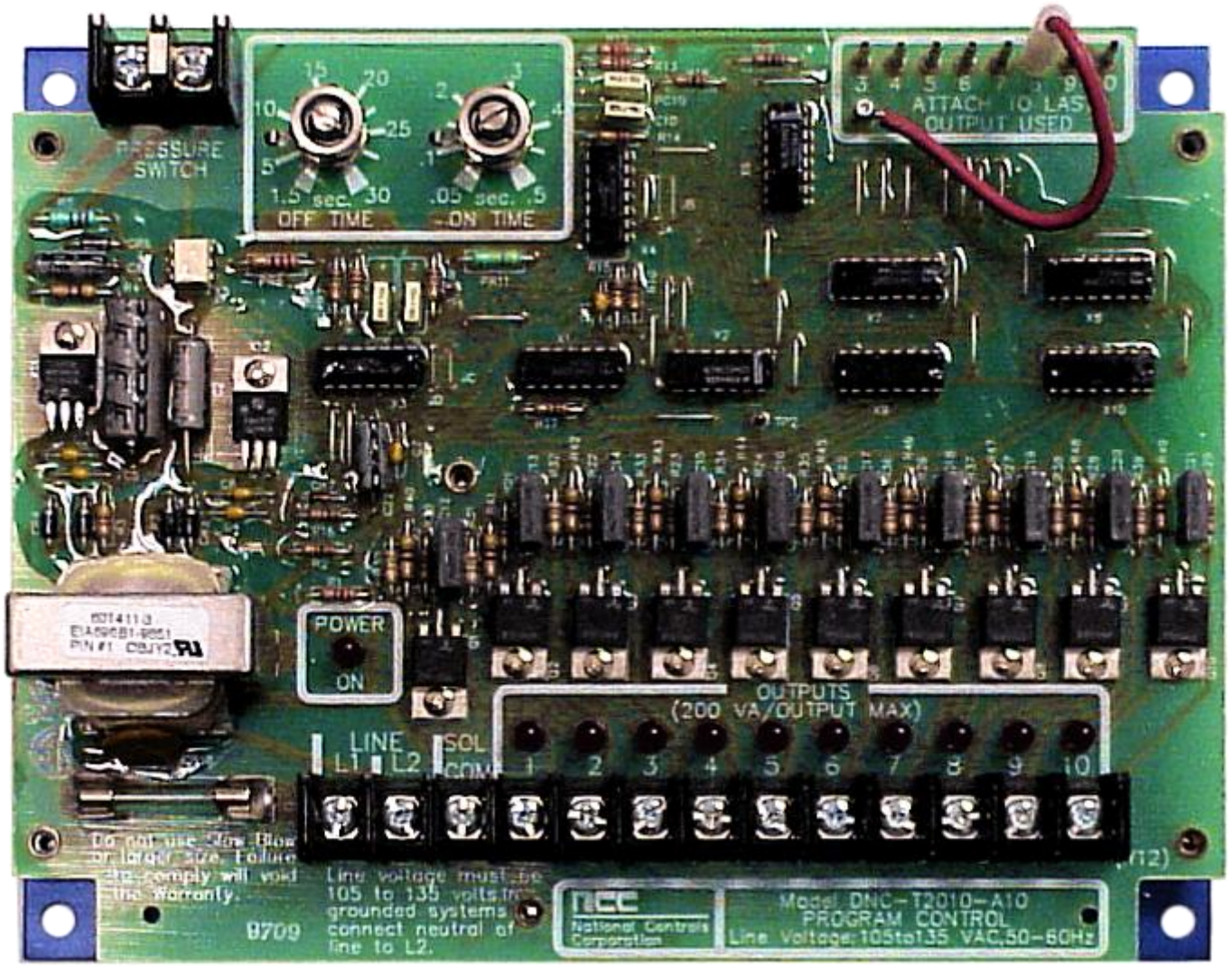


Blowpipe problem



Blowpipe manifold/bag seam alignment




PRESSURE SWITCH
1.5 sec. 30
OFF TIME
.05 sec. .5
ON TIME
ATTACH TO LAST OUTPUT USED
POWER
ON
OUTPUTS
(200 VA/OUTPUT MAX)
LINE
L1 L2
SOL
COM
1 2 3 4 5 6 7 8 9 10
Line voltage must be 105 to 135 volts. In grounded systems connect neutral of line to L2.
Model DNC-T2010-A10
PROGRAM CONTROL
Line Voltage: 105 to 135 VAC, 50-60Hz
National Controls Corporation
9709

Bag house refurbishment

Fabric characteristics and suitability for power generation applications

	Polypropylene	Polyester	Acrylic	Fiberglass	Aramid	PPS	P84 ***	Teflon® ***
Max. continuous operating temp.	170° F (77° C)	275° F (135° C)	265° F (130° C)	500° F (260° C)	400° F (204° C)	375° F (190° C)	500° F (260° C)	500° F (260° C)
Abrasion	Excellent	Excellent	Good	Fair*	Excellent	Good	Fair	Good
Energy absorption	Good	Excellent	Good	Fair	Good	Good	Good*	Good
Filtration properties	Good	Excellent	Good	Fair	Excellent	Excellent	Excellent	Fair
Moist heat	Excellent	Poor	Excellent	Excellent	Good	Good	God	Excellent
Alkaline dust	Excellent	Fair	Fair	Fair	Good	Excellent	Fair	Excellent
Mineral acids	Excellent	Fair	Good	Poor**	Fair	Excellent	Good	Excellent
Oxygen (>15%)	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Excellent	Excellent
Relative cost	**$**	**$**	**$$**	**$$$**	**$$$$**	**$$$$$**	**$$$$$**	**$$$$$$**

* Sensitive bag-to-cage fit

** Fair with chemical or acid-resistant finishes

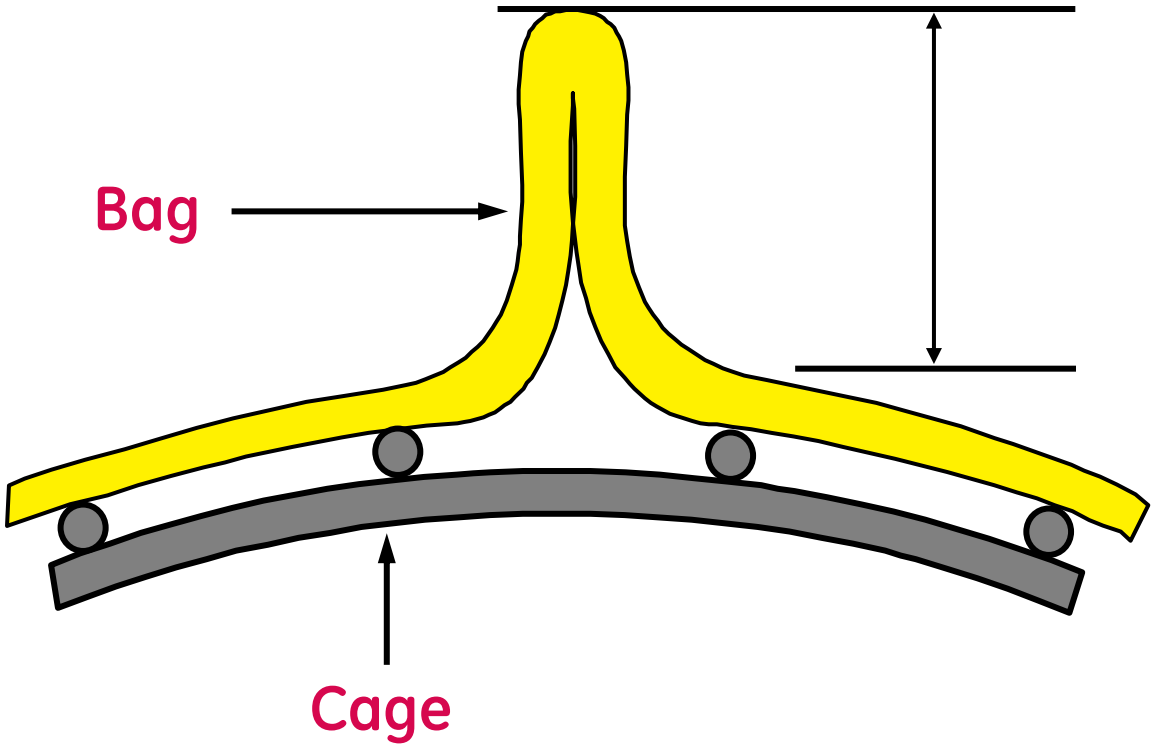
*** Must oversize bag for shrinkage for temperatures above 450°F (232°C)

