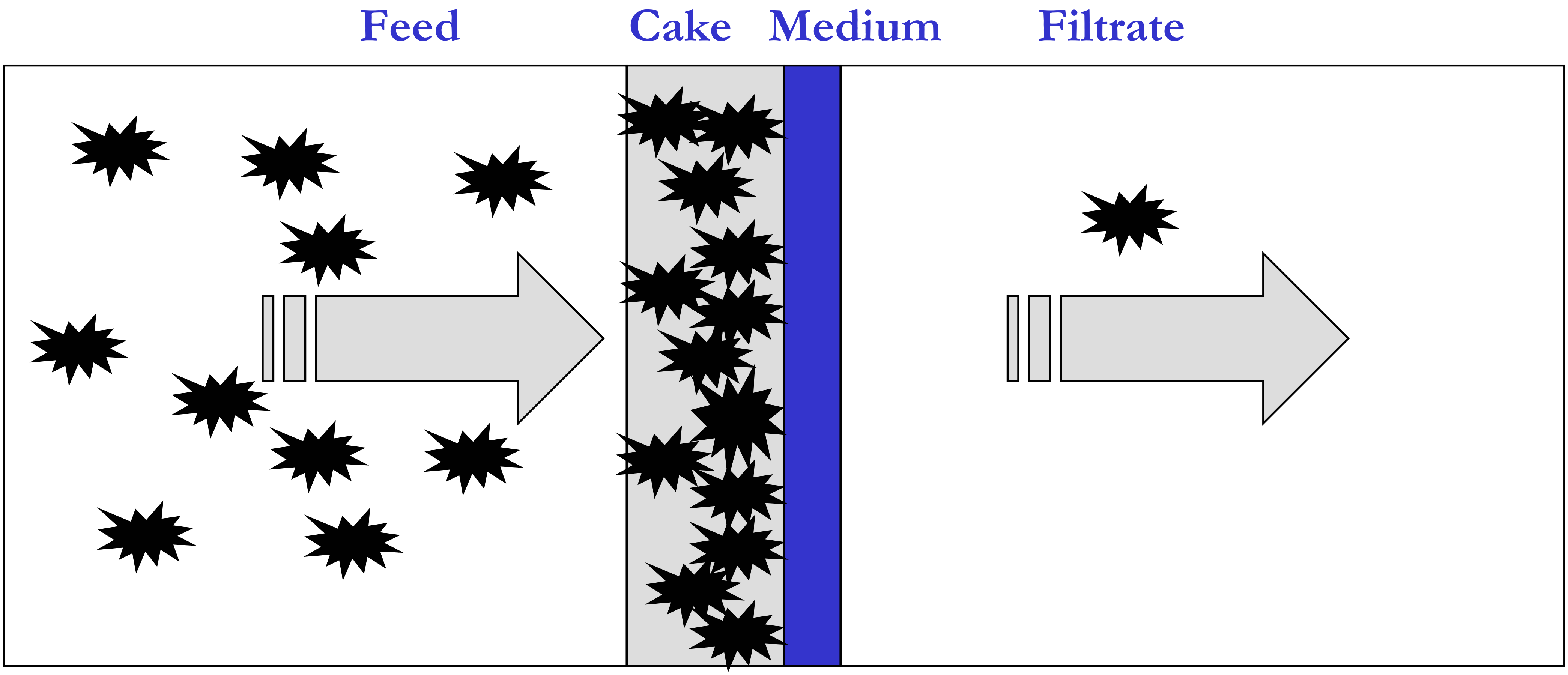
PARTICULATES #2

- Filter systems
- Wet scrubbers
- Cost comparison cyclone / ESP / filter
- High temperature high pressure particulate control
- Particulate emission control for vehicles

