REINHOLD ENVIRONMENTAL Ltd.

2013 APC Round Table & Expo Presentation

July 8-9, 2013, in St. Louis, MO / Hosted by Ameren

FABRIC FILTER O&M

APC Round Table

8th & 9th of July 2013, St. Louis, Mo, USA

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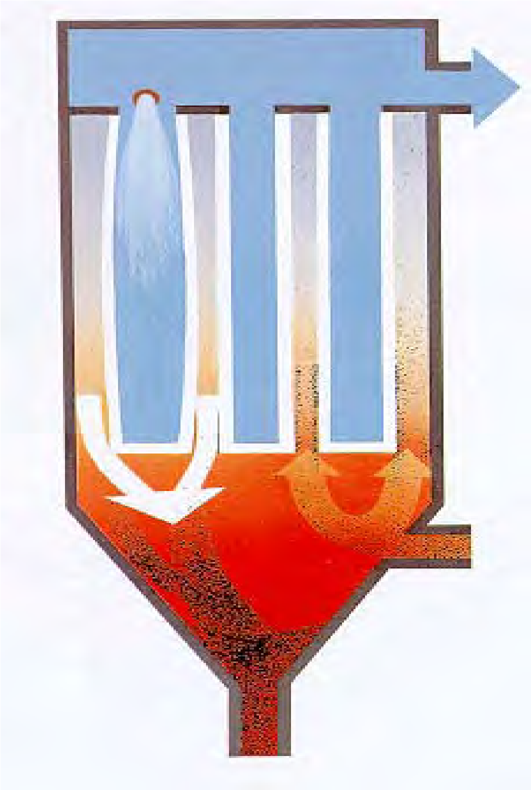
Content

- Bag filter plant description - PJFF
- ESP versus FFP
- Filter material constructions
- Filtration mechanism
- Coal fired boiler bag house filter materials
- Filtration with round and multilobal fibres
- Dust cake implications
- O&M risk analysis of FFPs
- Optimisation of FFPs
- FFP condition monitoring
- Mercury control
- References

Pulse Jet Fabric Filter Plants

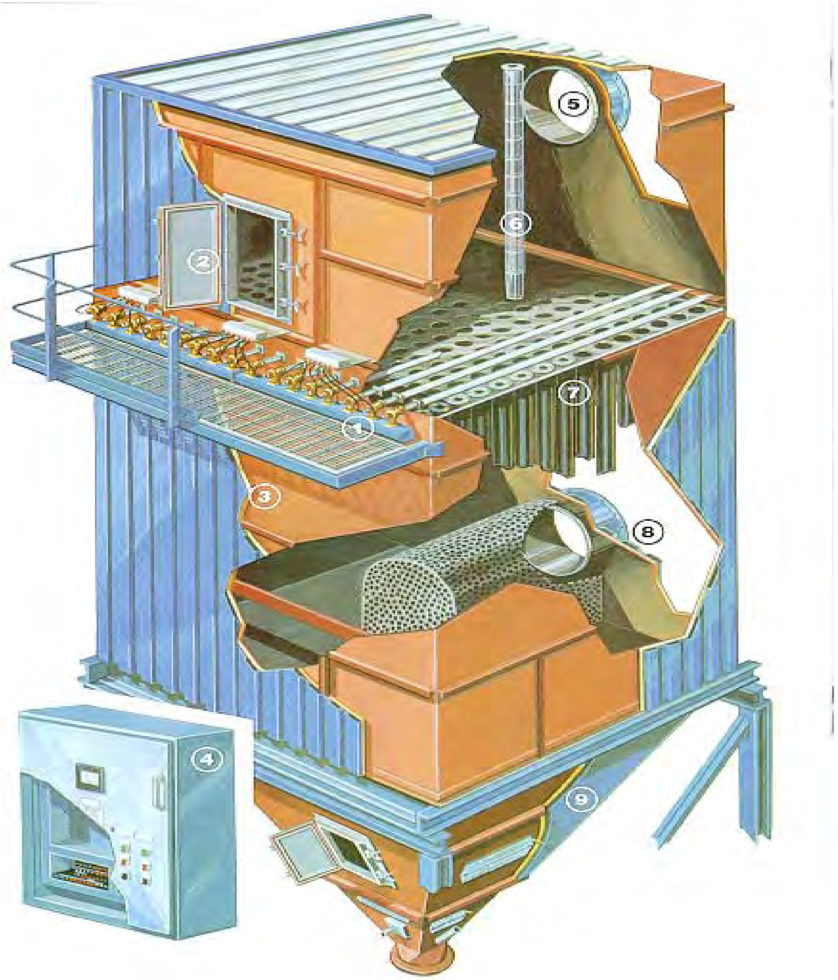
Pulse Jet Fabric Filter Plant

- Large vacuum machine
- Small footprint
- Low particulate emissions
- Low operating cost
- Low pressure drop
- Anti-collapse cages
- The pulse jet inflate the bag - deceleration
- In-line or off-line cleaning



Typical Pulse Jet Fabric Filter Plant

- Medium pressure pulsing
  1 - 3 bar
- High pressure pulsing
  > 3 bar
- Components

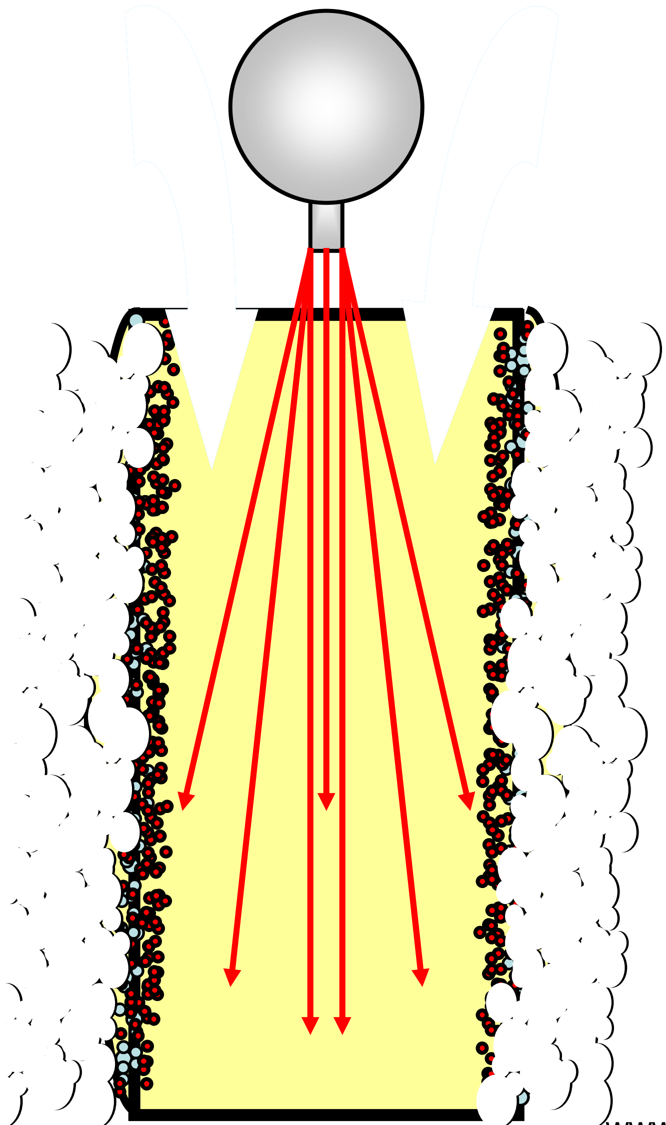


Bag Filter Cleaning

- **Pulse effect - secondary flow**
  - **reverse the gas flow**
  - **inflate the bag**
  - **create sufficient bag material deceleration**
  - **Deceleration force > cohesion forces between the permanent and non-permanent dust cakes**
- **Over-cleaning**

PJFF Cleaning Mechanism

1. Primary pulse
2. Secondary flow
3. Bag inflation
4. Bag back-slapping
5. Bag deceleration
6. Dust cake removal

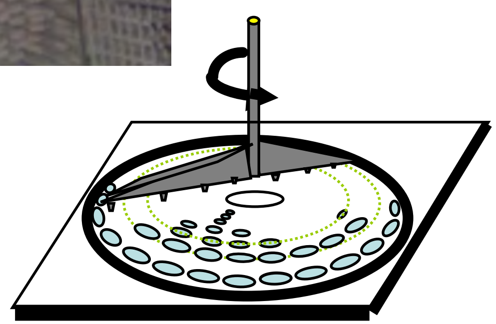


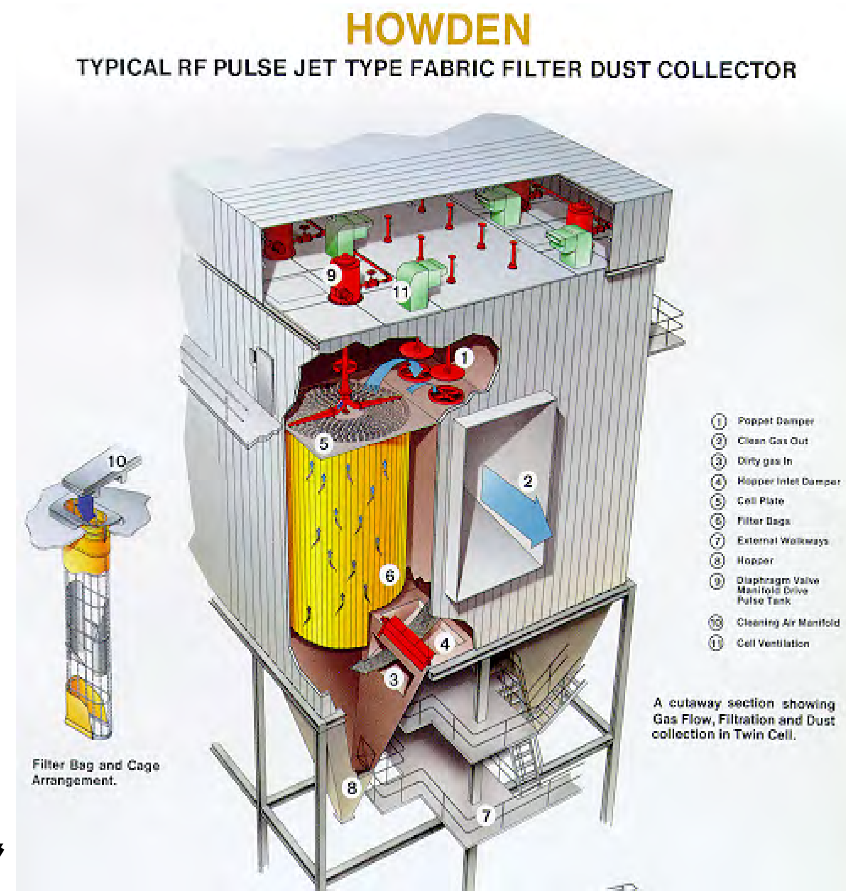
Typical Pulse Jet Fabric Filter plant Low pressure pulsing

- **Low pressure pulsing**

  max. 1 bar

- **Components**
- **Cleaning**





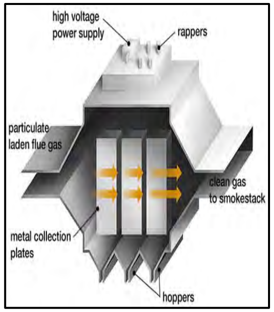
ESP versus FFP

Selection of the particulate emission control technology

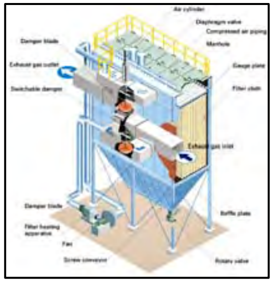
- An ESP is a <u>constant efficiency</u> device that cannot tolerate upsets in the process conditions without affecting negatively the particulate emissions:
  - increase in the gas flow
  - increase in the inlet fly ash burden
  - increase in temperature
  - fuel changes
  - dust resistivity
  - decrease in particle size distribution

Efficiency (%) = $100(1 - e^{-(AW/Q)})$

- e = 2.718282
- A = Collecting area
- W = Particle migration velocity
- Q = Gas volume

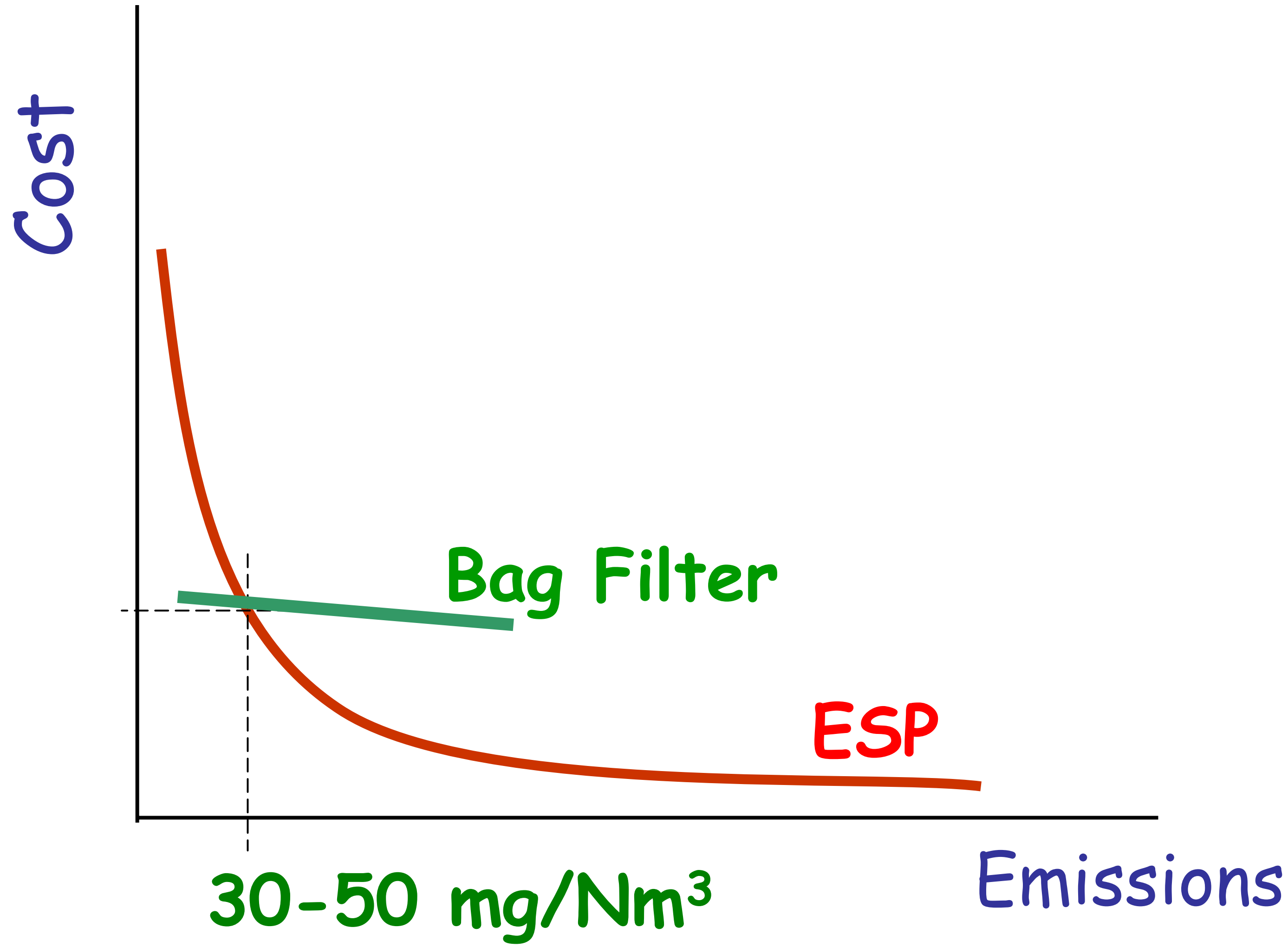


- A fabric filter is a <u>constant emission</u> device that can tolerate reasonable changes in the process conditions without affecting the dust emissions:
  - an increase in gas flow
  - an increase in gas temperature within the limits of the polymeric filter material
  - increase in the particulate dust inlet burden
  - fuel specification variations



