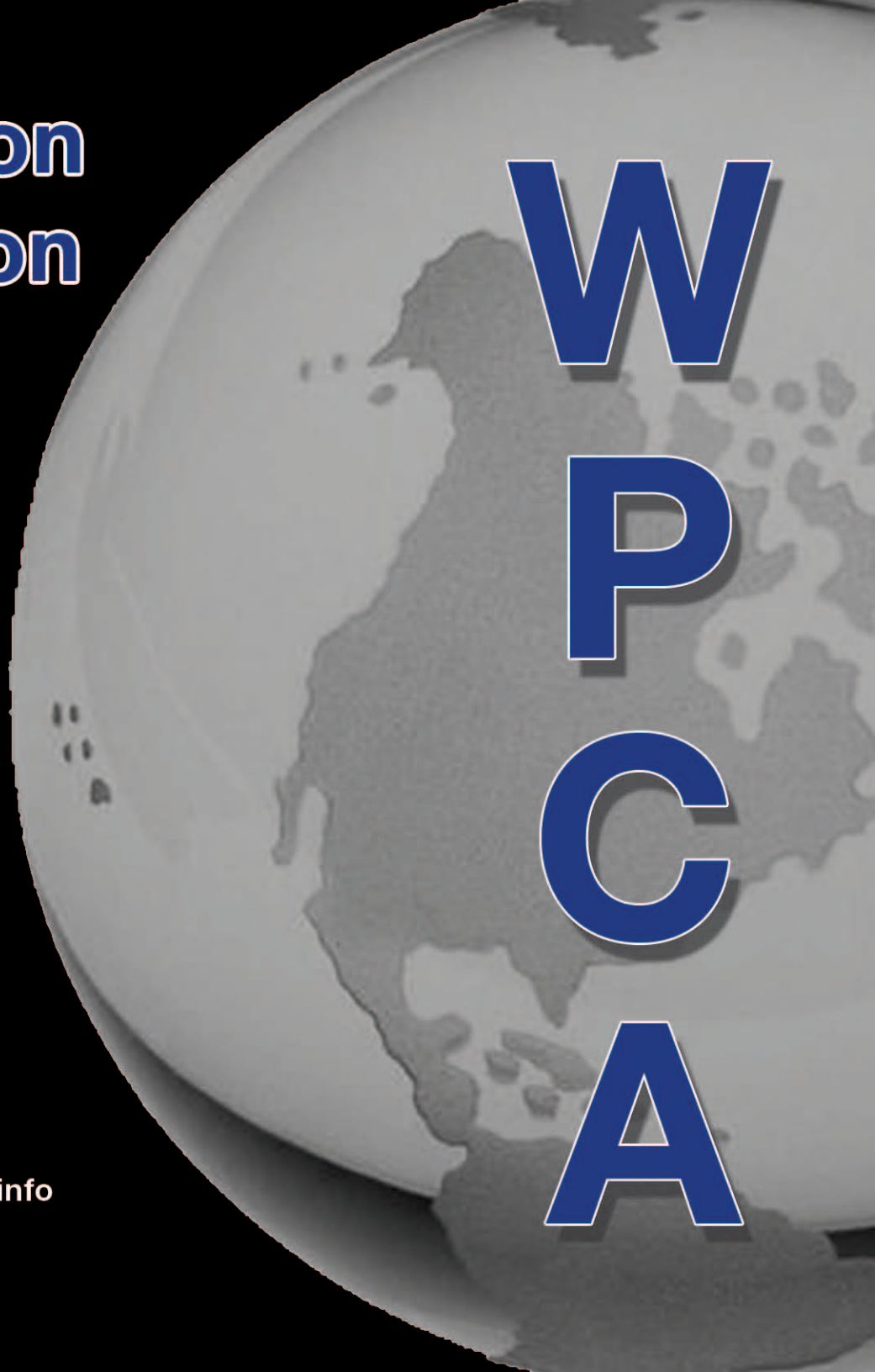
Worldwide Pollution Control Association



Duke Energy Seminar

September 3 – 5, 2008

Concord, NC

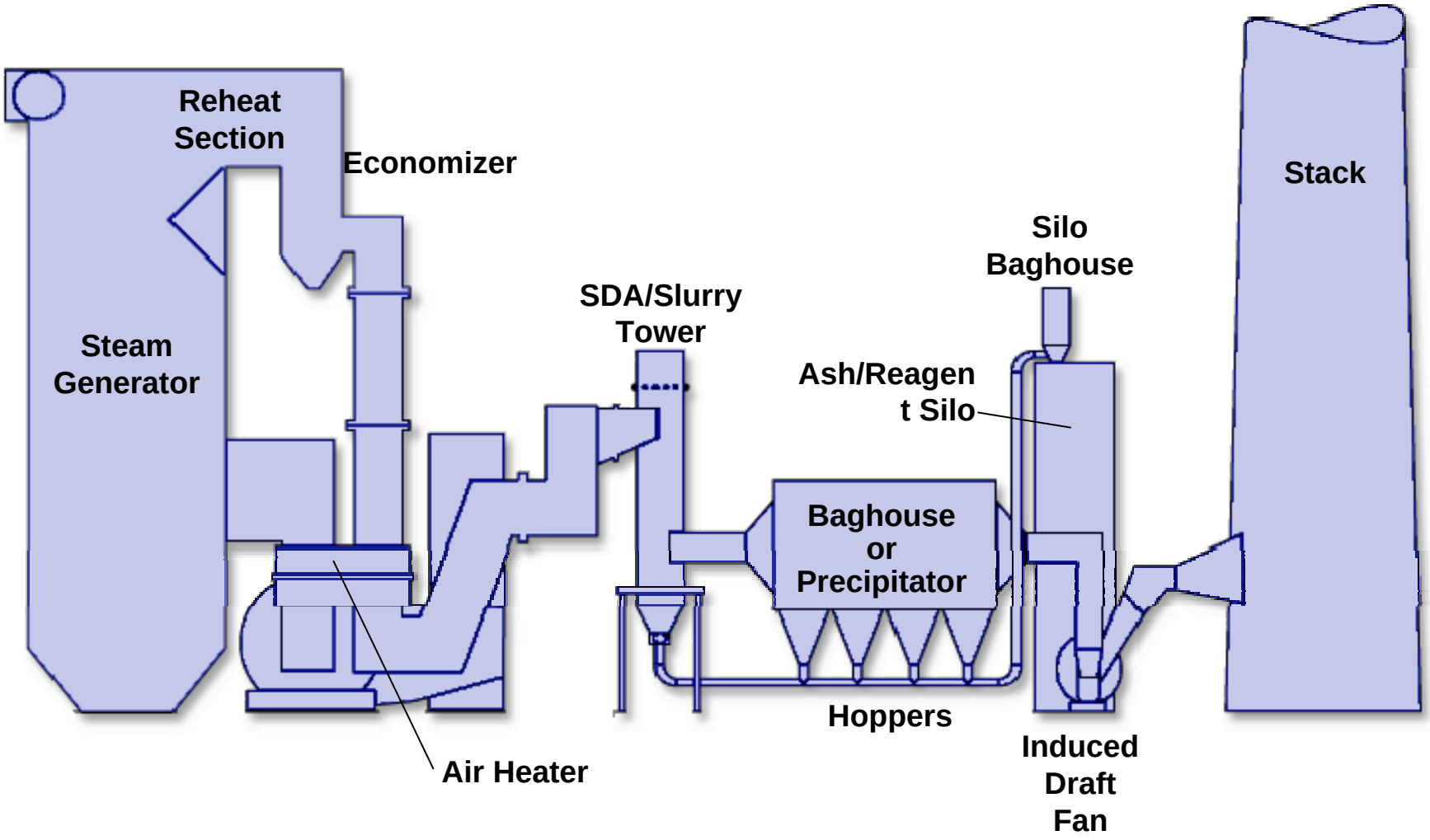
WPCA

Vist our website at www.wpca.info

2008 WPCA/Duke Energy Seminar

GE Energy

Typical SDA System Schematic



Fabric Filter – Reverse-Air or Pulse-Jet?

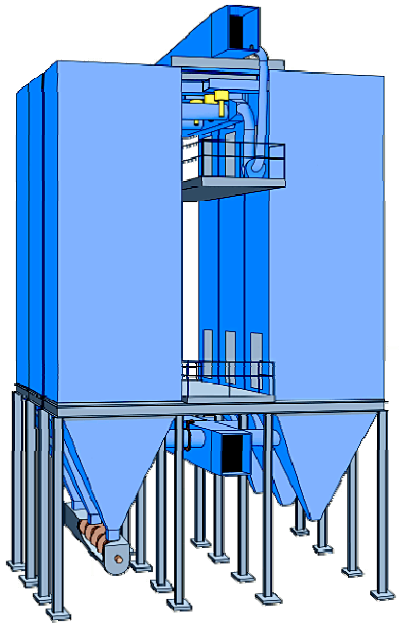
Depends on a variety of factors

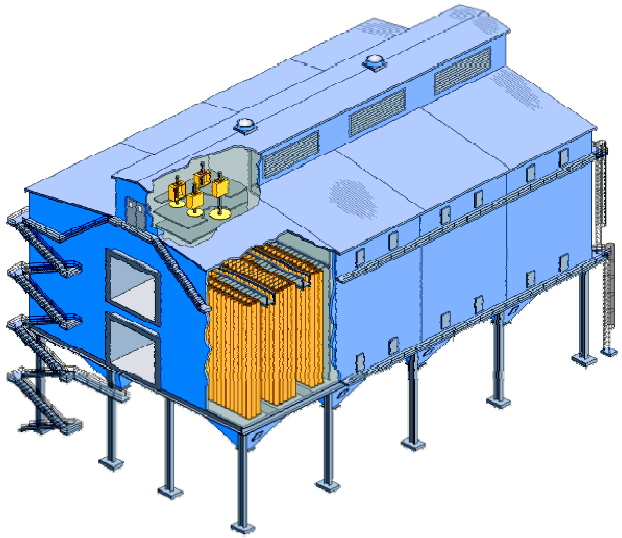
- Initial capital cost
- 20-year operating cost
- Available real estate

Utility Hot Gas Market APC Trends

Historically, 95% of applications utilized reverse-air collector designs:

- > Woven Fiberglass bags
- > 2:1 air-to-cloth ratio
- > 11.5" x 30' filters (29cm x 9m)
- > 4 – 10 year filter life
- > Large footprint housing





Utility Hot Gas Market APC Trends

Over past 5 years, trend is to Pulse Jet collectors (approximately 75% of applications):

- Needle felts (acrylic, PPS, P-84), woven fiberglass & PFE
- 2.8 – 3.5 (fpm) Air-to-Cloth ratio (ACR)
- 3 – 5 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

Hot Gas Pulse Jet Design Trends

	Pulse Pressure	Cage Type	Maximum Length	Issues
Traditional PJ High Pressure / Low Volume	60 - 100 PSI (4.1 – 6.9 Bar)	One-Piece	16 – 19 feet (4.9- 5.8m)	Housing Footprint
Medium Pressure / Medium Volume	25 – 50 PSI (1.7 – 3.4 Bar)	Multi-Piece	22 – 32 feet (6.7 – 10.0 m)	Cage wear; Penthouse restrictions
High Volume / Low Pressure	< 15 PSI < 1 Bar)	Multi-Piece	22 – 27 feet (6.7 – 8.2 m)	Cage wear; Penthouse restrictions