see: www.hut.fi/~rzevenho/gasbook

Principle of filtration



Filters : major types & characteristics

Bag filters fiber materials : textile, plastics, ceramic

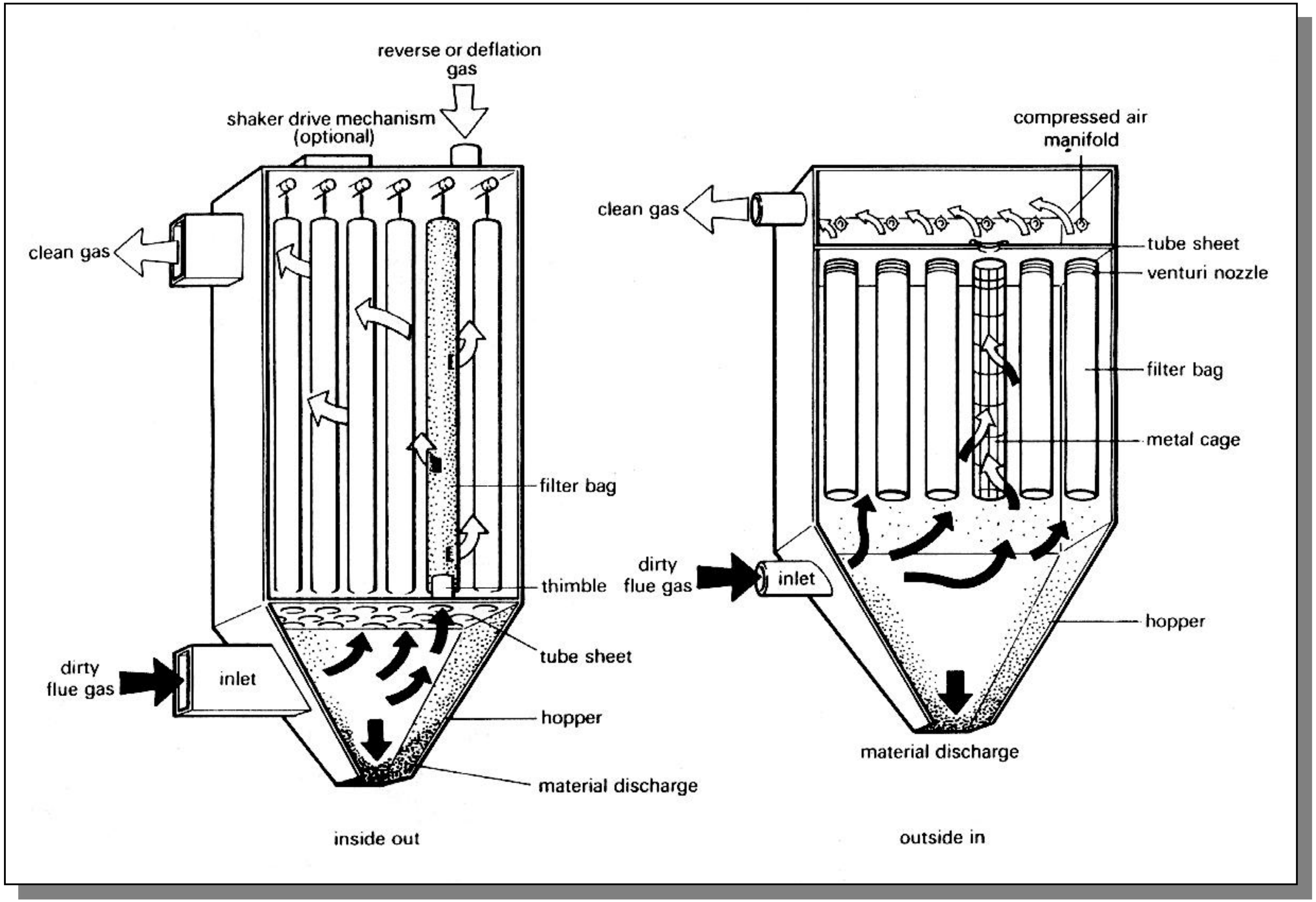
Barrier filters sintered ceramic or metal, powders or fibers