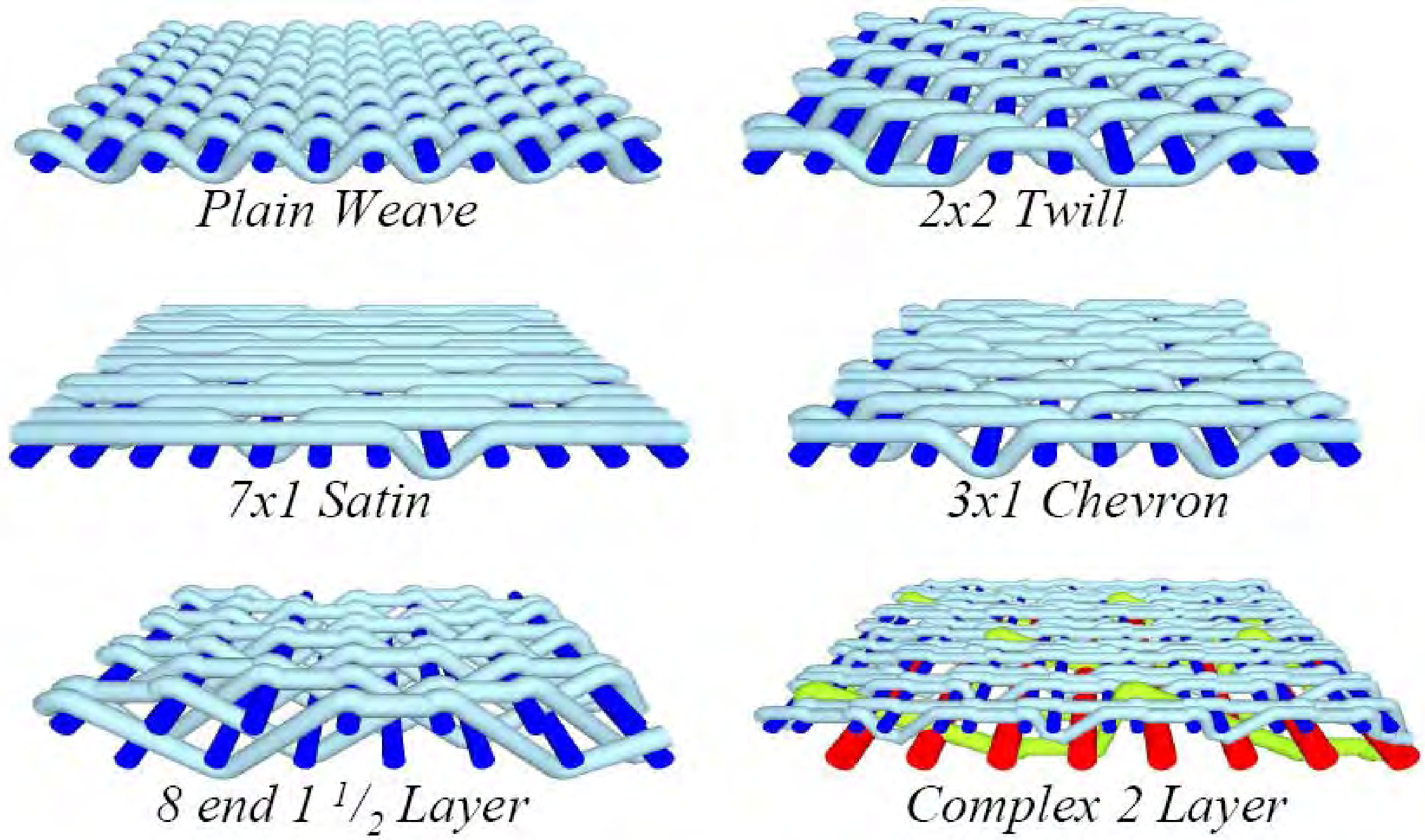
- Mercury abatement efficiency – significantly higher with FFPs

Bag Filter vs. ESP cost / emission characteristic



Filtration Material Constructions

Woven filter materials

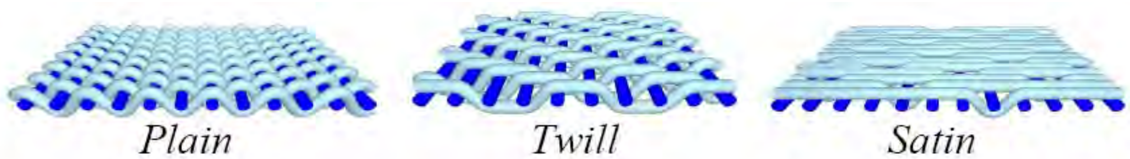


Woven filter media

Parameters which determine the woven materials quality

- Type of weave
- Type of fibres
- Thread design
- Thread count (warp/weft)
- Diameter of thread

- Low filtration efficiency
- High cloth area in relation to volume flow
- Reverse air cleaning plants
- Special coatings
- Mainly fiberglass materials
- Low mechanical resistance
- Use of PTFE membranes



Effect of Weave on Filtration Performance

Weave	Particle Retention	Dust Release	Resistance to Blinding	Mechanical Resistance	Throughput Capacity
Plain	1+	1-	3	3	3
Twill	2+	2+	2+	1	2+
Satin	3	1	1	2	1

1. BEST 2. MEDIUM 3. POOR

Threads (Yarns)

Thread constructions

- **Continuous threads**
  - **Multi-filaments**
    - **Multifilament yarns**
    - **Multifilament twisted yarns**
  - **Mono-filaments**
- **Spun yarns**
  - **Staple yarns**
  - **Double twist staple yarns**

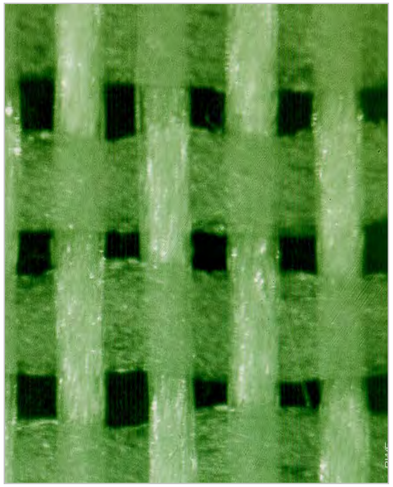
Woollen Spun

Cotton Spun

Multifilament

Monofilament

Needlefelts: Scrim + Fibers



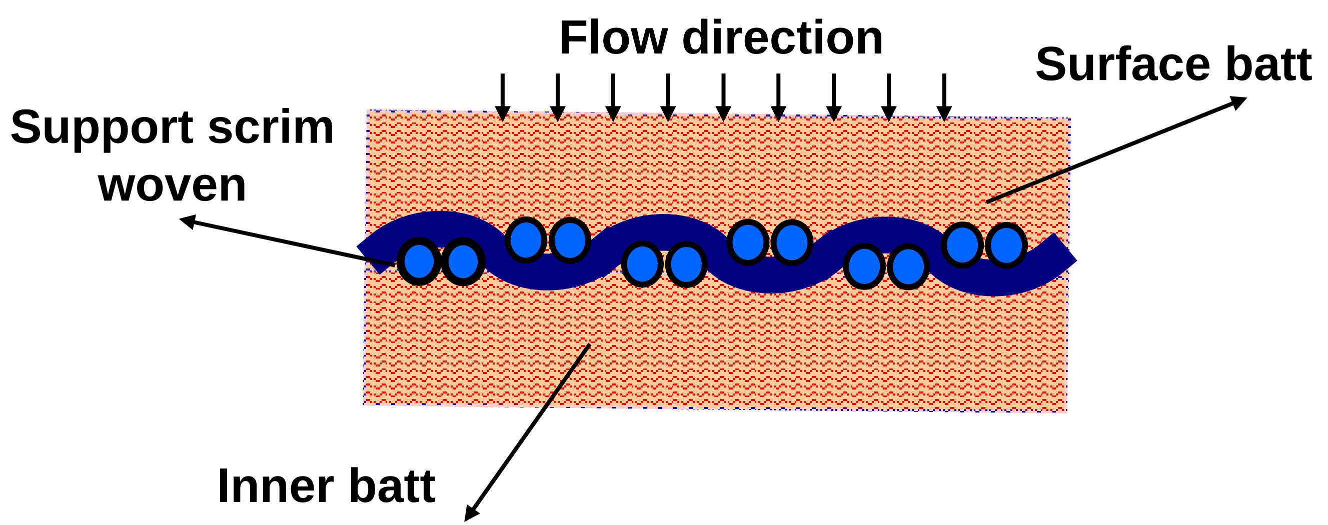
Scrims and fibres are the main components to produce a needlefelt filter media.

The Scrim:

- **is the backbone of the filter media**
- **provides high dimensional stability**
- **plays an important role in the reduction of emissions**
- **scrims are made from either staple fibre or multifilament yarns**

Needlefelt Filtration Materials

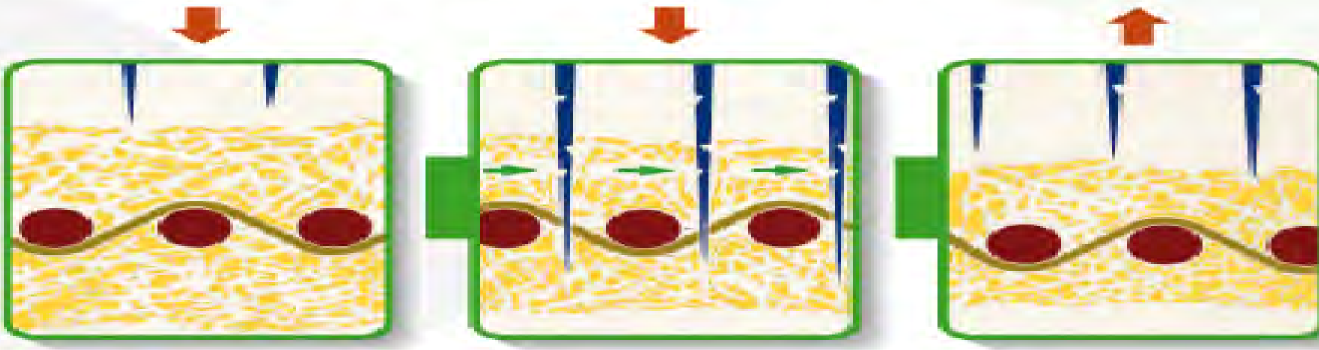
- High filtration efficiency
- Relative low cloth area in relation to volume flow
- Pulse jet cleaning plant, mainly
- Special coatings / finishes
- All types of filtration fibers
- Mechanical / abrasion resistance



FABRIC CONSTRUCTION - NEEDLE FELT

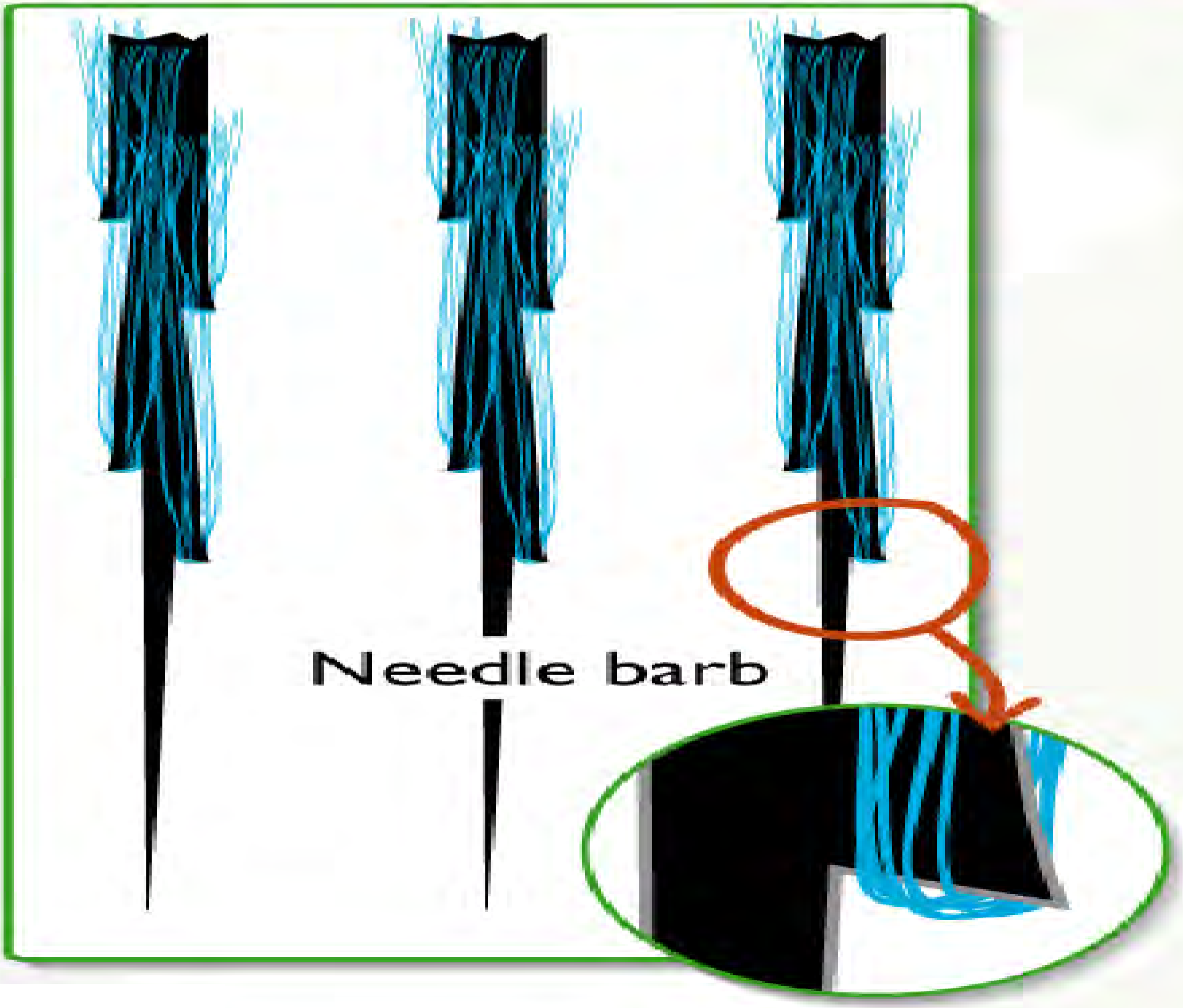
- Consist of a web of fibres
- Scrim between webs

