Media selection for Coal-fired Boilers
Hot Topic Hour, Jan 8, 2015

Analysis and discussion of media and fiber options as part of a GDPS™ system

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Agenda

- Format
  - Presentations with continuous discussion of issues
  - Create basis for ongoing web coverage, article in *Filtration News* and discussion at AFS spring conference
- Overview- Bob McIlvaine
- Presentations by
  - John McKenna, ETS
  - Clint Scoble, Testori
  - Jim Farrell, Eddie Rickets, Donaldson
  - Richard Lydon, Clear Edge
- Additional panelists available to address issues
  - Robert Waters, Menardi

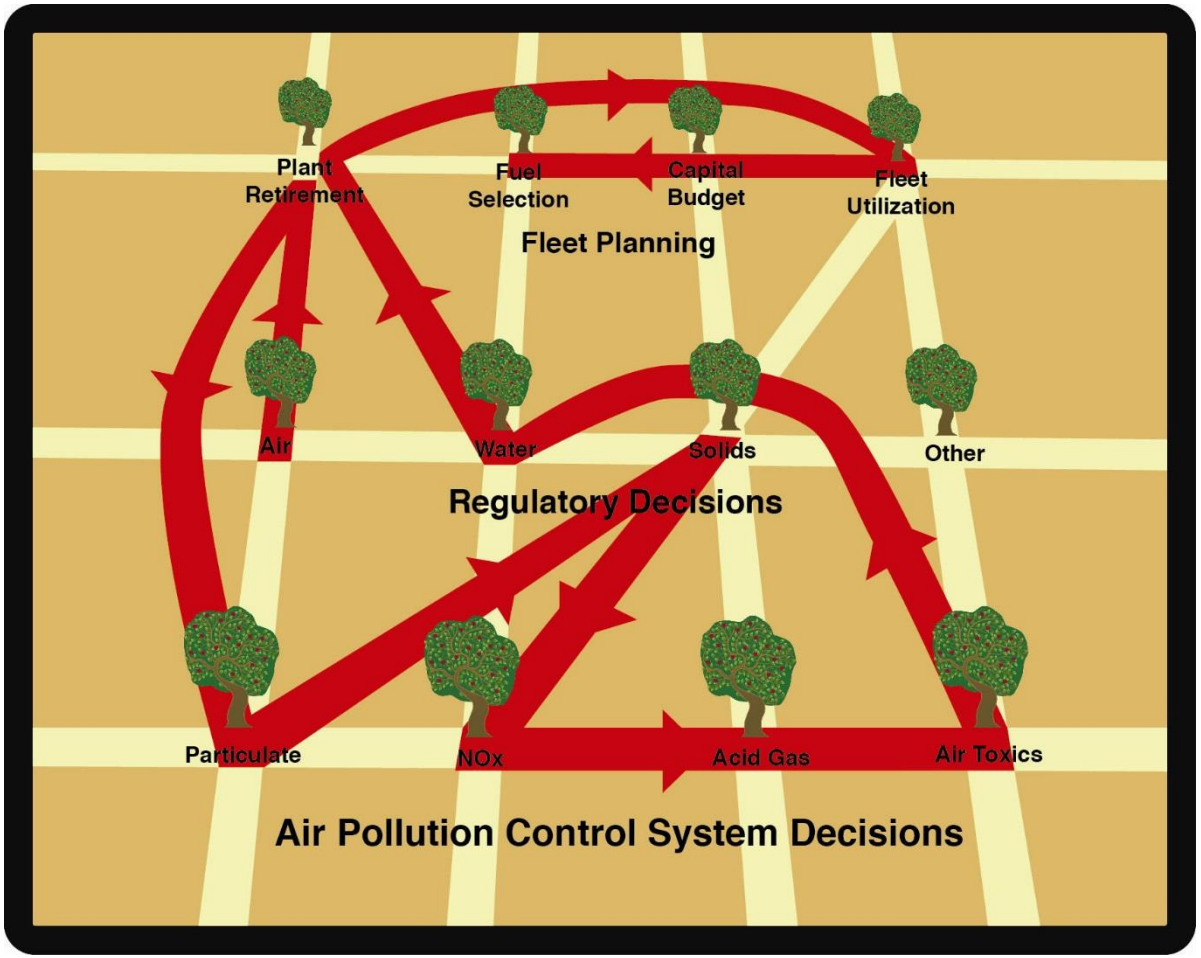
This webinar as part of a new system

- The recording of this meeting will be sent to large utility users in the U.S., Italy , South Africa, etc.
- The recording and power points will be available to all utilities as part of Power Plant Air Quality Decisions.
- This PPAQD website will continue to be populated with analyses and factual material.
- Synthesized versions will be published in journals and presented at conferences.
- An article in *Filtration News* will appear in the next several months.
- This topic will be covered at the AFS Spring conference in Charlotte. This conference is focused on coal-fired power.
- Summaries and additional information in Chinese are slated.
- The goal is to make this site a default position for media selection.