Factors Affecting Dust Cake Management

Inlet Grain Loading

- SDA – Lime Injection
- Coals with higher ash content
- Coals with fine ash – form denser dust cakes
- Type of Boiler (CFB vs.. Stoker vs. PC)

Will typically cause increase in cleaning frequency

Factors Affecting Dust Cake Management

Scrubbing

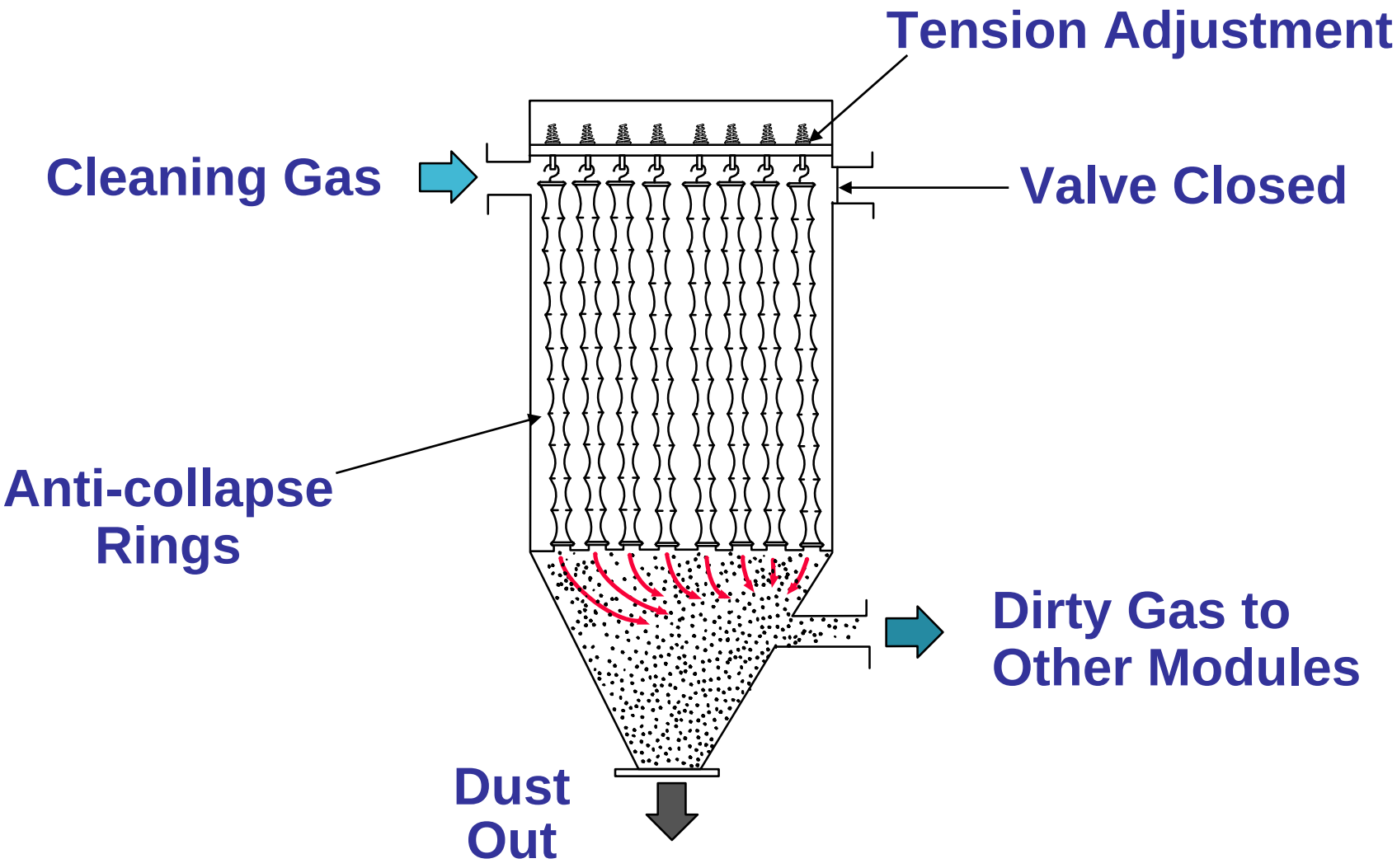
- NOx – SCR or SNCR
  - » Ammonia slip can cause sticky dust (ammonium bisulfate)
- SOx – Dry FGD / SDA / Lime Injection
  - » Operating near dewpoint – possibility of condensation, mudding of bags.
- Hg – Injection of Powdered Activated Carbon

Factors Affecting Design

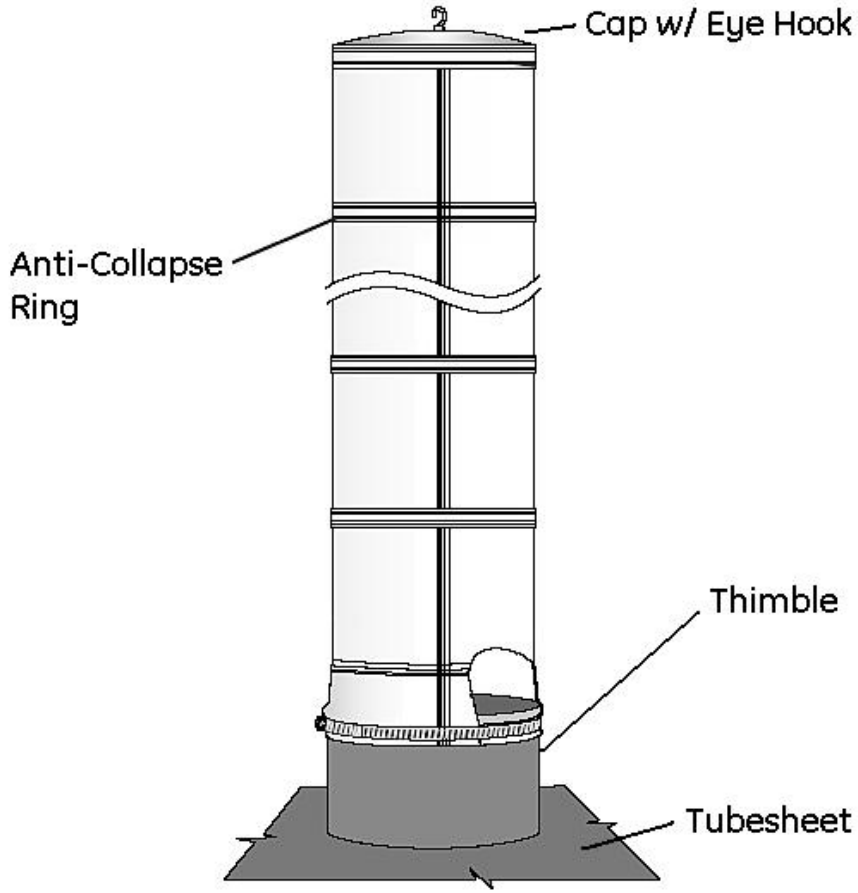
Emissions

- Emissions limits of 0.020 lbs/MMbtu trending down towards 0.012 lbs/MMbtu (and lower)
- Lower Total Emissions (Filterables & Condensibles)
- PM_{10} & $PM_{2.5}$ (higher efficiency for smaller particles)

Reverse Air Baghouse



Reverse-Air Baghouse Components



Typical RA Bag
(snapband bottom available)

Tensioning Assemblies

Commonly Used Filtration Fabrics for Reverse Air (Gas) Collectors

> Woven Fiberglass

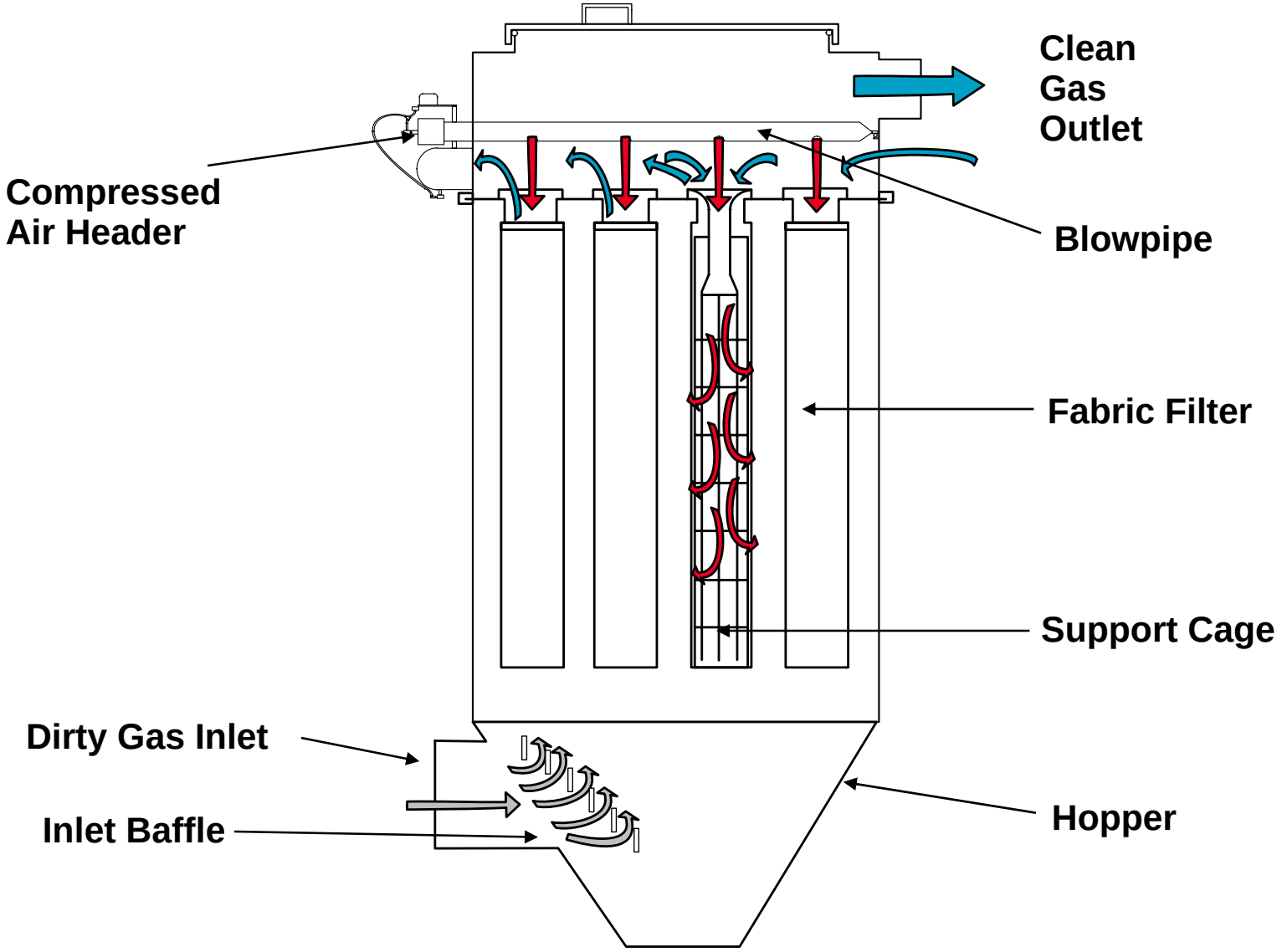
> ePTFE Membrane on Fiberglass

Reverse-Air Bag Manufacturing

Fiberglass Finishes

Finish:	Finish Purpose:
Silicone, Graphite Teflon (SGT)	**Protects glass yarns from abrasion, adds lubricity**
Acid Resistant	**Shields glass yarn from acid attack**
Teflon® B	**Provides enhanced abrasion resistance and limited chemical resistance**
Blue-Max CRF-70®	**Provides improved acid resistance and release properties, superior abrasion resistance, resistant to alkaline attack, improved fiber encapsulation**

Pulse-Jet Baghouse



Pulse-jet Baghouses (cont).