- Called "NEEDLE FELT" because needles are used to entangle the fibres



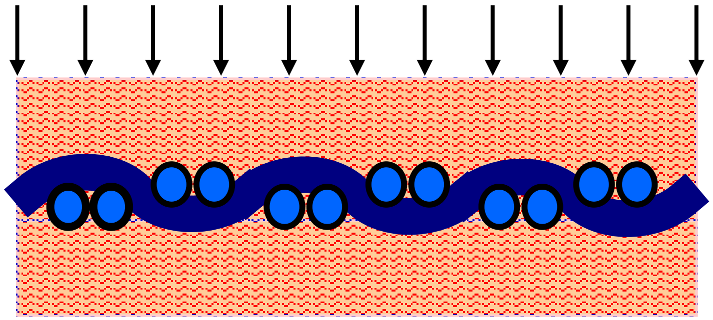
Courtesy of Beier-Albany

NEEDLE-FIBRE INTERACTION

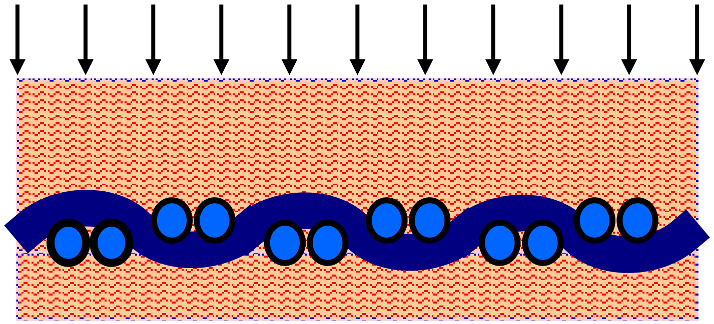


Courtesy of Beier-Albany

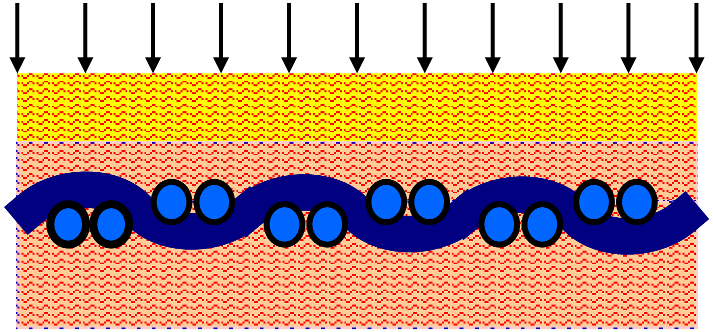
Type of Needlefelt Constructions



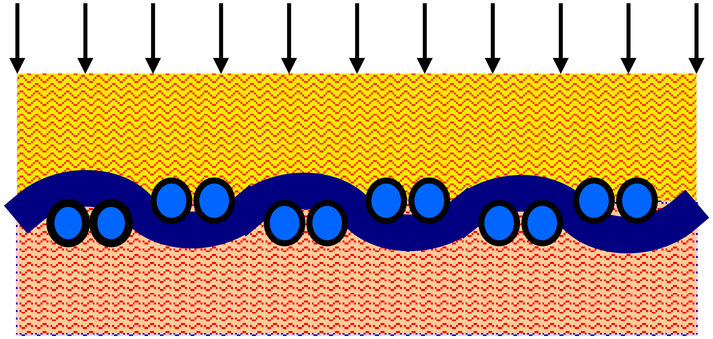
Symmetric construction



Asymmetric construction

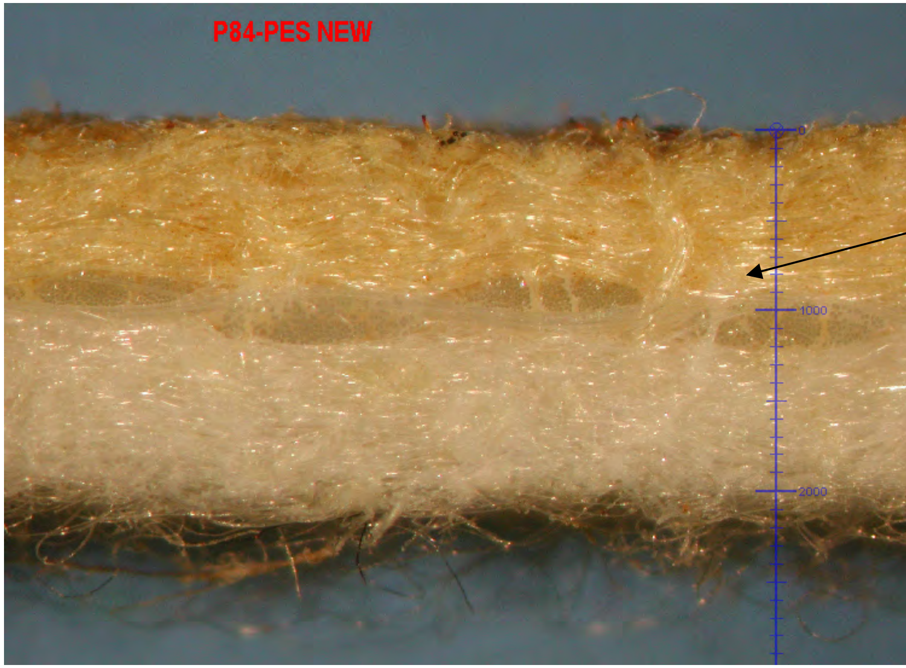


Cascade construction



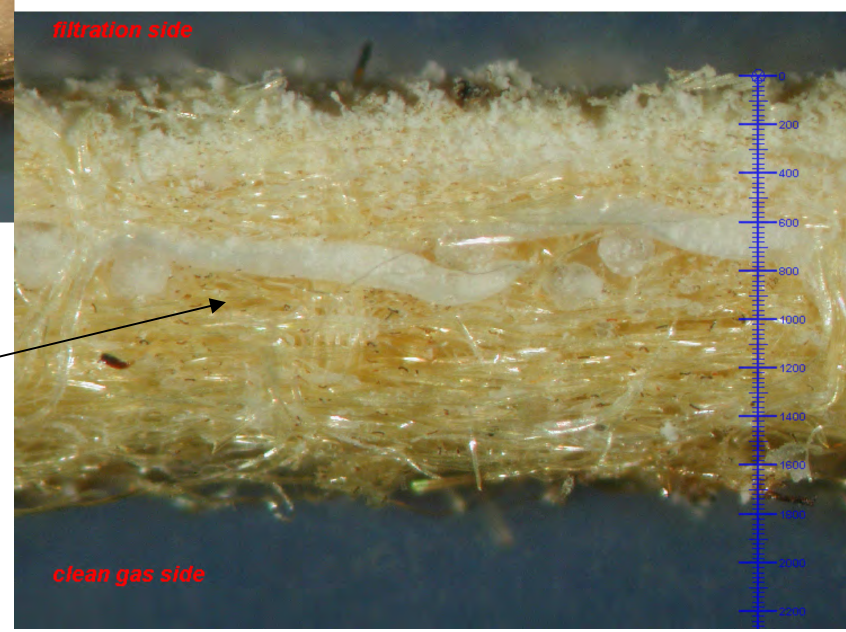
Fibre blends in one or more layers

Examples of Filter Materials based on Fibre Blends



Asymmetric design

50/50 blend of P84 and Procon on the filtration side
Procon scrim
100% Procon on clean gas side



Symmetric design

70/30 blend of PTFE and P84
PTFE scrim
70/30 blend of PTFE and P84

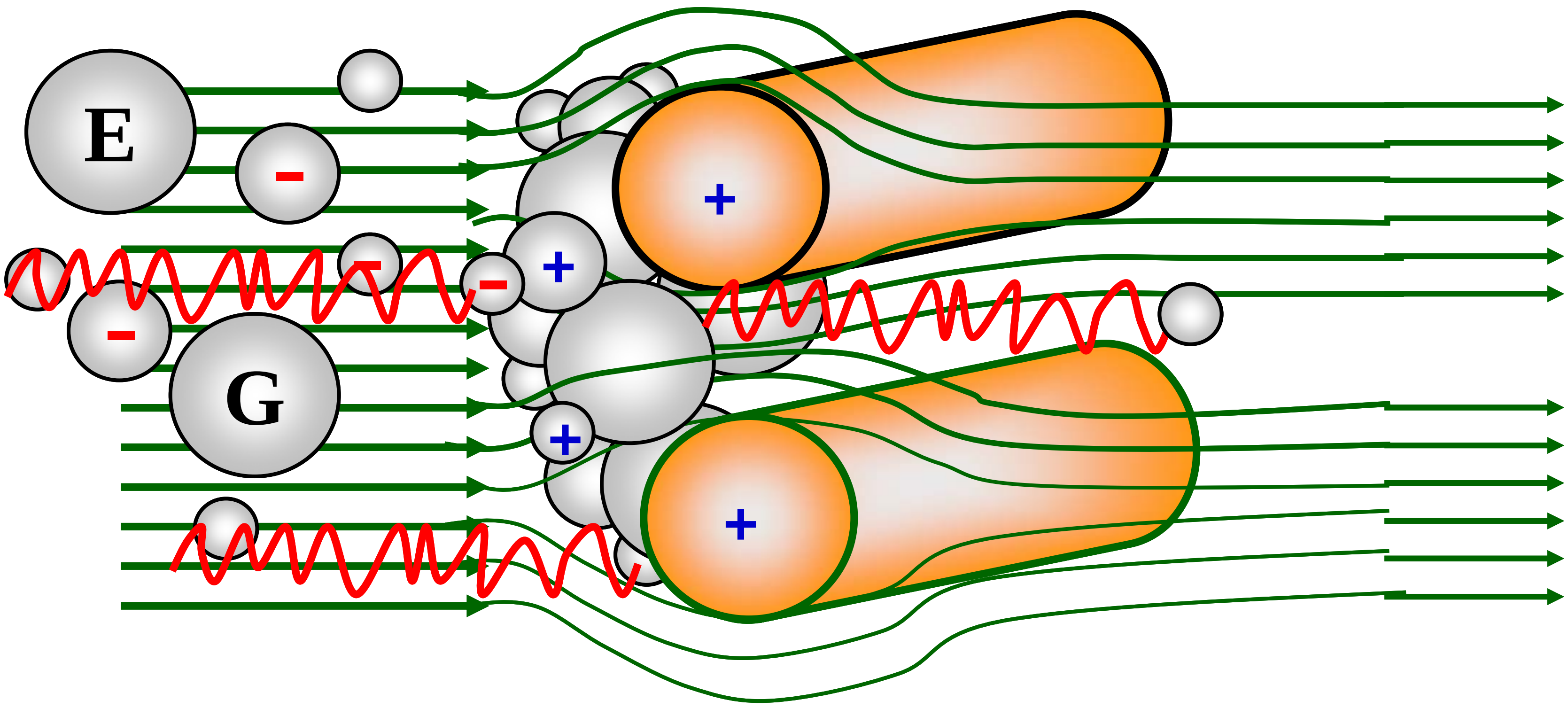
WHY needle-felts?

- Efficient dust capture is still assured when abrasion has damaged the surface of a needle felt
- Woven membrane bags lose the effective surface layer as a result of abrasion resulting in increased emissions
- Needle-felt bags can be kept on stock for years without damage
- Easy handling without risk for damage during installation
- No limitation for the cleaning / pulsing pressure
- No extra cage wires required for additional support, as with glass bags
- Modern needle felts can achieve consistently emissions lower than 1 mg/Nm^3

Filtration Mechanism

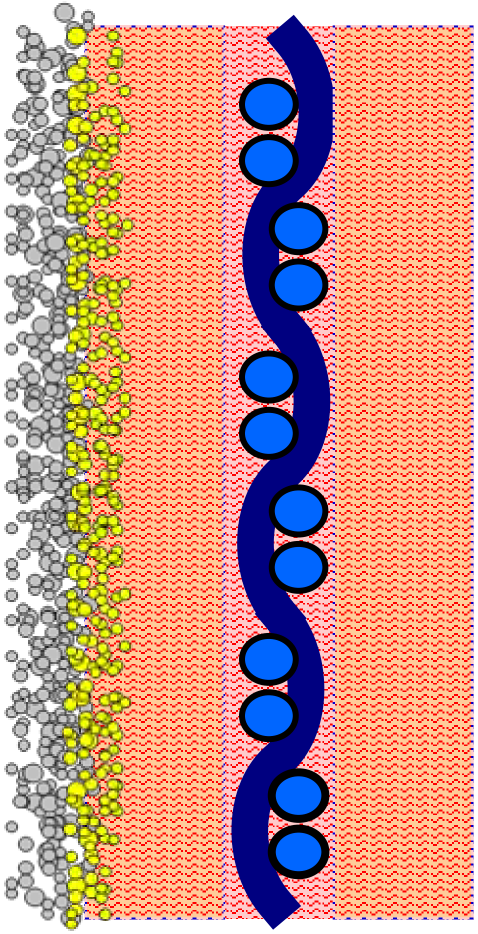
Filtration Mechanism

Sieving, impaction, agglomeration, electrostatic, cake filtration



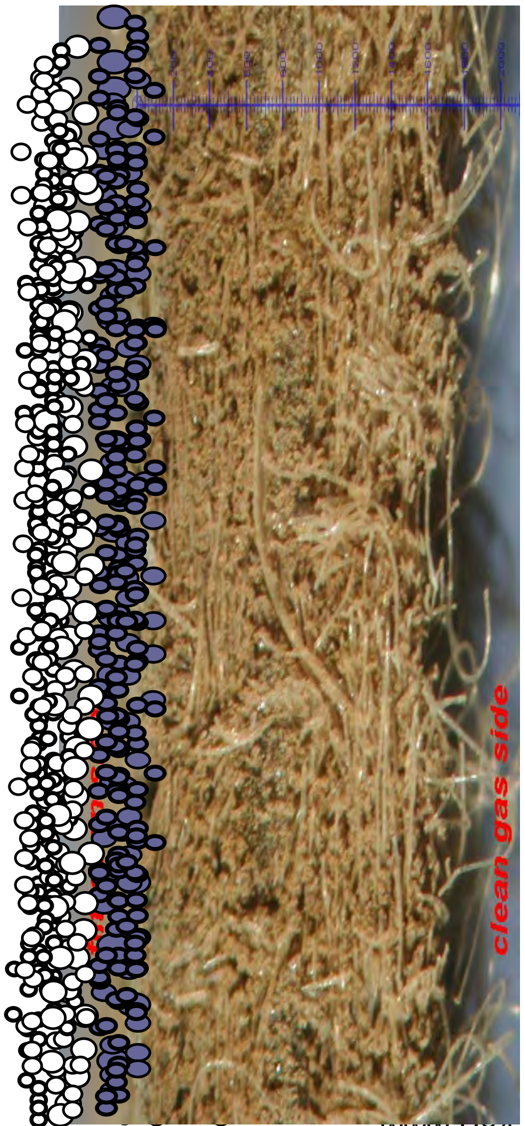
Dust Cake Filtration

- Permanent dust cake
- Pre-coating materials on start-up
- Removable dust cake
- Stability of dust cake – no dust migration
- Porosity of dust cakes – good flow
- Protection of filter material
  - Abrasion
  - Chemical attack
- Secondary reaction in case of dry FGD



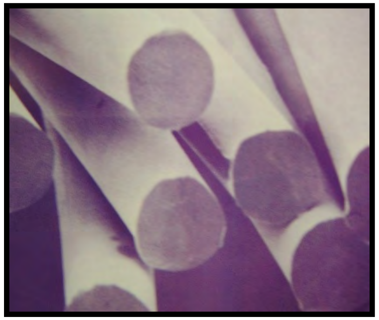
Blinding of filter media

- Blinding, short or long process
- High ΔPs
- Intensive pulsing
- Pulse emissions
- Material fatigue – loss of strength
- Load losses
- Replacement of filter bags



Characteristics of PPS, P84 and PTFE fibres

Characteristics of PPS Fibers

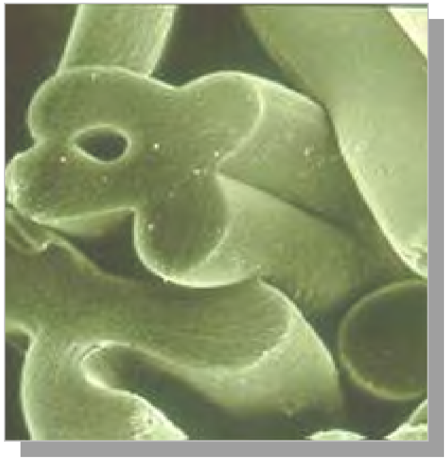


The PPS-fibre, developed in 1973 in the USA is now distributed as a high grade fibre. The fibre is produced by a melt spinning process. Coal fired boilers, cement, etc.

Maximum temperature (short duration): maximum: 190°C (374 °F)	
Recommended continuous operating temperature in CFB FFPs:	130 – 160 °C (266 - 320 °F)
Melting Point:	280 - 290°C (536 - 554°F)
LOI-Value:	39-41%
Density:	1,37 g/cm³
Tensile Strength:	46 cN/tex (5.2 g/den)

Resistance to hydrolysis:	excellent
Resistance to acids:	excellent
Resistance to alkalis:	excellent
Resistance to oxidation:	moderate
Resistance to organic solvents:	moderate

Characteristics of Polyimide Fibers



Blend of 2.2 and 0.6 dtex P84 fibres

Developed during 1984, P84 (PI) proved to be very good for filtration.
The fibres are produced in a dry spinning process.
Shape: multilobal
Applications: Cement plants, coal fired boilers, steel works, waste incinerators, etc.