Granular bed filters layer of granular solids

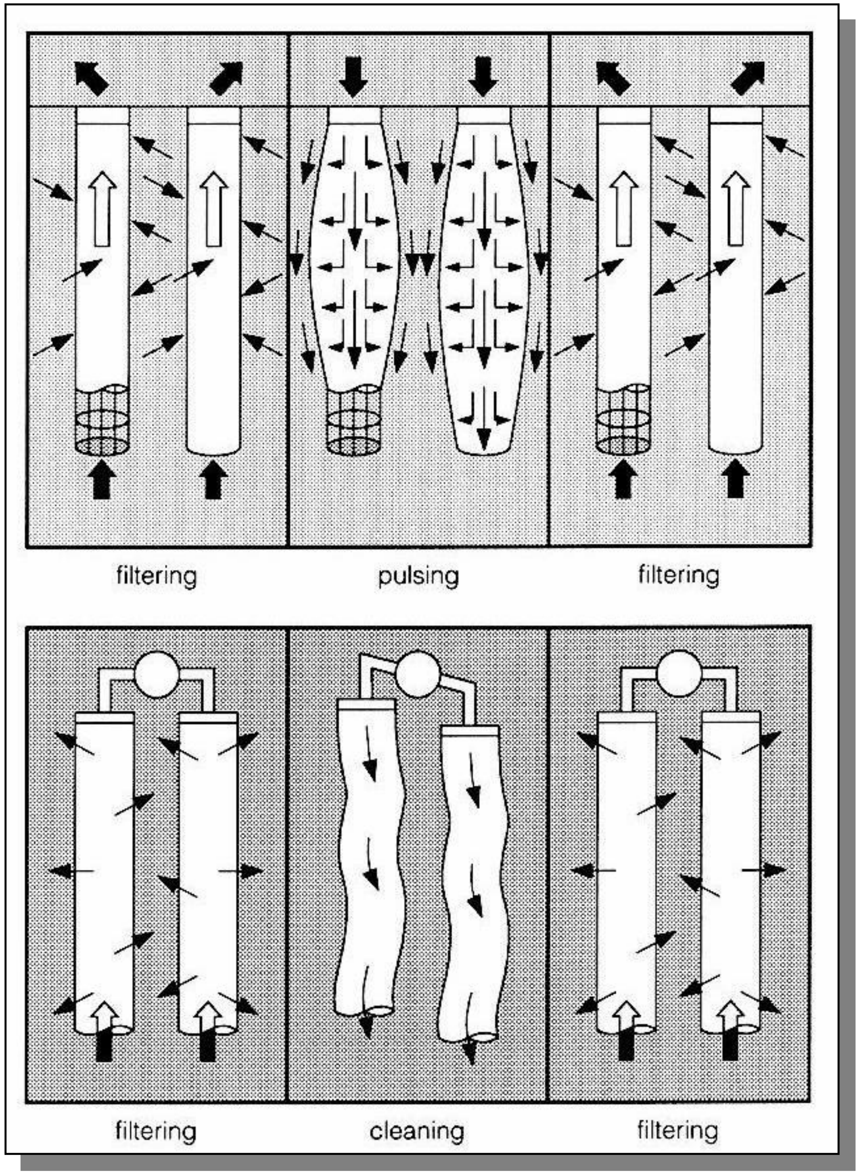
Factors determining filtration quality :

- Efficiency
- Pressure drop, pressure drop increase
- Filtration velocity = flow / filter area
- Medium properties : sustain, costs, cleanability
- Filter clean-up / regeneration