- Media Options:
  - > Bags and Cages (traditional)
  - > Top or Bottom Load Configurations

Baghouse Components

- Dirty Air Plenum: dirty side of media
- Clean Air Plenum: clean side (clean air to atmosphere or fan)
- Tubesheet or Cell-plate: Metal Floor (or Ceiling) that separates the clean side from the dirty side.
  - > Holds the filtration media.
  - > Has holes for the air to pass from dirty side to clean side (through the filter media).
- Hopper: collects the discharged dust

Baghouse Configurations

- Single compartment
- Multiple compartments
  - > Common dirty air and clean air duct plenums
- Stand-alone – has hopper
- Bin vent – mounted on equipment or vessel – no hopper
- Static Baghouse – has no fan at discharge

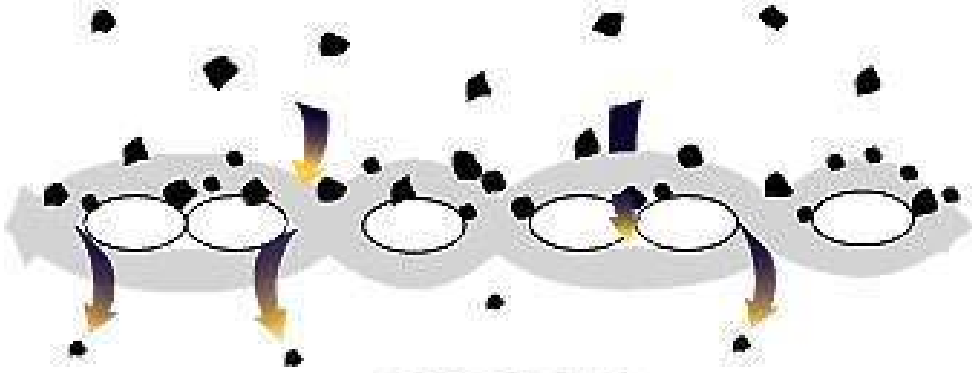
Commonly Used Filtration Fabrics
Pulse Jet & Low Pressure - High Volume

- Woven fiberglass – 25%
- PPS (Polyphenylene Sulfide) – 60%
- P84 and Others – 15%

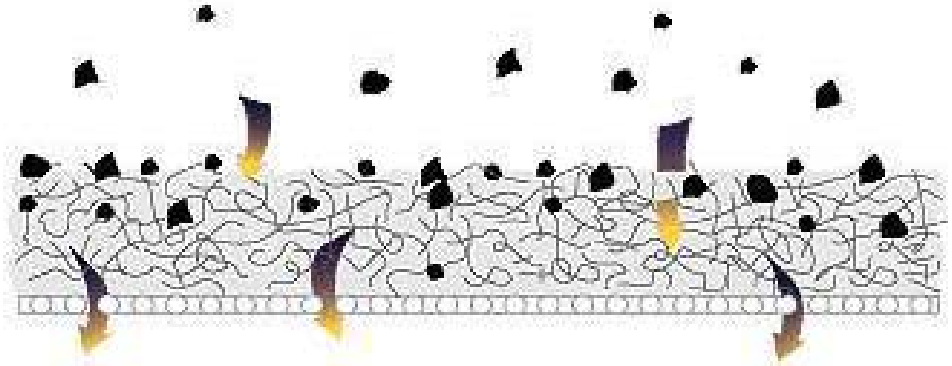
  - ePTFE Membrane applied to the above substrates
  - Pleated Filter Elements (PFEs)

Fabric Style

Woven

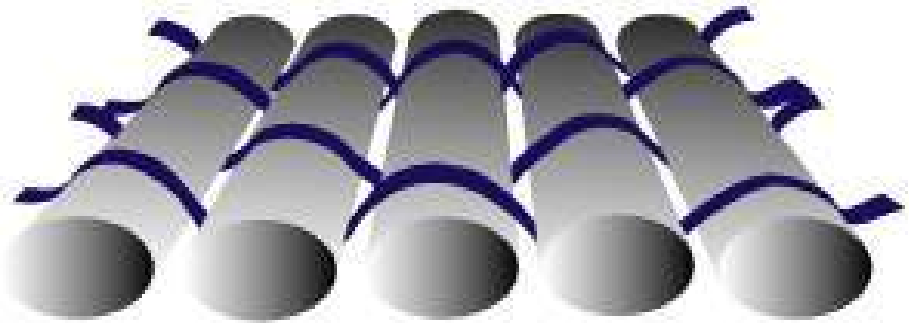


Felt

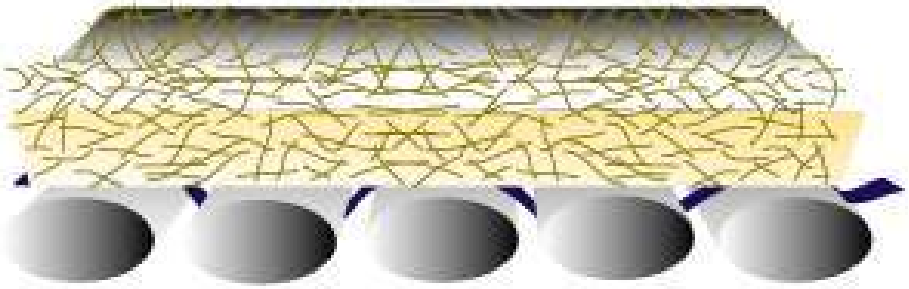


Felt Fabric Construction

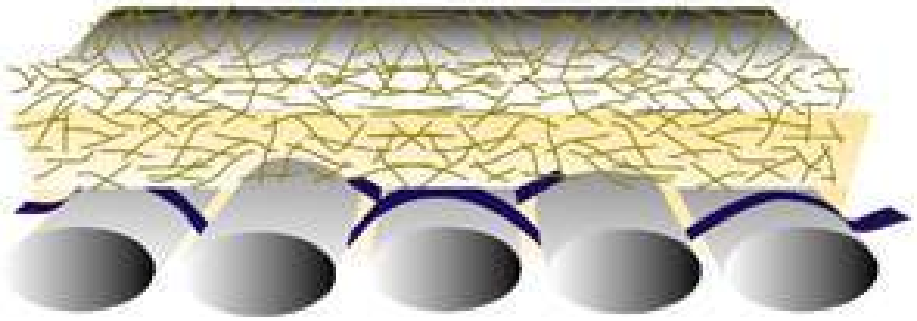
Base Fabric
(scrim)



Web on Base



Web Needled
Into Base



Fabric Selection Considerations

> Baghouse Operating Temperature
> Abrasion Resistance Needed
> Resistance to Cleaning Energy
> Gas Stream Chemistry
> Air-to-Cloth Ratio

Fabric Characteristics & 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	Good	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

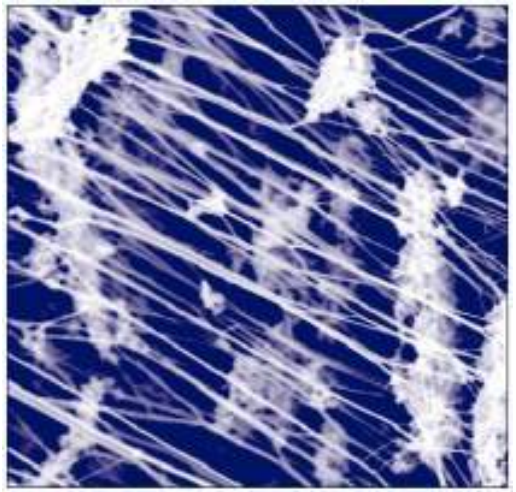
*** Must oversize bag for shrinkage for temperatures above 450°F (232°C)

What is ePTFE Membrane?

A microporous membrane laminated to traditional filtration fabrics

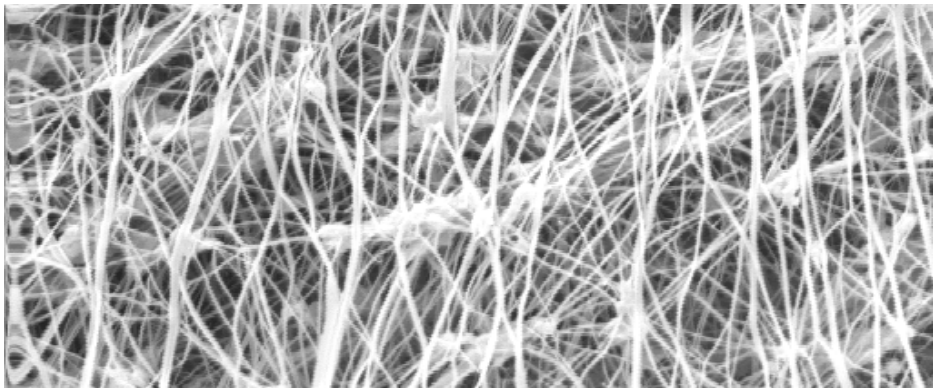
The PTFE membrane consists of a web of overlapping fibrous strands that form millions of air passages, much smaller than the particulate, for an extremely porous filter surface

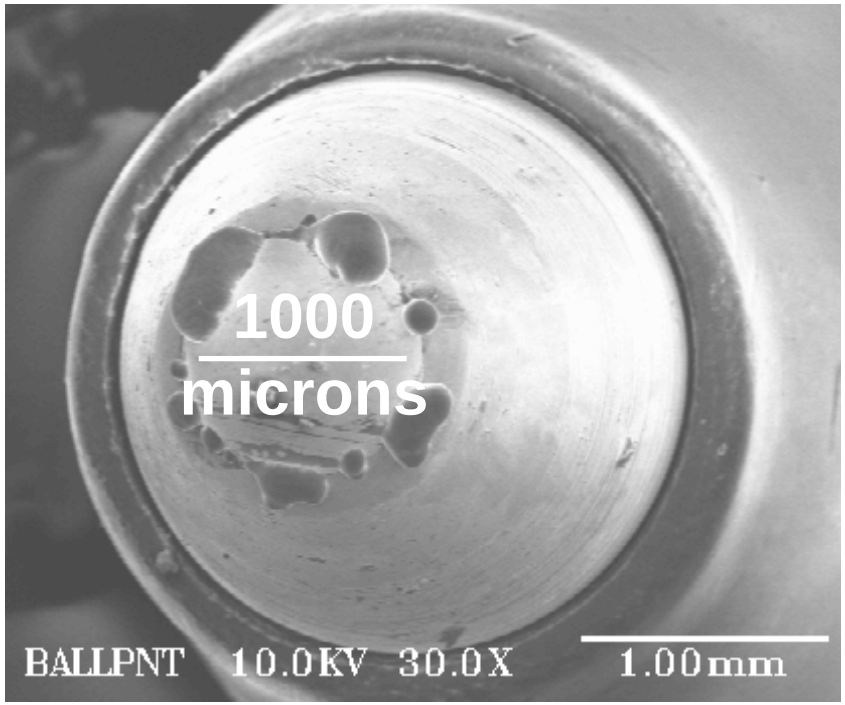
Because the membrane is slick, bag cleaning is more complete with less energy



Microphotograph of membrane

ePTFE Filtration Facts





-Average Membrane Pore Size 0.5 - 1 micron, effective pore size much smaller.