Maximum temperature (short duration):	**maximum: 260°C (500 °F)**
Recommended continuous operating temperature in CFB FFPs:	**130 - 190°C* (266 - 374 °F)**
Melting Point:	**does not melt**
LOI - value:	**38%**
Density:	**1,41 g/cm³**
Tensile Strength:	**38 cN/tex (4.3 g/den)**
Resistance to hydrolysis:	**good**
Resistance to acids:	**good (HBr-HCl-HF) fair (H2SO4)**
Resistance to alkalis:	**moderate [Na(OH)]**
Resistance to oxidation:	**good**

**** In cases of higher temperatures and / or a high oxidative environment a PTFE scrim may be recommeded for the filter material.***

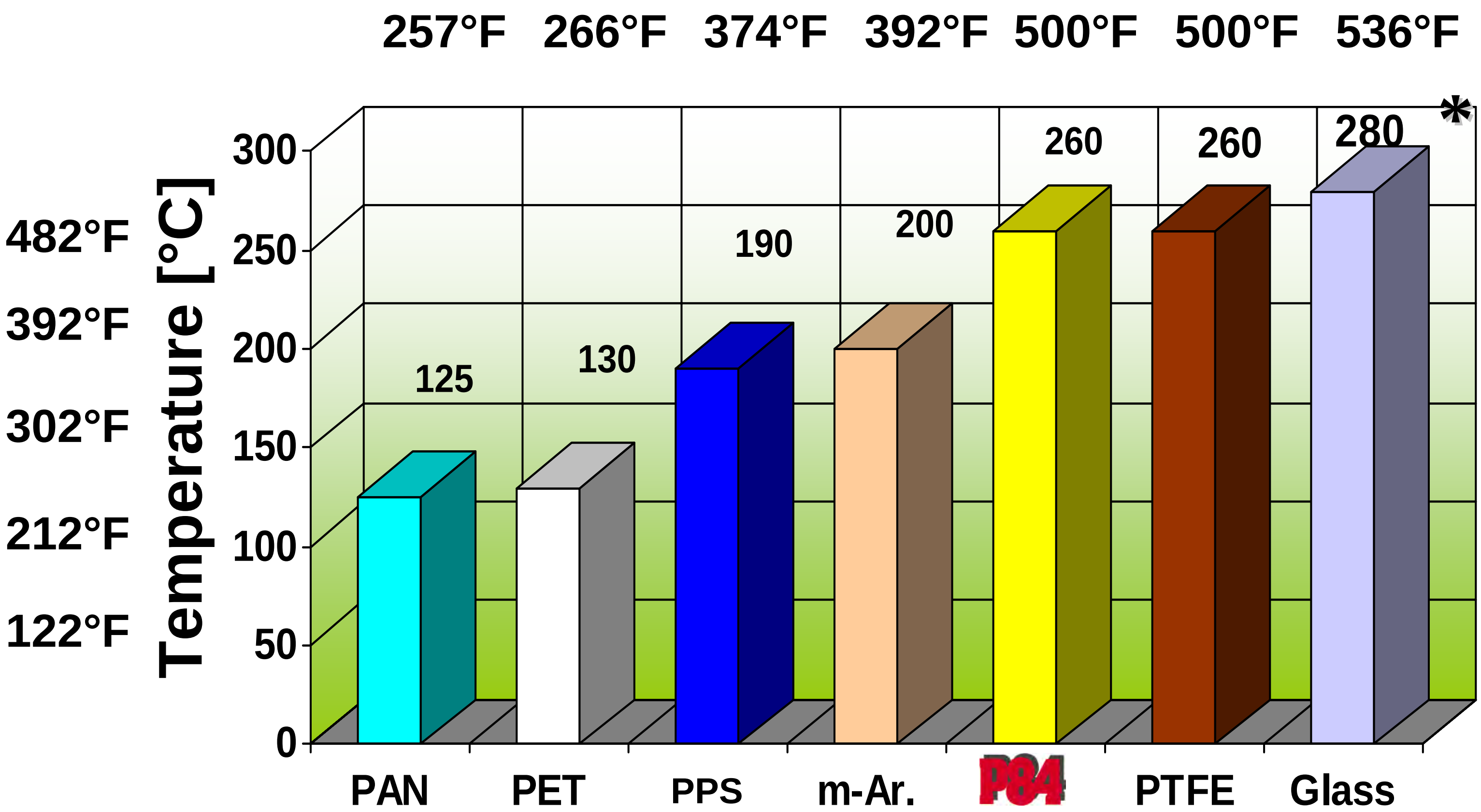
Characteristics of PTFE

The raw material for the PTFE fibre is a polymer made from tetrafluoroethylene by emulsion polymerization.

Thermostability:	**constant: 250°C (482 °F)** **maximum: 260°C (500 °F)**
LOI-Value:	**95%**
Density:	**2,1 g/cm^3**
Tensile Strength:	**10 - 40 cN/tex (1.13 – 4.53 g/den)**

Filtration properties:	**poor**
Resistance to hydrolysis:	**excellent**
Resistance to acids:	**excellent**
Resistance to alkalis:	**excellent**
Resistance to oxidation:	**excellent**
Resistance to organic solvents:	**excellent**

Maximum Service Temperatures

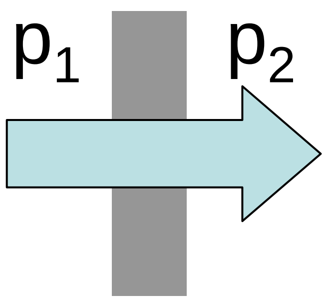


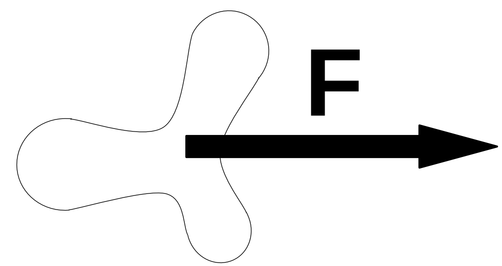
* Actual application temperature may vary to the shown maximum, depending on the flue gas composition!

Pressure drop of a fibre layer

The pressure loss Δp across a filter medium is the sum of fibre forces divided by the filter face area.

$$\Delta p = p_1 - p_2 = \frac{\sum F_i}{A} \approx \frac{n * F}{A}$$

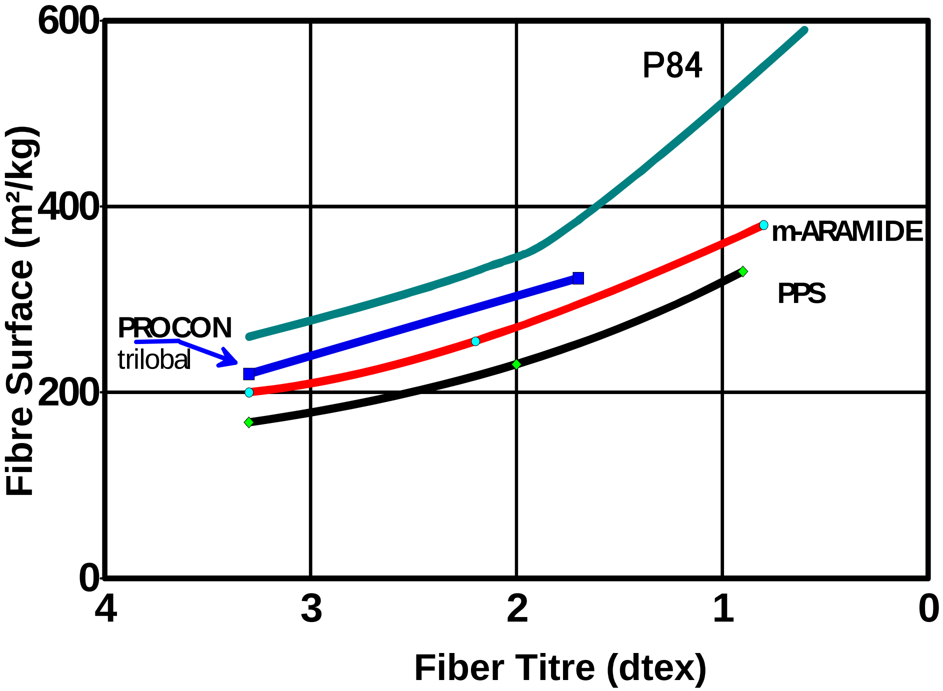




Flow within filter medium => force on fibres (dust)

The force F on a fibre is a measure for the pressure drop Δp.

Specific surface area



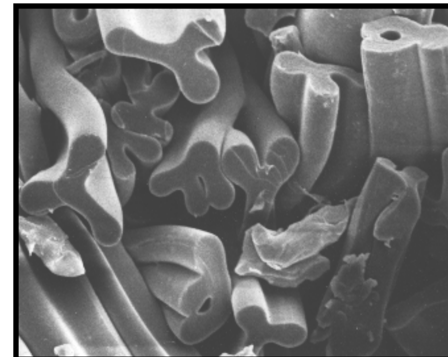
Fine fibres and irregular fibre cross sections are a common approach to

- increase filtration efficiency

and - prevent from dust penetration

P84

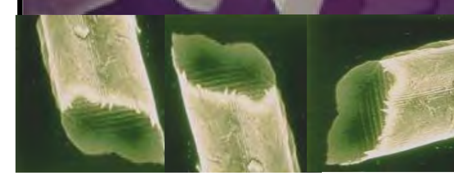
(multilobal)
2,2 dtex
(340 m²/kg)



Procon (PPS)
2,2 dtex
round
(206 m²/kg)

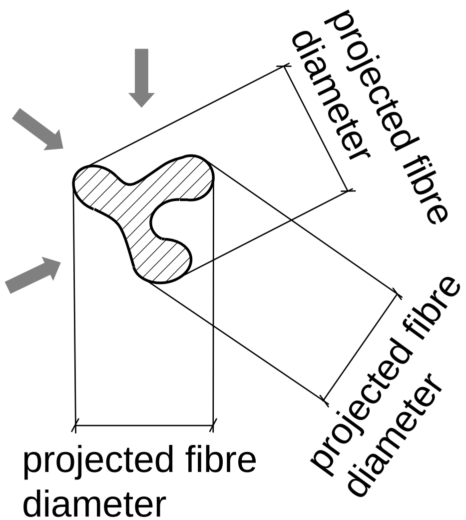
Procon (PPS)
1,7 dtex
trilobal
(317 m²/kg)

M-aramide
2,2 dtex

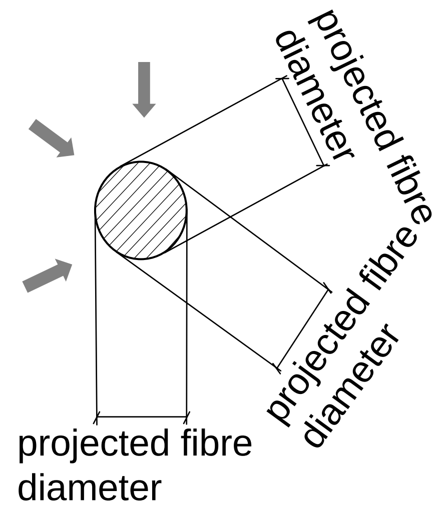


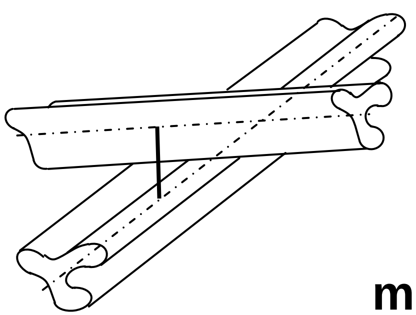
Filtration with Round and Multilobal Fibres

Differences in the felt thicknesses

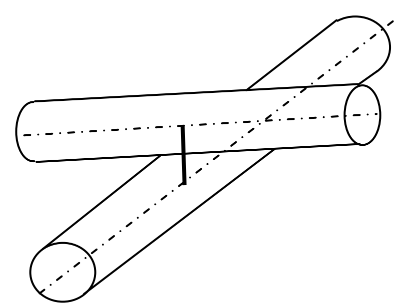


Multilobal fibres with the same fibre titre (2.2 dtex) show larger projected fibre diameters (~ + 30%).



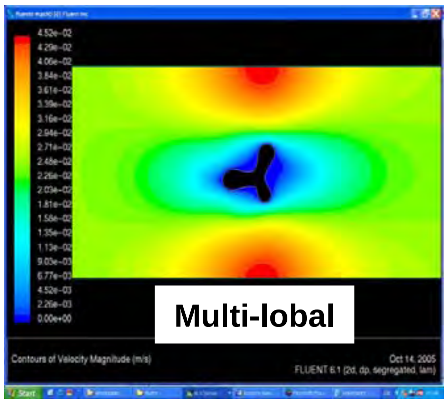


$$d_{multilobal} > d_{circular}$$

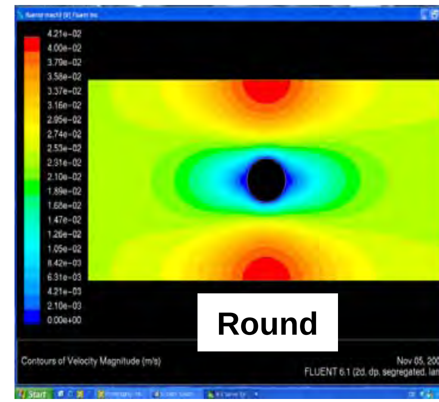


Filter materials built of P84 multilobal fibres are more porous and thicker than felts made of round fibres.

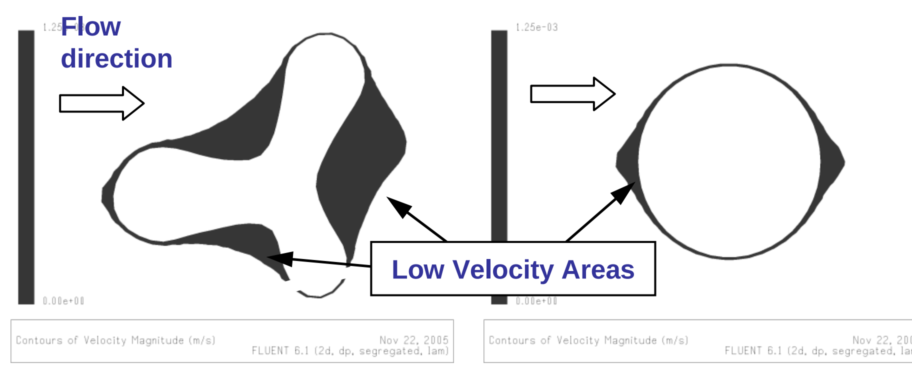
Flow Lines - Charging of Fibres



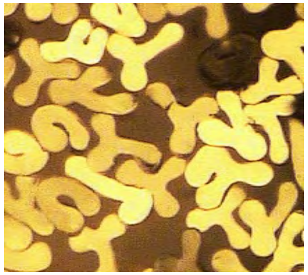
P84 multilobal fibres show larger areas with low flow velocities compared to round fibres.