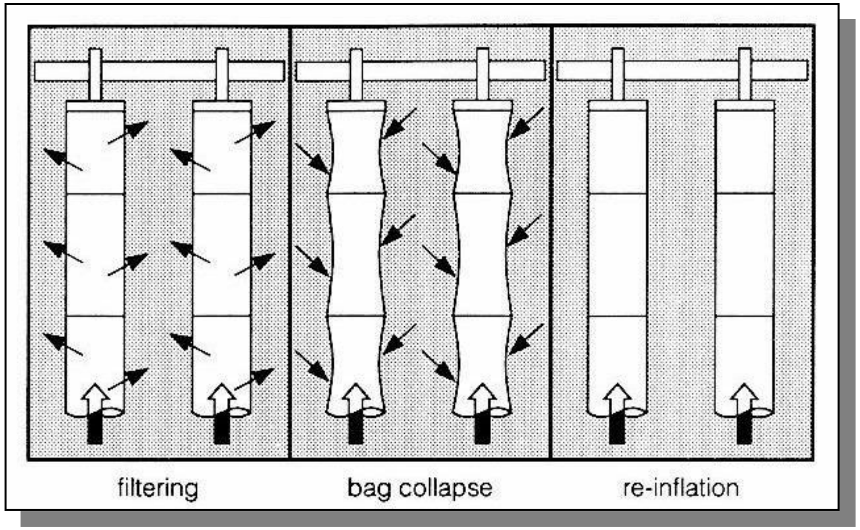
Gas flow options in baghouse filters



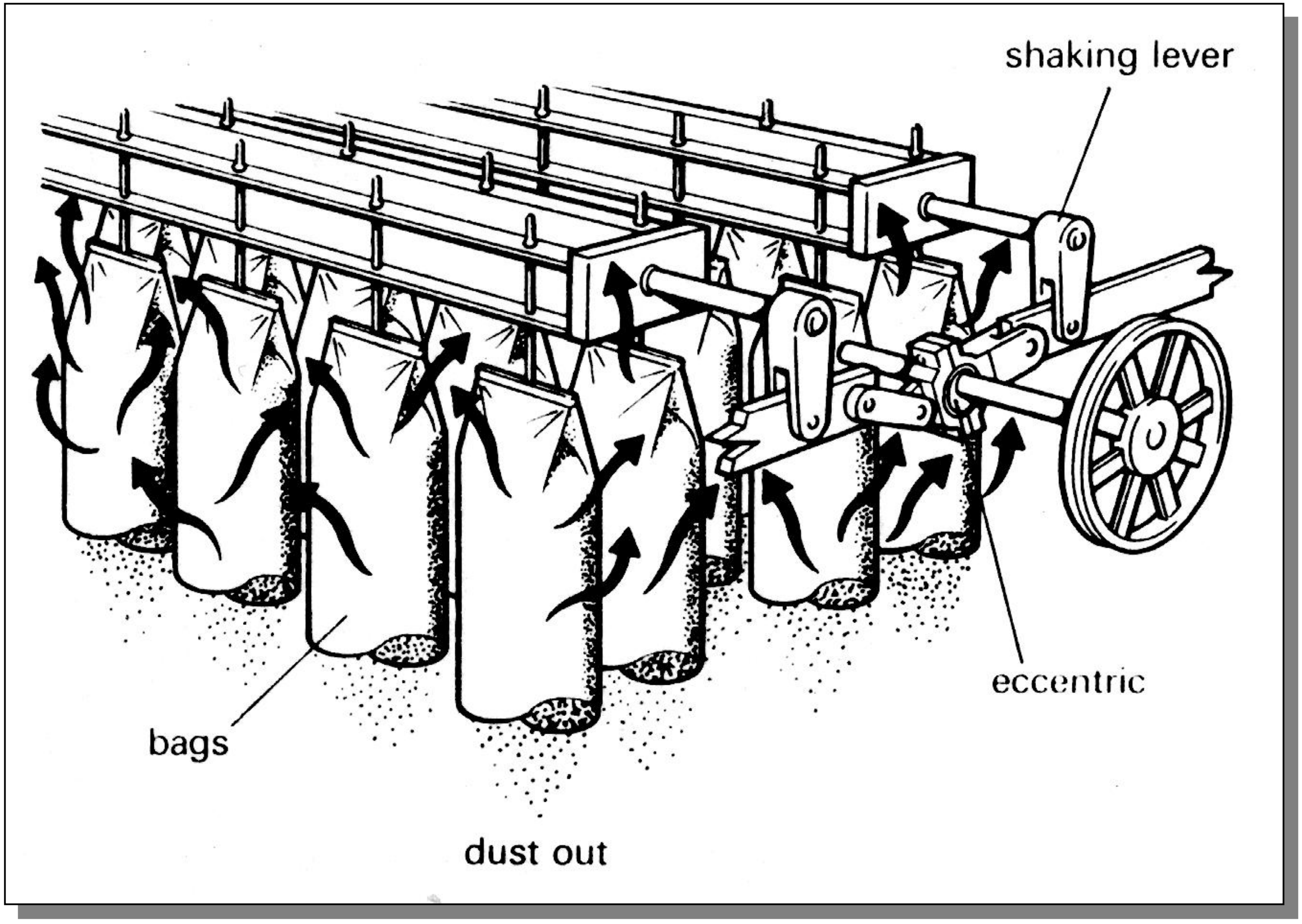
Three baghouse cleaning methods



- Pulse-jet
- Shake / deflate
- Reversed-air