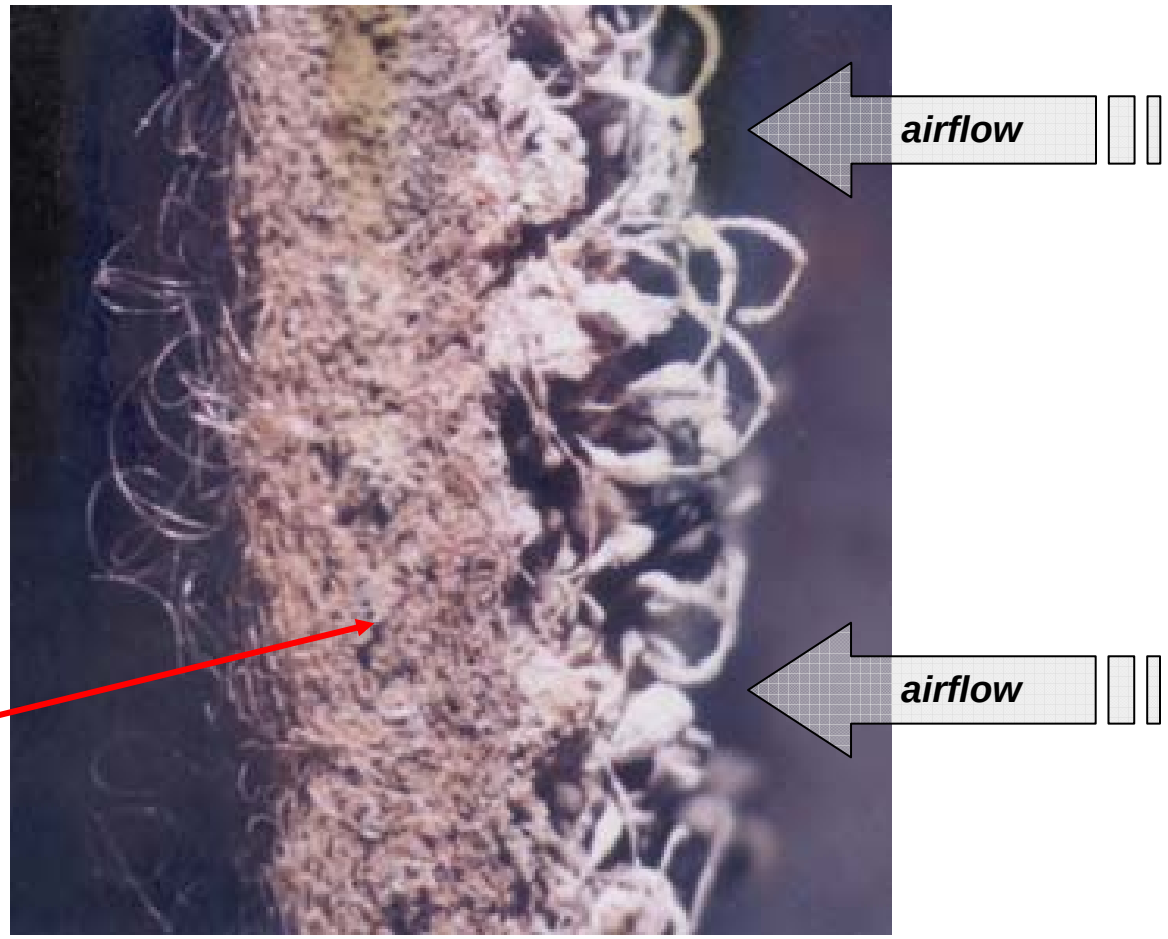
-Traditional woven / felts typically have a 20 micron pore size.

-Can fit approximately 1000-2000 pores across the tip of a ball point pen.

-100 million pores per square centimeter

Depth vs. Surface Filtration

A conventional filter bag collects particulate in the depth of the fabric.

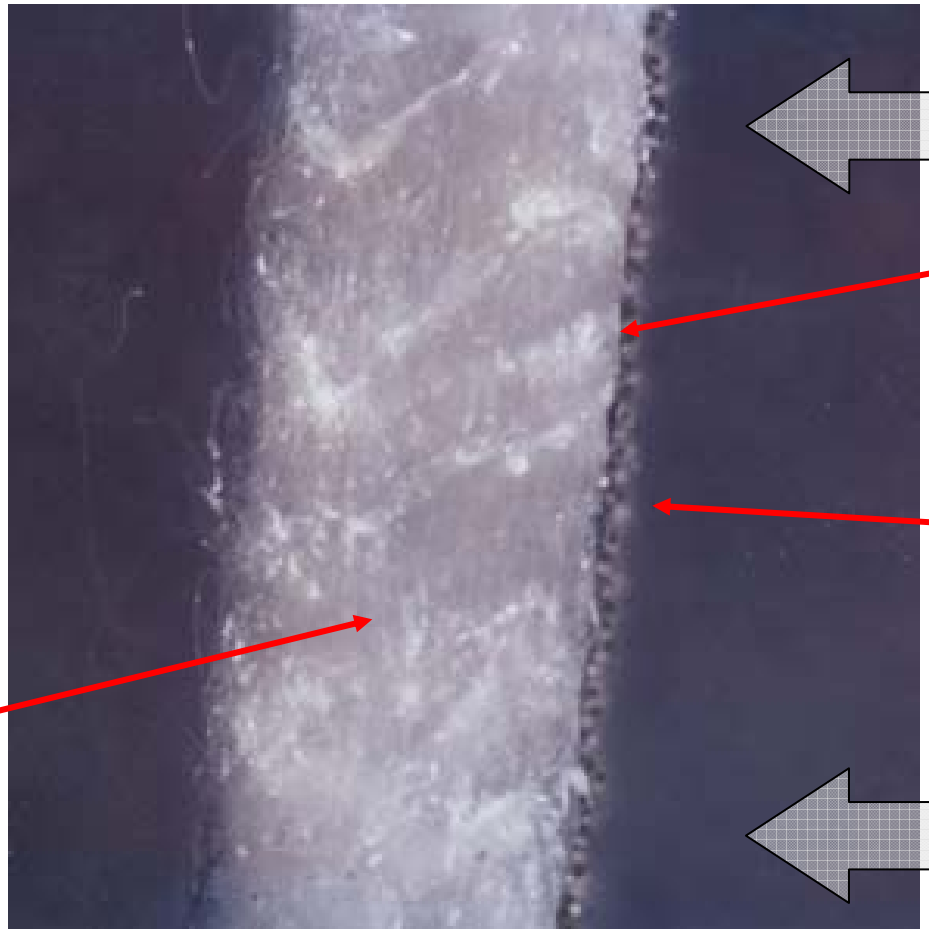


Dust gets trapped in the fabric

Cross section view – standard felt bag (used)

Depth vs. Surface Filtration

An ePTFE filter bag collects particulate on the surface of the membrane.



Cross section view – BHA-TEX laminated bag (used)

Reasons to Consider ePTFE Membrane

Scrubbing

- SCR
- SNCR
- Lime injection

Pressure drop management

- Load limited
- Helps avoid derates
- Decreased cleaning cycles
- Increased filter life

Fuel changes

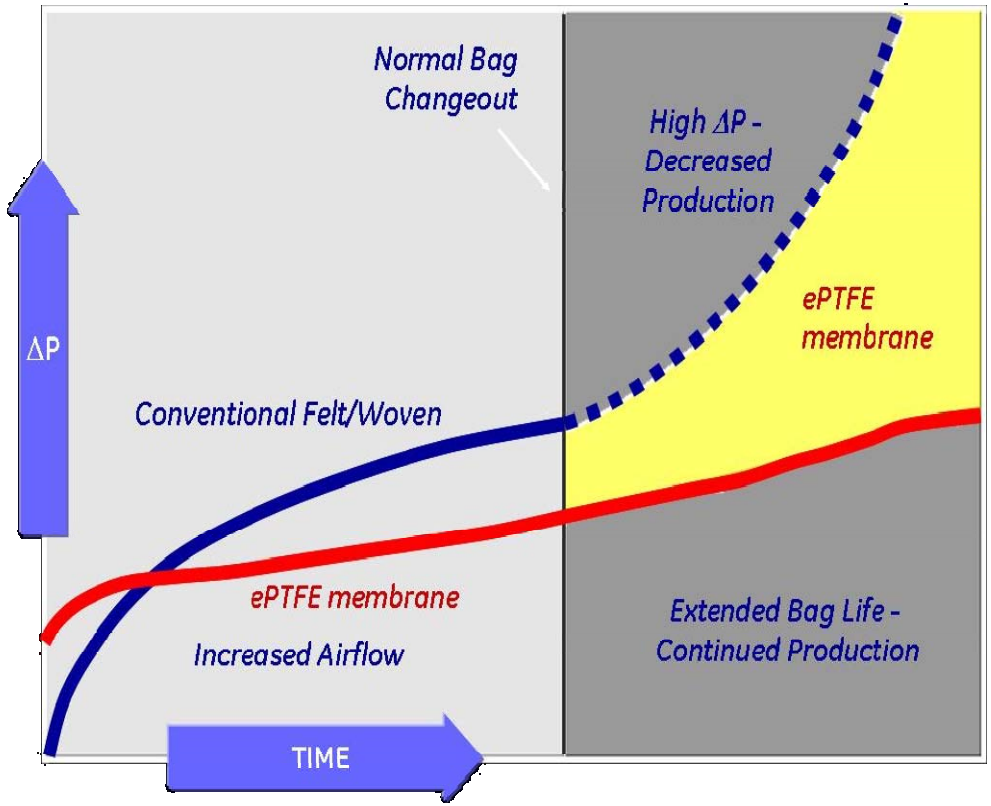
- Higher ash coal
- Coals producing finer ash