Filtration Application Conditions Where PPS Excels

- Continuous temperature is 375°F (192°C) or less
- Oxygen content is 15% or less
- Sulfur is present in the fuel, and/or oxides of sulfur are present in the flue gas
- Moisture is present in the flue gas
- Dew-point excursions take place

Bag and cage selection

Standard recommended bag pinch
Dependant upon fabric selection:



Precoating New Filters

GE Energy

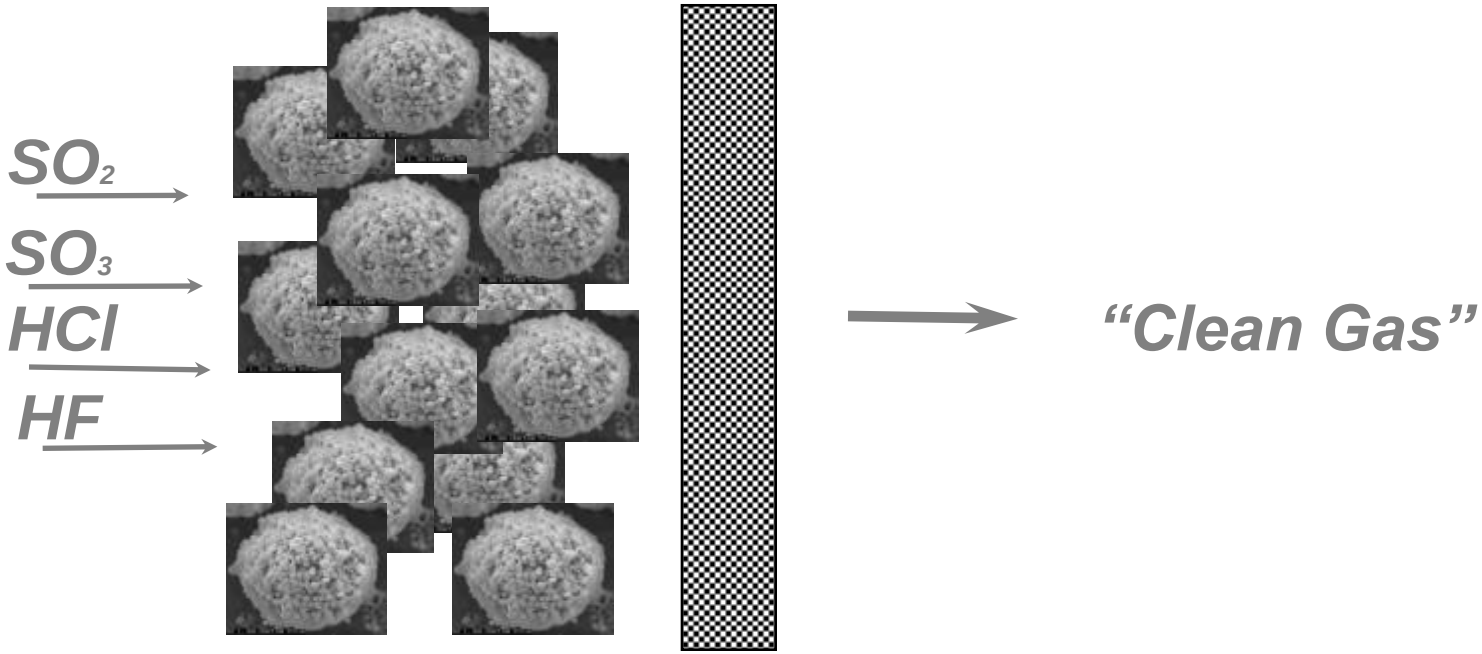
imagination at work

New fabric receives more airflow

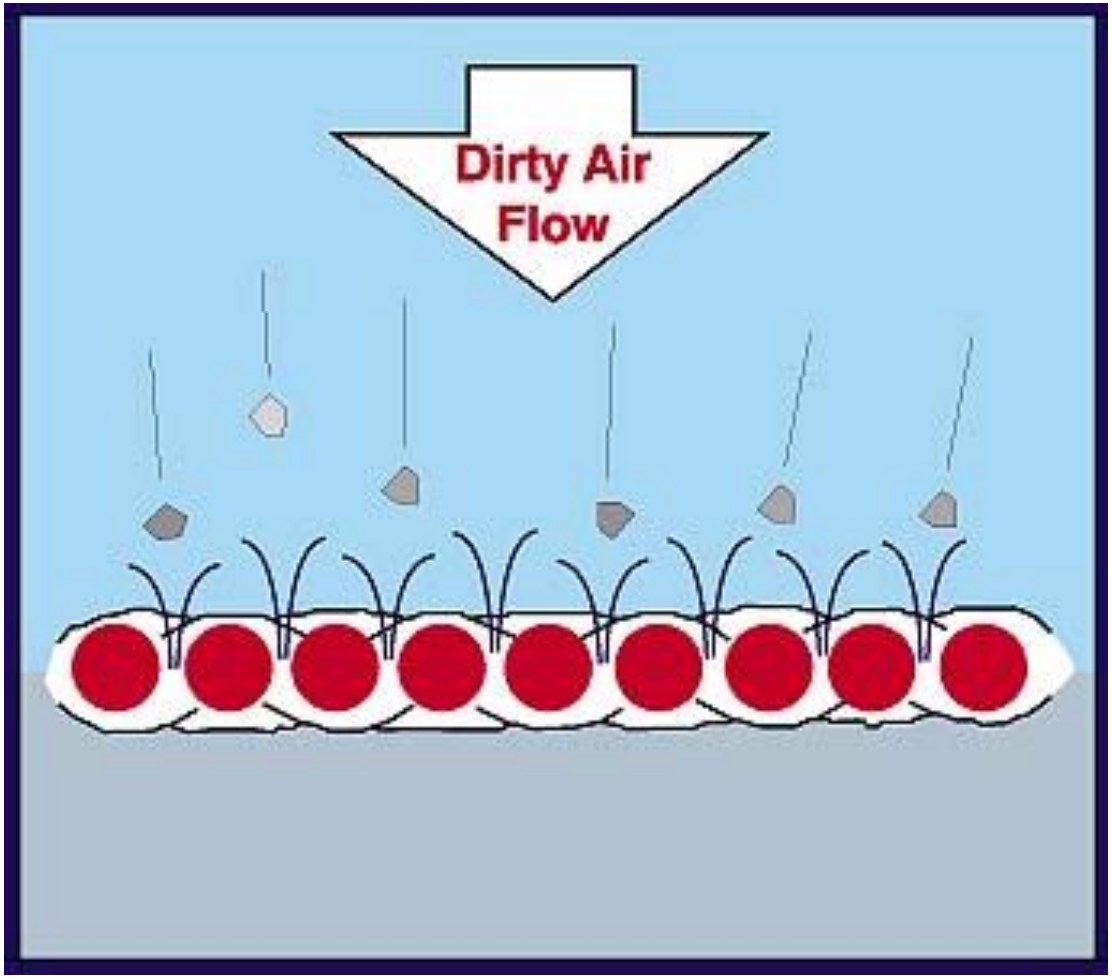
- New fabric accepts airflows in the range of approximately 20 to 50 cfm.
- Filter bags that have been in service and have a good porous dustcake have airflows at 5 to 10 cfm.
- The new filters will be subjected to three times the airflows as the bags that are currently in service, causing potential damage early in the bag's life.