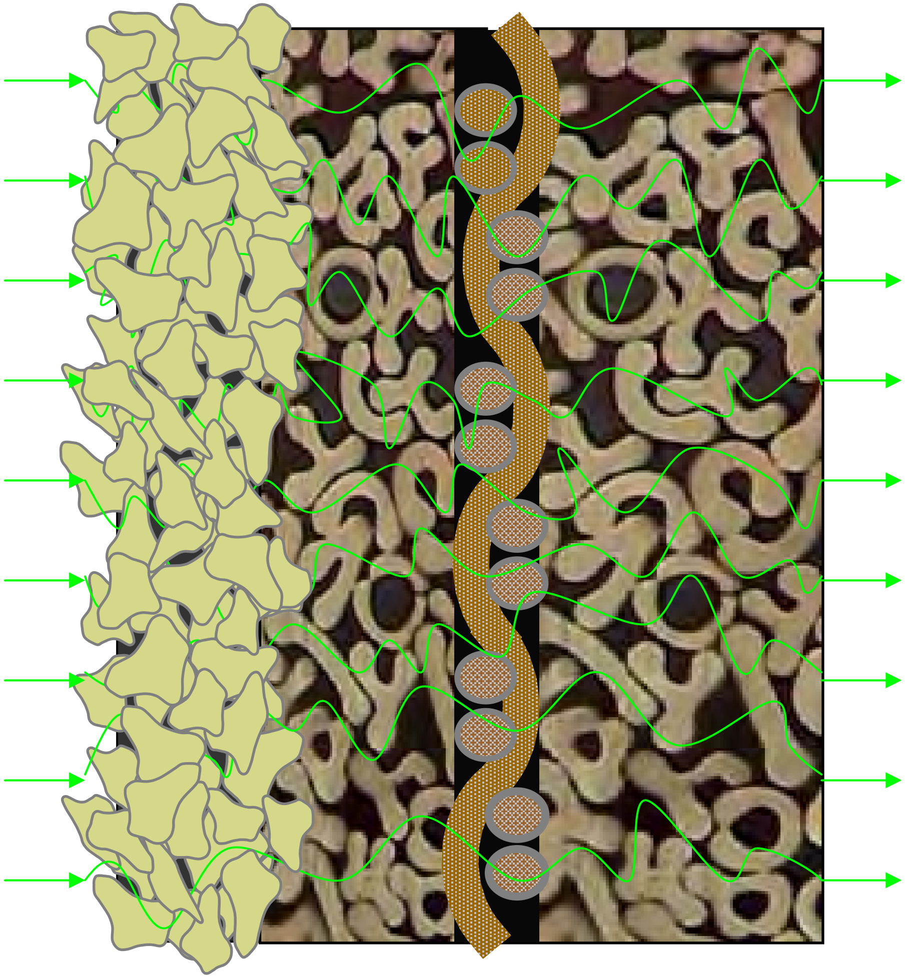
Charging of P84 multilobal and round fibres



Dust Cake Formation



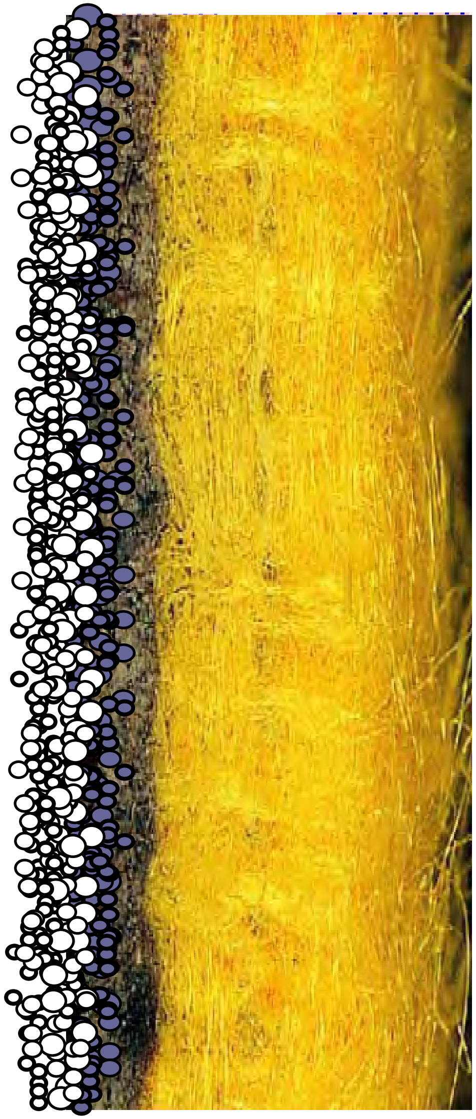
- Flow lines - Little obstruction caused by the collected dust
- Permanent dust cake irregular and porous



P84 dust cake formation on material filtration side

High Efficiency Filtration

- The felt constructed from multilobal fine fibres (high surface area) – <u>irregular / porous</u>
- <u>Dust separates in the low velocity zones</u> of the multi-lobal fibres forming the permanent dust cake
- The structure of the filter media is transferred to the permanent dust cake
- The <u>dust cake</u> formed by multilobal fibres is <u>irregular – porous</u>, flow-lines not affected
- The dust cake formed by multilobal fibres is <u>stable</u> during the felt cleaning phase as compared to the dust cake formed by round fibres.
- Multilobal felts (P84) can collect finer dust particles than felts based on similar titre round fibres.



CFB bag houses – typical filter media

- Polyacrylic (PAN) homopolymer: low temperature bag houses
  Polyphenylenesulfide (PPS): medium and high temperature bag houses
- Polyimide (P84): high and low temperature bag houses
- PTFE: high temperature bag houses
- Scrim or scrim-less

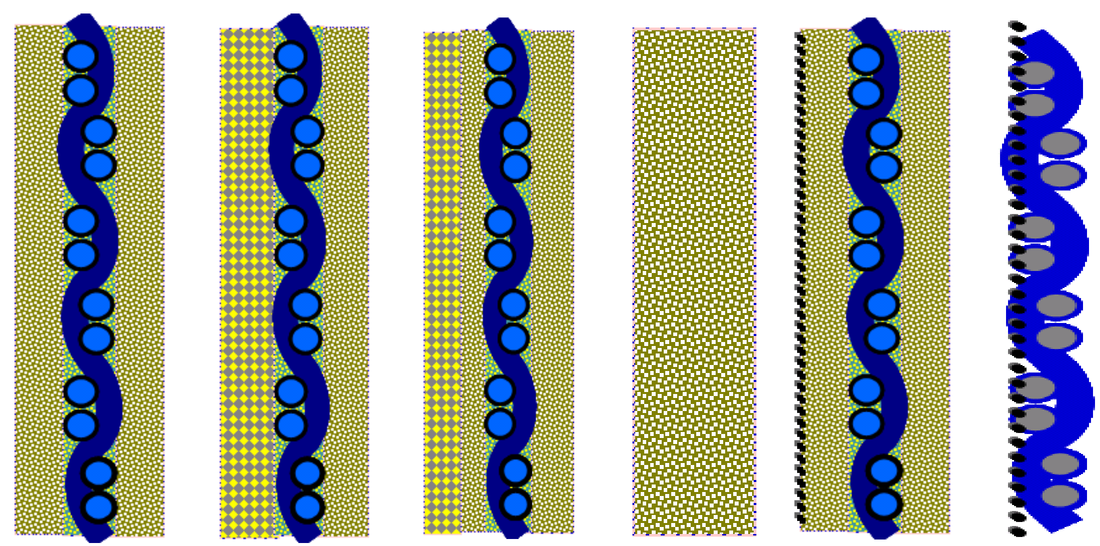
Fibre Blends:

- PAN + PI / PAN scrim
- PPS + PI / PPS scrim
- PPS + PI / PTFE scrim
- PTFE + PI / PTFE scrim

Membrane materials

- M / Woven glass
- M / PTFE felt
- M / PPS felt

CFB FFP filter material constructions

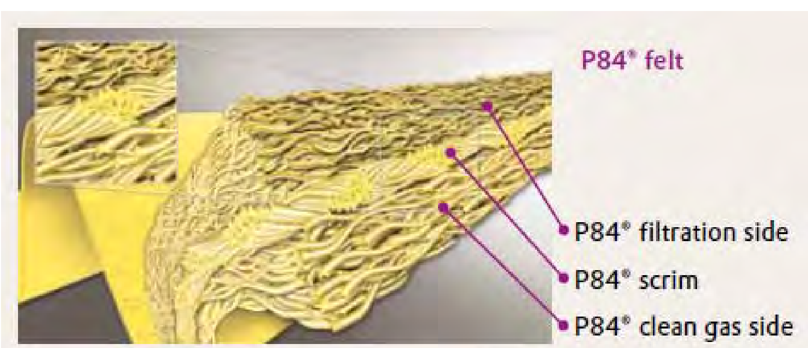


Dust Cake Implications

Benefits - multilobal felt based dust cake

Increased filtration efficiency

- Operation at low pressure losses – due to the dust cake structure
- Lower suction fan power (bag house on timer control)
- Low cleaning / pulsing rates (bag house on DP control)
- dust charging capacity of multilobal fibres – longer time to reach the ΔP cleaning initiation value
- No dust penetration – due to dust cake stability
- Low particulate emissions due to the dust cake structure

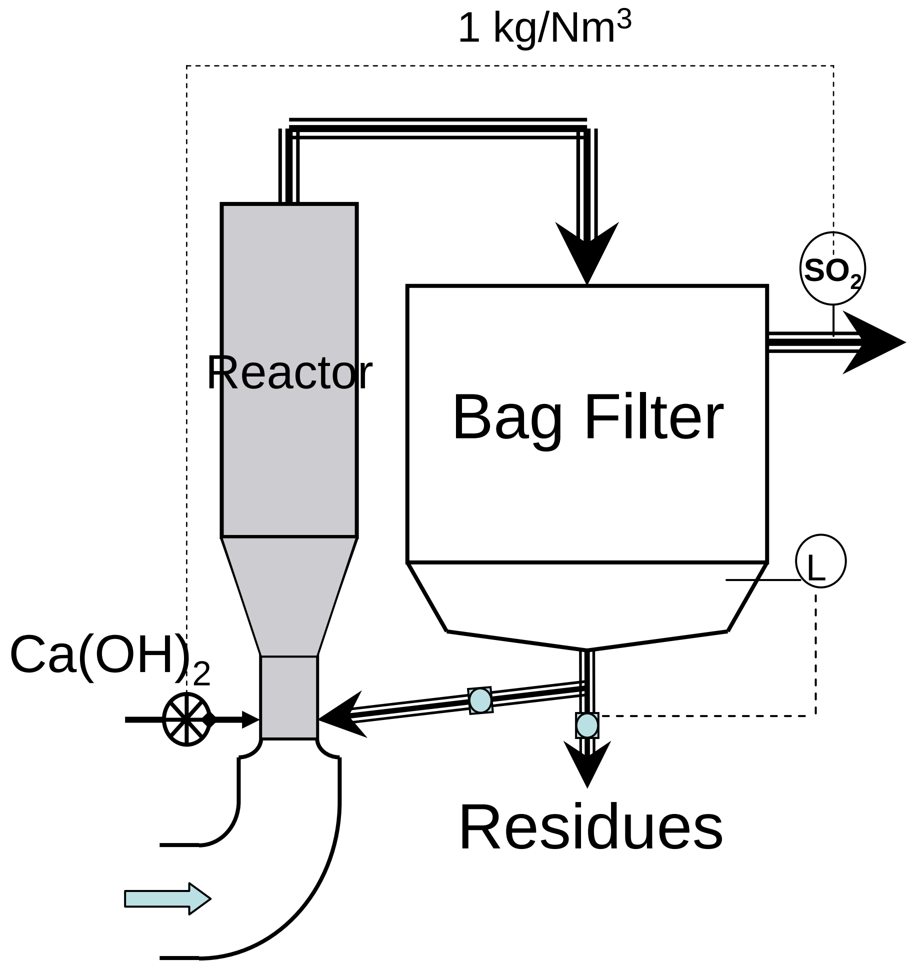


Benefits - multilobal felt based dust cake

Chemistry

- **The bag house acts as a fixed bed reactor**
  - **Protection of the fibres against acid degradation – the alkaline components present in the dust cake neutralise naturally the acidic components present in the flue gas while the gas passes through the dust cake**
  - **Secondary reaction in case of dry / semi-dry FGD systems – same as above but with the addition of activated carbon and of reagents lime or sodium based**
    - **Absorption of HCl, SOx and HF**
    - **Adsorption of dioxins, furans, Hg**
  - **For the same ΔP a multilobal felt holds a larger dust cake ensuring more surface contact with the gas molecules and more effective chemical reactions**

Typical Dry /Semi-dry FGD Plant



- Primary reaction
- Secondary reaction
- Recirculation of the material
- High dust loading in the bag
- house
- Good flow distribution
- Fibre characteristics
- Fibres with a high surface area

Benefits of multilobal P84 based felts in relation to G/M Filter Media

- **P84 based felts have very good abrasion resistance and can operate at high dust loads > 500 g/Nm³**
- **G/M based materials do not hold a significant dust cake continuously.**
- **After cleaning, the membrane is exposed to the potentially aggressive gas and processes and components:**
  - **Unburned hydrocarbons – generated during plant start-up, combustion support, combustion instability**
  - **Condensation of acids – acid dew point operation - blinding**
  - **Moisture condensation – water due point operation - blinding**
  - **Condensation of vaporised salts – blinding**
  - **Penetration of fine particles through the membrane – delaminating and blinding**

Failed membrane leading to dust penetration throughout the filter material - blinding

O & M
Risk Analysis of FFPs

Risk Analysis – Events - Causes

Temperature control

- Temperature gradient
- Thermal degradation of the filter material
- Polymer limitation
- Shrinkage
- Coating degradation in case of woven glass
- Catastrophic bags failure or bag life reduction
- Bag house protections
- Guarantee exclusion

Risk Analysis – Events - Causes

<u>Oil carry-over</u>

- **Caused by defective oil burners**
- **Start-ups**
- **Oil flame support**
- **After oil burner maintenance**
- **Bags blinding**
- **Bags protection by dust cake**
- **Bag house fires - catastrophic**

Risk Analysis – Events - Causes

High dust hopper level

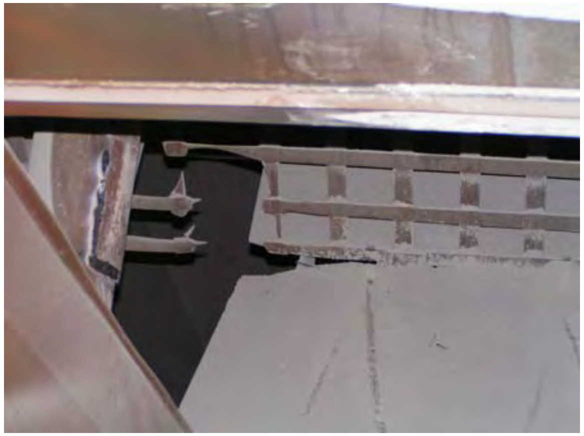
- Changes the flow dynamics in the hopper flow dynamics,
- Dust not settling
- Sand blasting effect on bags and structure
- Premature failure of filter bags – abrasion
- Blinding
- High ΔPs
- Load losses – combustion chamber suction
- Premature failure of the cleaning system - blowers and pulse valves
- Steel structure abrasion
- Tube plate collapse / sagging

- Hopper level detection reliability / alarms
- Automatic protection or operator intervention?

Risk Analysis – Events - Causes

General bag house steel structure abrasion

- ❖ Abrasion of the support structure
- ❖ Flow distribution plates
- ❖ Guide vanes (flow plates)
- ❖ Could create hopper flow disturbances
- ❖ Premature failure of bags – abrasion
- ❖ High pressure losses



Boiler / FFP interface

- Oil burner performance
- Volume flow control / secondary air / economiser O2 / combustion
- NO_2 formation / combustion / burners
- Start–up and shut–down / acid dew point crossings and or temperature excursions
- Air heater leakage – volume flow
- Temperature distribution after air heaters
- Mill classifier vanes – PF and fly ash finesse
- Boiler tube leaks
- Soot-blower performance / sonic horns – dust loading with potential temperature increase and high ΔPs

Bag house protections

Temperature detection

- ❖ Low temperature alarm
- ❖ High temperature protection or alarm
- ❖ Air attemperation control
- ❖ Spray water protection

- ➢ **High suction at the clean gas side**
  - ❖ Draught group trip
  - ❖ Implosion dampers for casing protection
- ➢ **High hopper level**
  - ❖ Hopper level detectors / trip?
- ➢ **Brocken bag detection**
  - ❖ Software linked to the process data: high emissions related to the cleaning of a specific compartment or row of bags

Typical bag failures

Bag too long

Longitudinal seam

Poor stitching

Abrasion

Abrasion

Pulse misalignment

Typical bag failures

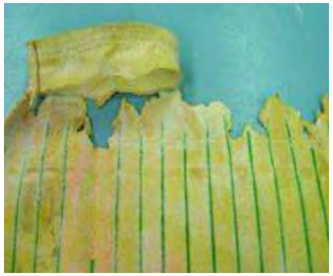
Heat damage – over-temperature

Acid damage

Moisture blinding

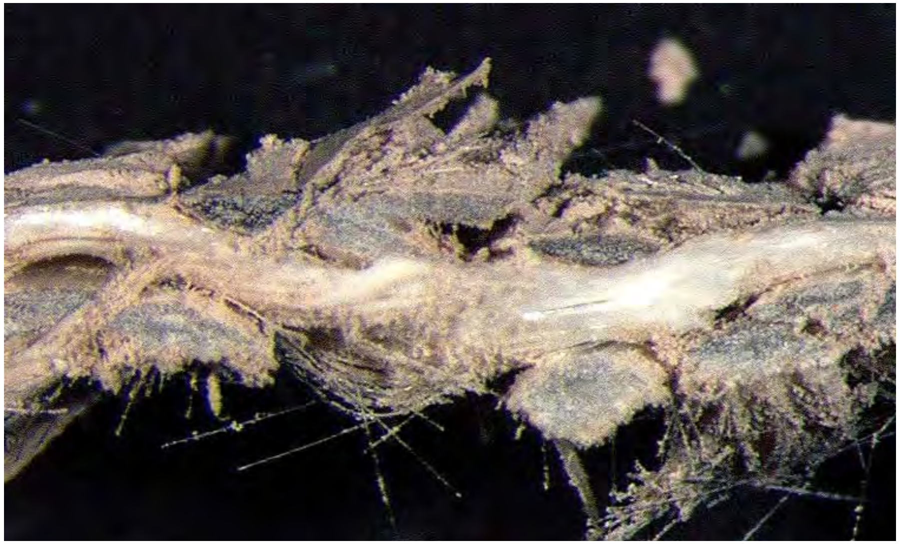
Cuff abrasion

Hydrolysis



Woven glass / membrane failures

Damaged membrane on a woven glass / PTFE substrate



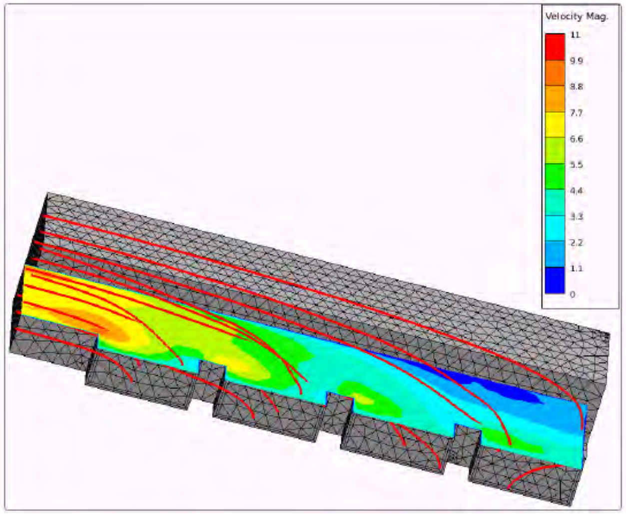
Damaged and delaminated membrane
Dust penetration – failure of filter material