Emissions

- PM 2.5
- Start-up emissions
- Regulatory
- Good neighbor

ePTFE membrane advantages

- Impact on sorbent usage / scrubbing
- Pressure drop management
  - > Load limited plants
  - > Scrubber upsets
  - > Boiler tube leaks
  - > ABS
- PM 2.5
- Fuel changes affect ΔP



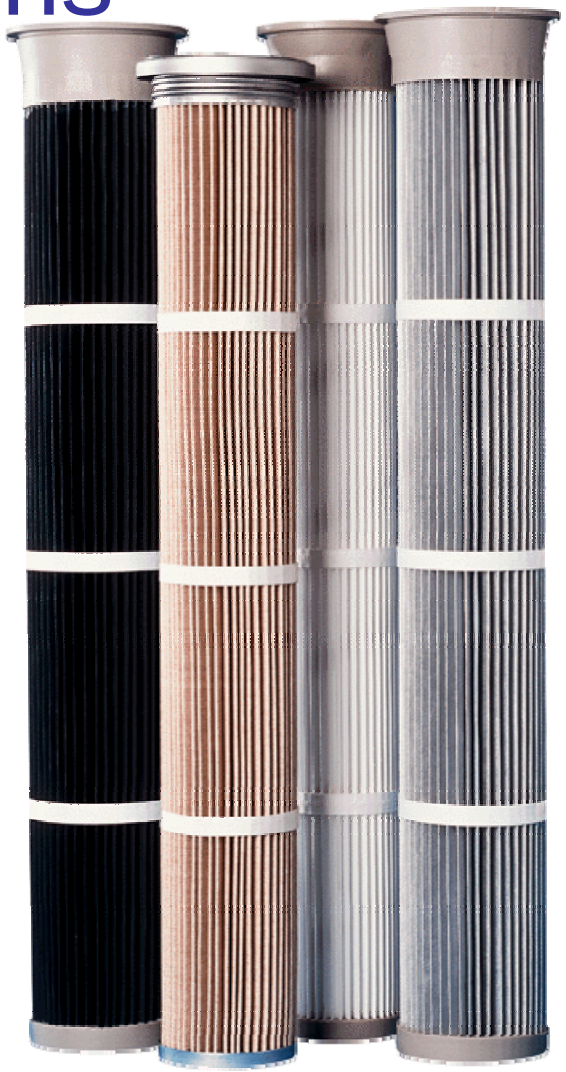
Possible Effects of Sorbent Injection

Reverse gas fiberglass filter bag 12” diameter x 35’ long	Filter Weight
SCR turned on	55-75 lbs.
SCR turned off	35-45 lbs.
Membrane filter bag (SCR on or off)	20 lbs.
New filter bag	16 lbs.

Due to filter bag failures directly related to excessive filter bag weights, a power producer installed membrane filter bags to combat the effects of agglomeration caused by moisture and the formation of ammonium bi-sulfite (ABS) in their boiler baghouse.

Pleated Elements in Power Industry Dust Collection Applications

- Traditional filters have been replaced in supplemental collectors necessary for Power Generation industry applications.
- Applications include:
  - Coal Crushers
  - Various Fuel Boilers
  - Ash and other Material Handling
  - Pneumatic Conveying
- New element construction for higher temperatures.



Common problems:

Abrasion Failure:

Bottom of filter bags located directly in line with inlet gas stream.

Excessive movement of filter causing bag to bag abrasion.

High Differential Pressure / Loss of Airflow:

High air to cloth ratios

Fine particulate

Poor cleaning mechanism efficiency

Aggressive Cleaning Cycles:

Accelerated filter bag fatigue and flex failure.

Difficult Installation and Removal:

Extra downtime to handle multiple and bulky components. Multiple piece cages.

Filter bags can become “stuck” to cages and have to be cut off.

Abrasion Failure:

Bottom of filter bags located directly in line with inlet gas stream

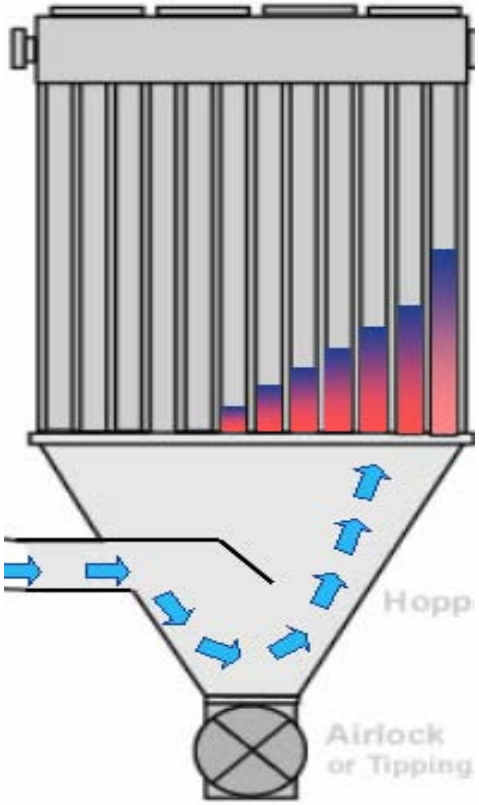
Excessive movement of filters causing bag to bag abrasion

PulsePleats Eliminate Bottom Bag Abrasion

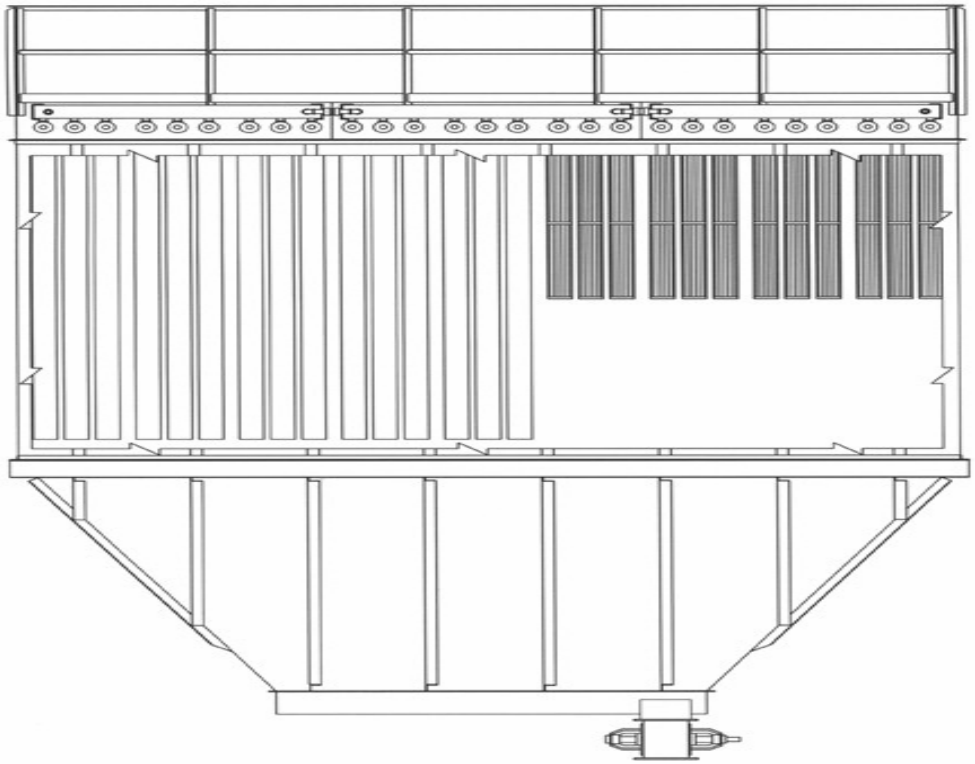
Provide a large drop–out zone beneath the filters