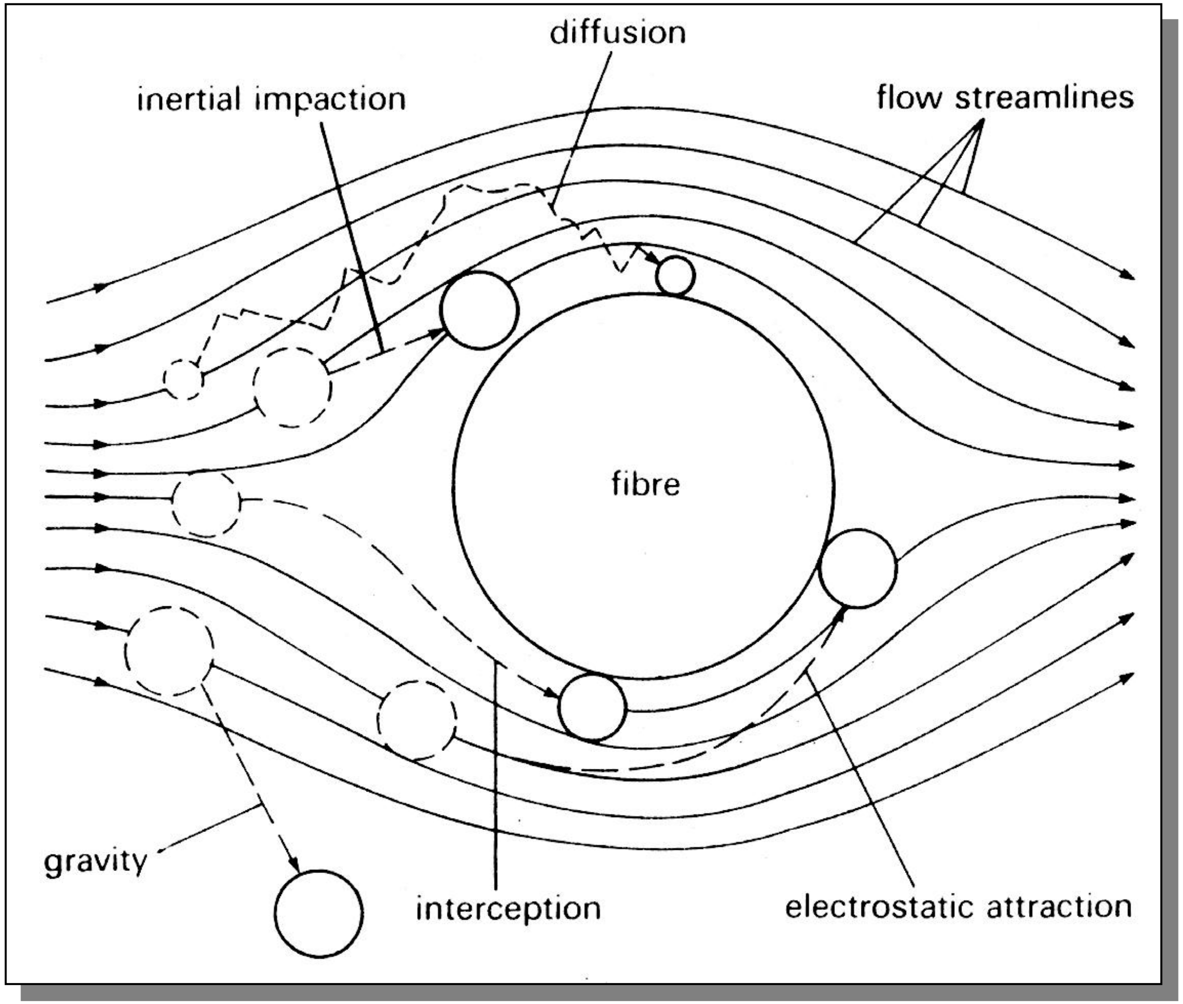
A shake/deflate-cleaned baghouse filter



Filters : cleaning methods

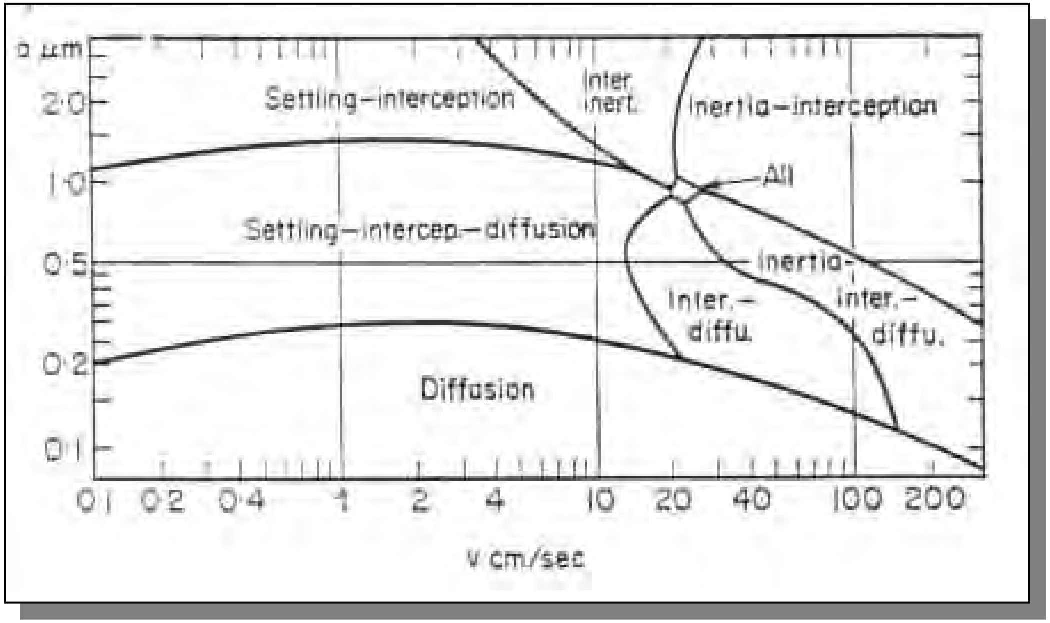
Type	*Method*	*Mechanism*
Bag filter	Pulse jet	Inertia / drag forces
	Shaking	Inertia
	Reverse flow	Drag forces
Granular bed filter		
fixed bed	Reverse flow	Elutriation
moving bed	Media recycle	Elutriation
Ceramic bag filter	Pulse jet	Inertia / drag forces
Barrier filters	Pulse jet	Drag forces