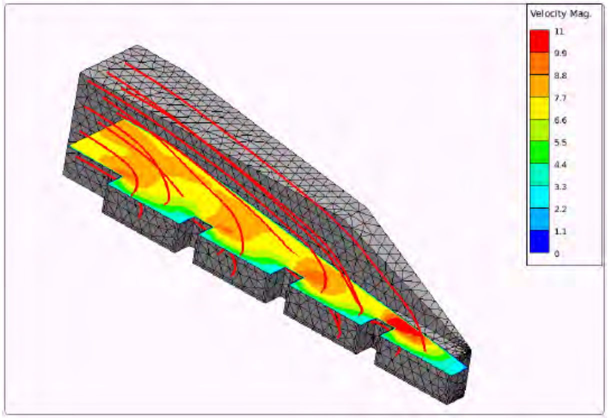
Optimisation of FFPs

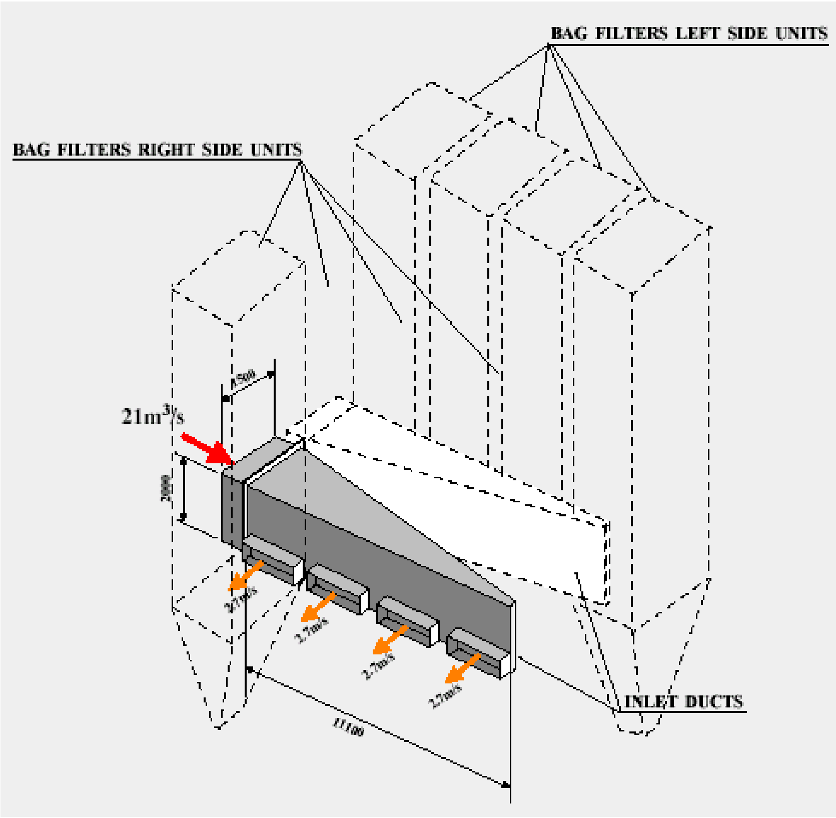
Tools for FFP Optimisation

- CFD modelling - flow improvement
  - Static and dynamic
- Process modelling
- Cleaning system evaluation and optimisation
  - pressure probe for pulse characterisation
  - load cells
  - accelerometer system
  - high speed photography
- In-situ bag filter cleaning device
  - life extension for blinded bags

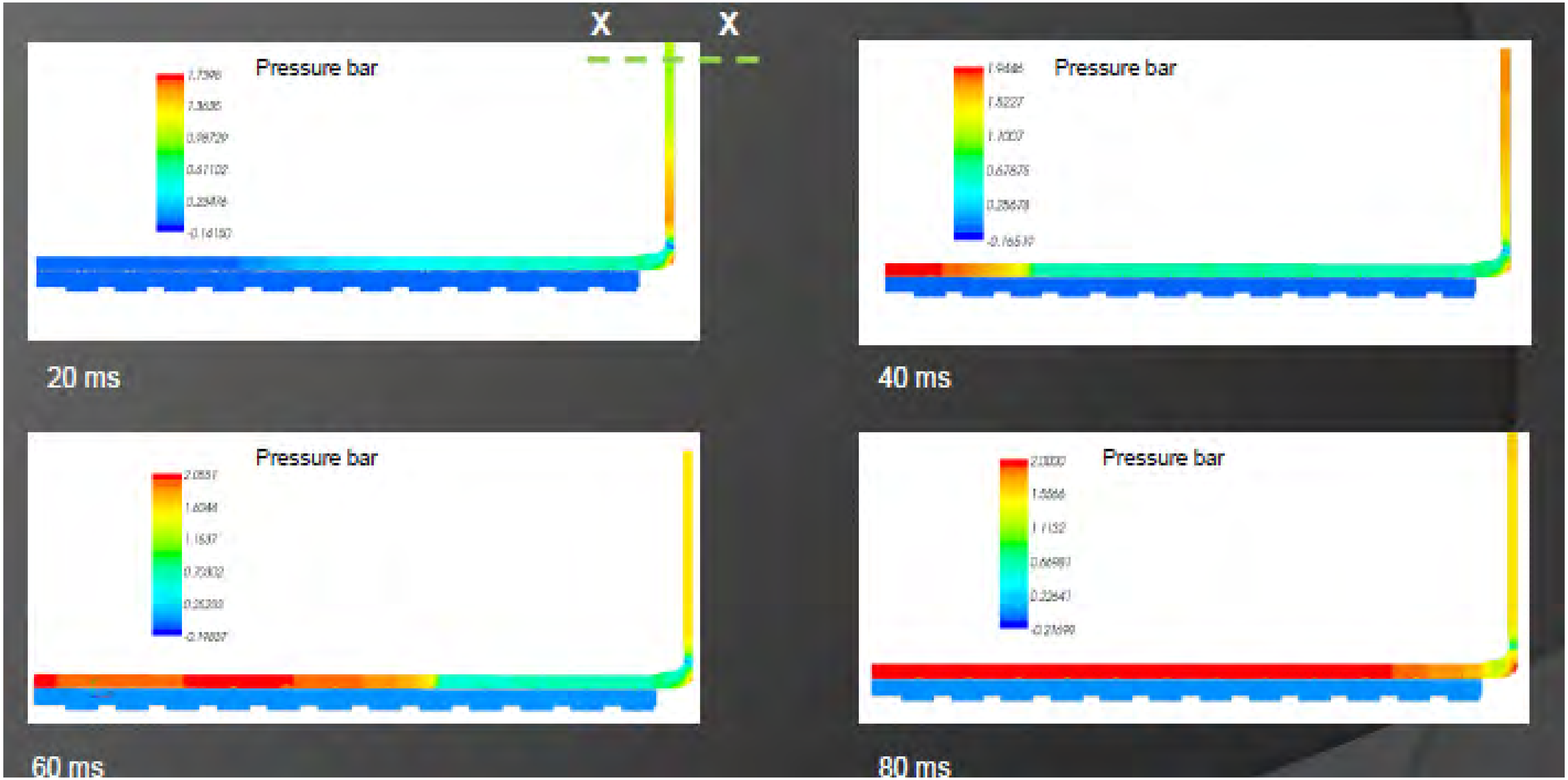
CFD modeling – static analysis







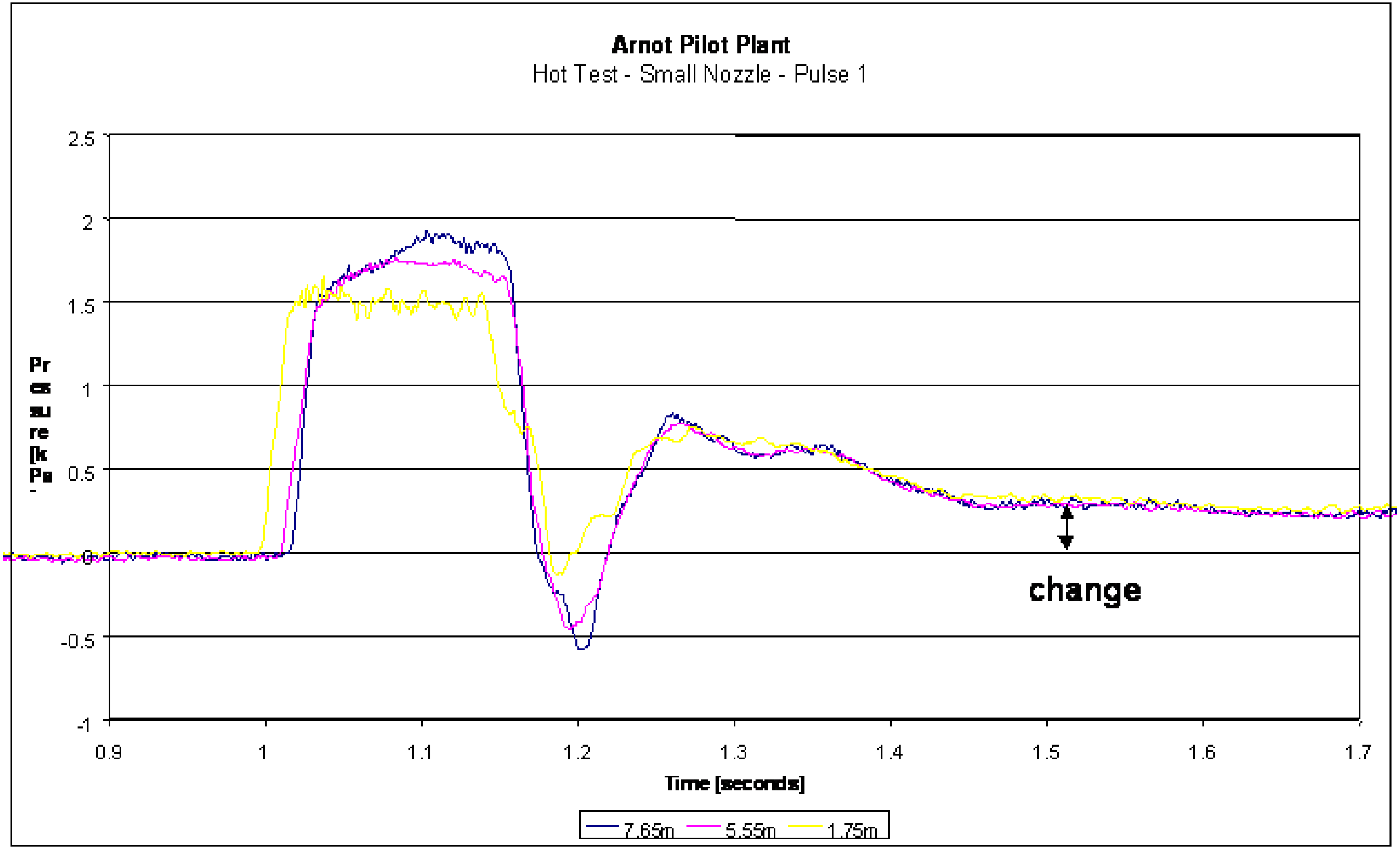
CFD modeling – transient analysis



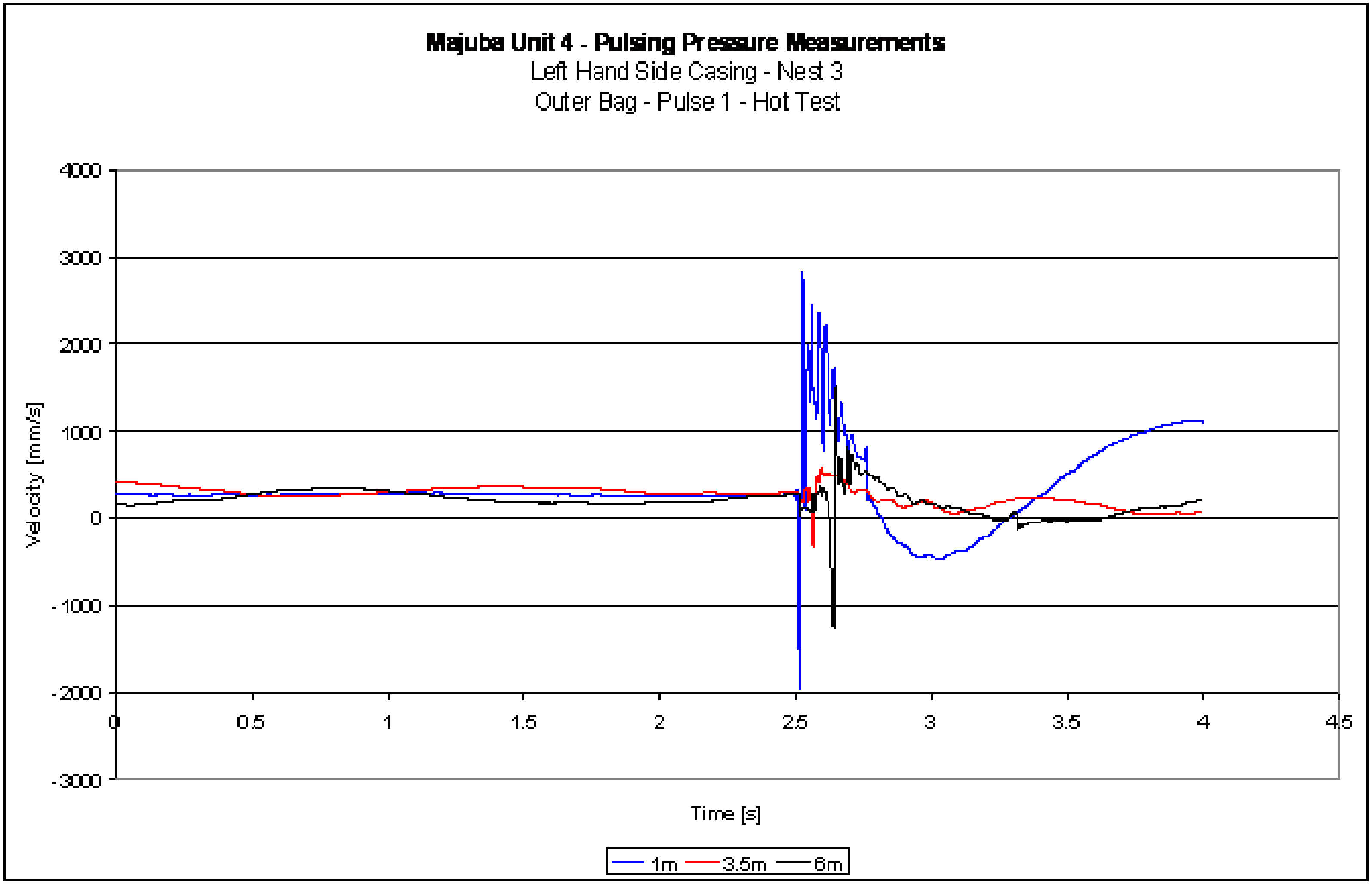
Pulsing probe – pulse characterization

In-situ pressure measurements during pulsing at different bag heights

Pulse pressure characterization



Pulse characterisation - velocity



FFP Condition Monitoring and Research Directions

Condition monitoring and process analysis

Condition monitoring of bag houses

- ➢ **Bag life prediction**
- ➢ **Identification of the failure mode**
- ➢ **Selection of new filter materials**
- ➢ **Cost reduction**