Heavier particulate drops out

Before

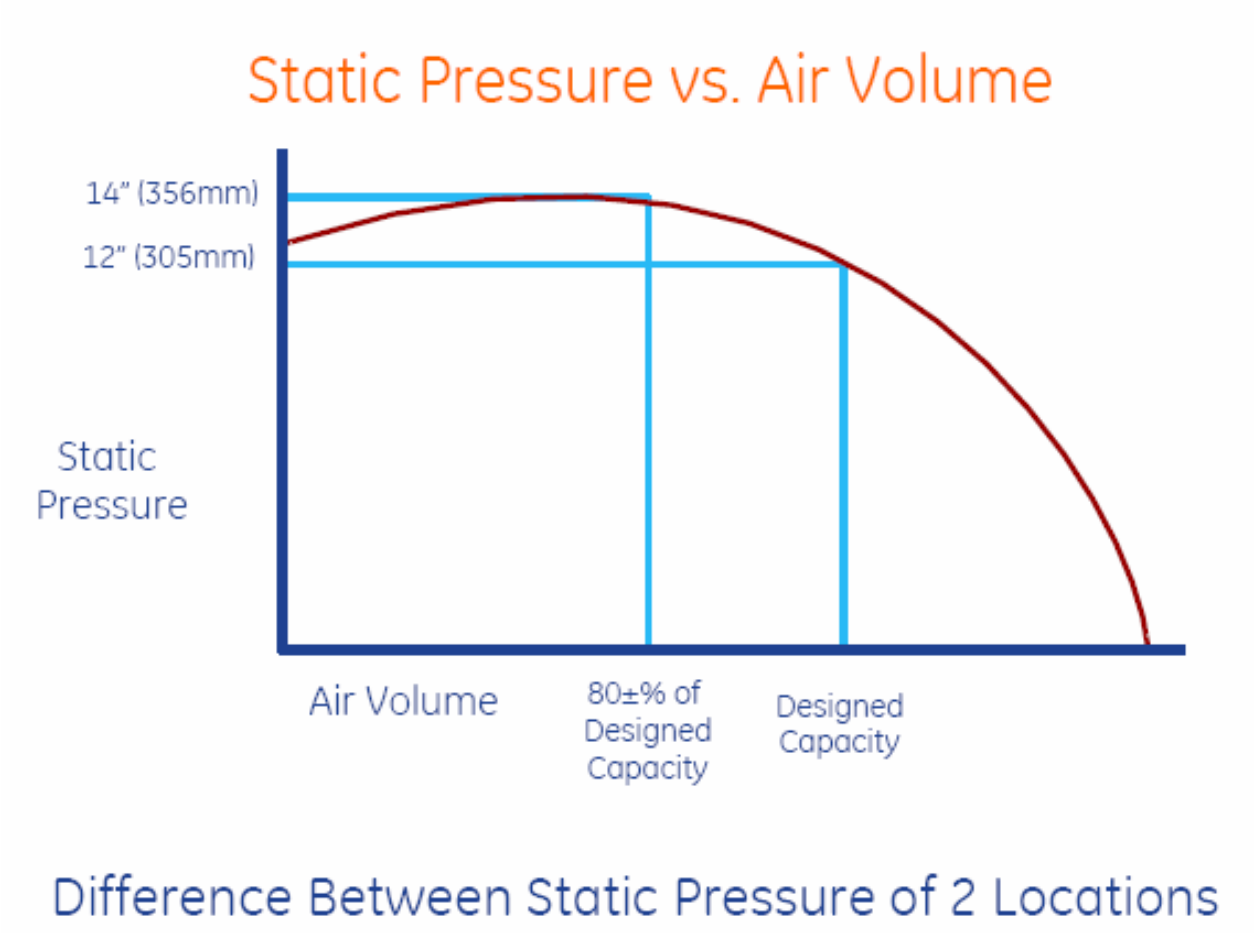


PulsePleat Filter

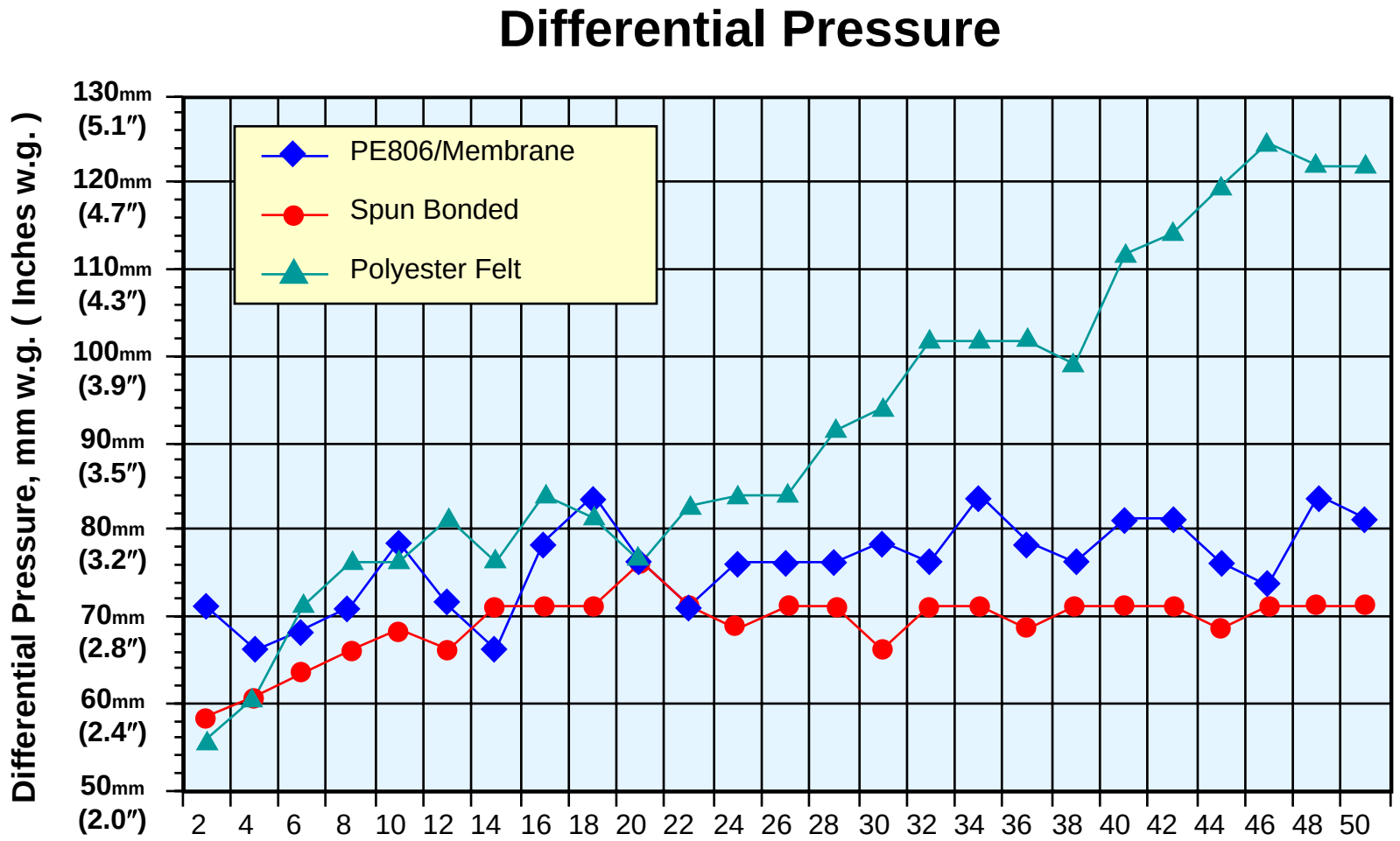


High Differential Pressure / Loss of Airflow:

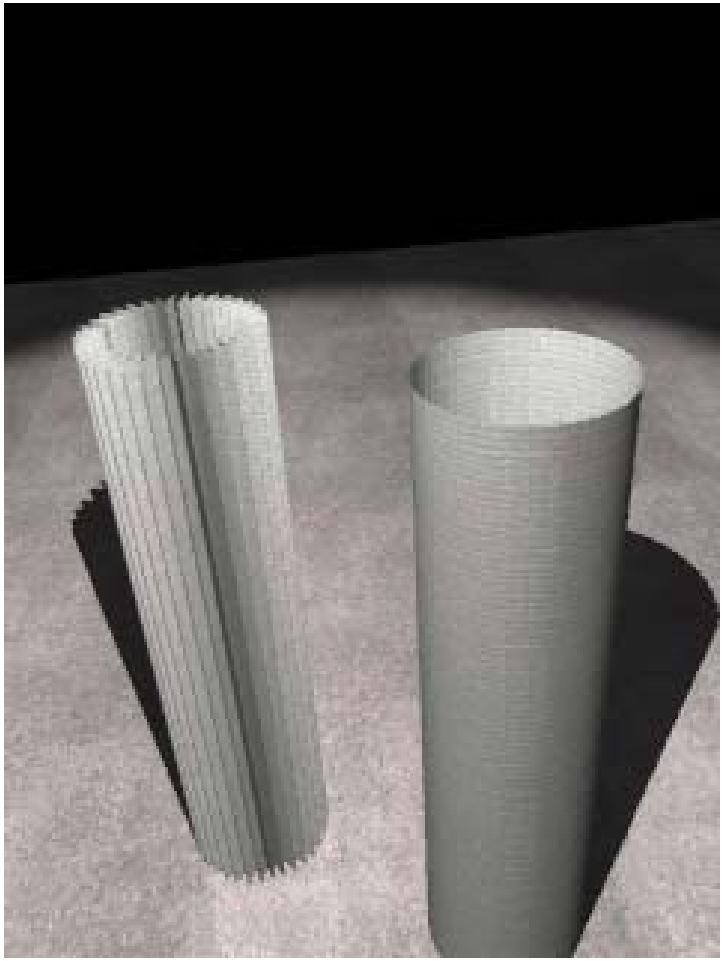
High air to cloth ratio
Fine particulate
Poor cleaning mechanism efficiency



Lower differential pressure



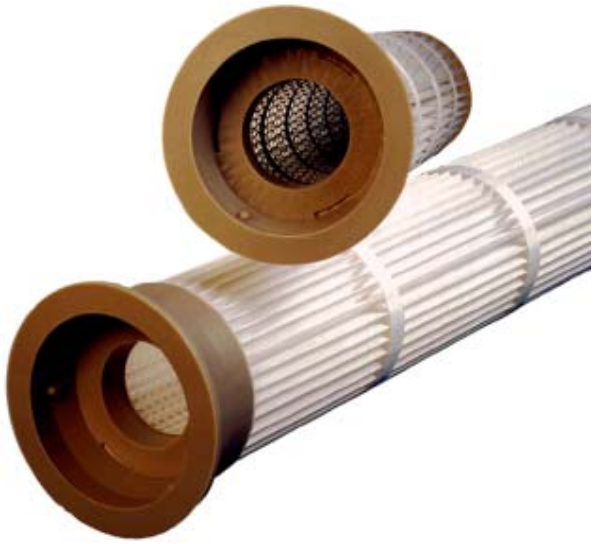
PulsePleat Filters Reduce Differential Pressure



Increase surface filtration area…
by as much as 2–3 times

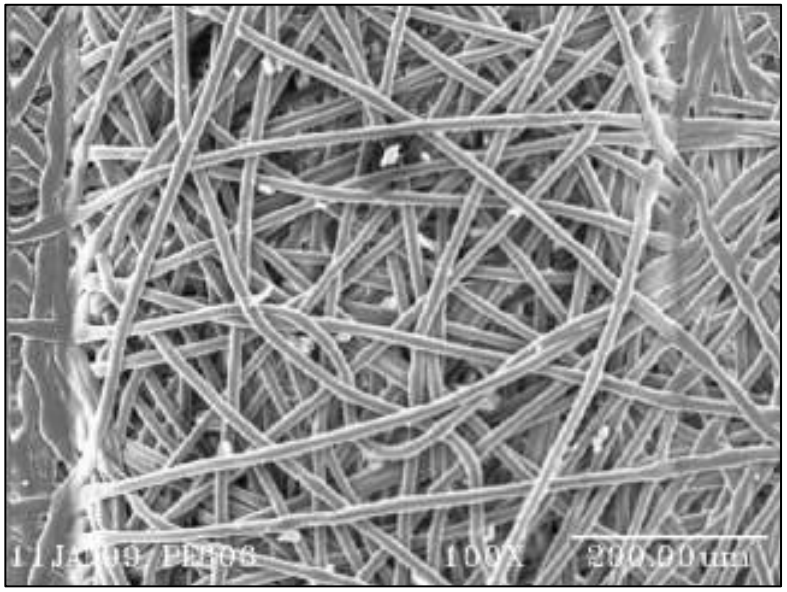
Lower differential pressure...
increased airflow