Particle capture by a filter fiber

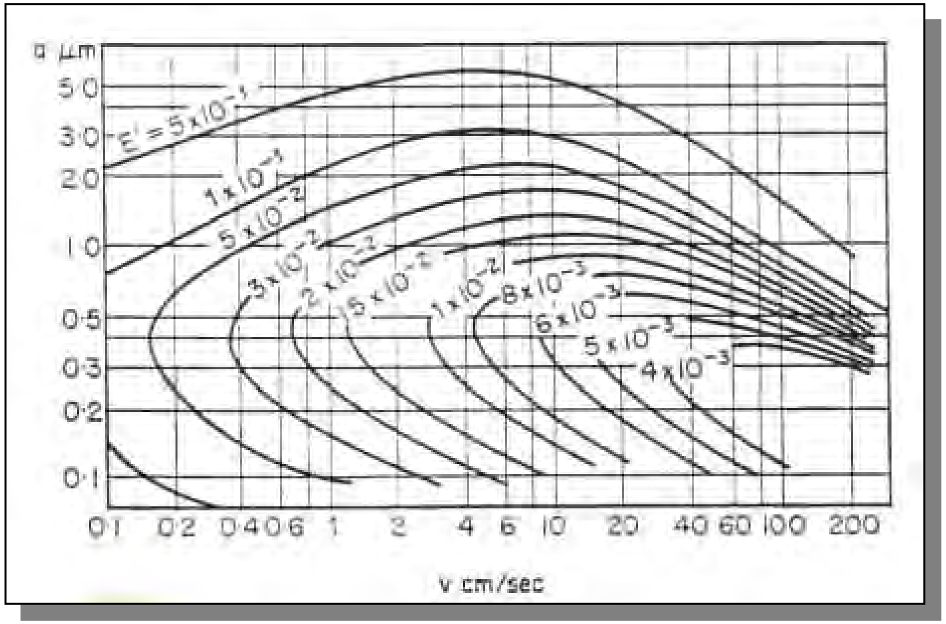


Filtration efficiency of a 5 μm fiber

dust in ambient air, a = particle size, v = gas velocity

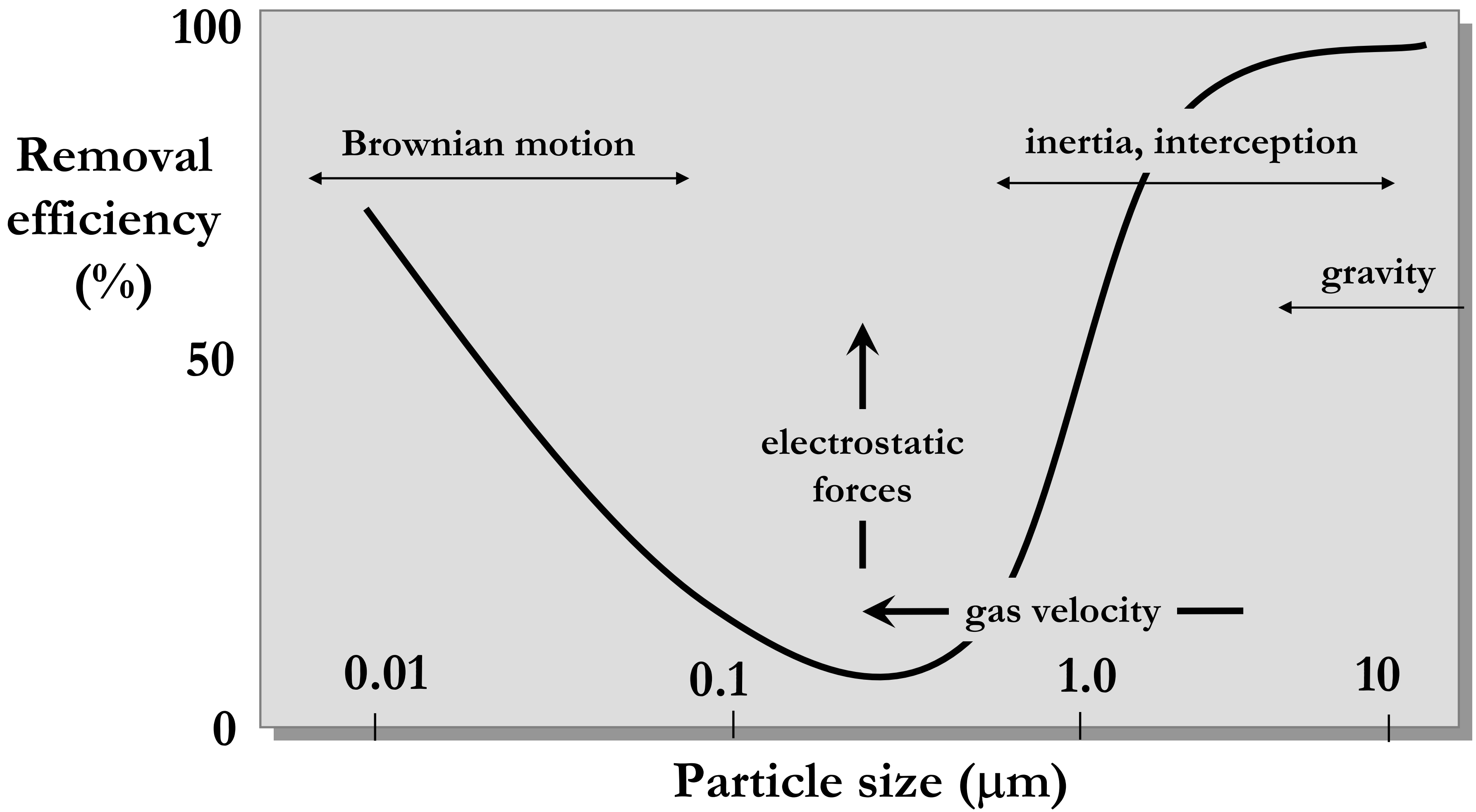


Capture mechanism "contours"



Efficiency contours

Filter efficiency as function of particle size



Fabric filter cloth characteristics (1996)

