REINHOLD ENVIRONMENTAL Ltd.

# 2015 APC Round Table & Expo Presentation

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

# Fabric Filter O&M

## APC Round Table

13th & 14th of July 2015, Atlanta, Ga, USA

**Florin Popovici**

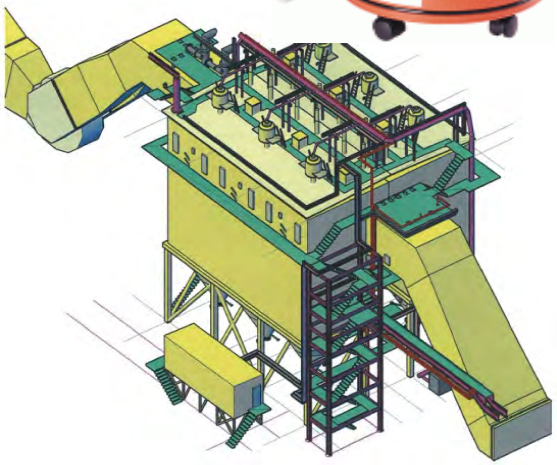
# Content

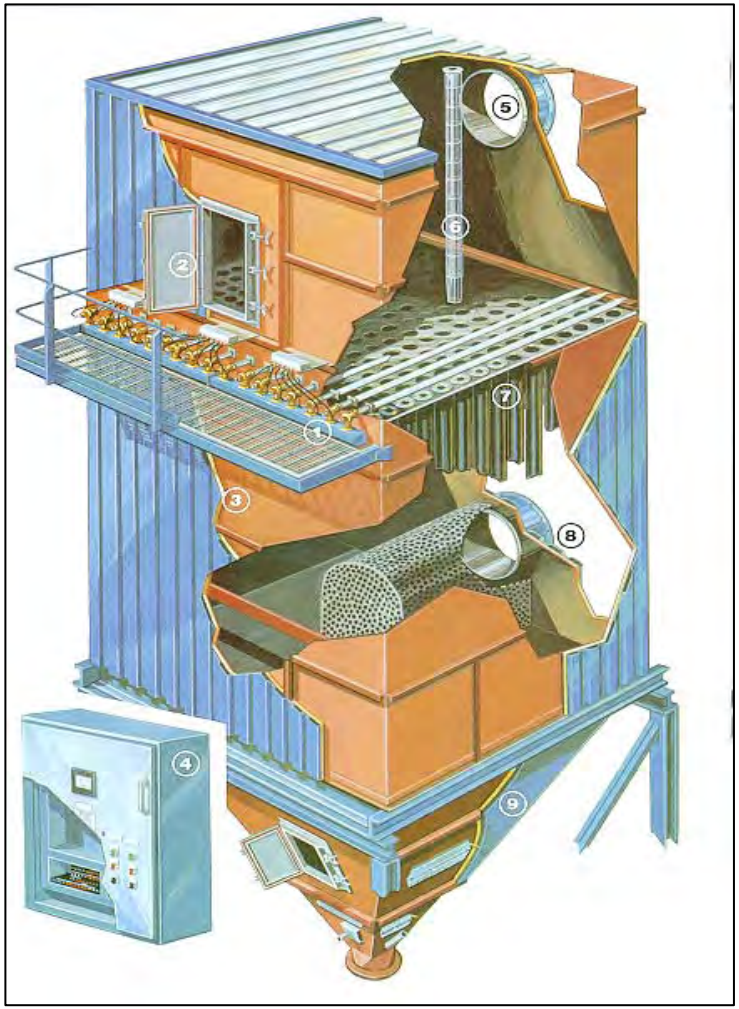
- Bag filter plant general description – PJFF
- Bag house components
- Bags and cages
- Filter materials and filtration mechanism
- Dust cake implications
- Bag house risk analysis
- FFP condition monitoring
- Filtration Test Rig (FTR)
- Utility references – South Africa

# Pulse Jet Fabric Filter Plants

# PJFF and components

- Filter bags - filter material
- Anti-collapse cages to support the bags
- Tube plate to support the bag / cage assembly
- Pulsing system to clean the bags
  - High / medium cleaning pressure
  - Low cleaning pressure
- Casing and hoppers (steel or concrete)
- Hopper dust removal system
- Inlet and outlet dampers
- Inlet and outlet ducts and manifolds
- Suction fan
- Control system
  - Operation
  - Protection
  - Monitoring

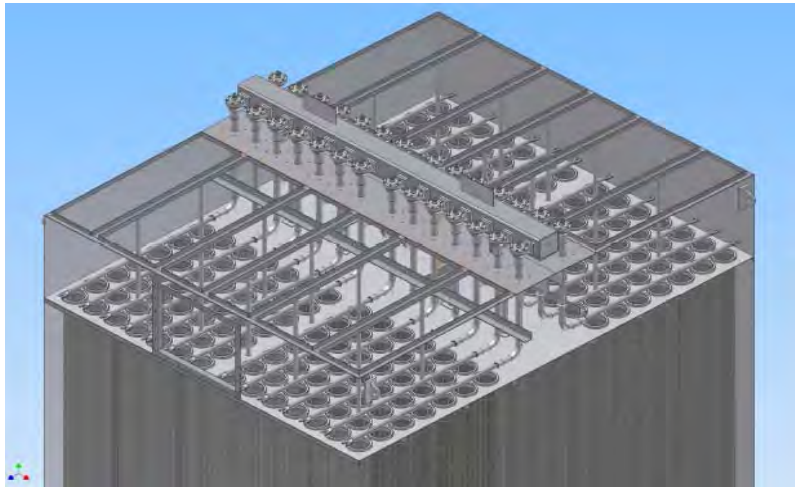


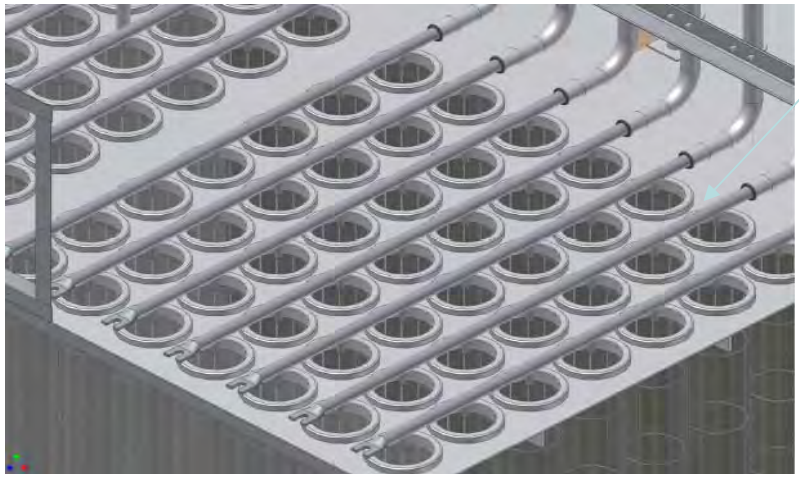


# Typical PJFFs medium / high pulsing pressure

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

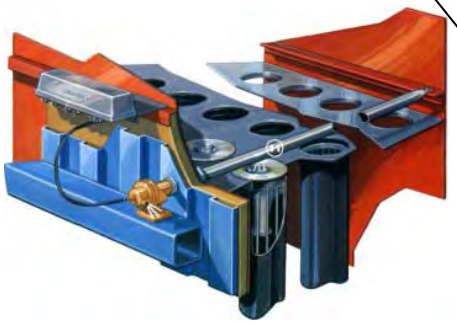
# Bags cleaning – high pressure system

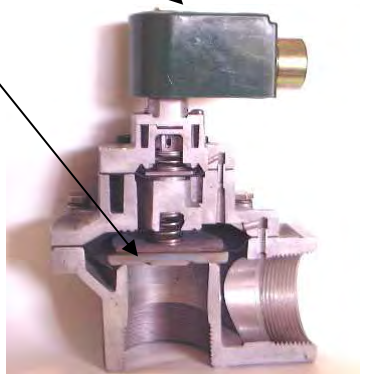




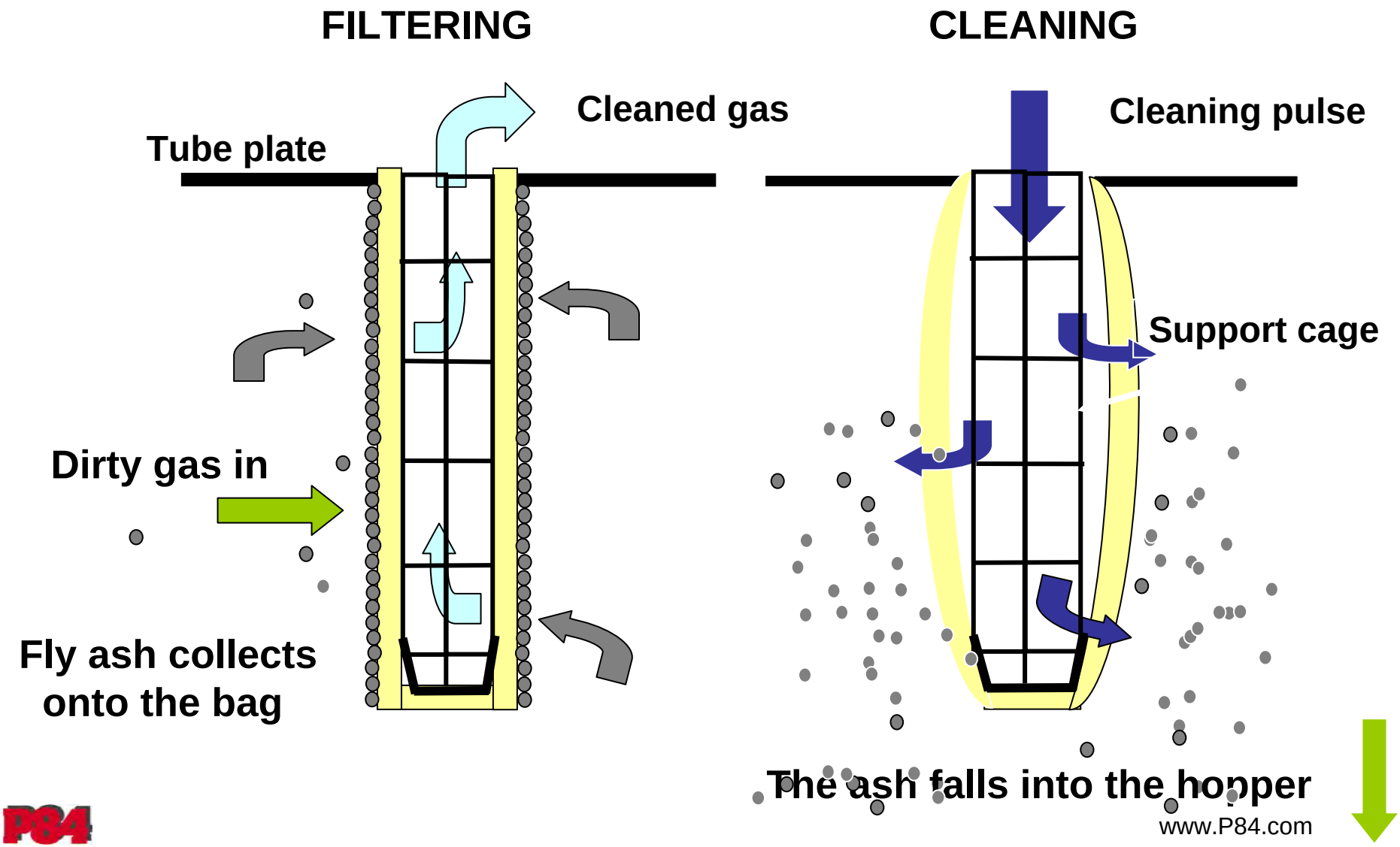
Compressors – air dryers – pressure regulating valve – pulse tank – pulse valve – pulse pipe – nozzles - Venturi

The Solenoid Pilot Valve is opened intermittently via the PLC pulse control. This releases the pressure from the back of the diaphragm allowing the Diaphragm to deliver a pulse of air to the Pulse pipe / row of bags.