Lower emissions...
double filtra



Spunbond vs. Traditional Felts

Spunbond
Polyester

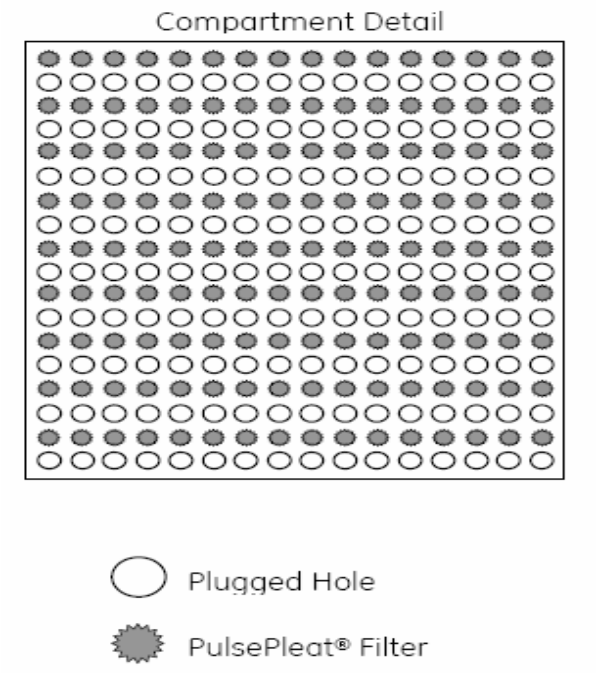


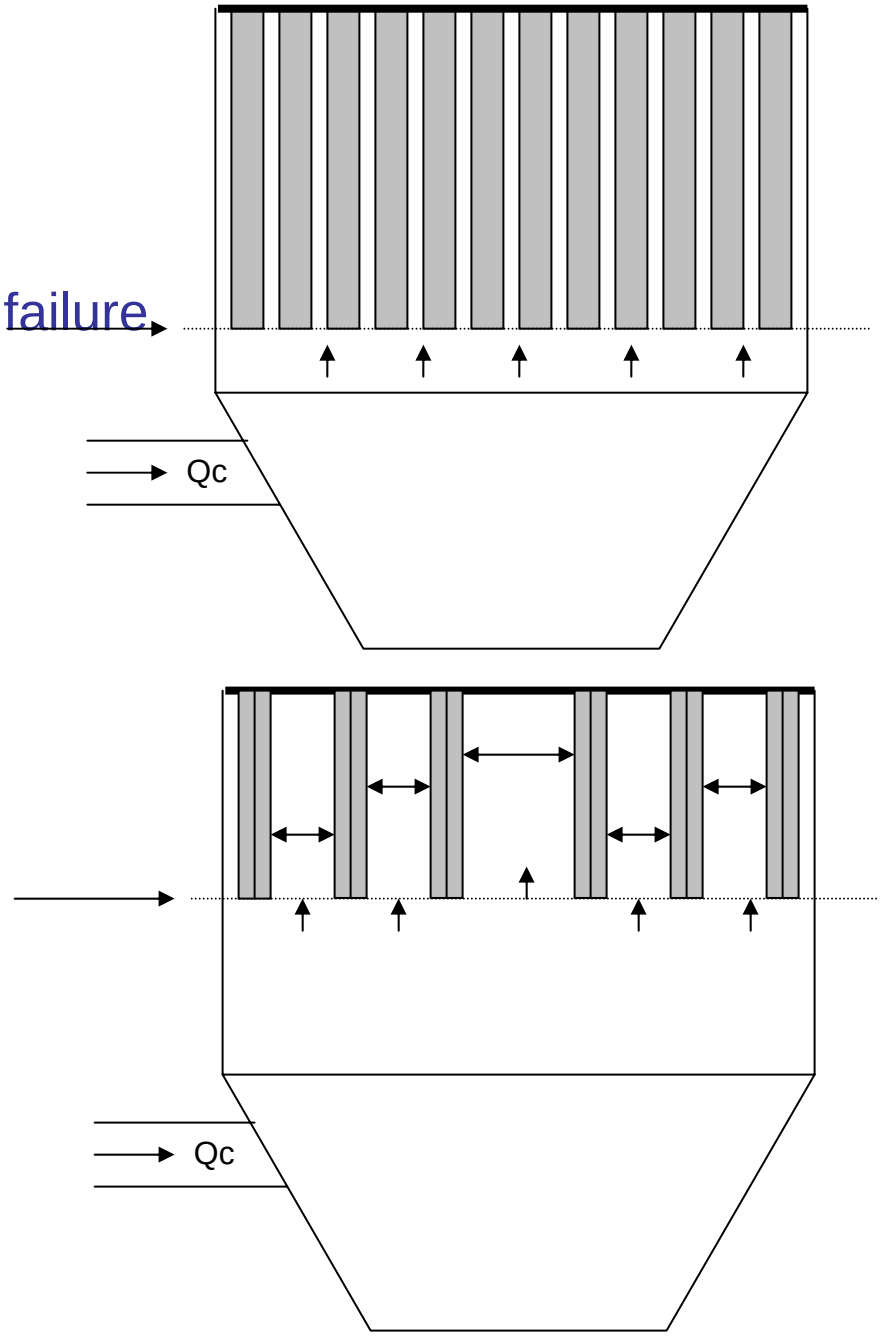
Polyester
Felt

Face view - magnified 100x

Aggressive Cleaning Cycles:

Poor cleaning mechanism efficiency
Inadequate pulse pressure
High can velocity
Accelerated filter bag fatigue and flex failure

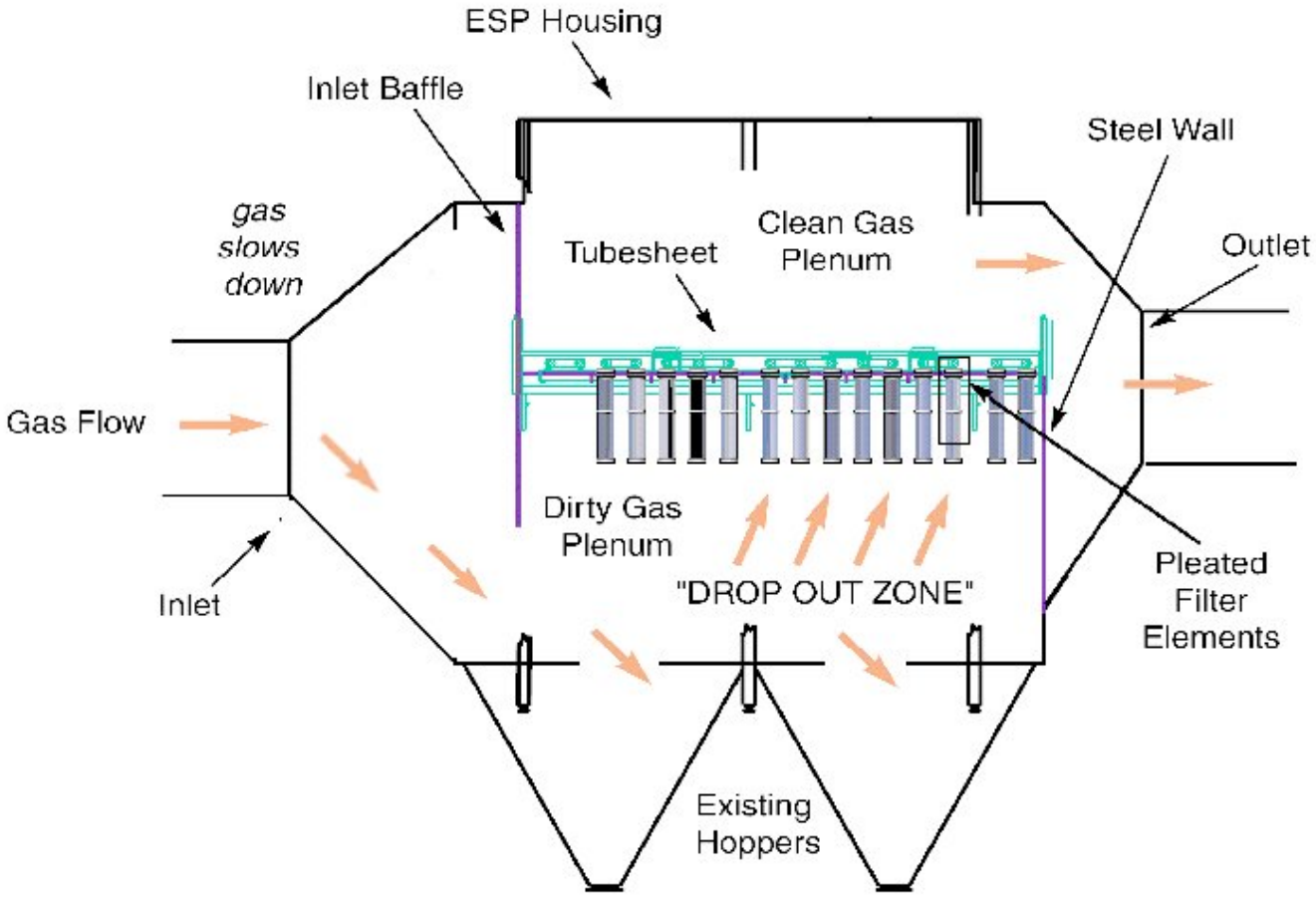




PulsePleats Reduce Cleaning Frequency:

Require 75 psi or less pulse pressure
Reduced can velocity
Staggered arrangement reduces can velocity

ESP Conversion w/Pleated Filter Technology



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

Glossary of Terms

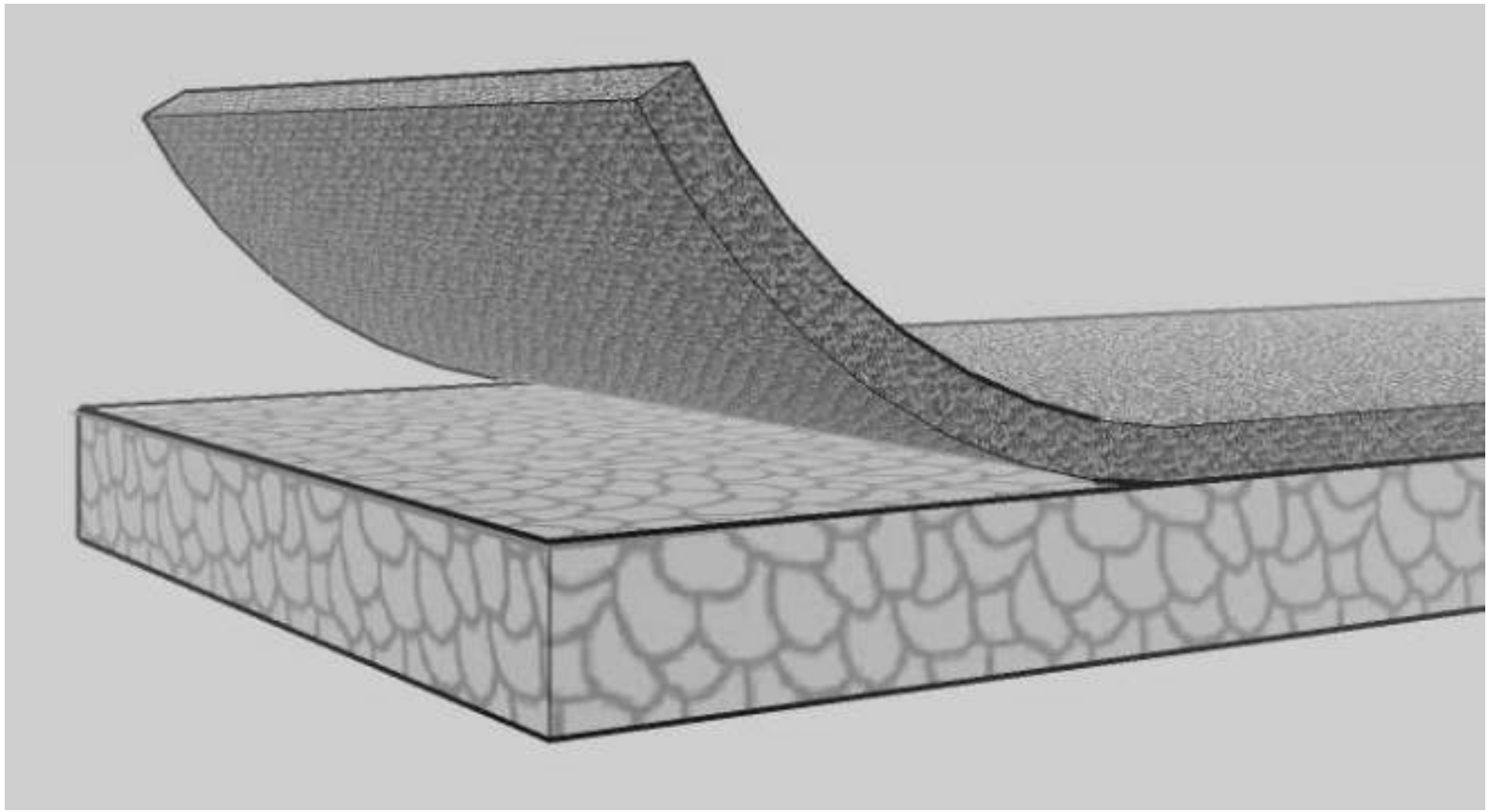
Denier - A system of measuring the weight of a continuous fiber. The lower the number, the finer the fiber. The higher the number, the heavier the fiber.