PJFF Theory

- Filters out particulates
- Filter cake on bags contributes about 20% of SO_2 reduction

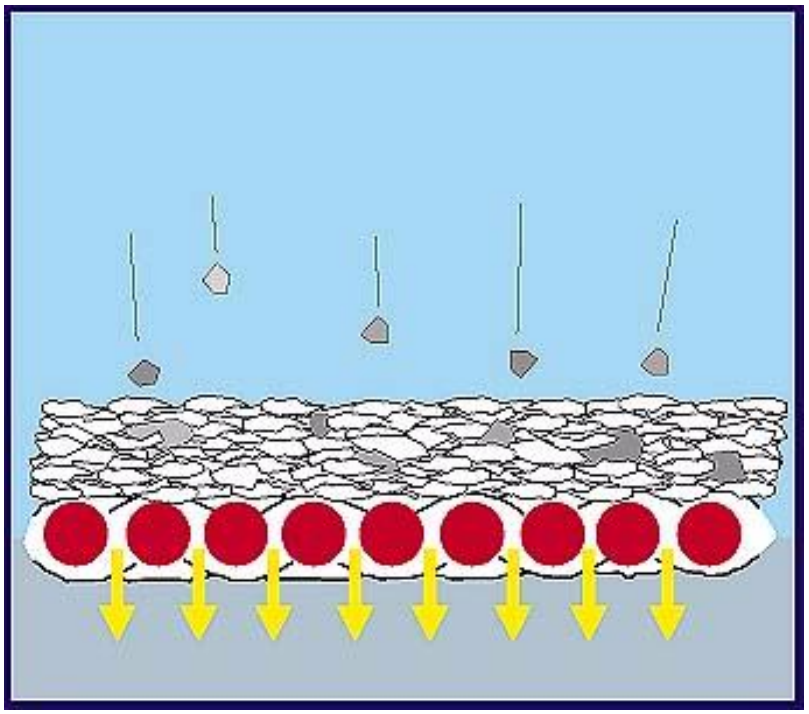


Unprotected fabric



Unprotected new fabric interstices work like miniature venturis to accelerate airflow through the fabric, causing particulate impingement.

Initial dustcake requirements:

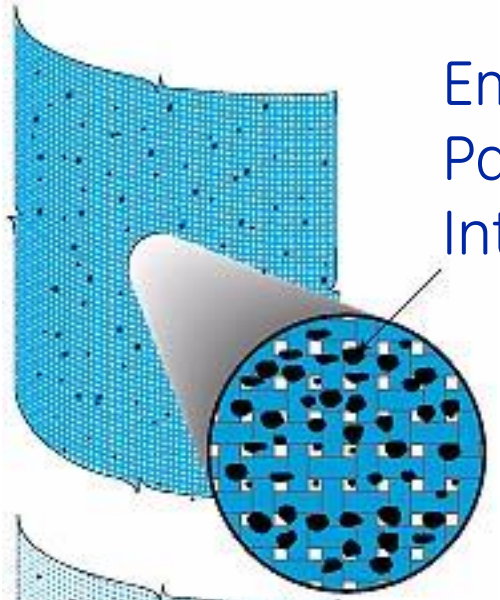


1. Porous, ensuring high airflows
   A. Range of particle sizes
   B. Varying particle shape
2. Provide a uniform coat.
   (1/16” to 1/8”)
3. Material should be neutral (pH).
4. Safe to handle.

New fabric protection & porosity

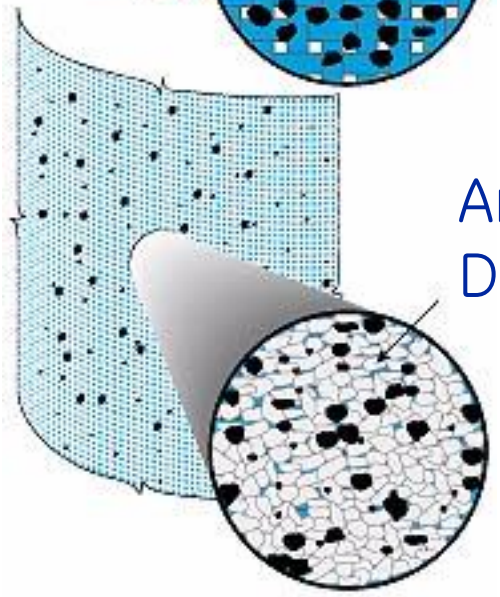
Unprotected

Embedded Particles in Interstices

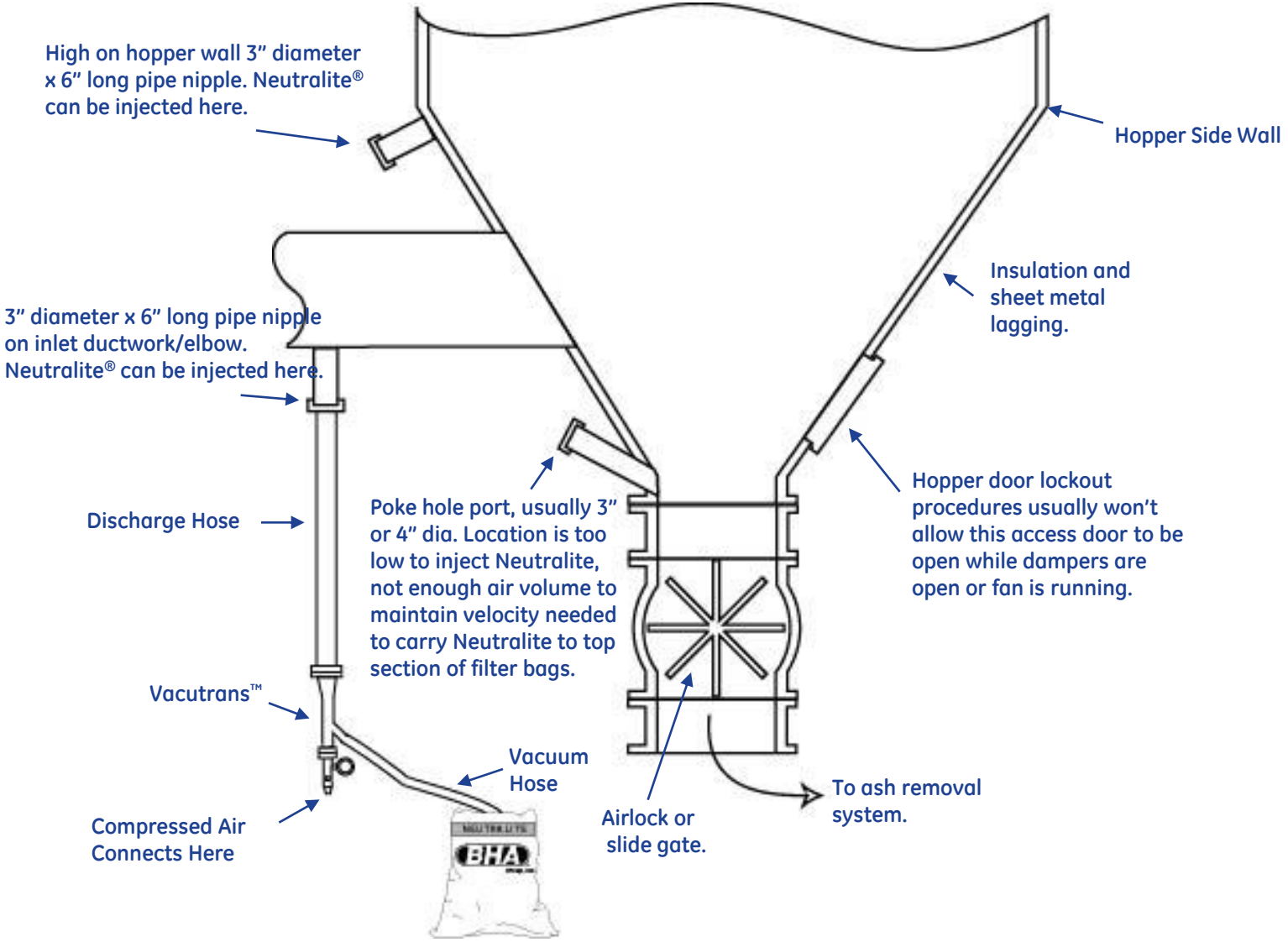


Protected

Artificial Dustcake



Pre-coat injection



Apply Pre-coat Material into Hopper Door

Startup Pre-Coated Bags

- Season Bags
- 2 pounds on a 10 Meter x 150 mm Bag
- Material
  1. **Limestone**
  2. Fly ash
  3. Aluminum Silicate
  4. Diatomaceous earth