# Cleaning of the filter bags

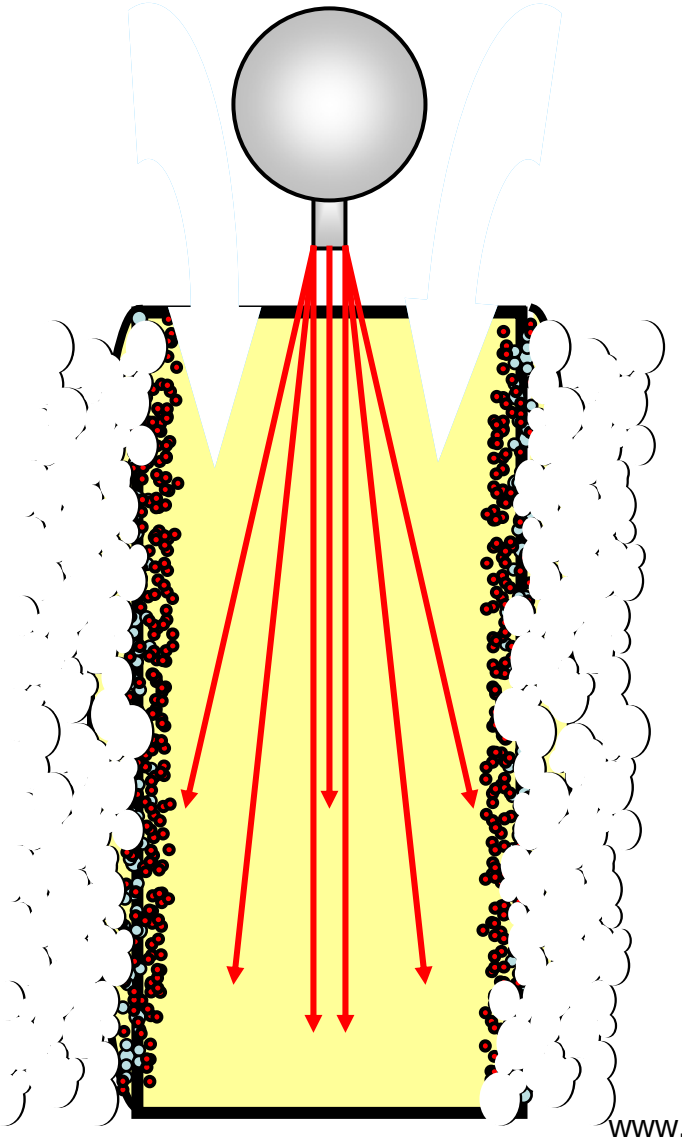


# In-line bag filter cleaning mechanism

- **The pulse generates a 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

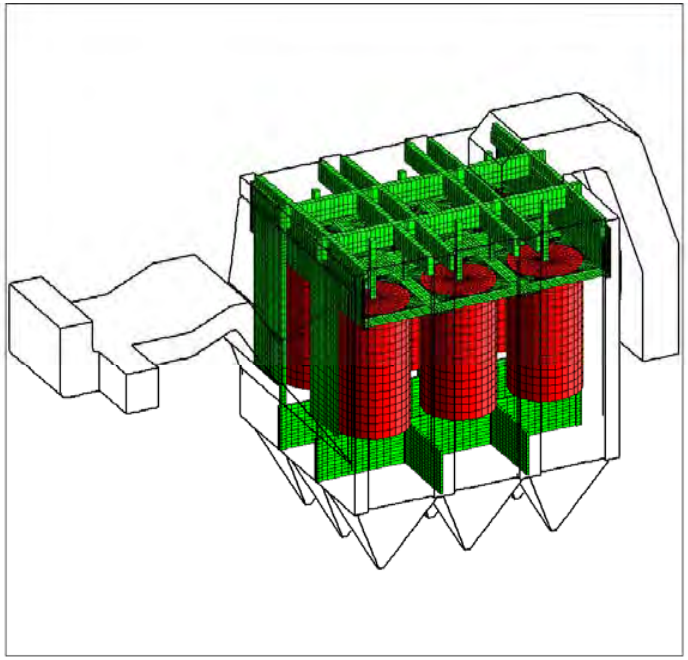


# High pressure cleaning system
## Problems

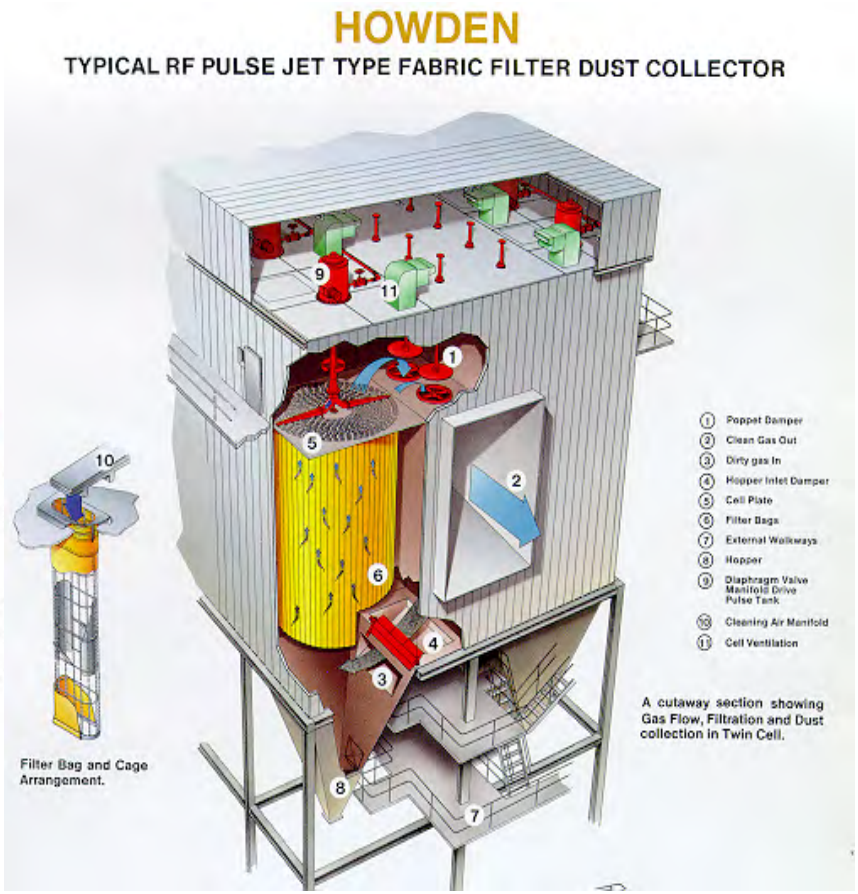
- Pulse pipes – loose, not fitted
- Miss-aligned pulse pipe nozzles
- Faulty pulses valves
- Solenoid valves – missing or not connected
- Corrosion - pulse tanks, pulse pipes
- Generate high pressure losses

# Typical PJFF
# Low pressure pulsing

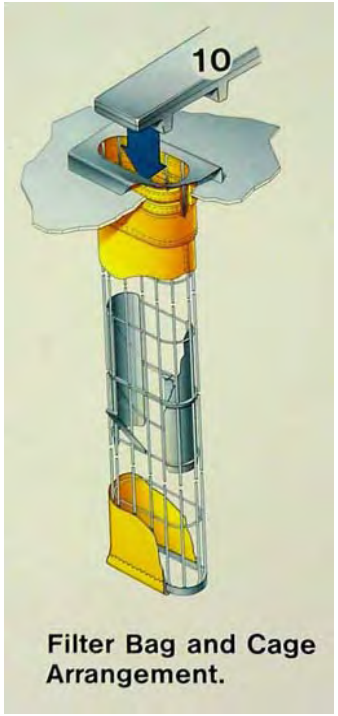
- **Low pressure pulsing**
  **max. 1 bar**
- **Components**
- **Cleaning**



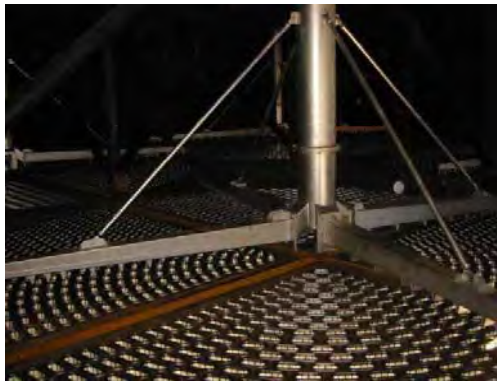
CFD Modelling of the BHSA Fabric Filter System at Hendrina Units 2–5

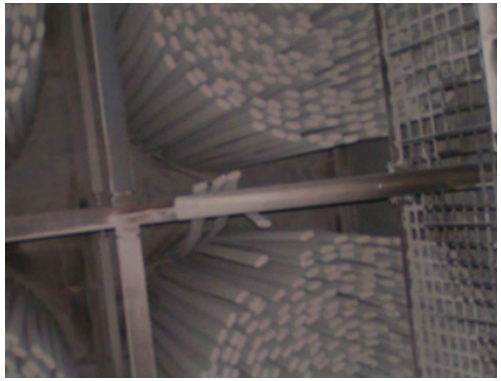


# Low Pressure pulsing PJFF




Filter Bag and Cage Arrangement.





# Bags cleaning – low pressure system

- Oval bags and cages
- Rotating manifold
- Pulse valve
- Pulse tanks – large - on the BH roof
- Blowers – reliability, back up
- Pulse characteristics – random, etc.

# PJFF components casing, tube plate…

- **Tube plate / casing seal – leaks!!!**
- **Lining of the concrete clean gas chamber**
- **Tight seal for doors and inspection windows - corrosion**
- **Structural supports – integrity - inspections**
- **Tube plate collapse risk**
- **Inspections!!!**
- **Operating procedures to prevent cell plate overloading**

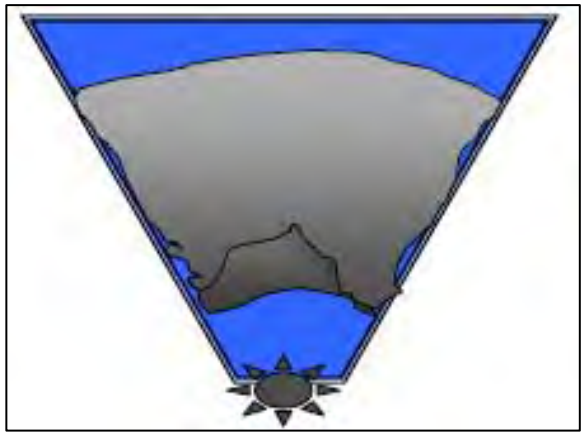

Bag or tube plate leaks!!!

Casing / tube plate corrosion

Casing / tube plate leaks

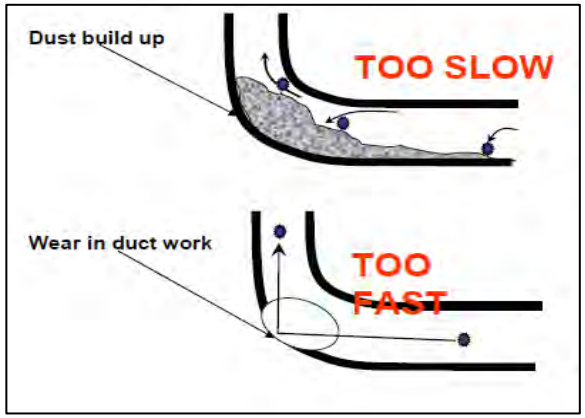
# …ducts, dampers, hoppers…

Brocken expansion joint



Hopper blockage – dust bridging

- **Ducts**
  - Air in-leakage, corrosion, gas turbulences, abrasion
  - Increased gas flow
- **Hoppers**
  - Blockages, high dust levels, flow dynamics, slope, heaters - condensation, lining
- **Dampers**
  - Sealing, emissions (by-pass)




Duct gas velocity

# …bags and cages

## Filter materials - to suit the process conditions:

- Gas flow, minimum, maximum, average and gradient temperatures
- Gas analysis including $SO_3$ concentrations, acid dew point, $O_2$, $NO_2$, moisture, etc.
- Dust loading, dust characteristics (particle size distribution, particle shape)
- Operating regime (acid dew point crossings, etc.)