Overview

- Media selection depends on a number of site specific conditions as well as mode of use including bag shape, type of cleaning and temperature.
- The pleated cartridge has captured much of the market for lower temperature (< 150°F) service but is more expensive and used in coal-fired boilers when space is a premium.
- Ceramic filters with embedded catalyst are now a potential major option in the high temperature segment. They operate at 850°F and capture NO_x.
- The need to capture SO_2 and mercury with dry injection is a significant factor in media selection.
- Membranes and nanofibers represent options for high efficiency.
- Media decisions are shaped by a whole complex decision system which can be viewed as a version of GPS which McIlvaine calls the Global Decisions Positioning System (GDPS™).

Global Decision Positioning System (GDPS) to select hot gas media



Parameters affecting media selection

fiber	pps	P84	ptfe	glass	ceramic	acrylic
media	Non woven	Membrane laminate	woven	sintered		
Plant conditions	Emission limit	Area available	Fan lmits	Mercury removal	SCR	FGD
gas	Flyash load	Sulfuric acid	Sulfates	Activated carbon	temperature	Other acid gases
Bag shape	Tubular	Pleated	Cartridge			
cleaning	Hi vol med Pressure air	High pressure air	Reverse air	shaker		

Media selection results from travel between decision trees

- **Emission Limits**: Will PM be used as a surrogate for toxic metals? If so media selection could be critical.
- **Area available**: Retrofitting the existing precipitator housing or installing the fabric filter in a tight area can restrict space. Pleated bags can be an answer even if more expensive.
- **Fan limits**: If the existing fan is going to be used and it is desirable to minimize energy consumption, glass bags with reverse air may be an option.
- **Mercury Removal**: If bromine is used as fuel additive there can be corrosion issues. If activated carbon is used then the dust loading will be higher and this leads to maintenance, energy, and emissions issues.
- **SCR**: If the particulate control device is preceded by an SCR, there is a potential sulfuric acid corrosion problem. This is also a function of the sulfur in the coal and whether a low conversion catalyst is used.
- **FGD**: If wet scrubbers follow the filter then there will be some additional particulate removal. If dry scrubbers are selected and the fabric filter must capture both flyash and sulfates then there are cleaning, life, and emission issues. The lower temperature with dry scrubbing also presents corrosion potential.
- **Coal selection**: If the power plant wants to blend coals and select the most economical, then it will want to consider the higher dust loadings with low sulfur coals and the higher SO_2 levels with high sulfur coals. The question is to what extent will media selection limit the coals which can be used?

Dust Collector Fiber Options

Material Characteristics

Fiber Type	Maximum Operating Temperatures Degrees F (C)		Chemical Resistance						
	Dry Heat	Moist Heat	Strong Acids	Weak Acids	Strong Alkalis	Weak Alkalis	Solvents	Oxidizing Agents	Hydro-lysis
UHMWPE	176 (80)		****	****	****	****	****	****	****
Polypropylene	200 (93)	200 (93)	****	****	****	****	****	***	****
Polyester	275 (135)	200 (93)	***	***	*	**	***	****	*
Nylon (Polyamide)	250 (121)	225 (107)	*	***	***	***	***	***	**
PTFE	500 (260)	500 (260)	****	****	****	****	****	****	****
Glass	500 (260)	500 (260)							

Hydrophobic versus Hydrophilic
Oleophobic versus Oleophilic

High temperature fiber options

IEA CLEAN COAL CENTRE

FF: Fabric types

Table 3 Fabric types (Stark, 2012; Popovici, 2011; Johnson and McMenus, 2011)