Apply Pre-coat Material into Hopper Door

Apply Pre-coat Material into Hopper Door

GE Energy

Leak Detection

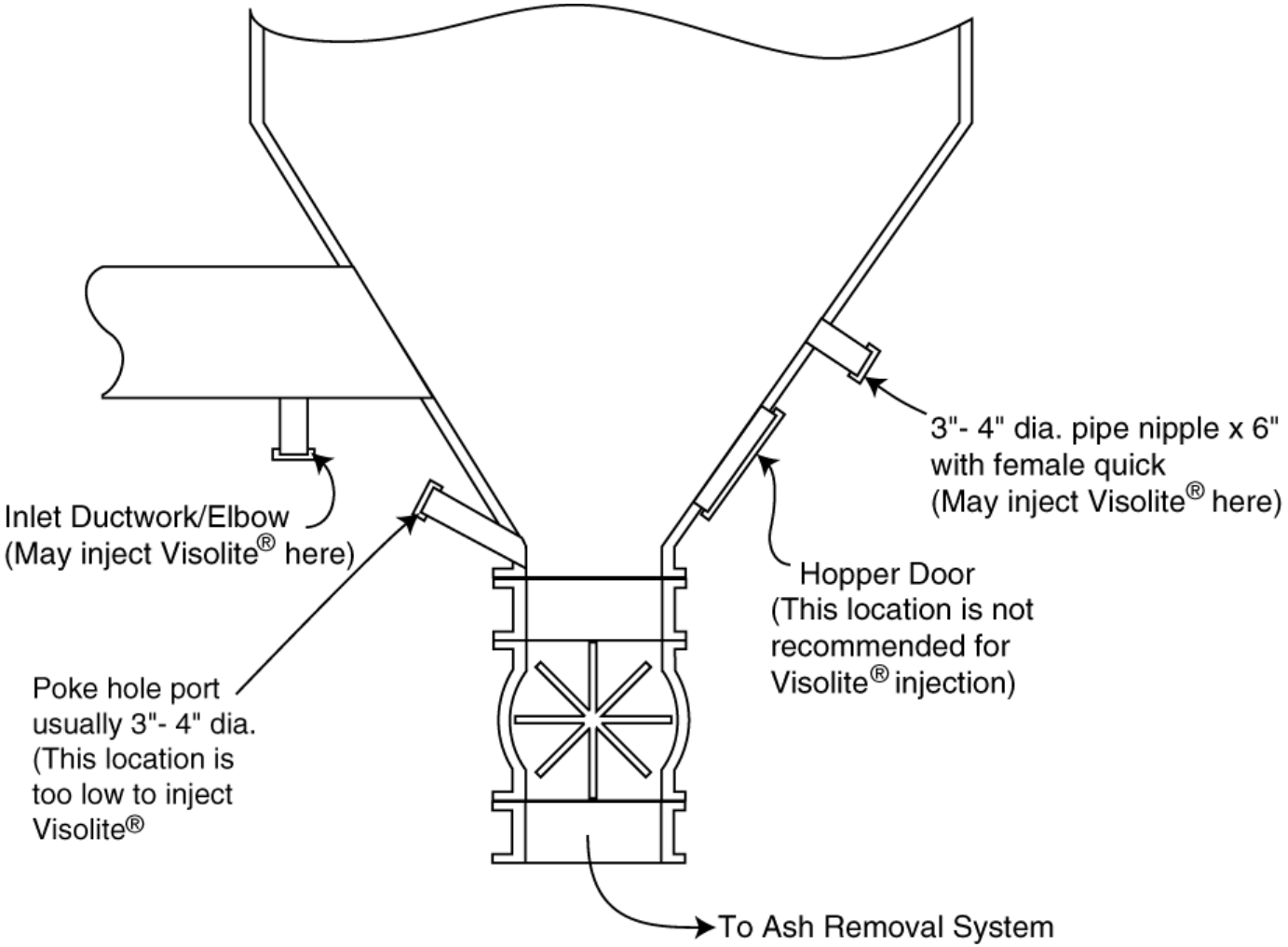
Purpose

- Identify holes in filters
- Check for proper installation
- Detect structural air leaks

Key information

- Clean Air Plenum Access
- Cloth Area
- Injection Location

Injecting Leak Detection Powder



Keys to successful test

- Shut off cleaning system
- Fan in operation
- Inject powder (1lb per 1000 sq ft of cloth)
- Shut off Fan after sufficient time for powder to disperse
- Test with light

BHA Visolite® Leak Detection System

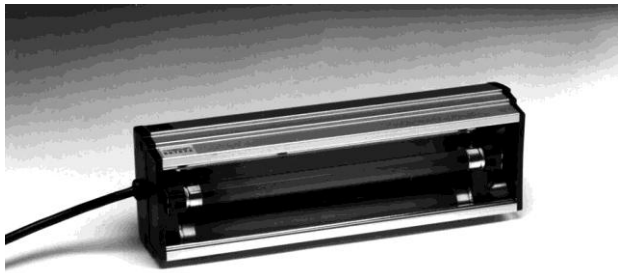
Powder collects around air leaks

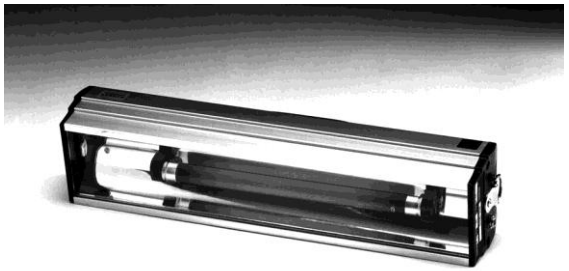
Options:

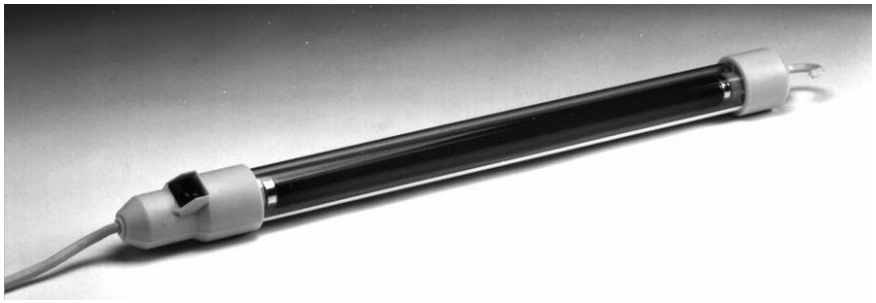
BHA Visolite® colors:

GREEN ORANGE PINK YELLOW

Monchromatic lights:



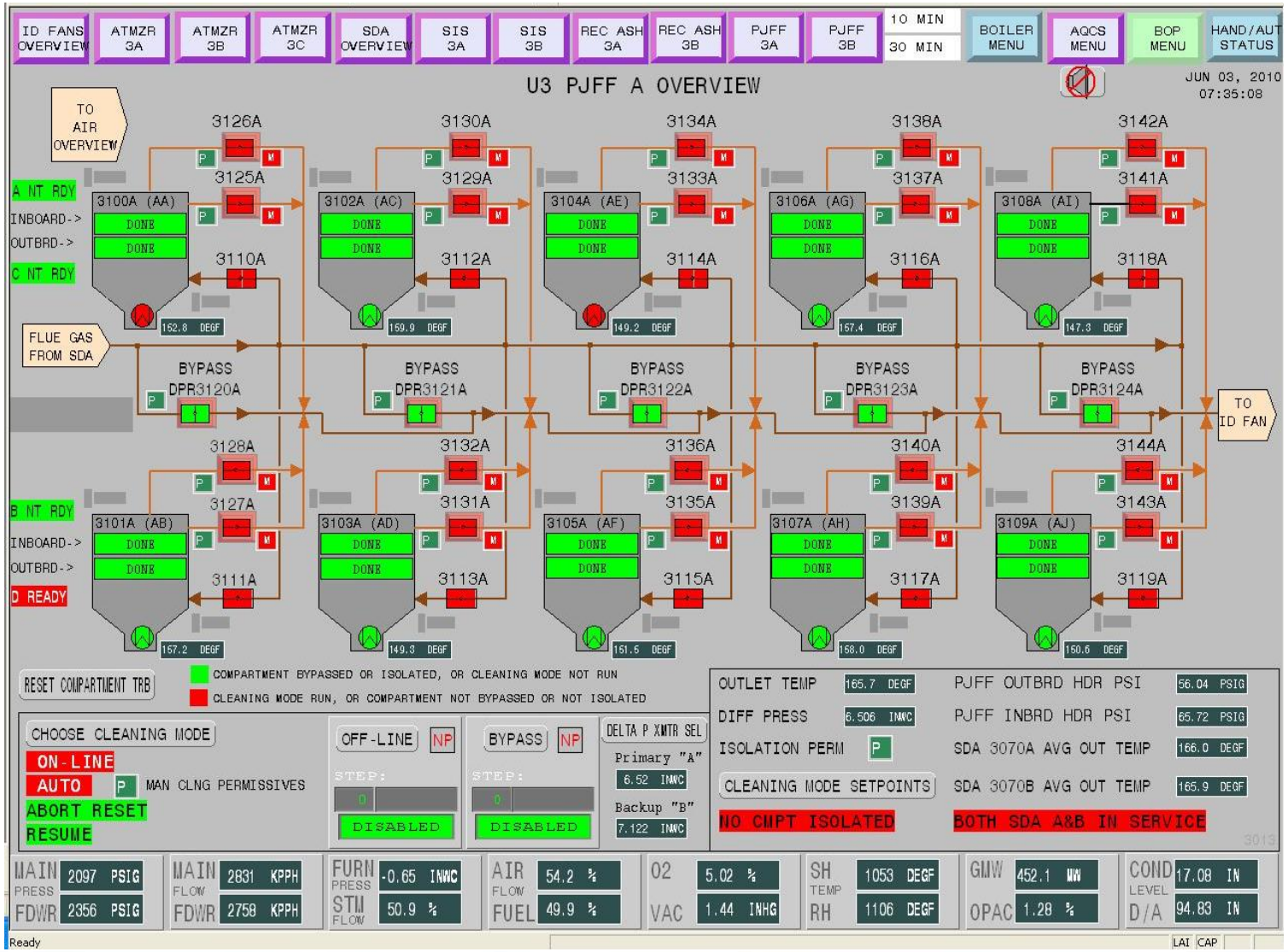




Startup

- Preheat hopper with heaters 24 hours prior to startup
- Close all doors
- Verify Pulse Jets are operational
- Monitor Temperatures & DP

PJFF Overview Screen

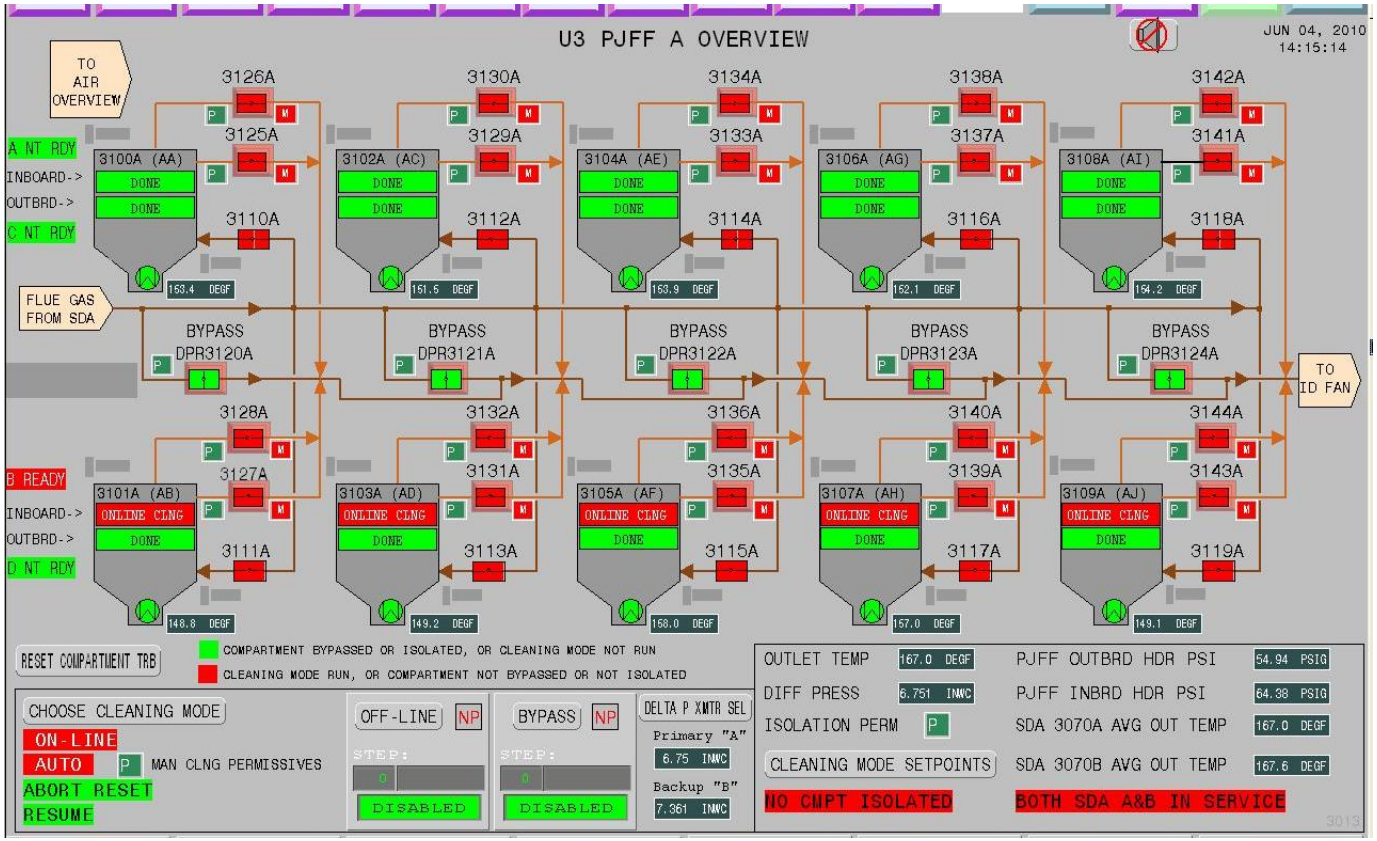


PJFF Control

- PJFF starts cleaning when the baghouse differential pressure exceeds the “start” setpoint. Stops cleaning when the dP drops below the “stop” setpoint.

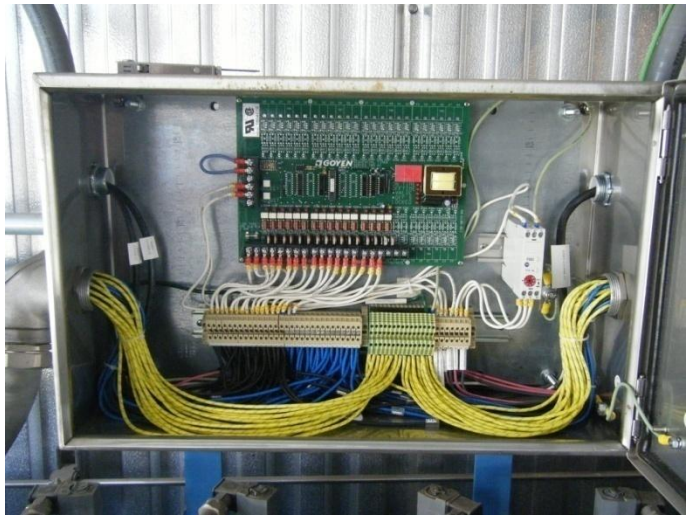
PJFF Control – Groups

- Whole baghouse doesn't clean at once!
- Cycles through pulse headers in "groups".