## Cage design

- To provide filter material support - needle felt (PTFE, PPS, P84 or woven glass)
- Allow the bag cleaning – tight tolerances bag / cage (needle felt, glass membrane)
- Material selection – carbon steel (coatings, galvanized), stainless steel
- Transport, packing, handling, storage, process environment

# Bag replacement installation problems

Installation problems:

- Snap bag fitting
- Oversized bag
- Venturi installation
- Membrane damage during storage, handling and installation
- Cage alignment (oval bags)

# Typical bag failures

**Bag too long**

Longitudinal seam

Poor stitching

Abrasion


Abrasion


Pulse misalignment

# Typical bag failures

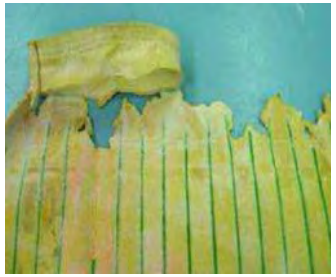
**Heat damage – over-temperature**

Acid damage

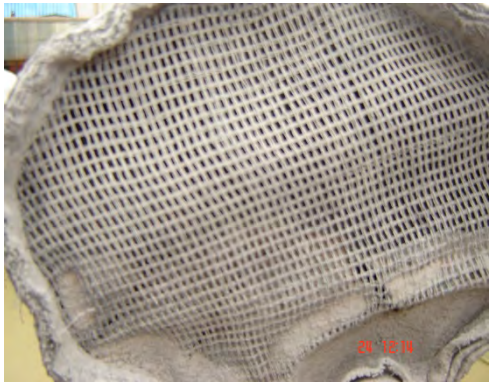
Moisture blinding

Cuff abrasion

Hydrolysis

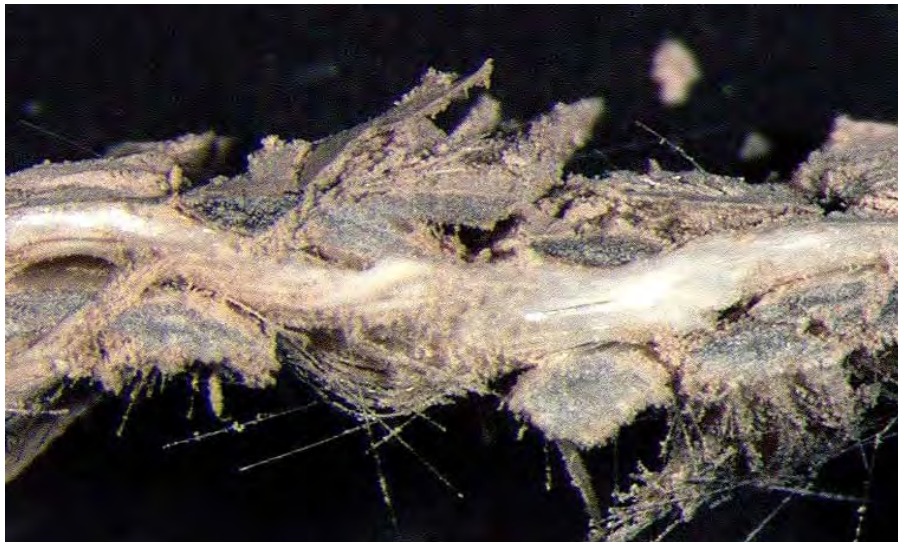


# Abrasion and repairing of bags



# Woven glass / membrane material failures

Damaged membrane on a woven glass / PTFE substrate

Damaged and delaminated membrane
Dust penetration – failure of filter material

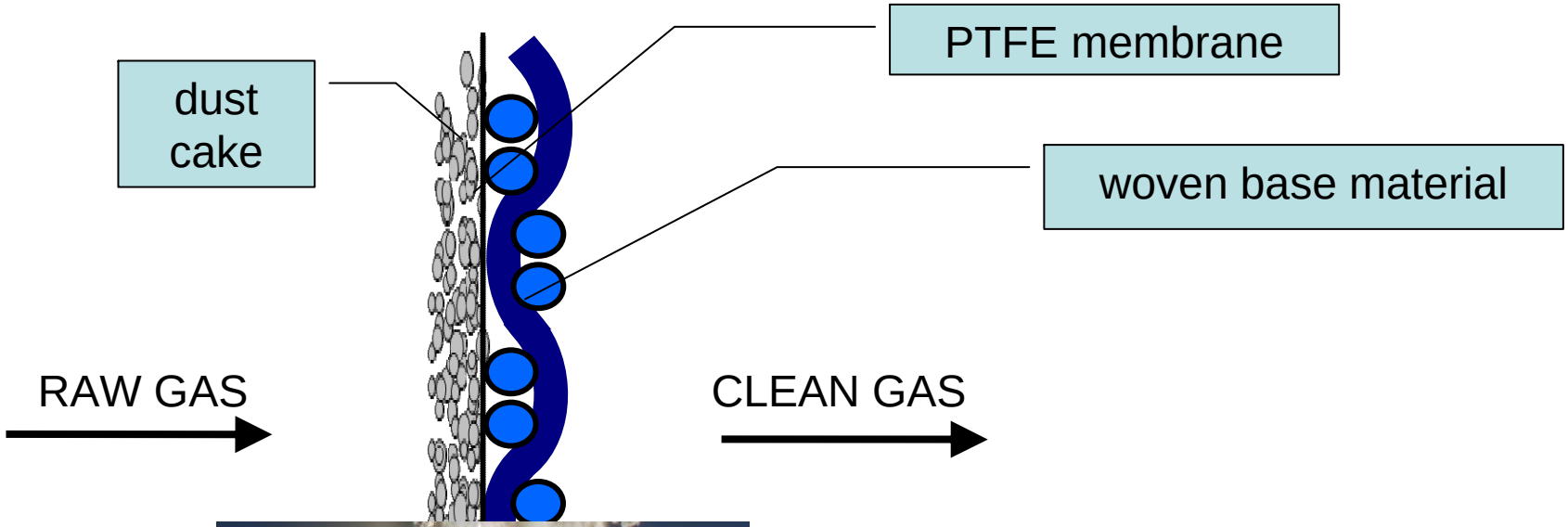
# In-situ bag cleaning - Air permeability meter

In-situ bag cleaning device

In-situ permeability measurement

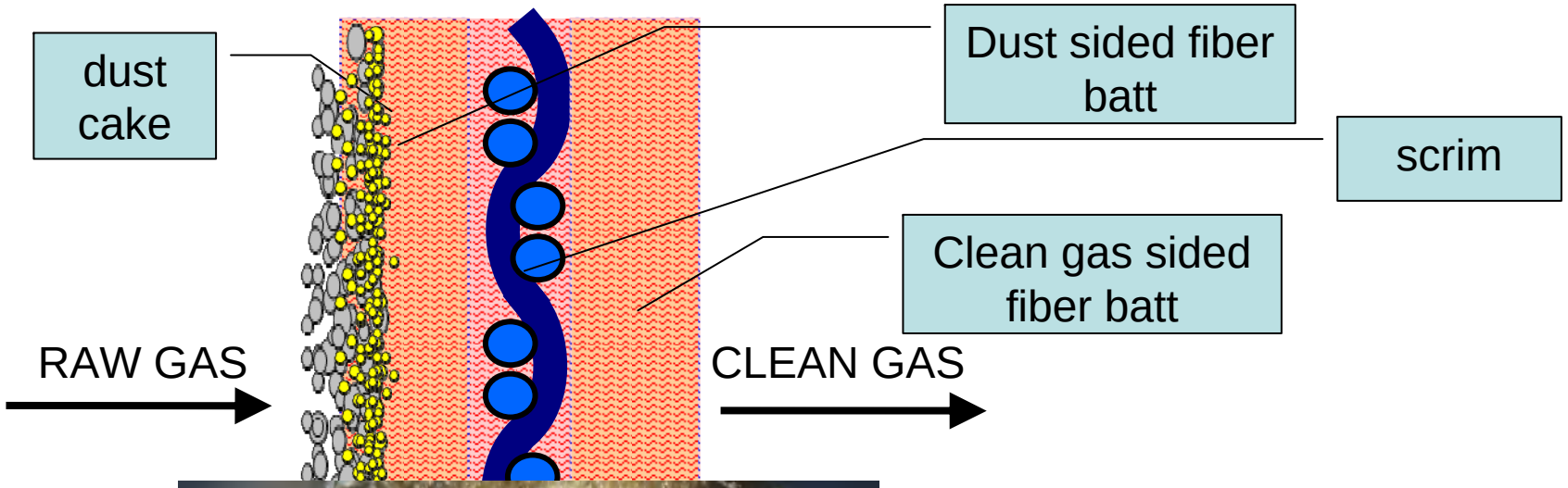
# Filter Media

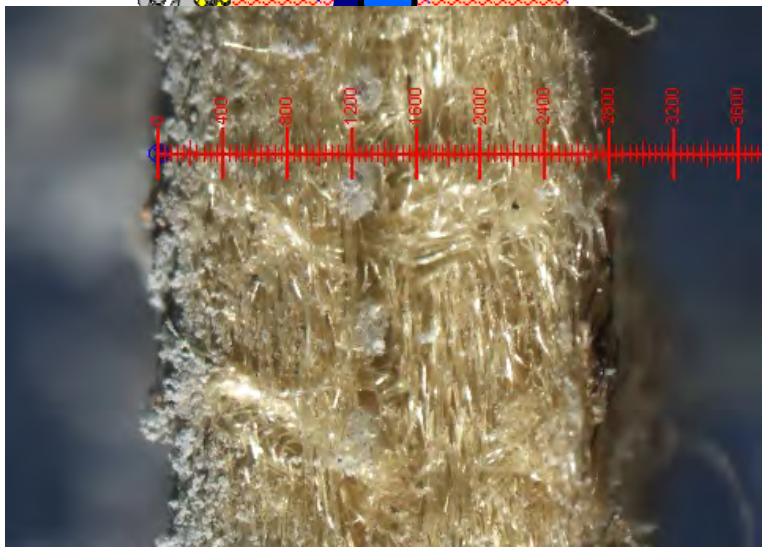
# Filter media construction
# Woven / Membrane materials




- **Woven fiberglass materials, also PAN**
- **Reverse air, shaker plants**
- **Laminated with PTFE membrane to increase the filtration efficiency**
- **Limitations (support, abrasion, flexing)**

# Filter media construction
# Nonwoven materials



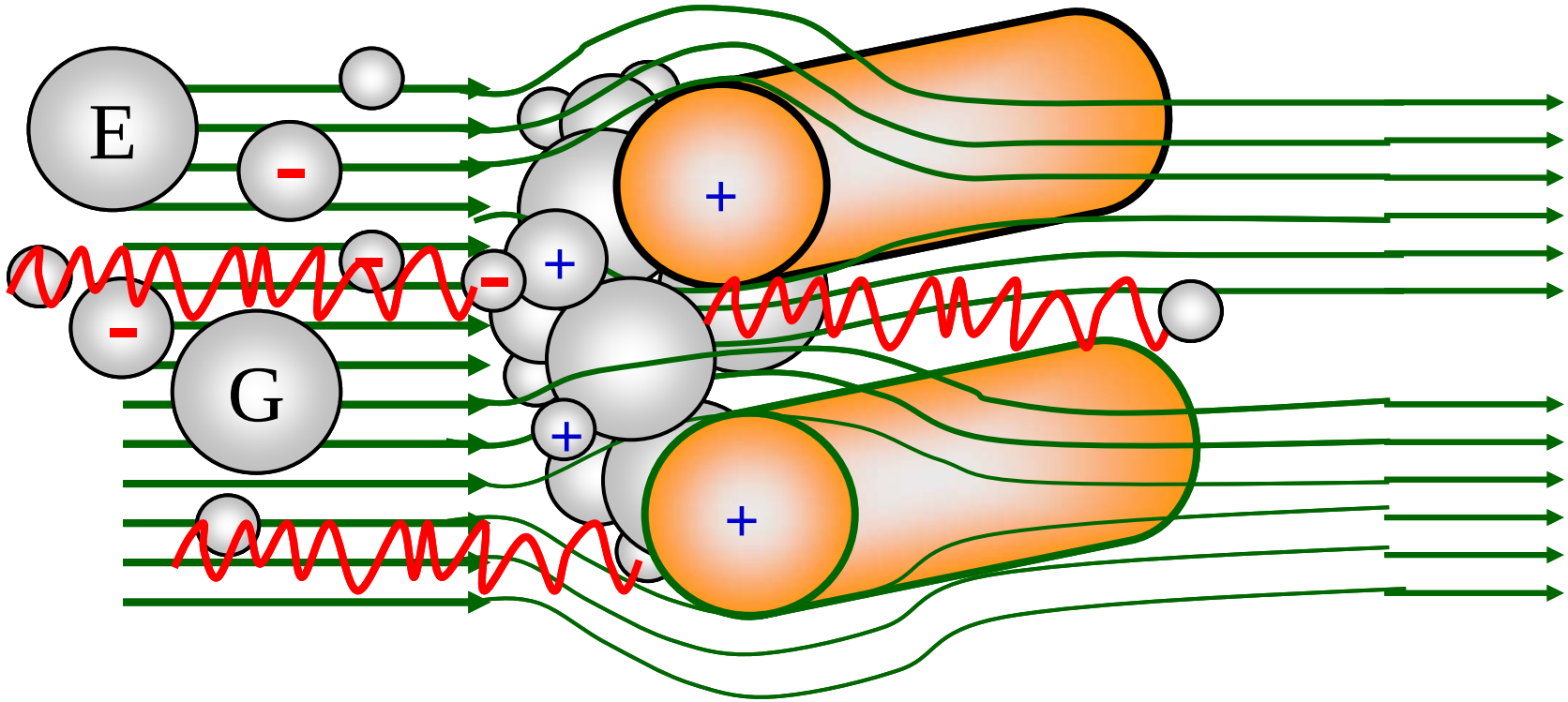



- **Best mechanical properties**
- **Good flexing characteristics**
- **Abrasion resistance**
- **High filtration efficiency**
- **High filtration velocities**
- **Blending of fibers**