Name	Maximum operating temperature	Remarks	Relative cost
Acrylic felt (PAN or polyacrylnitrile)	130°C	Lowest maximum operating temperature.	£
PPS felt (Polyphenylenesulphide)	190°C	Degrades at higher temperatures with >12% oxygen. Resist chemical and thermal attack. Effective when laminated with ePTFE.	££
Aramid felt	204°C	Not as capable as PPS in chemically active flue gas	£££
Woven fibreglass	260°C	Fragile, require tight tolerances. Suitable with reverse-air cleaning systems.	£
P84 felt by Evonik Fibres (polyimide, PI, multi-lobal, tri-lobal)	260°C	Dimensional stability over 204°C but requires oversizing of filter to maintain proper bag to cage fit. Small pore size of 0.5-1 µm (traditional needle felt scim have a pore size of 15-20 µm).	£££
Pleated elements	Dependant on scim fabric	A/C <3.5:1. Applicable only when additional cloth area is needed to lower A/C ratio and eliminate inlet abrasion.	£££££

Tubular bags

Tubular bags remain the major choice for higher temperature conditions and heavy dust loadings.

Pleated bags are more expensive and are generally used where space is tight.

The main use of wovens is in glass bags with reverse air cleaning.

Most tubular bags are non-woven felts.

Emission limits for coal plants around the world in mg/Nm^3

Pollutant	China Guangzhou, Shanxi	Sinopec Guangzhou	Zhejiang with SCR and WESP	China national regional	U.S Existing/new	EU Existing/new
NO_x	50	1.4 to 28.5	23,7	200/100	1060-640/117	200/200
SO_2	35	2.85 to 7.6	15	200-400/100	350/65	400/200
PM	5	3.4 to 4.6	3.08	30	45/8	50
SO_3	5	0.08				
Hg	0.003	0.0004 ug		.03	0.002/0.001	

China now has the most stringent particulate limits

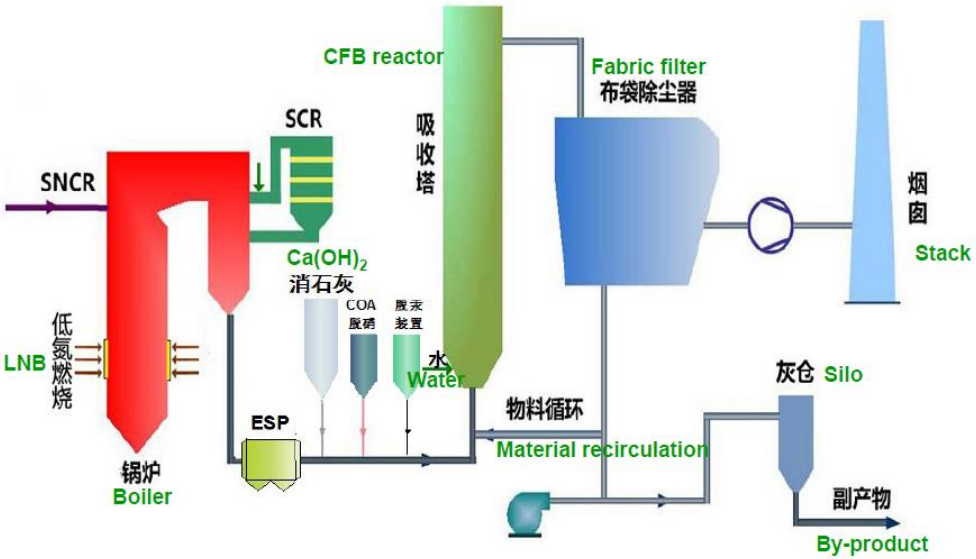
- Due to pressure from citizens due to smog, the Chinese government is initiating the toughest air regulations of any country.
- Tough national standards have now been followed by even more stringent standards in a number of cities and even provinces.
- The new national standard of 30 mg/Nm^3 for particulate was already tougher than the regulation for existing U.S. coal-fired power plants or for plants in the EU.
- The new regulation in Guangzhou and Shanxi limits dust to only 5 mg.
- Existing precipitators will not be able to meet these limits. Zhejiang is meeting the new requirements with a wet precipitator.
- Sinpoec Guangzhou is meeting the standards with a dry scrubber fabric filter system complete with activated carbon injection installed by Longking.

Dry scrubber, fabric filter to meet the low emission rates

Fujian Longking

How to meet the 50/35/5+5/3 requirements?

