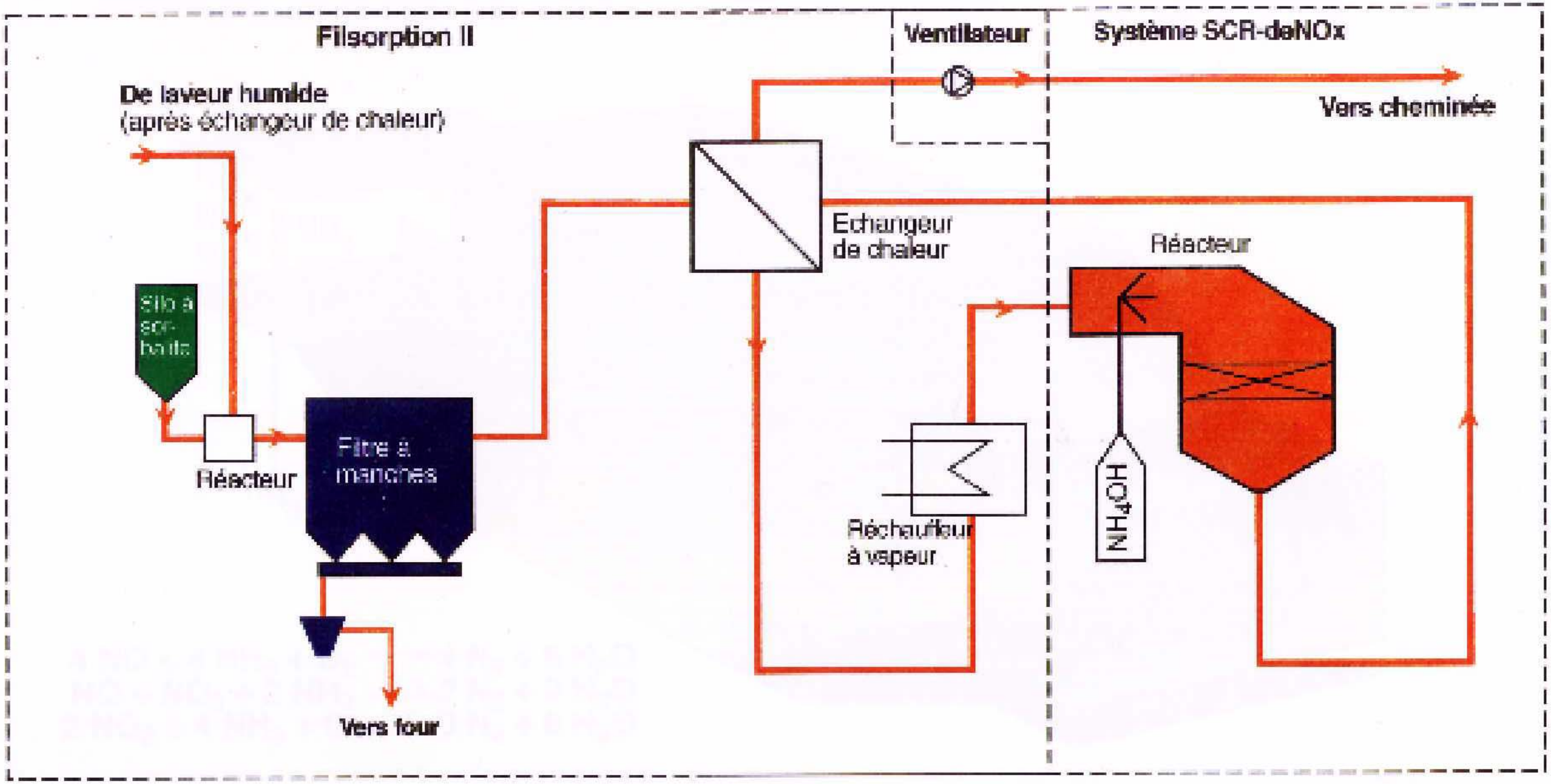
2. Catalytic purification process NOx SCR

- **Basic principles**
  - Same reactions as for non-catalytic procedure: with urea or NH3
  - After rinsing of acids and dust removal, reheating of gases to 240 / 380°C (recuperator + vapor)
  - Injection of NH3 in stoichometric proportion
  - Carrying out of reaction on the catalyzer containing Vanadium, Tungsten, Titanium oxide
  - Recuperation of gas heat before evacuation
- **Key points**
  - Mixture of NH3 in the gases
  - Regulation of the flow of NH3 contingent on NOx: avoid excess
  - distribution of gas on the bed of catalyzer
- **Performance**
  - Purification rate: 80 / 95%
  - Reagent consumption: 0,5 kg/t au stoichio
    electric: ? vapor: ?
  - Residues and effluent: none

- **Advantages**
  - Good performance: Netherlands' model (70mg/Nm3) easily attained
- **Inconveniences**
  - Risk of poisoning catalyzer by heavy metals or dust/impurities
  - Investment cost
- **Variants** (in the future)
  - Catalyzers functioning at a lower temperature