# Filtration mechanism

# Filtration mechanism

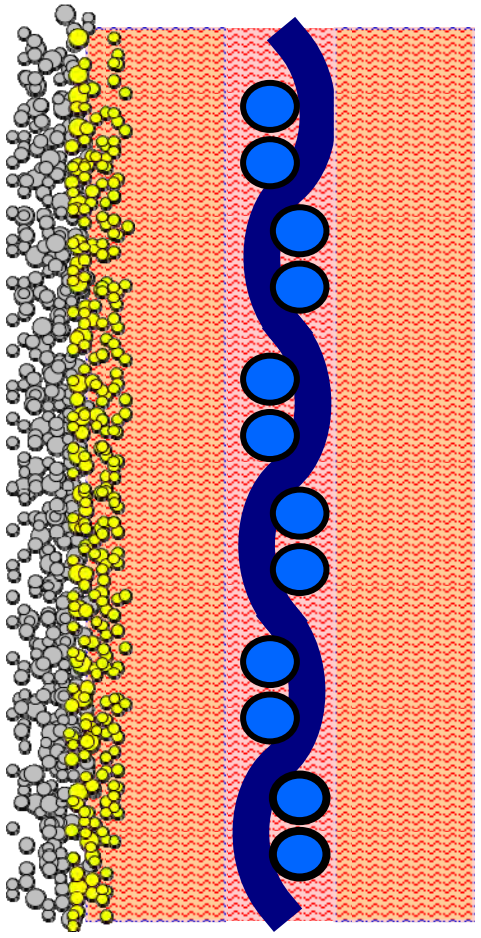
Sieving, impaction, agglomeration, electrostatic, cake filtration




Pre-coating of filter bags to establish the dust cake

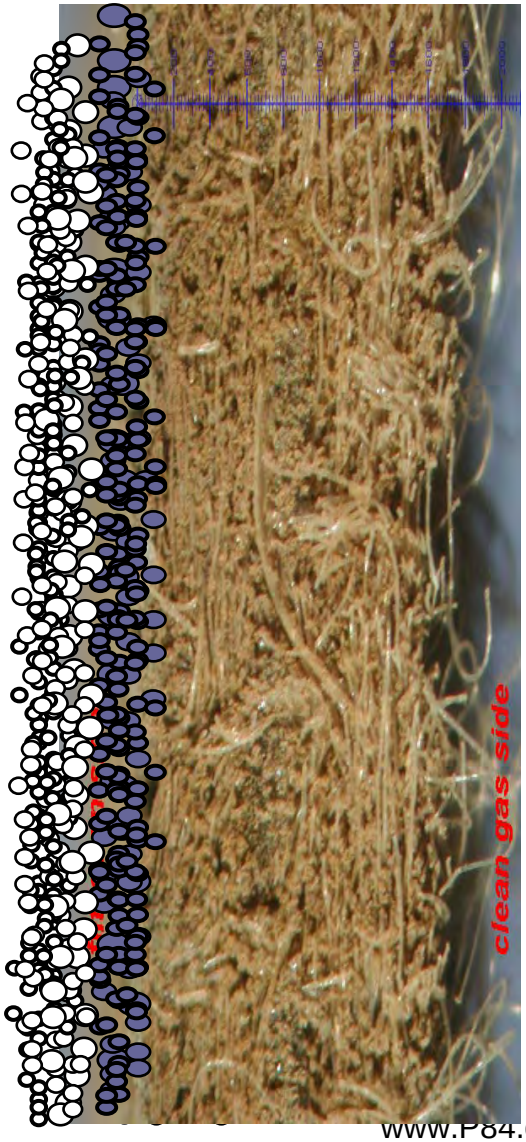
# Dust cake filtration

- 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

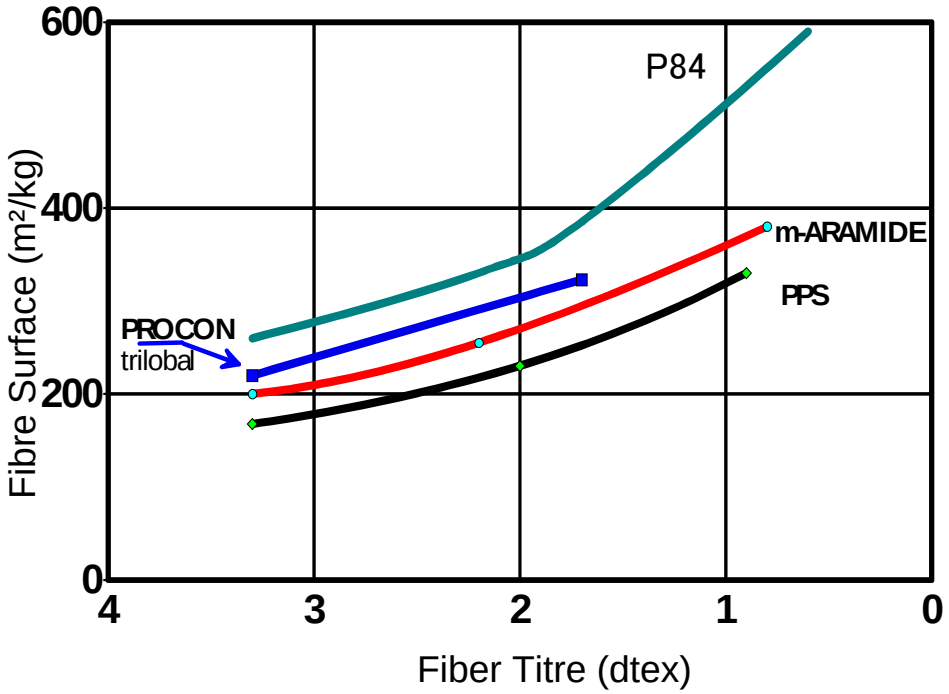


# Blinding of filter media

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



# Fibres - specific surface area

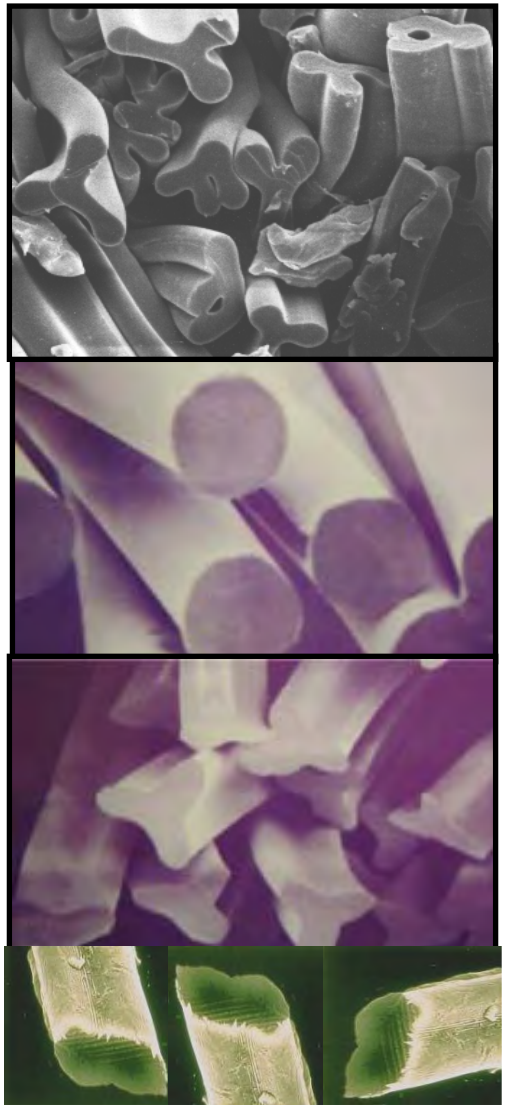



P84 (multilobal) 2,2 dtex (340 m²/kg)

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

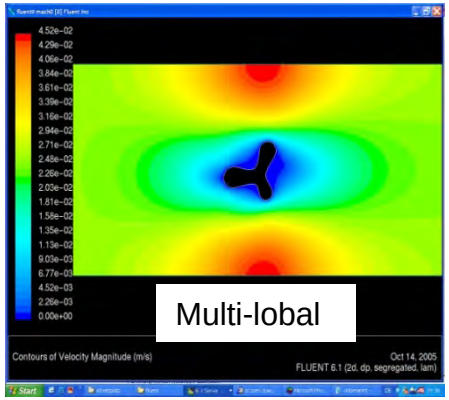
Procon (PPS) 1,7 dtex trilobal (317 m²/kg)

M-aramide 2,2 dtex

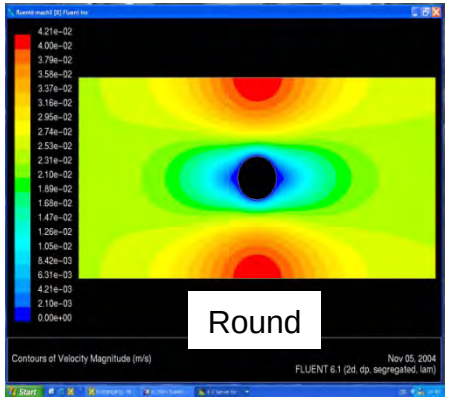


- Higher surface area at microscopic level
- Lower ΔPs (ΔPs = ΣF / A)
- Increased filtration efficiency