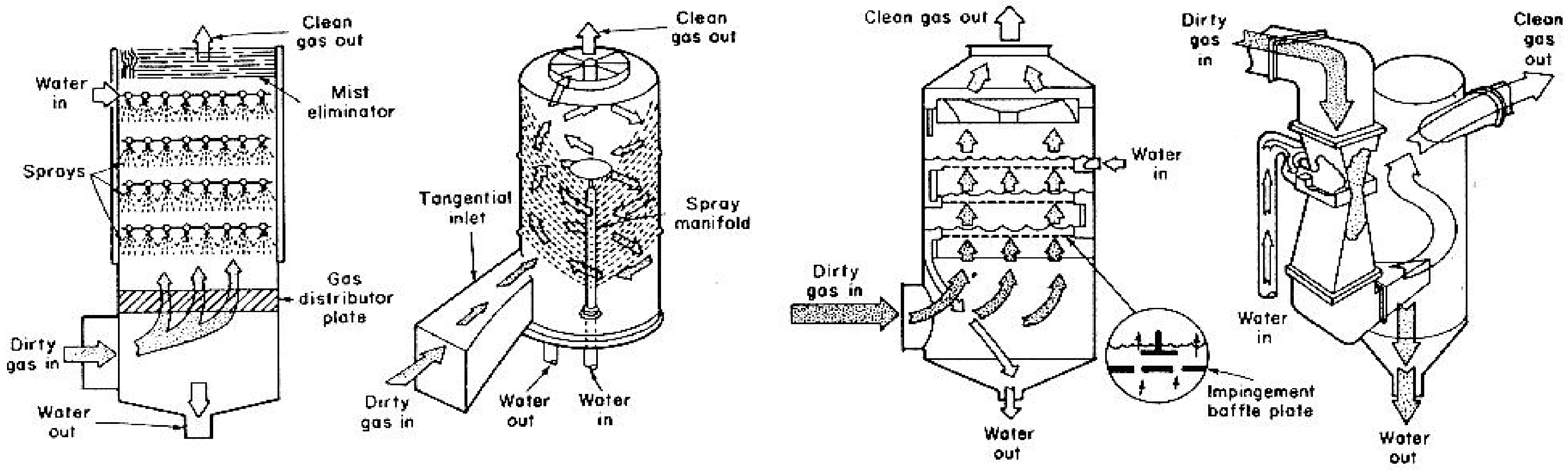
Fibre	Maximum operating temperature, °C	Acid resistance	Alkali resistance	Dry heat resistance	Wet heat resistance	Flex and abrasion resistance
Cotton	82	poor	good	fair	fair	good
Polypropylene (Propex)	94	excellent	excellent	fair	fair	very good
Nylon Neotex^R	120	fair	good	good	good	excellent
Acrylic (Dratex)	125	excellent	fair	good	good	fair
Polyester Terytex^R	148	good	fair	good	good	very good
Ryton^R	190	excellent	excellent	very good	very good	very good
Aramid Nomex^R	204	fair	good	excellent	excellent	very good
Glass	260	very good	fair	excellent	excellent	poor
P-84^R	260	good	fair	excellent	excellent	very good
Teflon^R	260	excellent	excellent	excellent	excellent	excellent
Tefair^R	260	very good	excellent	excellent	excellent	excellent

(Data in brackets) = Registered Trade Names

Properties of fiber materials for high temperature filters

Fibre	Generic name	Aramid	Glass	PTFE	Polyphenylene sulphide	Polybenzi-Midazole	Metal	Ceramic
	Trade name	Nomex	Fibreglass	Teflon	Ryton	PBI	Bekinox	Nextel 312
Recommended continuous operation temperature (dry heat)		204°C	260°C	260°C	190°C	260°C	450°C	1150°C
Water vapour saturated condition (moist heat)		177°C	260°C	260°C	190°C	260°C	400°C	1150°C
Maximum (short time) operation temperature (dry heat)		232°C	290°C	290°C	232°C	343°C	510°C	1427°C
Specific density		1.38	2.54	2.30	1.38	1.43	7.90	2.70
Relative moisture regain in % (at 20°C & 65% relative moisture)		4.5	0	0	0.6	14.0	0	0
Supports combustion		No	No	No	No	No	No	No
Biological resistance (bacteria, mildew)		No effect	No effect	No effect	No effect	No effect	No effect	No effect
Resistance to alkalis		Good	Fair	Excellent	Excellent	Good	Very good	Good
Resistance to mineral acids		Fair	Very good	Excellent	Excellent	Excellent	Very good	Very good
Resistance to organic acids		Fair	Very good	Excellent	Excellent	Excellent	Very good	Very good
Resistance to oxidising agents		Poor	Excellent	Excellent	Attacked by strong oxidising agents	Fair	Very good	Excellent
Resistance to organic solvents		Very good	Very good	Excellent	Excellent	Excellent	Very good	Excellent

Wet particulate collectors



Spray tower | *Cyclone spray tower* | *Impingement scrubber* | *Venturi scrubber*

Wet scrubbers : some characteristics

- Collects still very fine particles, and also gases & alkali
- Low capital costs compared to ESP and baghouse filters
- High pressure drop, operation costs, up to %'s of a power plant net output
- Gaseous waste stream → liquid waste stream

Typical data :

- Gas inlet velocities ~ 100 m/s
- Collection efficiencies ~ 99 %
- Pressure drop up to 1 bar (!)

Operation problems :

corrosion, abrasion, solids build-up, rotating parts failure
re-start after a down-period

Cost comparison cyclone, ESP, baghouse

Cost comparison for particulate control equipment at 10 $MW_{thermal}$

	Efficiency %	Capital cost US$ 1982	Operation cost US$/ton removed
High efficiency cyclone	87.0	10500	1.68
ESP	98.3	96500	2.84
Reverse air baghouse	99.9	49000	3.14

Assumptions: coal ash, electricity costs 0.0614 US$/kWh, 8000 h/year, filter bags lifetime 2 years