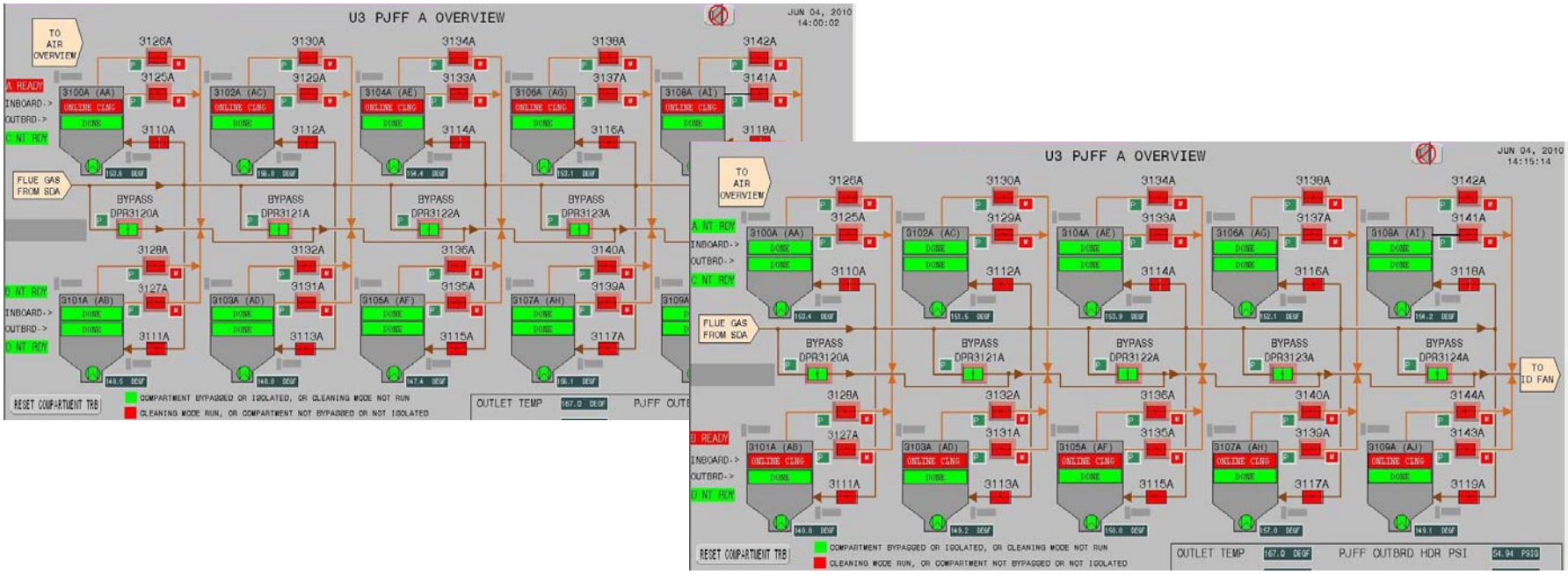
PJFF Control - Pulse Air Header Sequencers

- One sequencer for each header.
- The DCS gives the sequencer a command to start firing pulse valves when it is time to clean.
- Two valves per header pulse at the same time.
- 30 valves on a header, so it takes 15 pulses to complete a header.
- Pulses are 10 seconds apart.
- The last pulse valve on a sequencer sends a “sequencer complete” signal back to the DCS.



PJFF Control

- Once all 5 headers in a group say they are complete, the DCS moves on to the next group.
- Just because a group is “ready”, doesn’t mean it is pulsing!

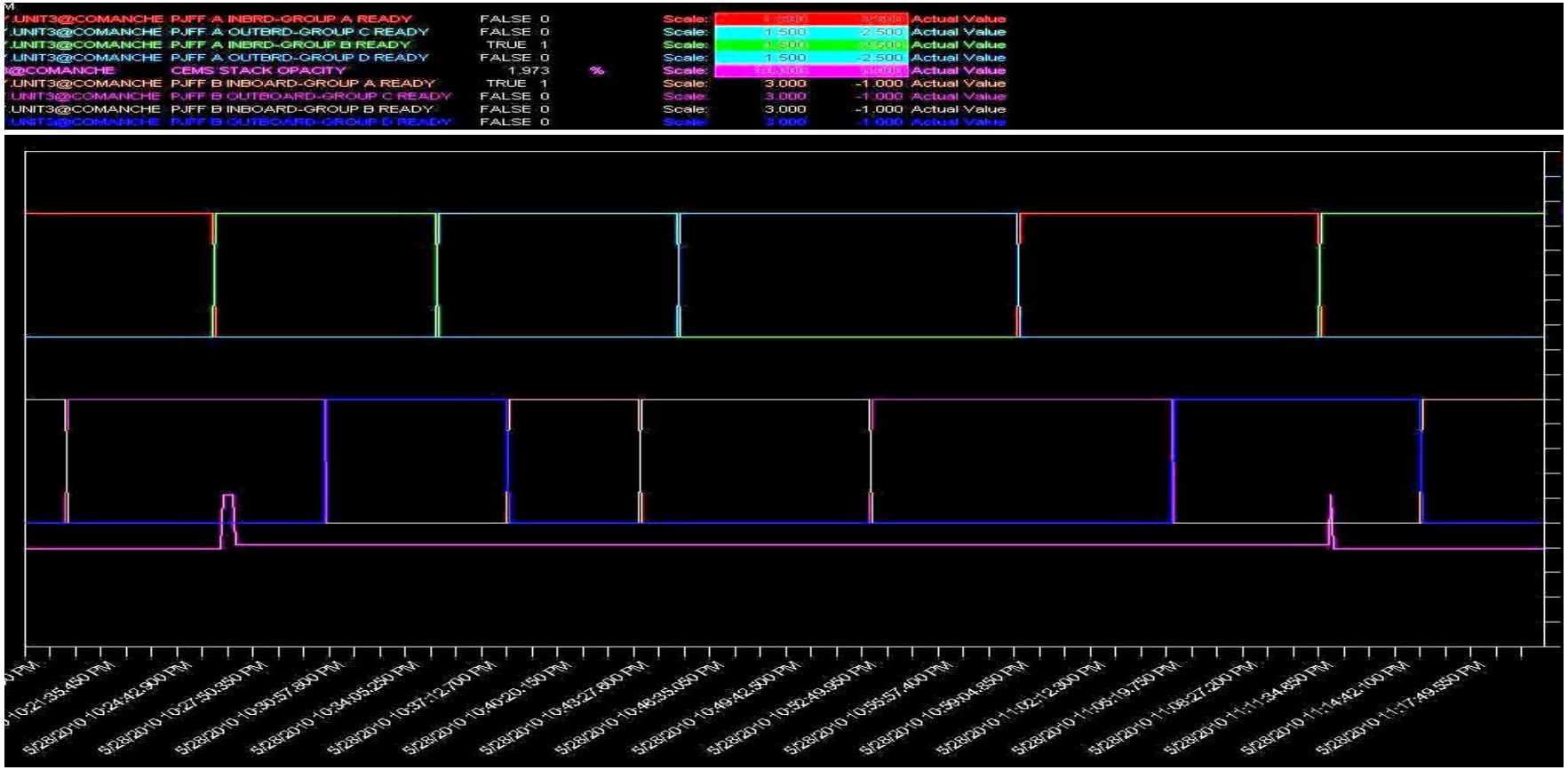


Monitoring the System

- Usually, not much to look for.
- BUT – If a pulse valve sticks open or pulse header air supply line ruptures:
  - Typically the PJFF air compressor pressure indication will drop a few psi and become erratic.
  - If the leak is bad enough, the pulse headers will stop firing due to low pulse header pressure. This is VERY BAD because differential pressure can rise rapidly without cleaning at full load!