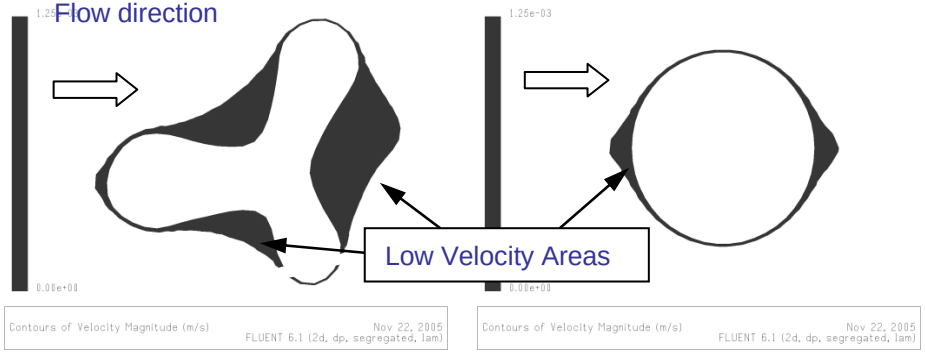
# Charging of fibres



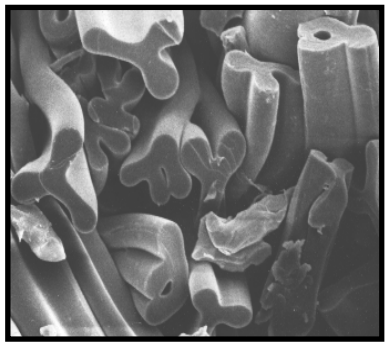

**P84 multi-lobed fibres show larger areas with low flow velocities compared to round fibres.**



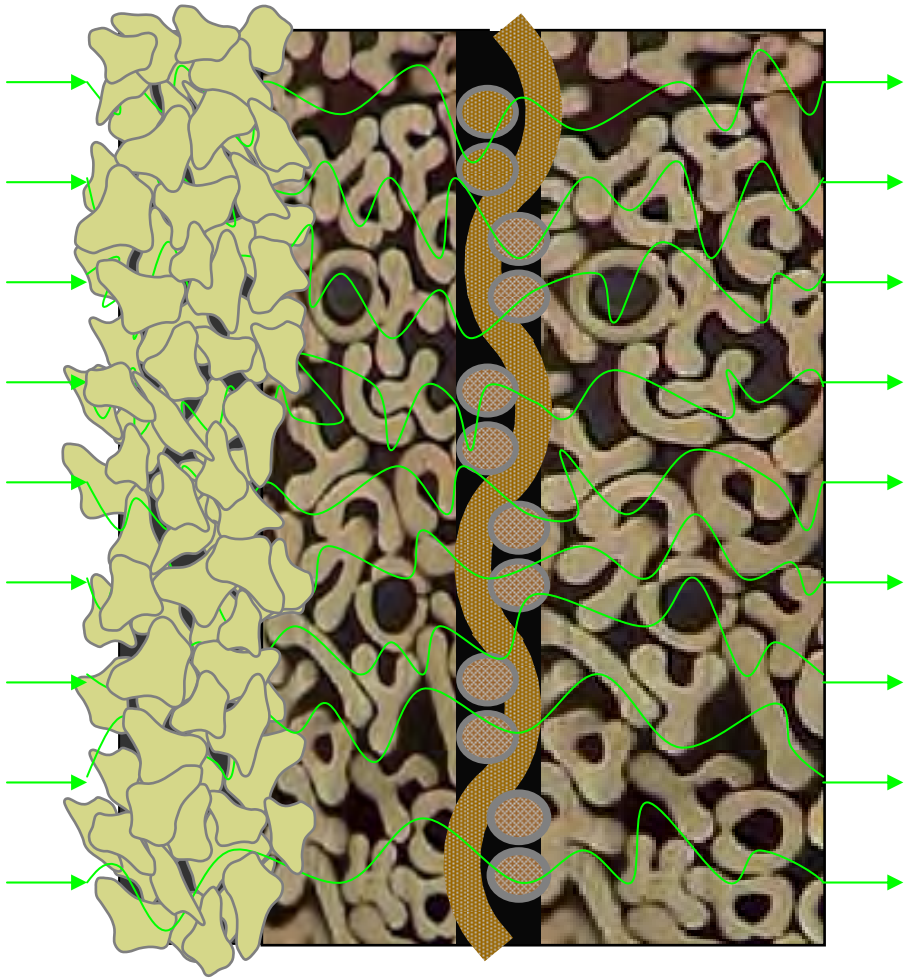

**Charging of P84 multi-lobed and round fibres**



# 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

# 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**

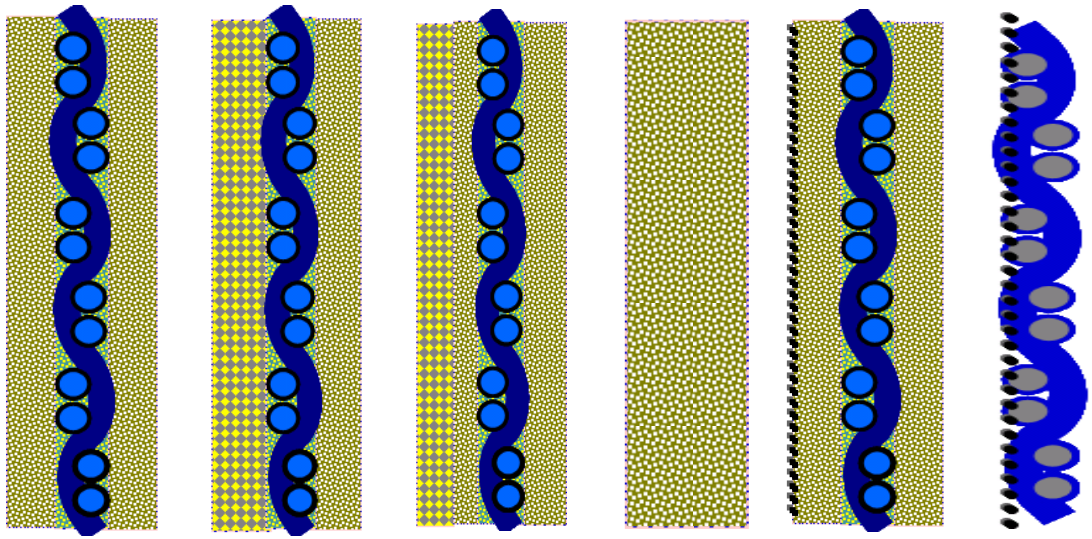
## Fibre Blends:

- **PAN + P84 / PAN scrim**
- **PPS + P84 / PPS scrim**
- **PPS + P84 / PTFE scrim**
- **PTFE + P84 / PTFE scrim**

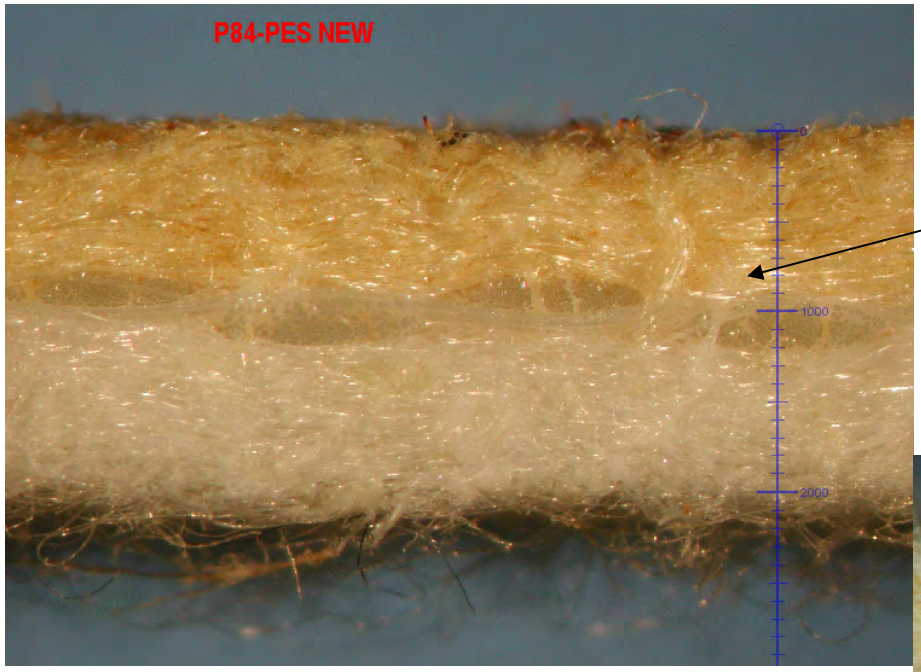
## Membrane materials

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

## CFB FFP filter material constructions

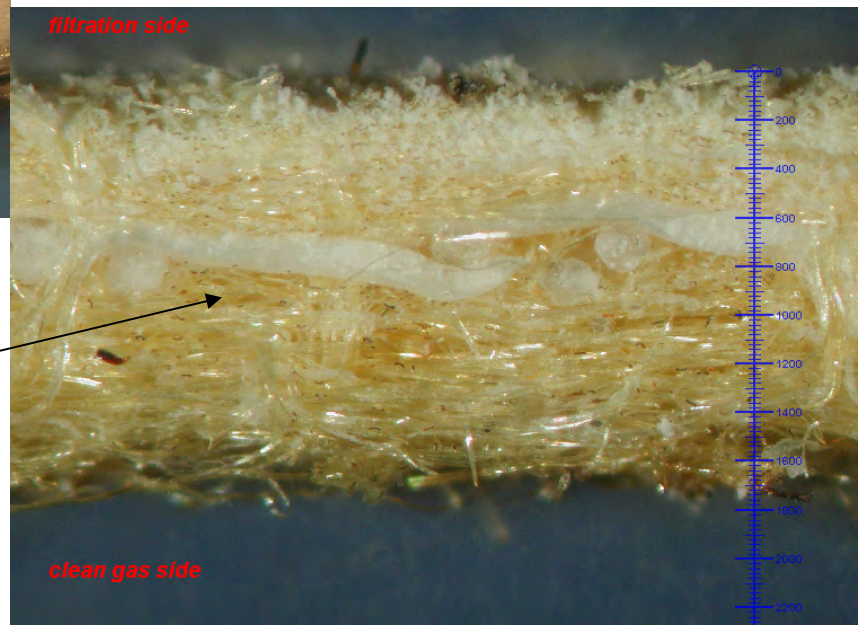


# Examples of filter materials based on fibre blends




## Asymmetric design

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




## Symmetric design

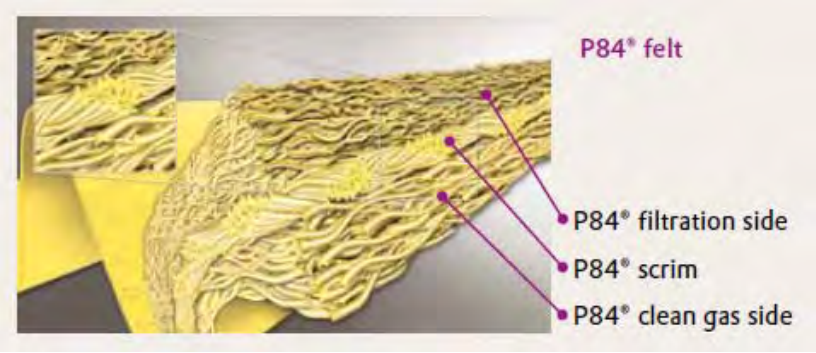
**70/30 blend of PTFE and P84**
**PTFE scrim**
**70/30 blend of PTFE and P84**

# Dust Cake Implications

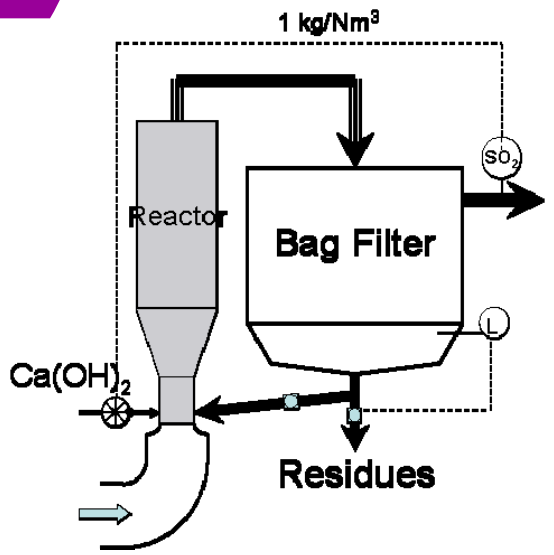
# Benefits – multi-lobed felt based dust cake

## 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 multi-lobed 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 – multi-lobed felt based dust cake - chemistry




**The bag house acts as a fixed bed reactor**

- **Fibres protection against acid degradation as the 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 multi-lobed felt holds a larger dust cake ensuring more surface contact with the gas molecules and more effective chemical reactions**

# Mercury control - CFBs

- Hg enters the emission control device as a mixture of Hg, $Hg^{2+}$ and $Hg_p$
- Hg and $Hg^{2+}$ are entrapped in the AC and dust pores
- $Hg_p$ is removed as a solid
- ACI: AC required with high surface and pore areas
- ESP, FF, Dry FGD (reactor + FF)
- Hg / $Hg^{2+}$ gas and vapour: good contact with AC required
- Dust cake is very important - the filter material must generate a cake with a surface area
- Multi-lobed P84 fibres
- The membrane type materials are not holding a dust cake

# 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)

# 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

## Oil carry-over

- 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

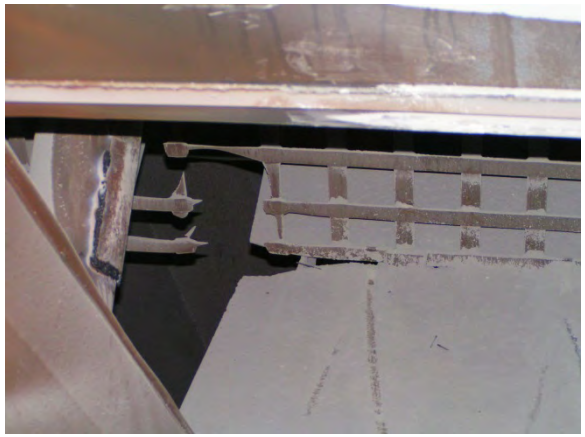
- Changes the flow dynamics in the hopper flow dynamics,
- Dust not settling
- Sand blasting effect on bags and structure
- Premature failure of filter bags – abrasion
- Blinding
- High ΔPs
- Load losses – combustion chamber suction
- Premature failure of the cleaning system - blowers and pulse valves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

# FFP Condition Monitoring

# Bag filter condition monitoring

**Why?**

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

**How?**

- **Laboratory analysis of bags**
  - **Basic analysis**
  - **Advanced analysis – failure investigations**
- **Laboratory testing of filter media**
  - **VDI guideline 3926**
- **In-situ testing**
  - **Evonik Filtration Test Rig (FTR)**

# Bag filter condition monitoring

- pH
- Weight
- Visual Inspection
- Air Permeability
- Tensile Strength (stretch)
- Mullen Burst Test (overall stretch)