Microdenier - Fibers made from Microfiber technology produce fibers which weigh less than 1.0 Denier. This offers a higher weight specific surface area or more collection surface.

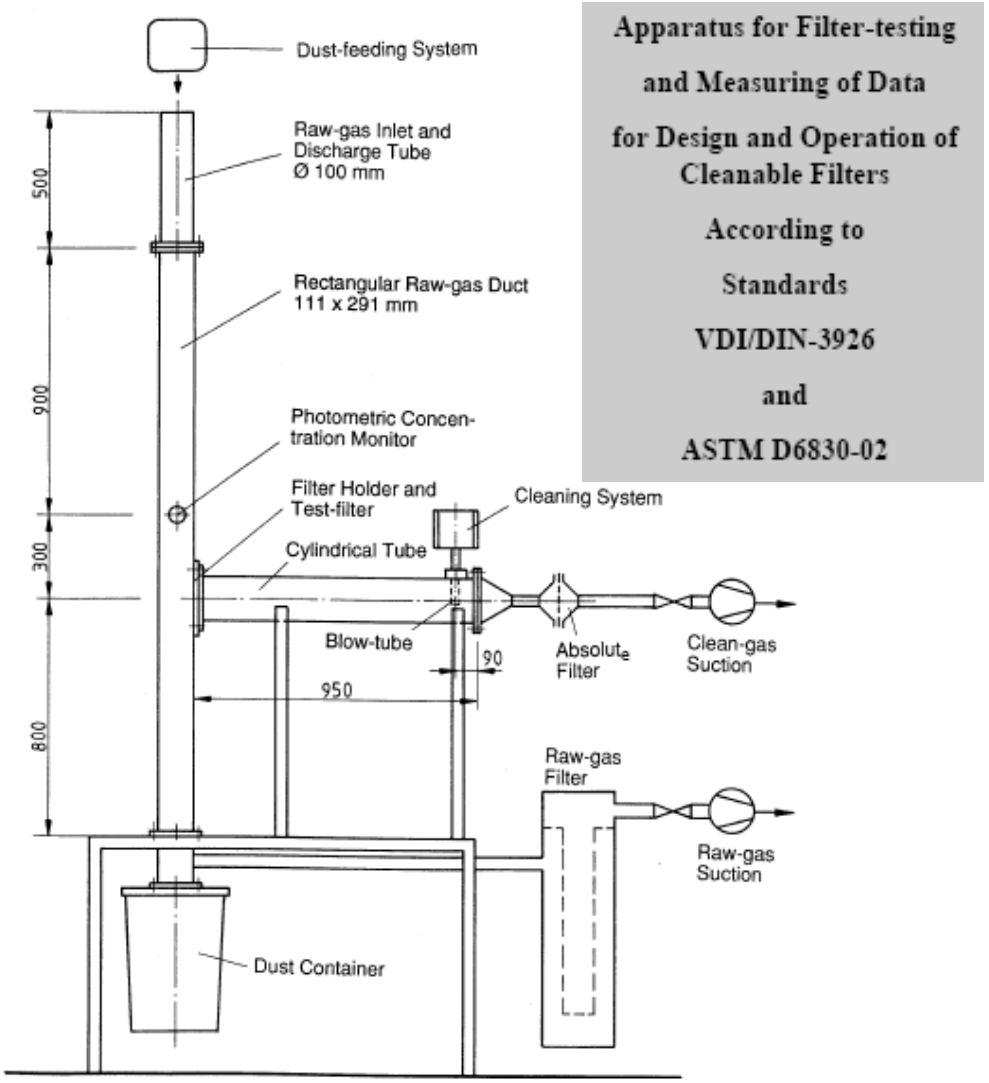
Microdenier Cap - Process of using a Microdenier fiber in a cap form at the filtration surface on a coarser denier base.

Duo Density - Media utilizing a homogenized blend of 2 fibers at the filter face to affect efficiency, while the cap design uses a distinct cap of one fiber size on the filtration surface so the filter side of the media is actually layered.

Duo-density and fabric capping-not new technology, but underutilized in US utility market.



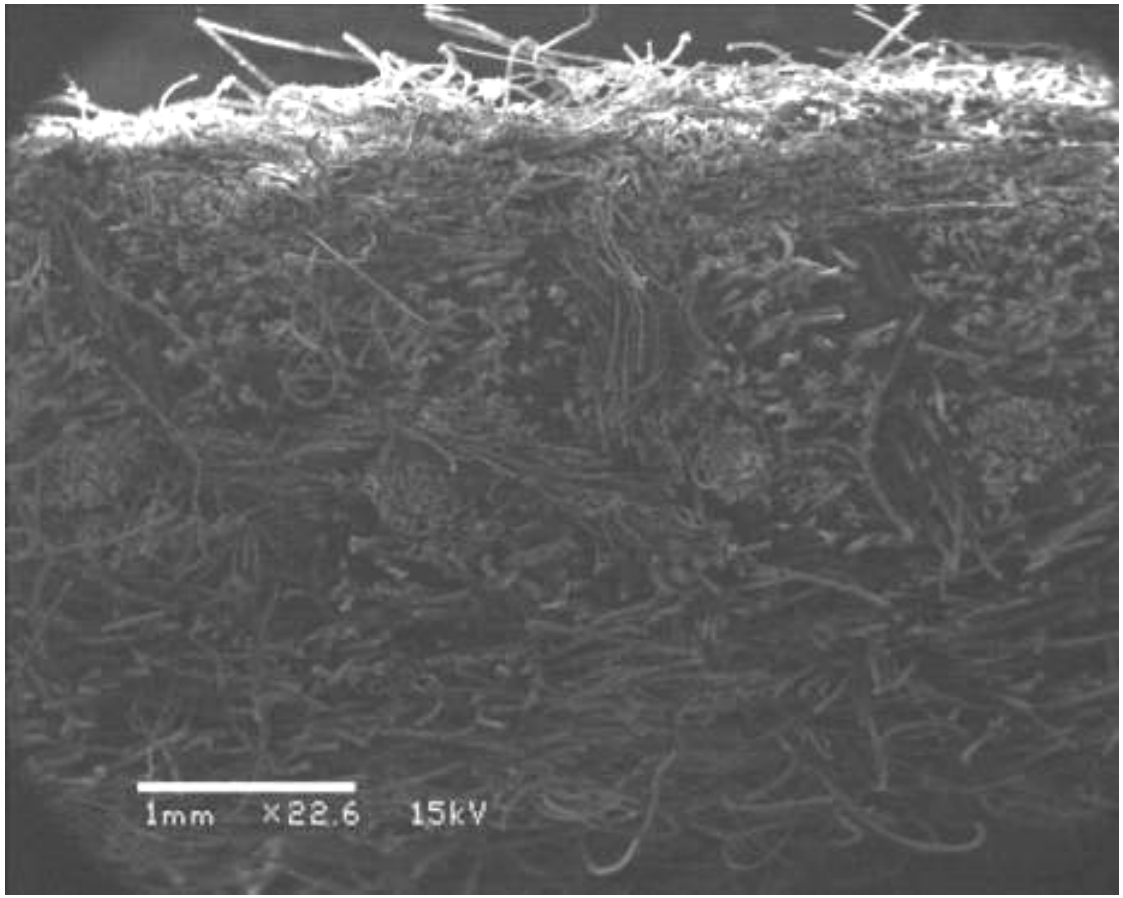
VDI Test Apparatus



Apparatus for Filter-testing and Measuring of Data for Design and Operation of Cleanable Filters According to Standards VDI/DIN-3926 and ASTM D6830-02

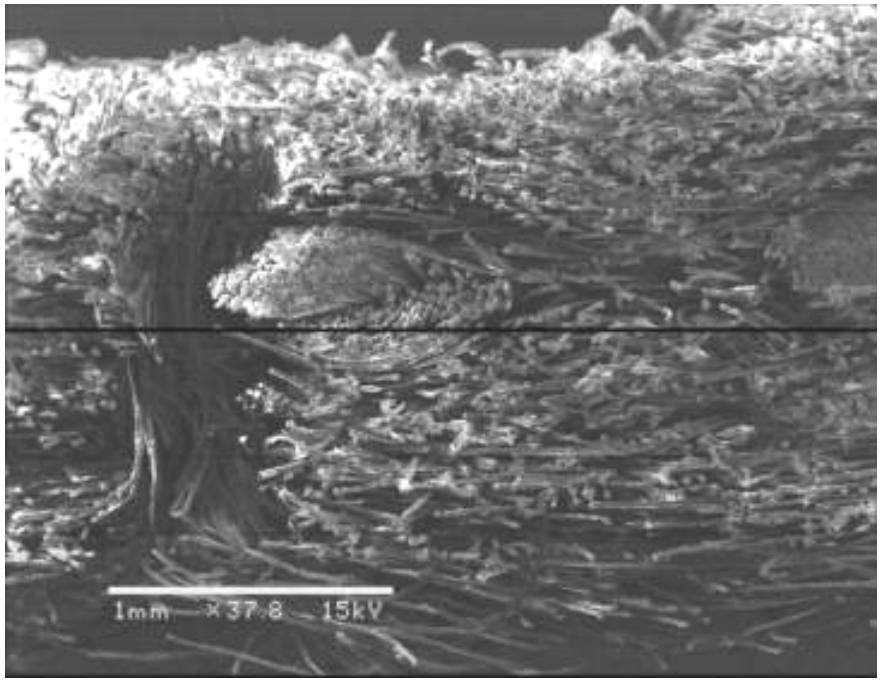
GE uses VDI Testing – the Industry Standard

Progen PPS filter cross section view



Dust particles collect on the surface

Regular PPS cross section view



Dust has more penetration

VDI Test Results on Progen* Filters

Parameters	Conventional PPS filter bags	Progen filter bags
Outlet Particulate Concentration (g/dscm)	.000738	.000734
Average residual pressure drop (in. wg)	1.19	.65
Initial residual pressure drop (in. wg)	1.14	.64
Residual pressure drop increase (in. wg)	.05	.01
Filtration cycle time (s.)	122	251
Mass gain of test sample filters (g.)	1.57	1.89
Number of cleaning cycles	61	29

Test standard conditions: 14.7 psi and 68ºF. Tests consists of 3 sequential phases in which dust and gas flow rates are constantly maintained to test specs.

Q & A

Thank you for your time