Catalytic process of filtration NOx and activated charcoal



from ABB

3. Adsorption process on activated charcoal

- **Basic Principles**
  - Dispersion of fine particles of coke in gases to be refined around 100 / 150°C
  - dioxins, heavy metals adsorb to themselves or absorb to the coke during transport and to the FAM
  - Filtration of gases
- **Key Points**
  - Good dispersion of particles in the gas
  - Duration of time on the sleeve filter
- **Performance**
  - Purification rate: dioxins < 0,1ng/Nm3 (instead of 1 to 10?)
  - Reagent consumption: 0,25 to 1 kg/t
    electric: ?
  - Residues : the coke is eliminated with the fly ash

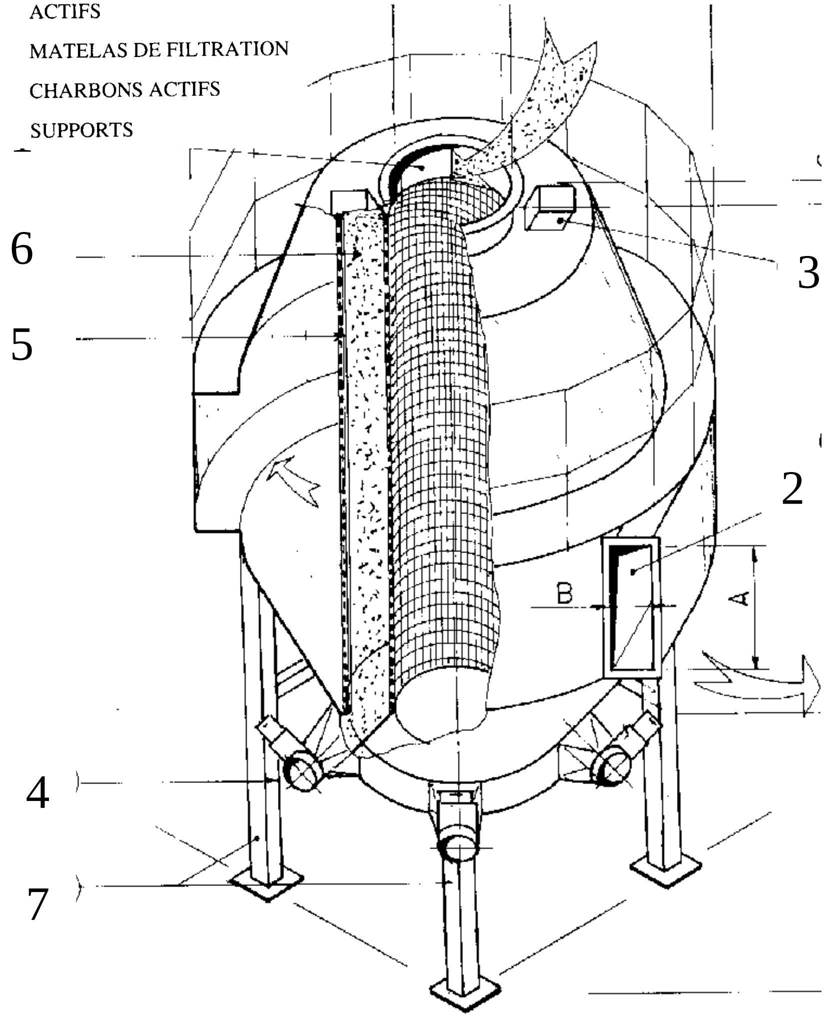
- **Advantages**
  - acts certainly upon the totality of the organic compounds (PAH, COV)
- **Inconveniences**
  - Supplementary costs (limited if using existing FAM)
- **Variants**
  - Utilization of brown coal coke
  - Addition of a reactor with a circulating fluid bed or a fixed bed in order to increase contact