Sample cutting

**Mechanical Test**

**Air Permeability**

**Chemical Analysis (FT-IR )**

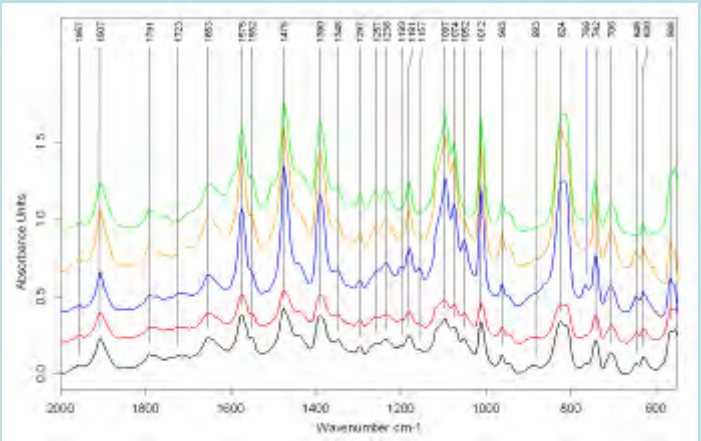
**Performance Test (VDI 3926)**

# Laboratory filter media analysis PPS

## FTIR (Fourier Transformed Infrared)

- Identification of polymers
- Determination of ageing and degradation mechanisms

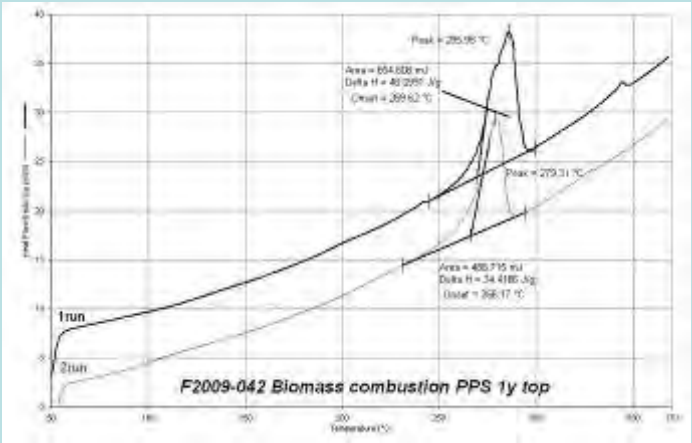
FTIR




## DSC (Differential Scanning Calorimetry)

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

DSC



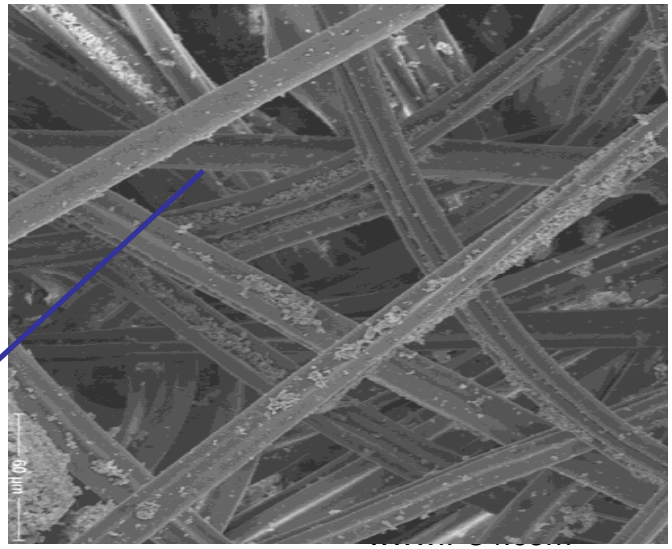
# Charging of P84 fibres & filter media

- **P84 fibres charged with dust before laboratory pulse cleaning**

Fine dust captured between the P84 fiber lobes


- **Filter media laboratory pulse cleaned**

Round fiber with little dust on the surface



# Filtration Test Rig

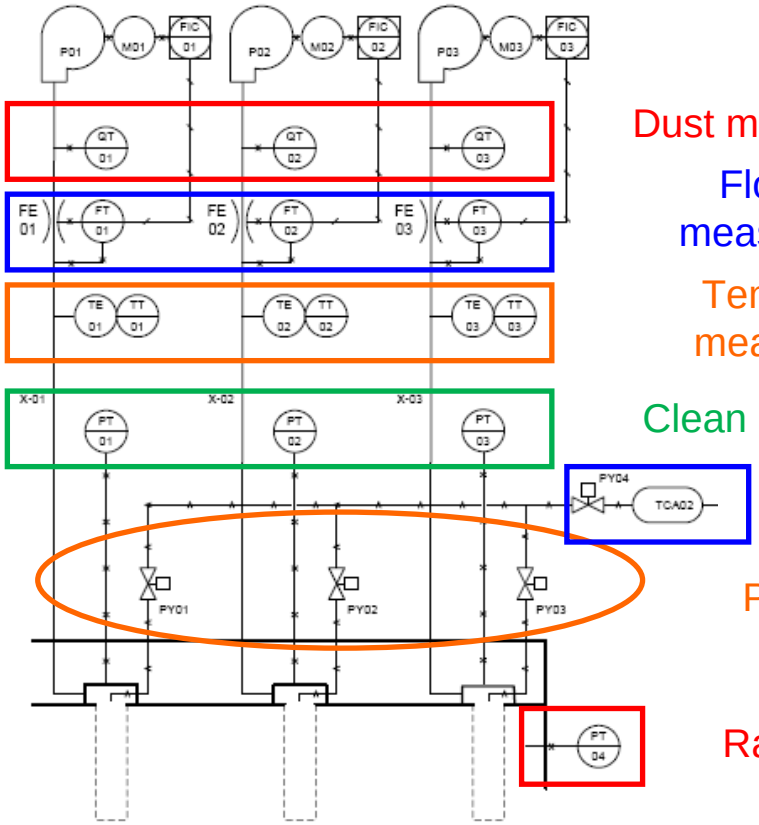
## Enel – Evonik Fibres Cooperation

# In-Situ Filtration Test Rig (FTR) Description

- **The FTR is aimed at testing 2 or 3 types of filter materials (bags) in a fabric filter plant in relation to:**
  - **Filtration properties - ΔP, pulse rate, particulate emission**
  - **Chemical behaviour**
  - **Shrinkage**
  - **Abrasion resistance, etc.**
- **The bags are installed in the main plant and are exposed to the actual gas and dust. Same chemical and temperature conditions.**
- **The acceleration of the test or ageing of the bags (if required) is achieved through the operation of the test rig at higher gas flow rates as compared to the actual bag plant.**
- **The bag filter ageing effect can be achieved by increasing the filtration face velocity by a factor of 2 - 3.**
- **FTR programmed to run with selected parameters for each bags specific test.**

# Schematic of the Filtration Test Rig

Fans with variable speed controller




Dust measurement

Flow rate measurement

Temperature measurement

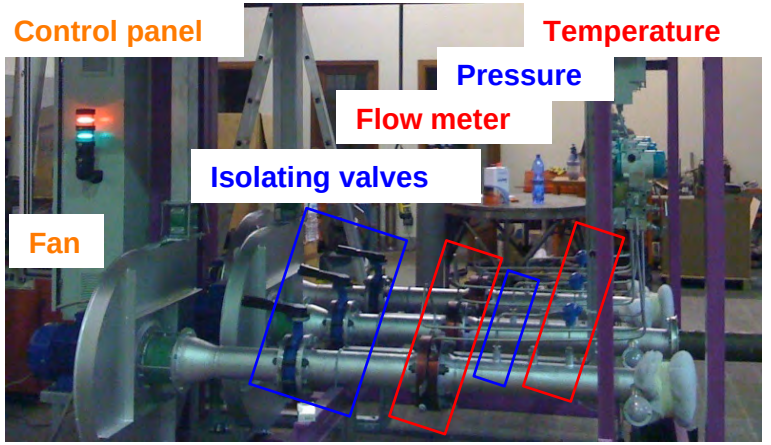
Clean gas pressure

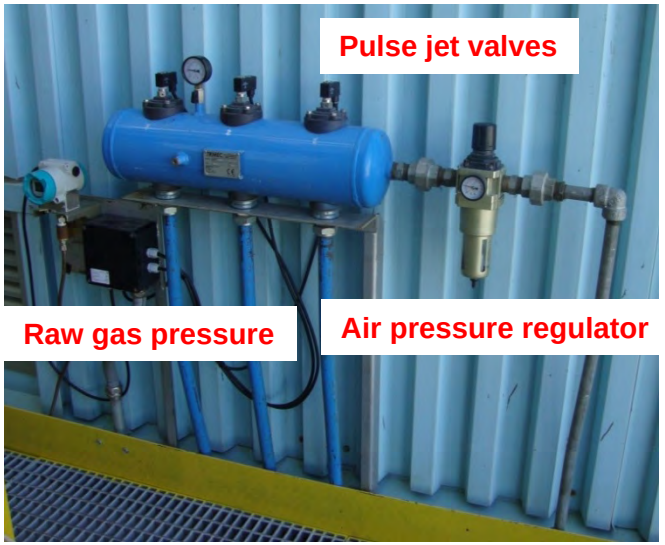
Pulse jet cleaning air tank

Pulse jet cleaning valves

Raw gas pressure

Test Filter Bags inside the full scale FF

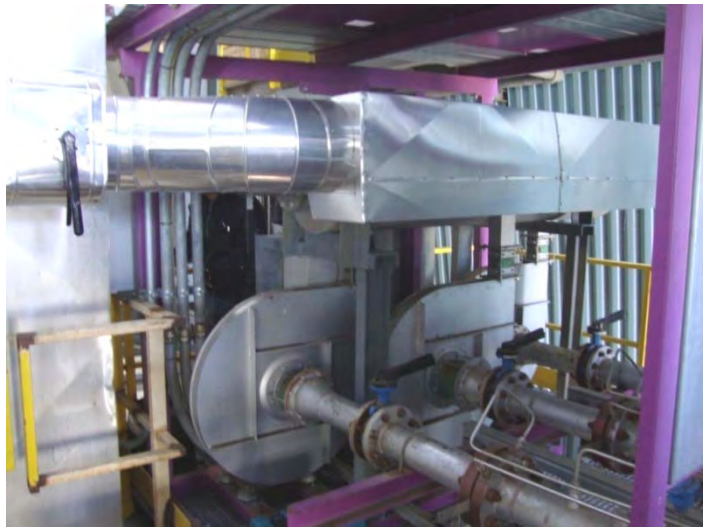


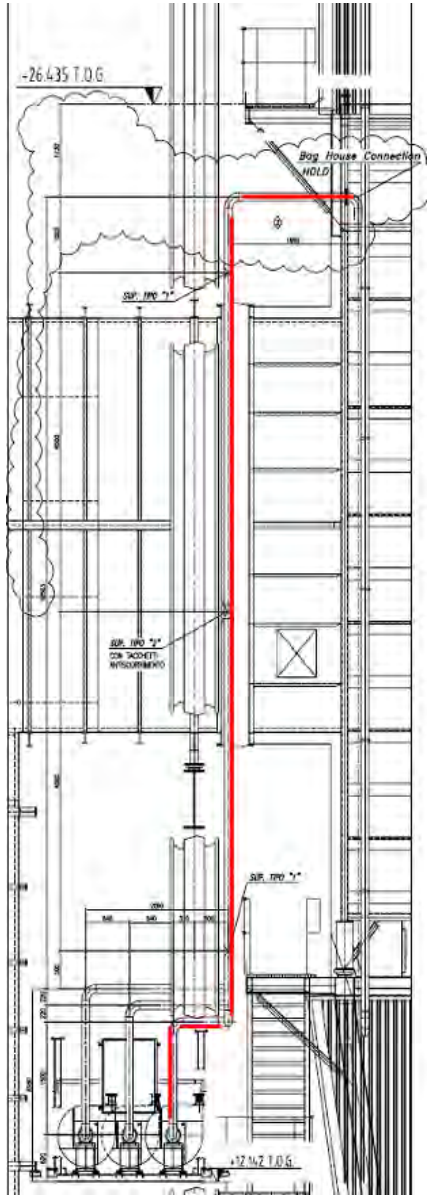



# Enel - Evonik FTR 1 - TVN

Main features of EEFTR-1:

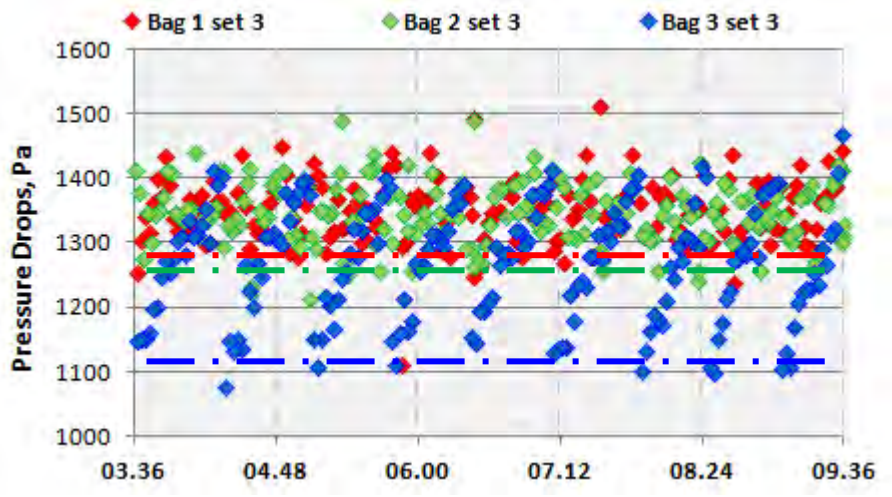
- ✓Installed on a 660 MWe coal fired PP;
- ✓Multi-compartment FF (16);
- ✓Design filtration velocity of FF 1,1 m/min;
- ✓The FF is equipped with a HPLV cleaning system;
- ✓Operated with low-medium ash content (6-15 g/Nm$^3$);
- ✓Low NOx content;
- ✓3 test lines with dedicated fans and flow rate controller;
- ✓Because of long pipe path heat tracing has been added;
- ✓Reverse flow problems
- ✓Automatic valve on gas restitution to automatically exclude the skid

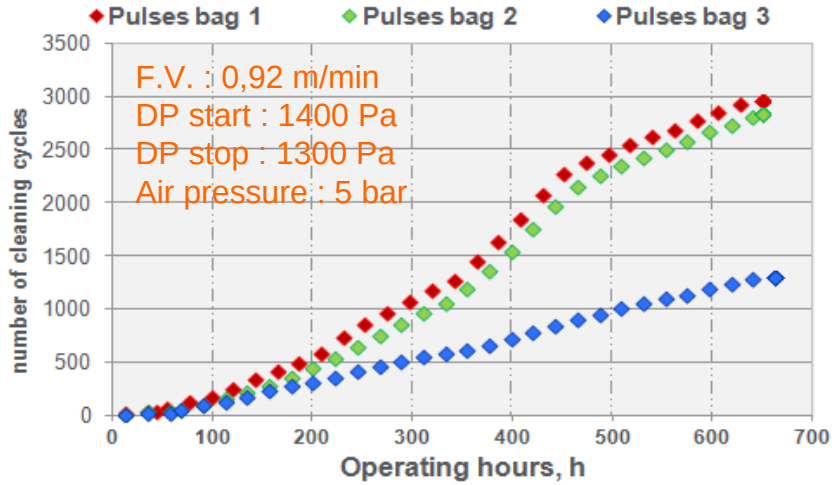


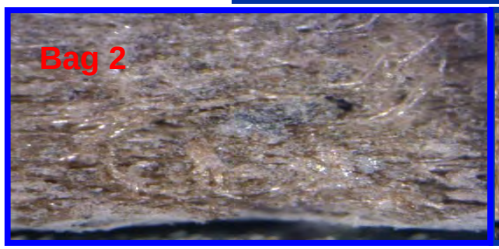
# EEFTR-1- TVN results 3

| | | |
|---|---|---|
| Bag 1: | PTFE felt + PTFE Membrane | NEW |
| Bag 2: | PPS felt + PTFE Membrane | NEW |
| Bag 3: | PPS+(PPS 2,2 dtex+P84 1,7 dtex) reference | NEW |









| Specific weight | | Bag 1 | Bag 2 | Bag 3 |
|---|---|---|---|---|
| As Received | g/m² | 1013 | 635 | 952 |
| Cleaned | g/m² | 990 | | |
| Washed | g/m² | 959 | 586 | 749 |
| **Air permeability** | | | | |
| As Received | l/dm² @200 Pa | 9 | 13 | 16 |
| Cleaned | l/dm² @200 Pa | 10 | 21 | 44 |
| Washed | l/dm² @200 Pa | 14 | 49 | 109 |
| **Breaking load** | | | | |
| longitudinal | N | 852 | 877 | 1379 |
| cross | N | 747 | 1816 | 1689 |
| **Elongation** | | | | |
| longitudinal | % | 11,5 | 26,5 | 26 |
| cross | % | 19 | 25 | 36 |

**Higher residual pressure drops for membrane bags;**

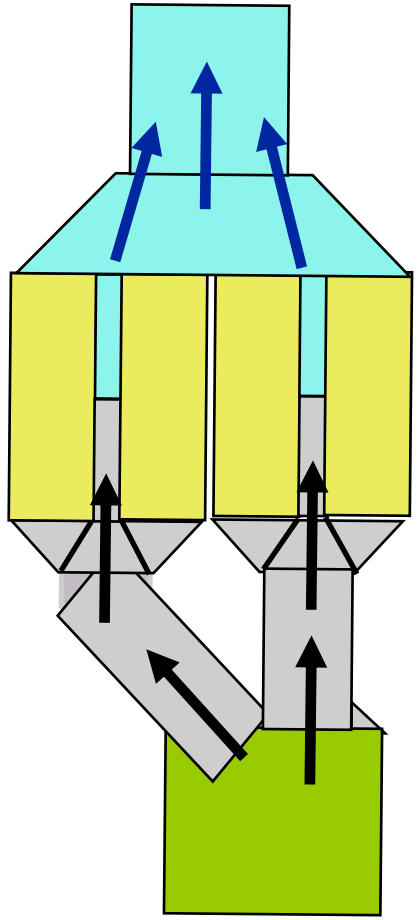
**No significant dust penetration;**

**No significant bag properties degradation;**

**Reference bag allows lower power consumption**

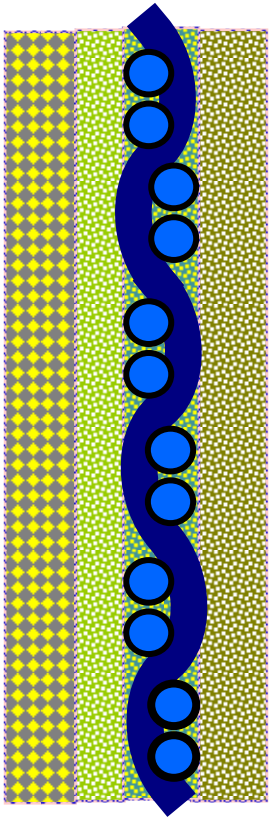
# References

# Arnot P/S FFP



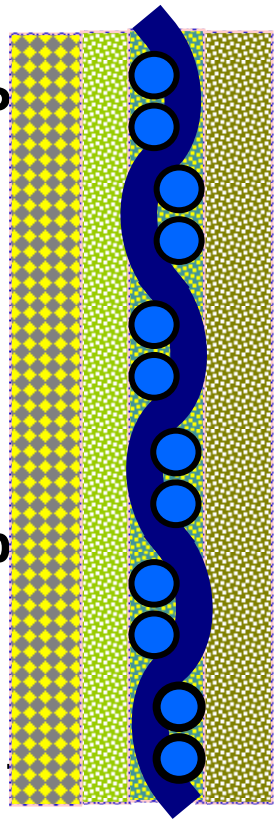
# Technical specification - Arnot FFP, Units 4, 5, 6

- PF Boiler - ICAL
- OEM: Walther Environmental Systems
- Fabric: PPS/(PPS scrim)/ PPS/P84& Procon trilobal
  - PPS is 2.2 den
  - Procon trilobal 1.7 dtex
  - P84 1.7 dtex
- Number of bags: 10966 /unit
- Length: 8m Surface area: 3.74m$^2$/bag
- Temperature set points: 160$^o$C alarm, 170$^o$C trip
- $\Delta$P set point: 12 - 14mbar for normal operation
- Gas to cloth ratio (filtration velocity): 0.0177m/s for 350 MW
- Type of cleaning pulse: high pressure low volume



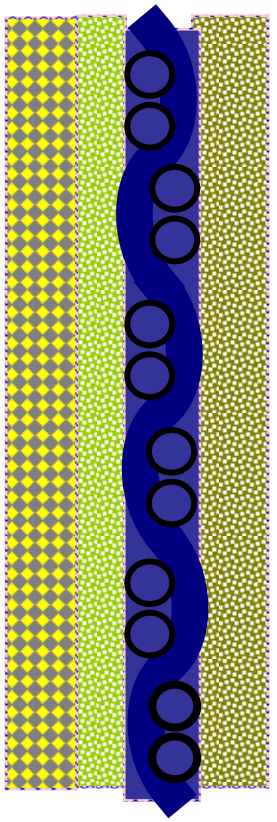
# Technical specification - Arnot FFP Units 1,2 & 3

- PF Boiler - ICAL
- OEM: Alstom
- Fabric: PPS/(PPS scrim)/ PPS/P84 & Trilobal PP
  - PPS, 2.2 den
  - Procon 1.7 dtex
  - P84 1.7 dtex
- Number of bags: about 14000 /unit
- Length: 8m Surface area: 3.74m$^2$/bag
- Temperature set points: 160$^o$C alarm, 170$^o$C trip
- ΔP set point: 12 - 14mbar for normal operation
- Pulsing pressure: variable 3 – 6 bar
- Gas to cloth ratio (filtration velocity): 0.0177m/s
  MW
- Type of cleaning pulse: high / medium pressure low volume



# Events / Performance

- Temperature excursion unit 4 LH
- Control philosophy – FFP cleaning
- Tube plate sealing leaks: modification for units 1, 2 & 3
- Fabric damaged due to inadequate length
- Pulse pipe design modification
- Failure mode: breaking of material / abrasion, oxidation
- Fine fibre surface area required to prevent blinding
- Future plans: quality checks,
- Oil carry-over, high ΔPs, limited bag life, etc.
- Best performance: 55000 hours of operation – Unit 2



# Tube plate leaks (unit 4) / long bags (unit 5)

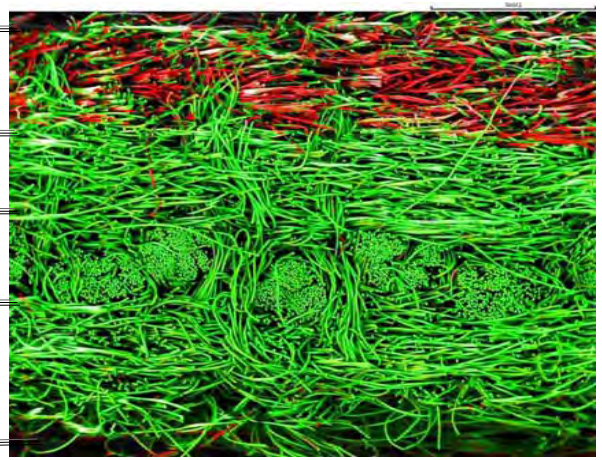
# Scanning Electronic Microscopy
# EDS Arnot