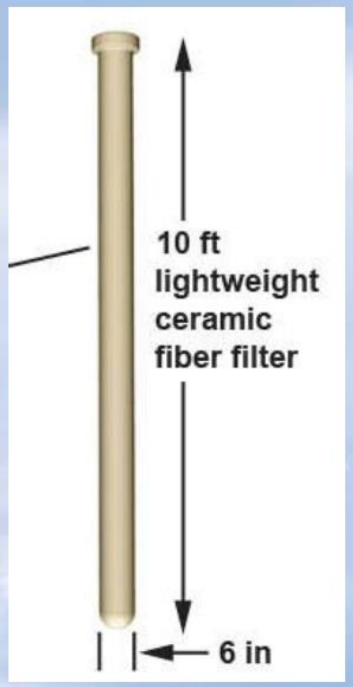
Dry process : SCR/SNCR + Advanced CFB-FGD + COA



Catalytic filter with embedded catalyst

Filter Element

UltraCat Catalyst Filter: Structure and Size



Nano-bits of NOx, CO, VOC catalyst are embedded into the walls and adhere to the fibers.

Tri-Mer® CORPORATION

50 YEARS 2010

ENEL has converted ESPs

Fabric Filters running in Enel's national fleet

Plant	Capacity (MWe)	FF type	Installation	Supplier	Year	Bag Lenght [m]	Comp.	Emissions guarantees [mg/Nm3] (°)	Expected FF Emiss. in Operation [mg/Nm3]
Fusina 1&2	2 x 160	PJ, HP/LV	Conversion	TMK	1999	8,5	2	<30	<15
Genova 6	160	PJ, HP/LV	Conversion	TMK	2003	9	4	<30	<15
Sulcis 2 (*)	340	PJ, HP/LV	New (**)	Aster	2005	8,5	16	<25	<15
Torrevald. 1÷3	3 x 660	PJ, HP/LV	New (**)	TMK	2005	8	16	<10	<9
Brindisi S.# 3&4	2 x 660	PJ, HP/LV	Conversion	TMK	2010-12	8	4	<20	<10

(*) Circ.Fluid.Bed Boiler (CFB) (**) Over the existing Electr. Precip. ESP foundations (°) hourly basis

- Italian references regarding conversions from electrostatic precipitators (ESPs) to fabric filter (FFs) are all "brown field" installations.
- "Conversion" means "transformation" from an electrostatic precipitator to a fabric filter using the previous casing.
- "New" fabric filters → to use only the existing foundation of the old previous electrostatic precipitator and to design new filter steel structure and casing.
- There is in addition a small fabric filter installed in a ~ 30 MWe Biomass PP in Calabria (South of Italy)

Acronym: PJ pulse jet; HP/LV high pressure low volume type; ESP Electrostatic Precipitator; TMK Termokimik spa ; Torrevald.: Torrevaldaliga North power plant.

Enel has FF on boilers in Russia, Chile, Spain (Evonik presentation)

Fabric Filters in Enel's abroad fleet and programs

ENERGY TO LIFE

Plant	Country	Capacity (MWe)	FF type	Installation	Supplier	Year	Bag Lenght [m]	Comp.	Emissions guarantees [mg/Nm3]	Expected FF Emiss. in Operation [mg/Nm3]
Alcudia	Spain	2 x 125	PJ, HP/LV	New	Fisia Babcock	n.a.	8	6	<20	<15
Alcudia	Spain	2 x 130	PJ, IP/IV	New	ABB/BWE	n.a.	7	6	<20	<15
Tarapacà	Chile	158	PJ, IP/IV	New	ALSTOM	2013	10	8	<10	<10
Bocamina I	Chile	128	PJ, IP/IV	New	ALSTOM	2007	8	6	n.a.	20
Bocamina II	Chile	350	PJ, HP/LV	New	Slavex	2012	6,5	20	<30	<15
Reftinskaya 5	Russia	300	PJ, IP/IV	Conversion	ALSTOM	2013	8	4	<50	<20
Reftinskaya 7	Russia	500	PJ, HP/LV	Conversion	Clyde Bergmann	2014 (°)	8,5	16	<50	<20
Reftinskaya 4	Russia	300	PJ, IP/IV	Conversion	ALSTOM	2015 (°)	8	4	<50	<20

(°) Note: expected date / schedule to be confirmed.