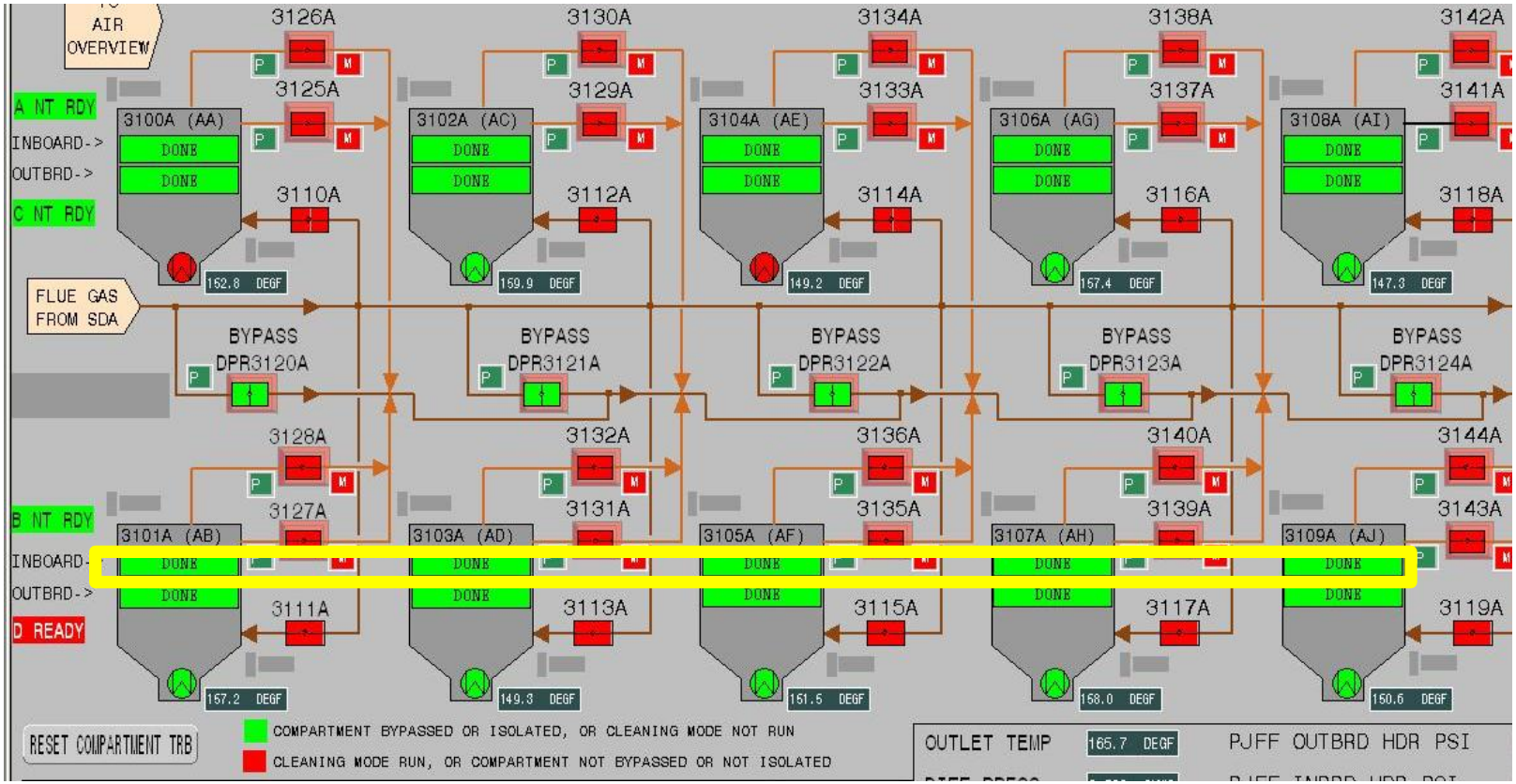
Hunting a Bag Leak

- Typically, an opacity spike will occur when the leaking bag is pulsed.



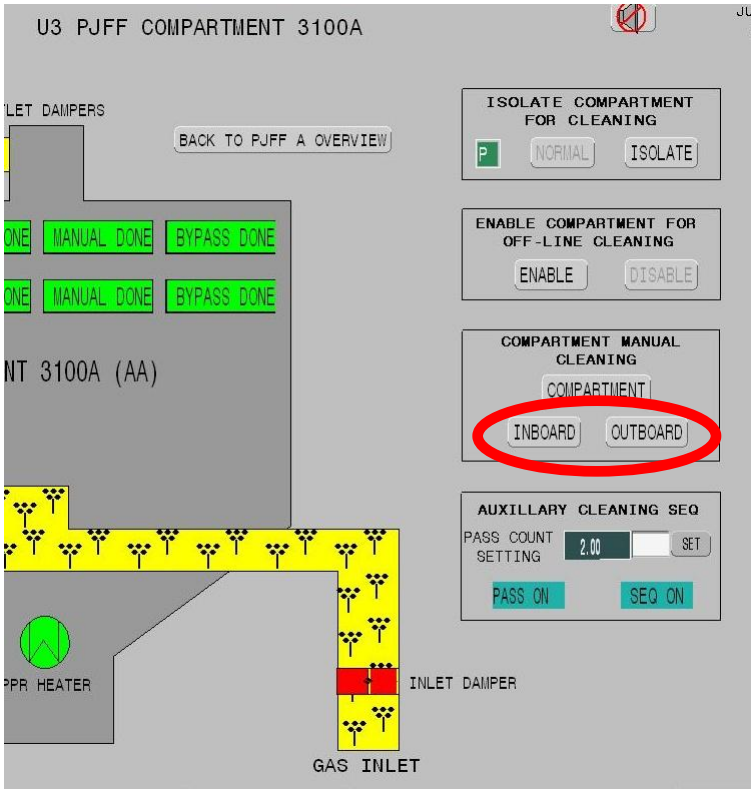
Hunting a Bag Leak

- Trend data showed this leak was likely in PJFF-A, group B.



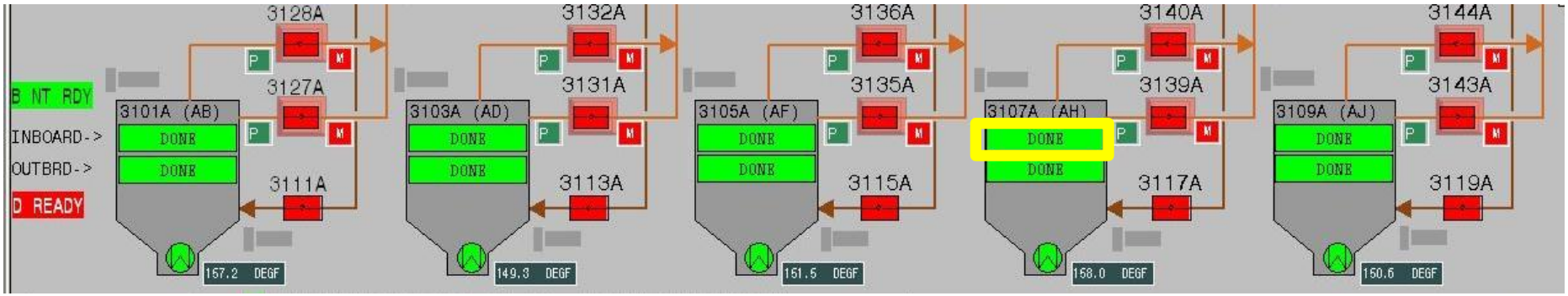
Hunting a Bag Leak

- The location of the leak can be quickly narrowed down to a particular compartment header.
- After the offending group is identified:
  - Manually pulse each of the headers in the group one at a time and wait for an opacity spike to occur.



Hunting a Bag Leak

- The header of the leaking bag is found!
- So, we've got it down to 500 out of a possible 22,000 bags.
- That's still a lot of bags. What is the next step?



Hunting a Bag Leak

- The leaking bag can usually be identified easily once the compartment is locked out and entered. BUT – only if previous leaks in the compartment have been thoroughly cleaned up!

Repairing a Bag Leak

- The blow pipe is removed, the bag cage is pulled out, and the broken bag is extracted.

Repairing a Bag Leak

- This bag was damaged by rubbing against the compartment wall.