Surface defined P84 layer

Second defined PPS layer

Support scrim

Inner PPS layer

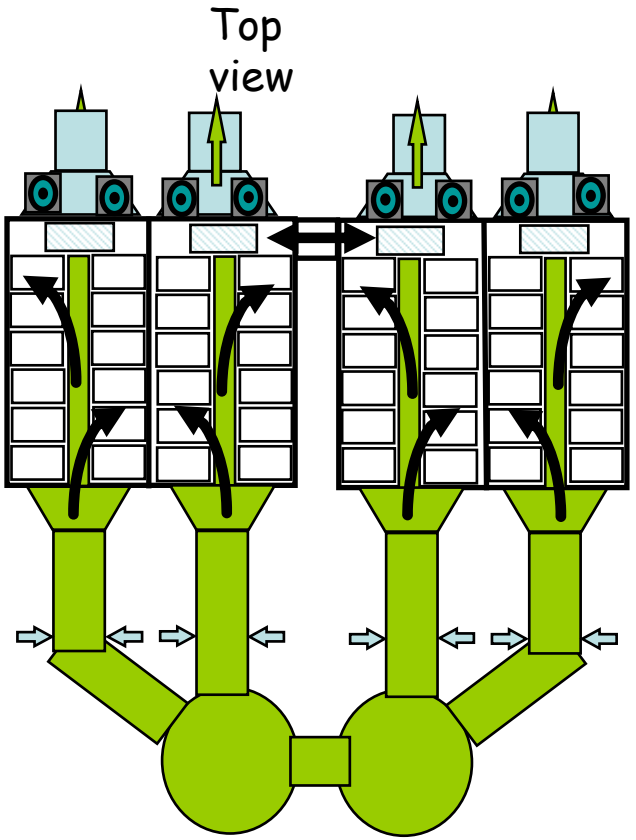


Only few P84 fibres spread in a single fibres layer

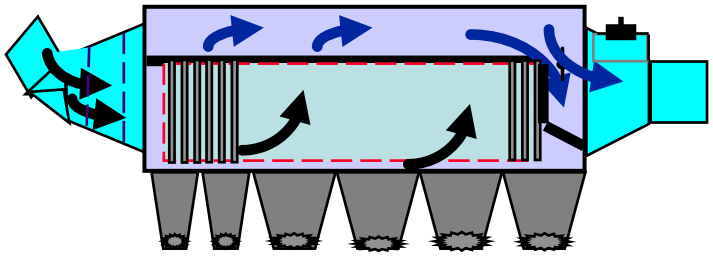
Support scrim

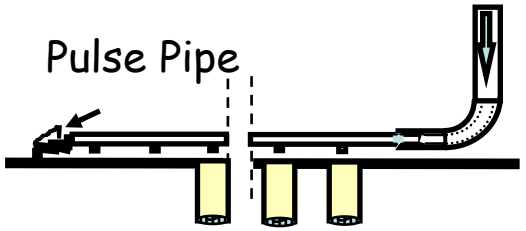
Inner PPS layer

# Duvha P/S FFP




Side view

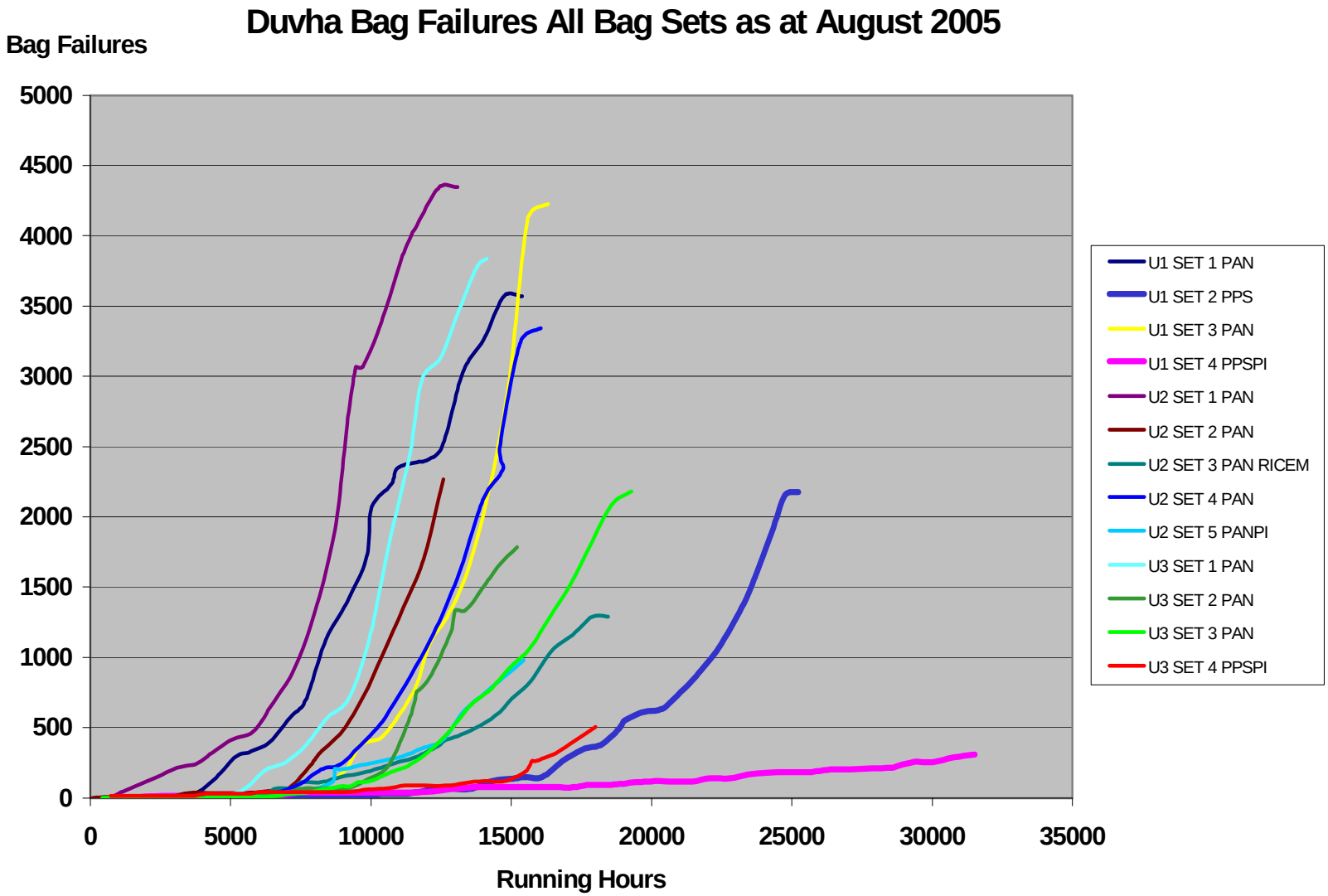




# Duvha - Fabric filter design

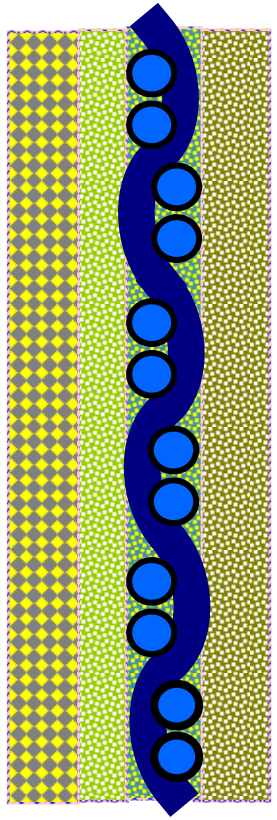
- OEM: ABB Flakt
- Number of bags per unit: 26900
- Fixed DP set point controls the pulsing initiation
- Bag: 8 m long, 130 mm diameter
- Total cloth area: 86170 $m^2$
- Number of cells: 4
- Filtration velocity: 0.02 m/s with one cell isolated
- Type of filtration material: PAN, PPS initially
- Present filtration materials: P84/PPS composites
- Pulsing pressure: Medium 2.5 – 3.5 bar
- Compressed air system dryer: No

# Duvha – performance of bag sets



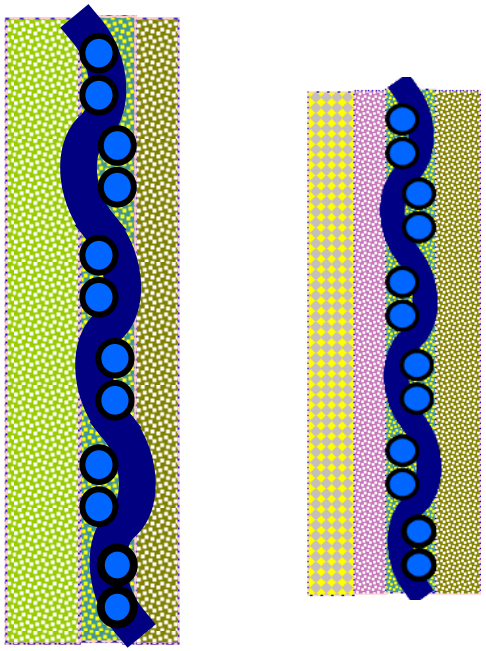
# Duvha performance

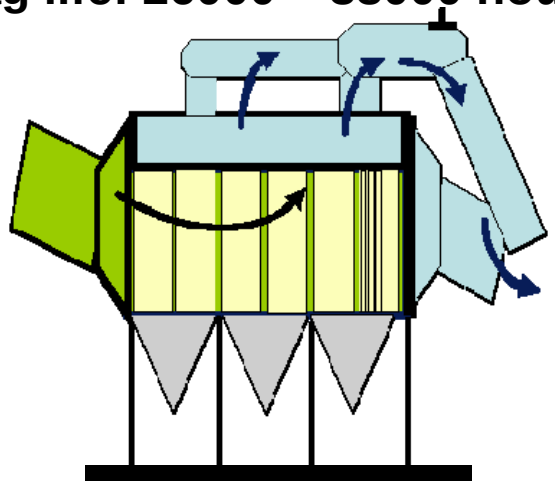
- Premature fabric failure
- Acid enrichment of fibres: degradation
- CaO in dust is not reactive
- Improved performance: PAN 5000 - 18500 hrs
  - fuel oil
  - higher ΔP control set point
  - better operation
- Bag failure pattern
- $SO_3$ Neutralisation Plant - option
- Converting of the bag houses to high temperature filtration materials
- PPS/P84composite: 25000 – 52000 hrs



# Hendrina performance

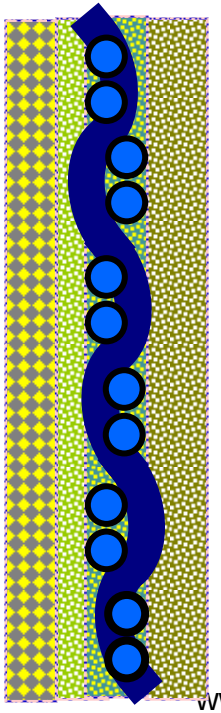
- Low pressure pulsing design
- Fabric shrinkage
- Tube plate collapse
- PAN , PPS and PPS/P84
- Oil carry over
- A/H and bag house fires
- Bags burning on installation
- Bag life: 26000 – 38000 hours





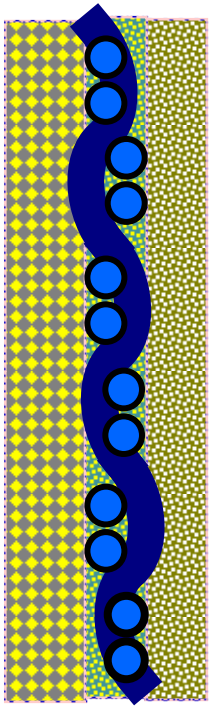
# Majuba P/S

- Corner Fired Boilers – Steinmuller
- FFPs – Bateman Howden (Lurgi design)
- Initial filter material PAN/(PAN)/PAN
- PAN+P84/(PAN)/PAN
- Pulse Jet low pressure - on line
- Bags: 31000 – 33000
- Flow: 1450 $m^3/s$
- Cloth area: 95 000 $m^2$
- Temp:125 - 130 °C
- ACR: 1.07 m/min
- ACRc: 1.2 m/min with one cell isolated
- $H_2O$: up to 7 vol%
- $O_2$: 5 -7 vol%
- Air attemperation
- Emission: < 10 $mg/m^3$ (new)
- Life time: 22000 - 32000hrs



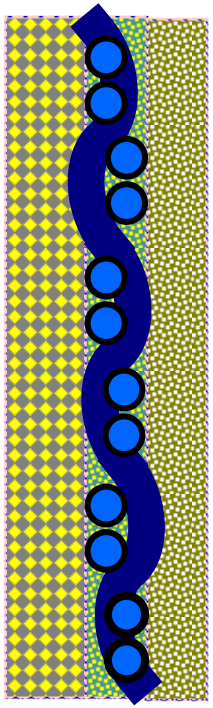
# Botswana Ash Utility Boilers x 2

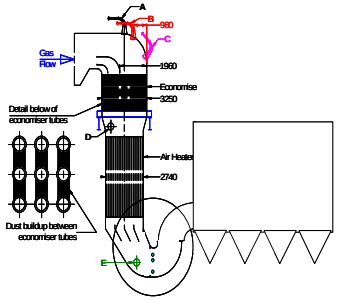
**Fluidised Bed Boilers – Babcock OEM**
**OEM / upgrade: Intensiv / Eskom TSI**
**Filter material: P84+PPS / PTFE scrim**
**Cloth area: 3240 m²**
**Type of cleaning: Pulse Jet - On Line**
**Temp.: 150 - 180 °C**
**Acid dew point: 140°C**
**ACR: 1.1 m/min**
**$H_2O$: up to 7 vol%**
**$O_2$: 7.0 - 10 vol%**
**SOx: 1000 - 2000 mg/Nm³**
**$NO_2$: < 5 mg/Nm³**
**Air attemperation: Yes**
**Particulate emission: 5 - 7 mg/Nm³**
**Guarantee: < 50 mg/m³**
**Bags operating life: 5 years**
**Failure mode: abrasion**



# AEL Utility Boilers x 1
# South Africa

**Fluidised Bed Boiler – Babcock OEM**
**FFP OEM: Davy**
**Material: P84+PPS / PTFE scrim**
**Type of cleaning: Pulse jet - off line**
**Pulsing pressure: 4 bar**
**Temp.: 160 - 180 °C**
**ACR: 0.9 m/min**
**$H_2O$: up to 7 vol%**
**$O_2$: 9.0 - 14 vol%**
**$SO_x$: 200 - 300 mg/Nm³**
**$NO_2$: < 5 mg/Nm³**
**Air attemperation: yes**
**Emission: 5 mg/m³ (after upgrade)**
**Guarantee: < 30 mg/Nm³**
**Bag life: 7 years**
**Failure mode: abrasion**





# 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!

# ?