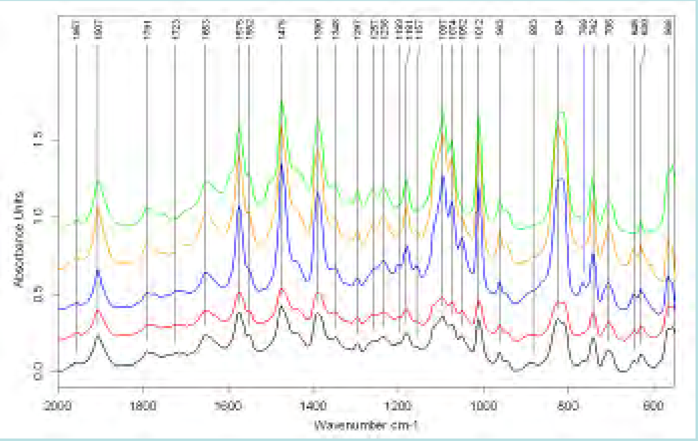
- ❖ **Laboratory analysis of bags**
  - ▪ **Basic analysis**
  - ▪ **Advanced analysis – failure investigations**
- ❖ **In-situ testing**
  - ▪ **Evonik Filtration Test Rig**

Laboratory filter media analysis PPS

FTIR (Fourier Transformed Infrared)

- Identification of polymers
- Determination of ageing and degradation mechanisms

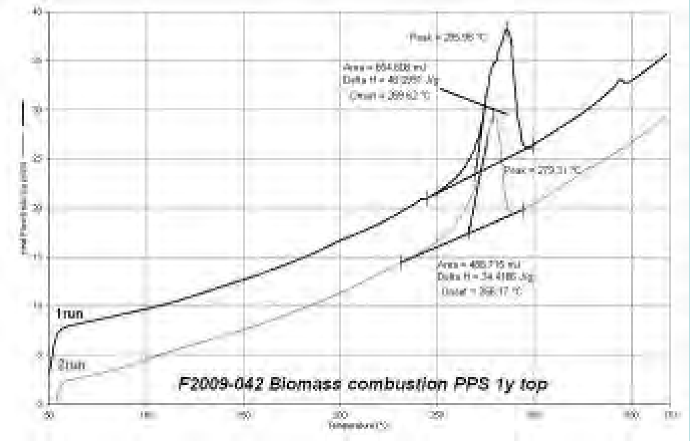
FTIR



DSC (Differential Scanning Calorimetry)

- Determines the thermal history of the PPS polymer
- Identification of the remnant life

DSC



Laboratory filter media analysis P84

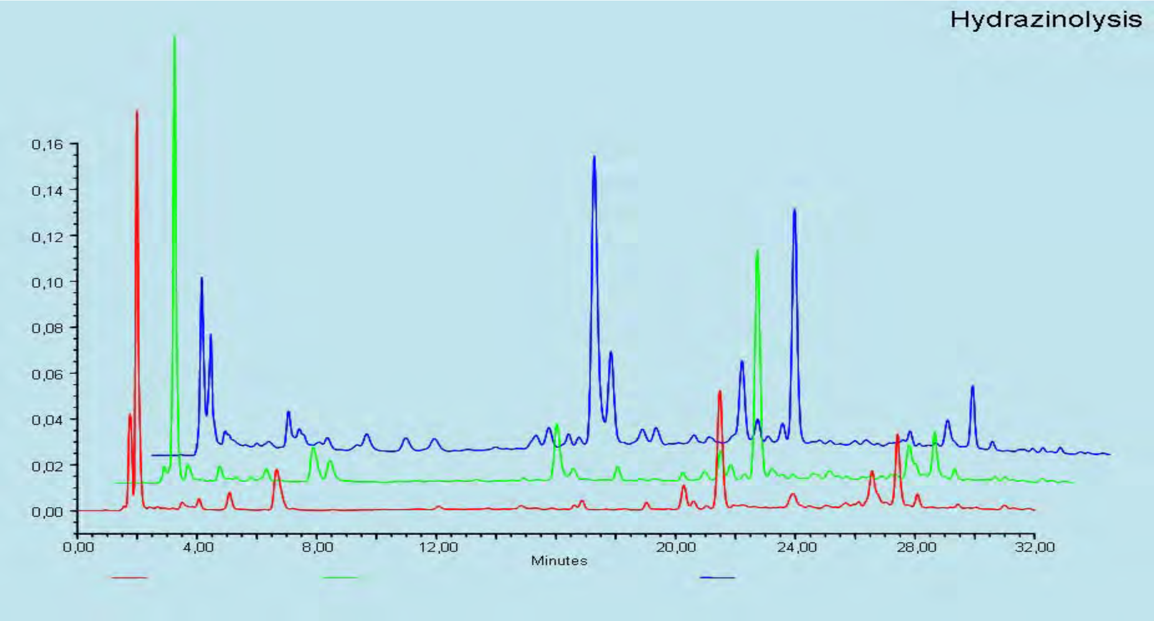
EVONIK INDUSTRIES

Hydrazinolysis

- Breaking of the P84 polymer into its building blocks.
- HPLC analysis
- Degradation patterns
- Quantitative analysis of the P84 content

Inherent Viscosity

- Change of the polymer structure leads to the variation of the molecular mass
- Quantification of the residual life



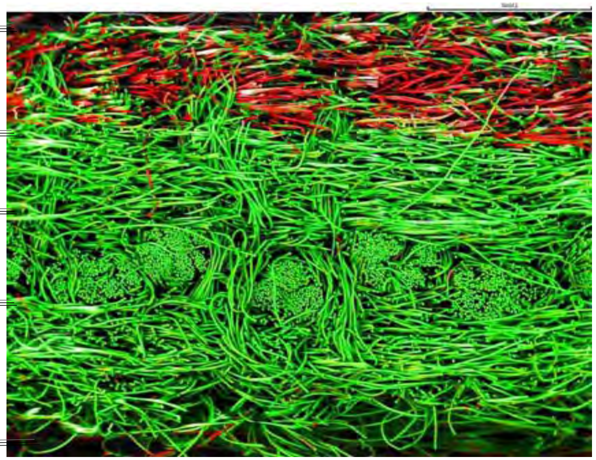
Scanning Electronic Microscopy EDS example

Surface defined P84 layer

Second defined PPS layer

Support scrim

Inner PPS layer

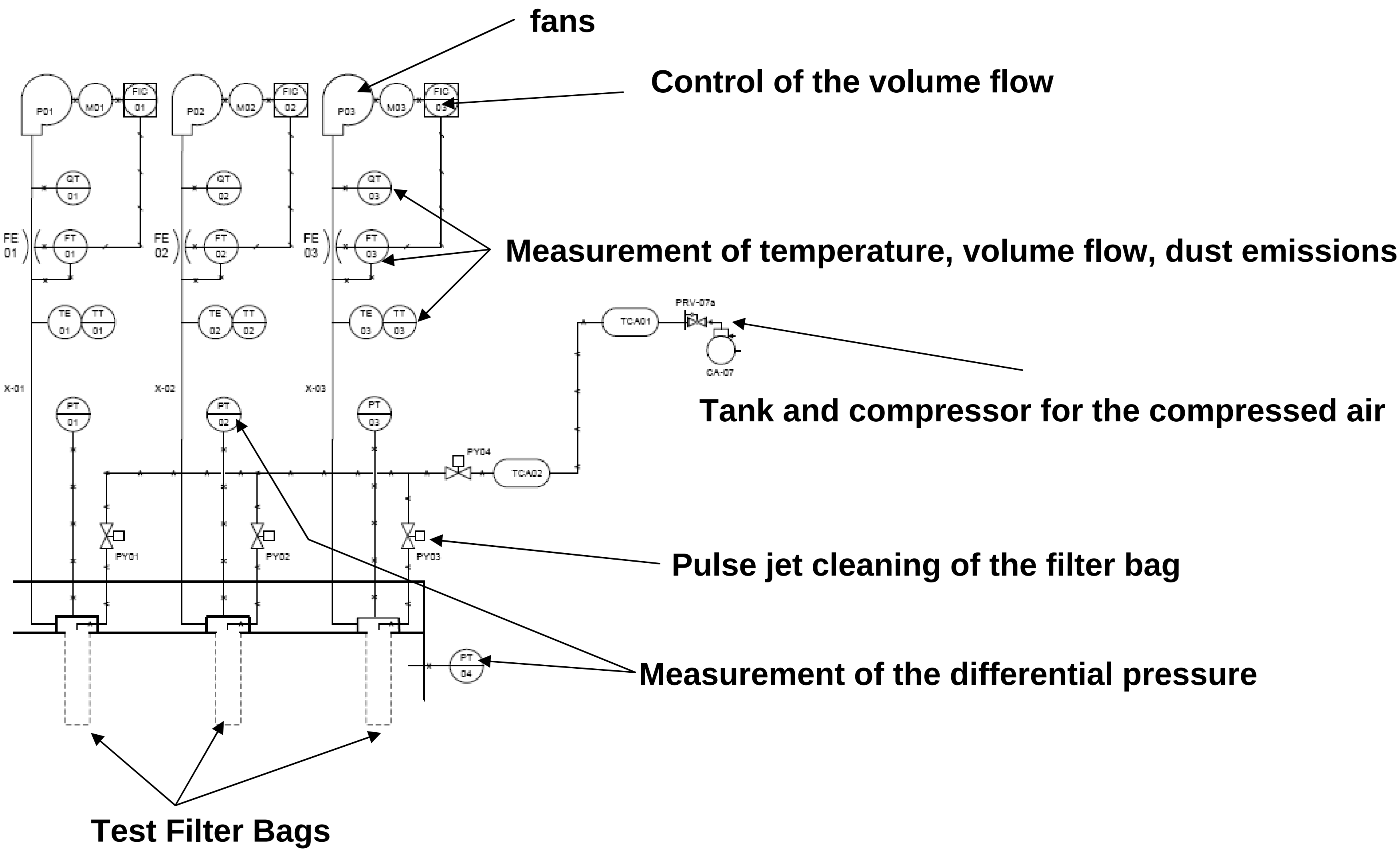


Only few P84 fibres spread in a single fibres layer

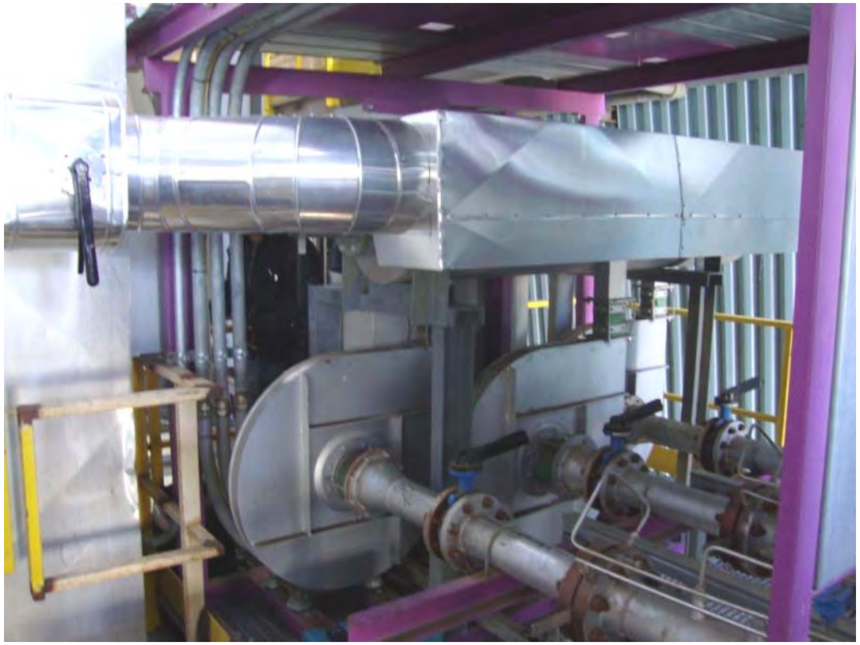
Support scrim

Inner PPS layer

Schematic of the in situ Filtration Test Rig (FTR)



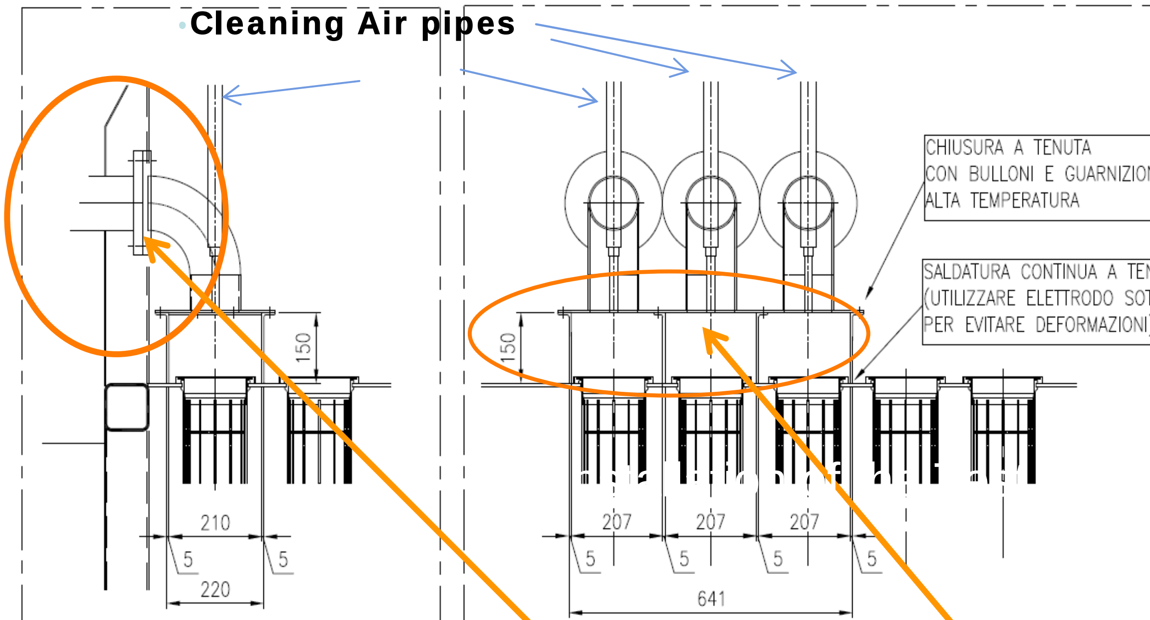
The ENEL / Evonik Fabric Filter Test Rig - EEFTR

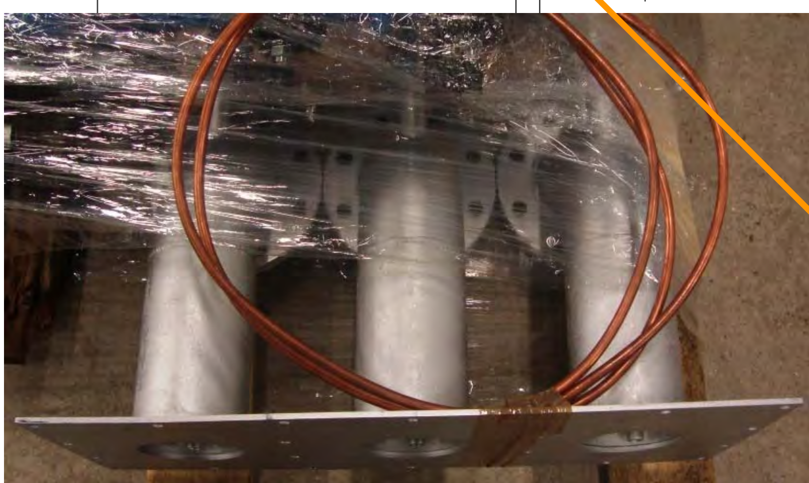


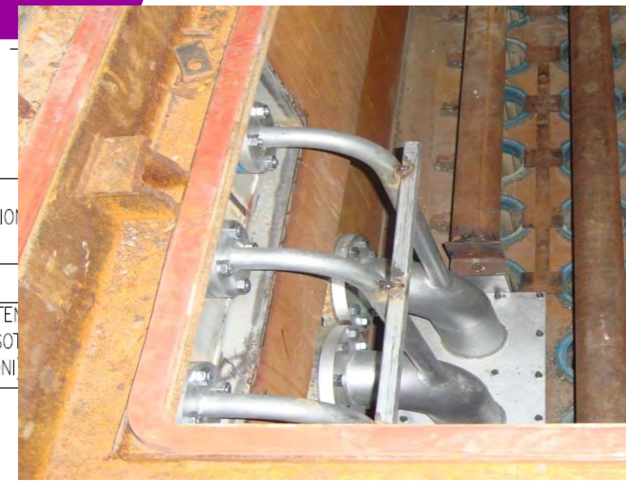
Torrevaldaliga North Fabric Filter Unit 4