Repairing a Bag Leak

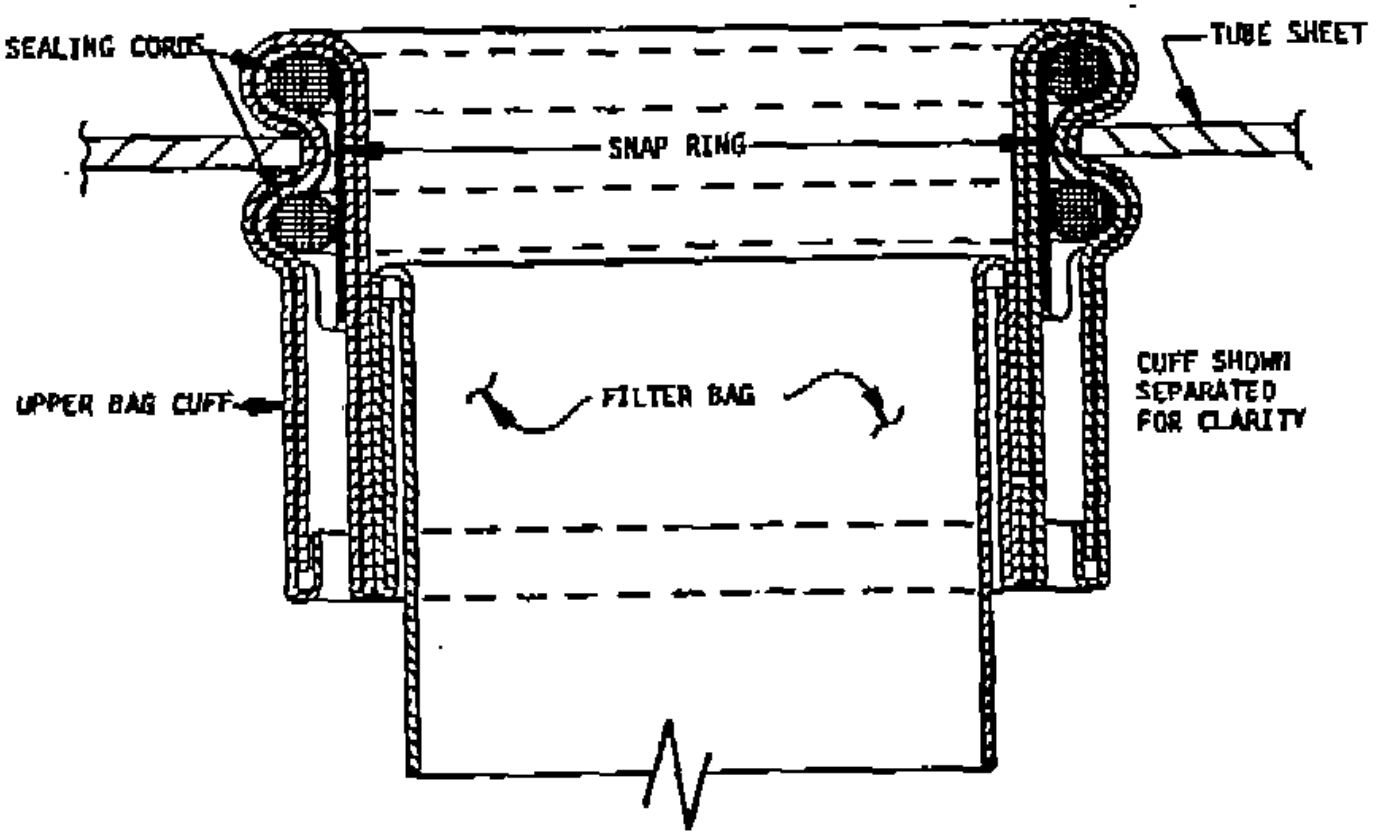
- The area is vacuumed up, a new bag is installed, and the cleaned and inspected cage is re-inserted.

Bag Leaks – Final Thoughts

- Bag leaks are relatively painless to identify and correct – IF opacity spikes are checked regularly and compartments are thoroughly cleaned when bags are replaced.
- Flue gas velocity in the compartments is very low. The ash path from bag to outlet damper won't just sweep itself clean – it must be vacuumed.

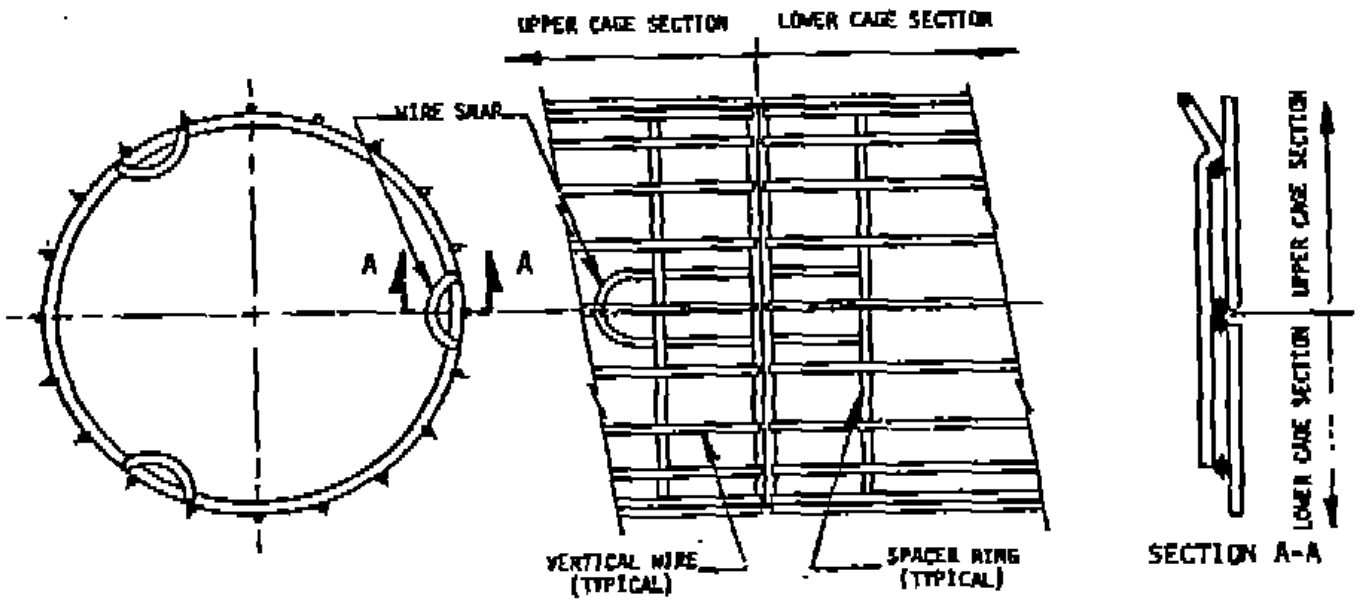
Questions ?

Bag Attachment to Tubesheet



Bag Cages

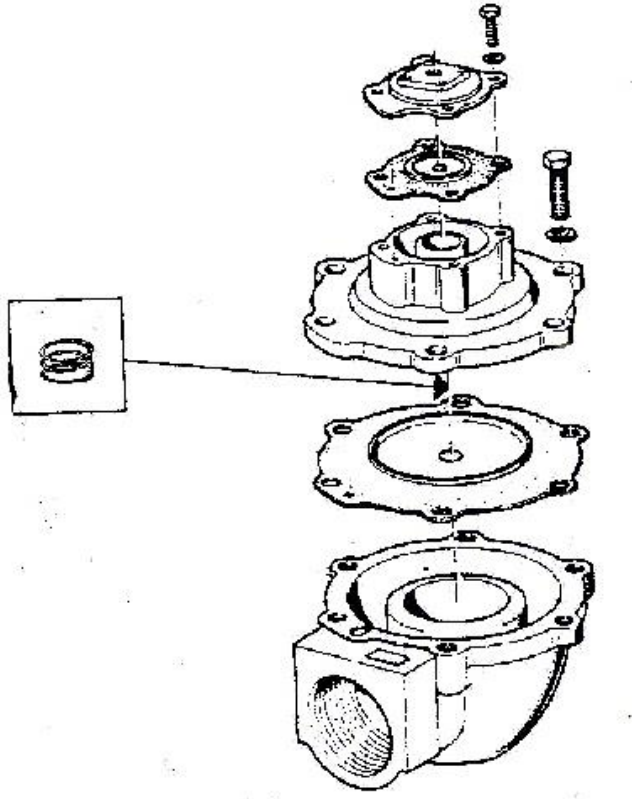
Process gas flows from the outside to the inside of the filter bags. Bag cages are installed inside each bag to prevent their collapse during operation



Pulse Valves

Pulse Valves and Pilot Solenoids

- **Compressed air is sequentially discharged to each blowpipe through a pilot controlled pulse valve. The pulse valve is a double diaphragm valve. The pulse valve is controlled using a normally closed electrically operated solenoid air valve**



Pulse Valve

10 meter Filter Bags

Surface Area -

8,704 filter bags
10 - meter length?

10 – Acres

435,600 ft^2