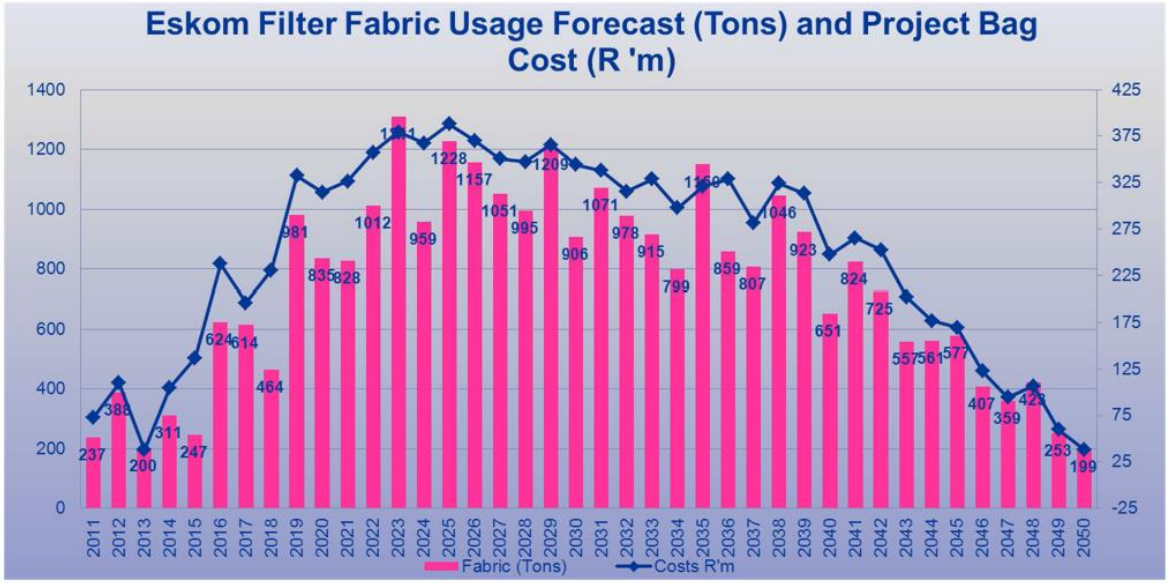
- The filters in Russia could be taken as the more challenging in terms of operation and maintenance considering the very high dust content of the coals (up to 40%) and the high NOx inside the flue gas.
- About the remaining units in Russia: #1÷ 4 and #8 ÷ 10 the conversion of the existing electrostatic precipitators ESP to fabric filters FF are today foreseen before the end of this decade.

Other Acronym: HP/LV High Pressure Low Volume type, IP/IV intermediate Pressure - Intermediate Volume, n.a. not available

Eskom will be spending $100 million/yr. for bags (Evonik Presentation)

Fabric Usage Forecast following FFP Retrofit

Eskom



This equates to an average consumption of approx. 350 000 bags per year.
Currently all bags are disposed of in a Class H:H Hazordous Waste Dump at Holfontein (350 000 bags = +1 000 000 m^2 of fabric)

1923-2013

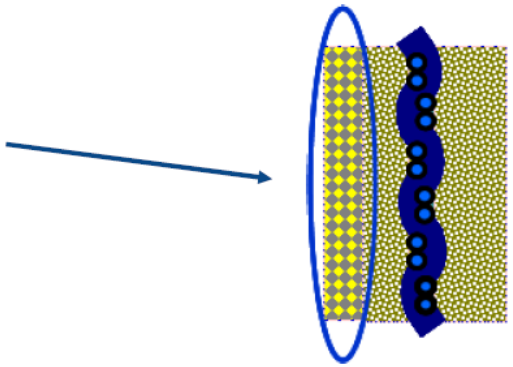
ESB Moneypoint has 25,000 hrs. of operation with bags on dry FGD (Evonik presentation)

FF Bags Specification

Energy for generations

New Bags Specification:-

- PPS scrim
- Outer layer blend of P84 & PPS
- Change of fibre type & density



Technical Details

- Physical arrangement same
- Weight average 600 g/m2
- Air permeability (at 200 Pa) 120 l/dm2.min
- PTFE treatment
- Singed on one side
- Calendered

Outotec low pressure filter uses PTFE, P84 fiber mix on several installations (Evonik Presentation)

RF TECHNOLOGY - New Installations

PROJECT	:	BLUEWATERS POWER STATION UNIT 1&2 – PROJECT N° 50260
CLIENT	:	IHI
LOCATION	:	COLLIE, WESTERN AUSTRALIA
COMPLETION:		2009
TYPE OF CONTRACT:		TURNKEY, FIXED PRICE
PERFORMANCE GUARANTEE:		YES, EMISSIONS <47 mg//Nm³

Special Features:

RF low pressure filter installed on two new PF boilers
Six compartments (full flow with five compartments)
Water spray for over temperature protection
Large module fabrication in China

Scope of Supply:

Design, supply, erection and commissioning of the filter with turnkey responsibility for the project.

Pre coating with hydrated lime