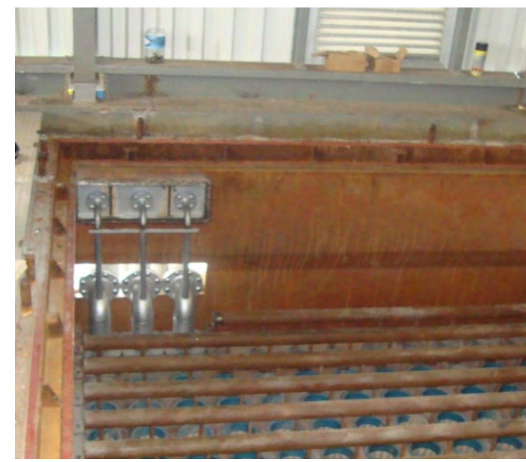
Installation of the test bags

Cleaning Air pipes





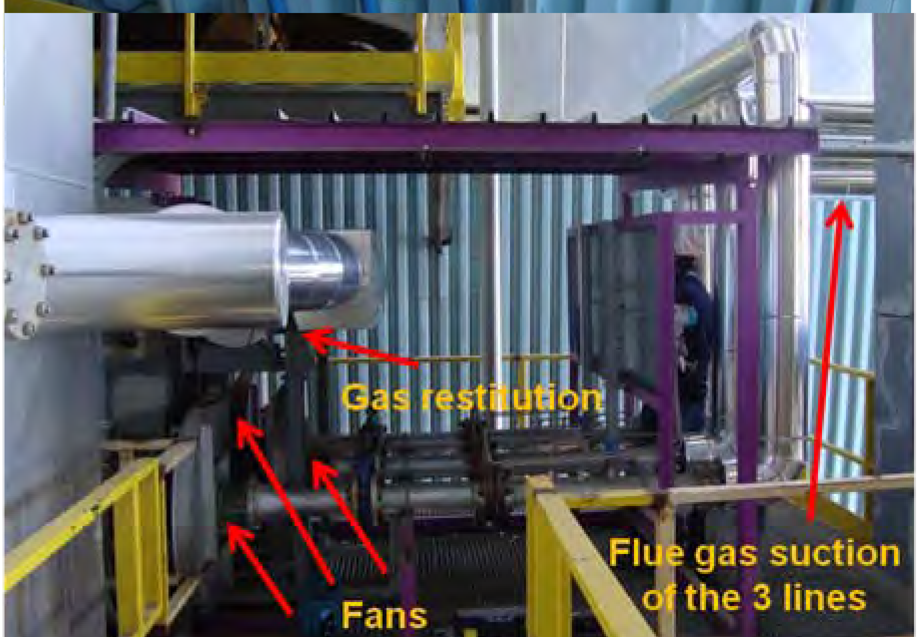


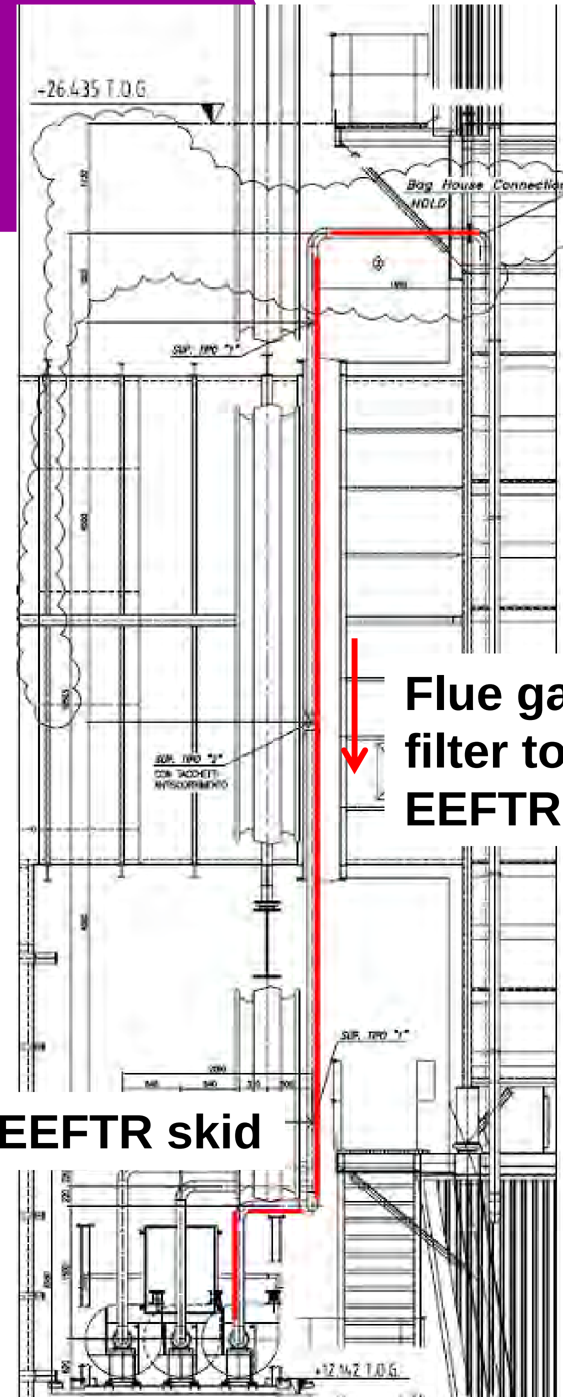


Cover box

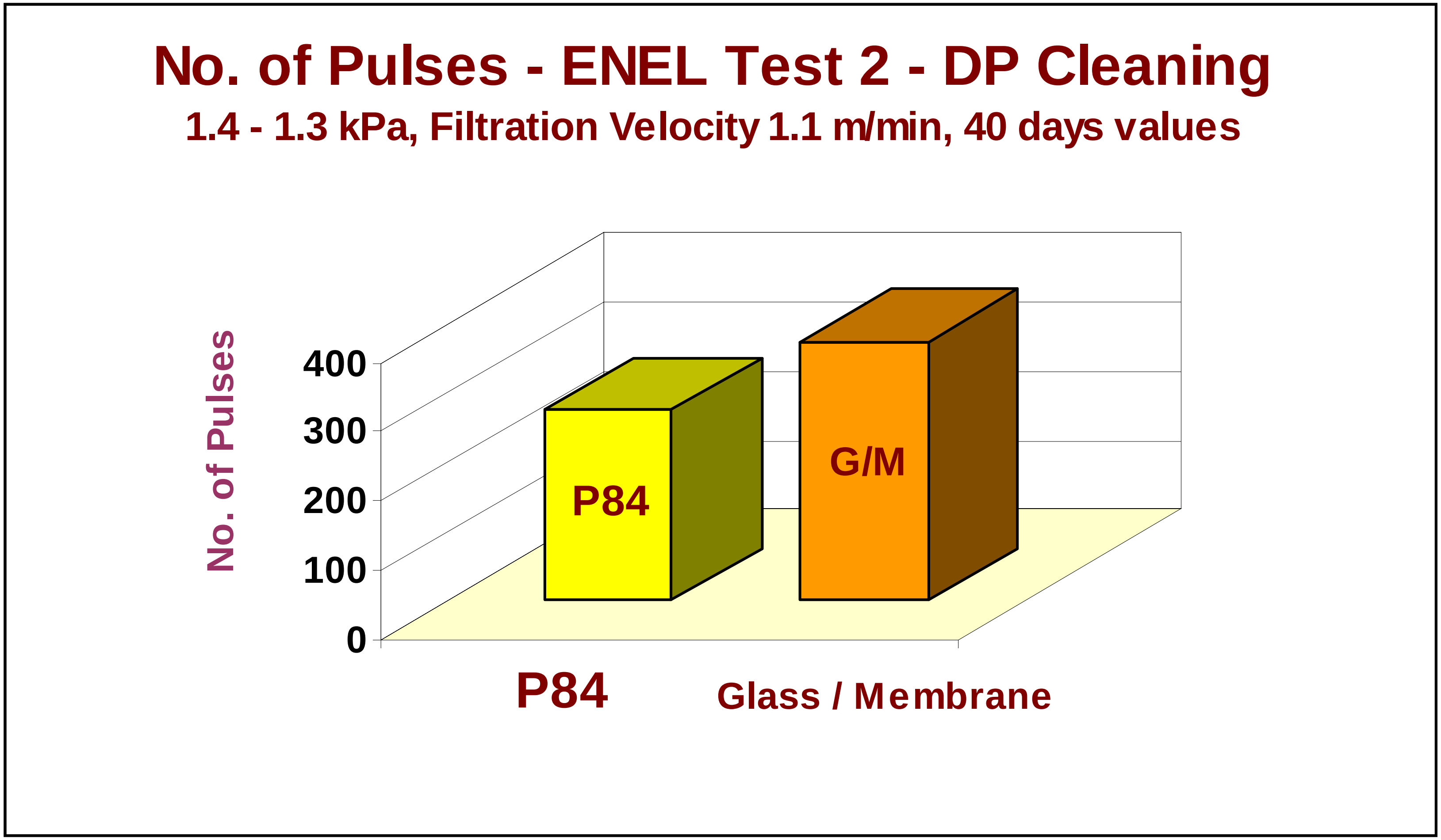
Connection pipes
(inside the power plant filter)

EEFTR installed in the TVN Power Plant





ENEL TVN EEFTR - P84 versus G / M



Mercury species and control

- Combustion - high temperature boiler zones
  - Hg in coal is volatilized = elemental Hg vapour
- Gas cooling down zones
  - elemental Hg converted to ionic Hg^{2+} compounds (gas), Hg_p solid and Hg adsorbed on other solid particles (dust and unburned carbon)
- Flue gas cleaning temperature zones
  - Formation of mercuric chloride $HgCl_2$ (Hg_p) in the presence of chlorine and other oxidizing agents
- Mercury speciation
  - Hg enters the emission control device as a mixture of Hg, Hg^{2+} and Hg_p

Mercury capture – emission control configuration

Post-combustion Control Strategy	Post-combustion Emission Control Device Configuration	Average Mercury Capture by Control Configuration Coal Burned in Pulverized-coal-fired Boiler Unit		
		Bituminous Coal	Subbituminous Coal	Lignite
PM Control Only	CS-ESP	36 %	3%	0 %
	HS-ESP	9 %	6 %	not tested
	FF	90 %	72 %	not tested
	PS	not tested	9 %	not tested
PM Control and Spray Dryer Adsorber	SDA+CS-ESP	not tested	35 %	not tested
	SDA+FF	98 %	24 %	0 %
	SDA+FF+SCR	98 %	not tested	not tested
PM Control and Wet FGD System[(a)]	PS+FGD	12 %	0 %	33%
	CS-ESP+FGD	75 %	29 %	44 %
	HS-ESP+FGD	49 %	29 %	not tested
	FF+FGD	98 %	not tested	not tested

CS-ESP = cold-side electrostatic precipitator
HS-ESP = hot-side electrostatic precipitator
FF = fabric filter
PS = particle scrubber
SDA = spray dryer absorber system

(a) Estimated capture across both control devices

(Courtesy of EPA)

Mercury control - CFBs

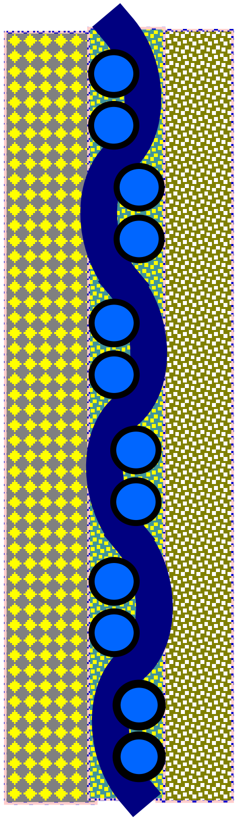
- Hg capture in wet FGDs – only Hg^{2+} (water soluble)
  - ❖Hg is insoluble in water and cannot be absorbed
  - ❖Oxidising catalysts for Hg to form Hg^{2+} (i.e. Evonik catalyst)
- SCR can enhance the Hg oxidation
- Activated Carbon Injection (ACI)
  - ❖Hg and Hg^{2+} are entrapped in the AC pores
  - ❖Hg_p is removed as a solid
  - ❖Required: AC with high surface and high pore areas
  - ❖ESP, FF, Dry FGD (reactor + FF)
    - ❖ Hg / Hg^{2+} gas and vapour contact with AC
    - ❖ dust cake importance / critical
    - ❖ filter material – high surface area dust cake
    - ❖ Multilobal P84 fibres
    - ❖ Membrane type materials are not holding a dust cake

References

Coal Fired Boiler - CZR

P84+Procon/Procon scrim
Dry scrubber - $Ca(OH)_2$
Pulse Jet - On Line

Area: **8.000 m^2**
Flow: 356.803 Nm^3/h
Temp: 125 - 130 °C
(max 200° C)
ACR: max. 1,32 m/min
H_2O: 6,5 - 7,3 vol%
O_2: 6,0 vol%
SOx: 500 - 2.000 mg/Nm^3
ADP: 110 - 120° C
Emission: < 10 mg/Nm^3



2 FBC Units, 1 Grate Firing
2.930 Filter bags
Life time > 8 years

CFB References – Nebraska Power

General Information

Filter bag material: P84/P84
Start up: January 2000
Two systems installed on existing cyclonic fired boiler, burning low sulfur, Powder River Basin Wyoming Coal.
26 compartments, 360 bags/compt.

Operating Conditions

Filter area: 31.000 m^2
A/C - ratio: 1,10 m/min
No. of shut-downs: Continuous - max. 6/a
Neutralisation: None

Raw gas data

Parameter	Unit	Value	Range (from)	Range (to)
Temperature	°C		170	175
H_2O Humidity	Vol %		11	12
O_2 Oxygen	Vol %		5	6
SO_x Sulfur oxides	mg/Nm^3	430		1.450
NO_x Nitrogen oxides	mg/Nm^3	480		
Raw gas dust load	mg/Nm^3		1.199	3.531
Gas flow [@ 20 °C, 1.013 mbar]	Am^3/h	2.000.000		

CFB References – ENEL, etc.

Station	Country	Capacity (MW)	No. of Bags	Bags Type
Torrevaldaliga Nord	Italy	3 x 660 MW	3 X 14000	PPS / P84
Brindisi South	Italy	2 x 660 MW	2 x 16000	PPS / P84
Porto Tolle (Not yet built)	Italy	3 x 660 MW	3 x 16000	PPS / P84
Millmerran	Australia	2 X 440 MW	20000	PPS / P84
Kogan Creek	Australia	1 X 740 MW	24000	PPS / P84
Reftinskaia	Russia	6 X 300 MW & 4 X 500 MW	1 X 14136	PPS / P84

CFB References - Eskom

Plant	Unit	No. of bags	Bag life	Type of bag
Arnot	1 to 3	13584	35000	PPS / P84
Arnot	4 to 6	10934	32000	PPS / P84
Camden	1 to 8	9616	35000	PPS / P84
Duvha	1 to 3	26928	25000	PPS / P84
Grootvlei	1 to 3	8832	40000	PPS / P84
Hendrina	1 to 5	8000	36000	PPS and PAN
Hendrina	6 to 10	8160	32000	PPS / P84
Majuba	1 to 3	30976	25000	PAN / P84
Majuba	4 to 6	32512	28000	PAN / P84
Medupi	1 to 6	18480	32000 guarantee	PAN / P84
Kusile	1 to 6	18480	32000 guarantee	PAN / P84

Thank you!

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