Activated charcoal absorption reactor

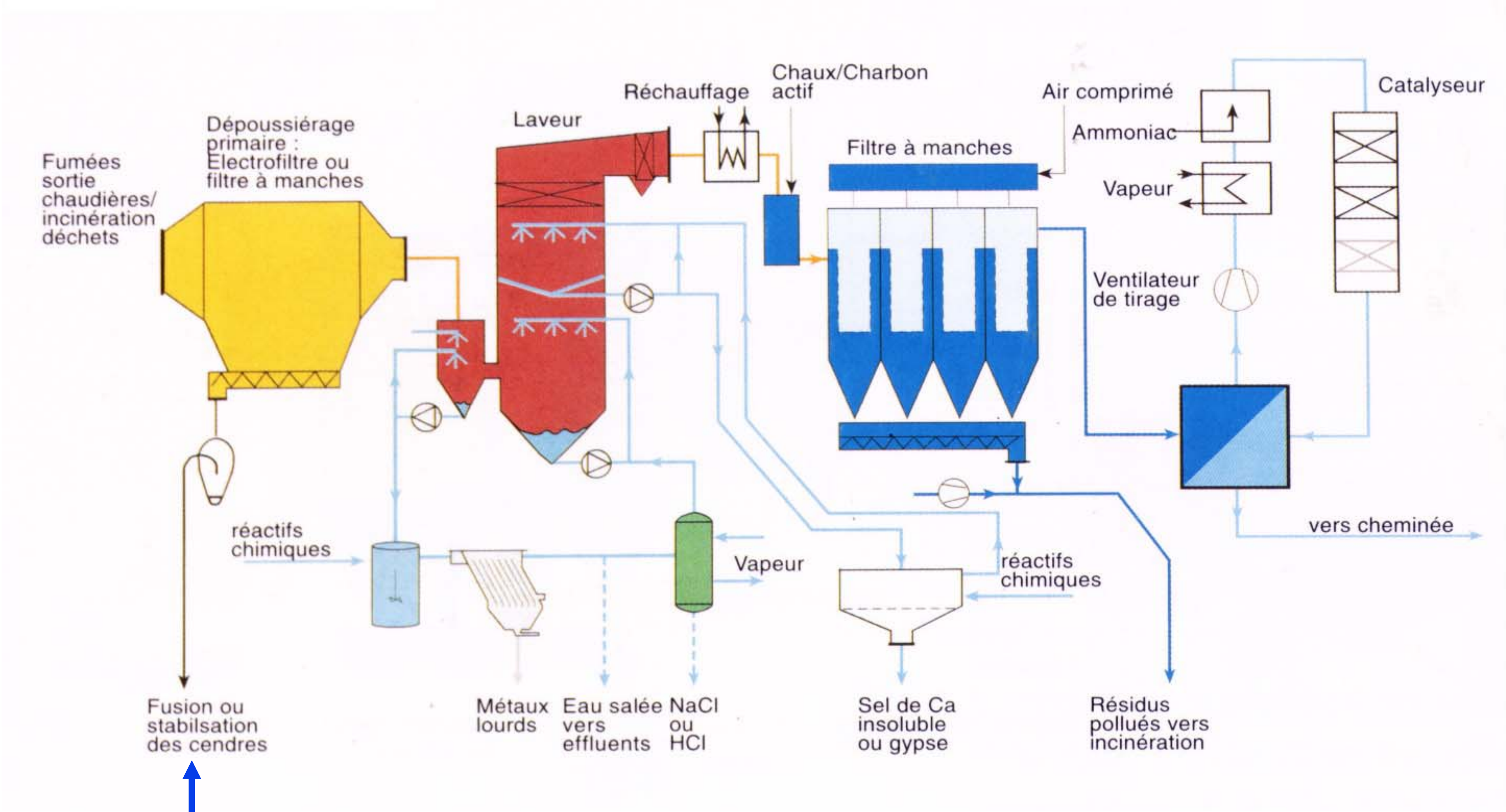
from Ventilazione Industriale

LEGENDE

1 ENTREE AIR A EPURER
2 SORTIE AIR EPUREE
3 PORTILLON DE CHARGEMENT DES CHARBONS ACTIFS
4 CLAPETS POUR DECHARGEMENT DES CHARBONS ACTIFS
5 MATELAS DE FILTRATION
6 CHARBONS ACTIFS
7 SUPPORTS



Complete purification process of gases and residues



Fly ash to be stabilize prior to landfill

from ABB

4. Gas dust removal

Dust removal : sedimentation chambers

- **The particle falls at its fixed speed V_{li} whereas the gas progresses to a speed V_0**

- **The efficiency is the relationship between the necessary time of decantation of a height H and the duration of time it takes to cover L**

- $\eta = \frac{\tau_s}{\tau_d} = \frac{V_{li} L}{H V_0}$ where $V_{li} = \frac{d_p^{\,2} g(\rho_p - \rho_g)}{18\mu}$

- **We have deduced the maximum diameter of the collected particles:**

$$d_{p\,max} = \left[\frac{18 \mu H V_0}{g L(\rho_p - \rho_g)}\right]^{1/2}$$

Dust Removal: impaction systems

- **the harnessing efficiency is directly related to the number of Stokes of the particles and of the obstacle**

$$Stk = \frac{2Li}{D_0} \quad \text{où} \quad Li = \frac{\rho_p V_0 d_p^2}{18\mu}$$

- **It also depends on the geometry of the obstacle**

- **Given the dimensions of the conceivable obstacles, good results are obtained for particles greater than 10µm**

Dust removal: dust collectors

- **Rosin, Rammler and Intelmann give the efficiency of a dust collector contingent on the diameter of the cut**
  - **The particle moves laterally in relation to the gas until it touches the wall**
  - **It is subject to the centrifugal force and to the trail force;**
    in equaling these 2 forces, we obtain the expression of relative speed:
  - **The particles which have the yield diameter are**
    those which must cover the distance b/2 in order to reach
    the wall during the time duration of the gas
  - **We can explain the duration of time contingent on**
    the number of theoretical spins executed by the gas
  - **We thereby obtain the expression for the yield diameter:**

- **for other diameters, the efficiency will be equal to the relationship between the lateral distance covered and b**
- **it will therefore be proportional to $(d_p / d_{p\,50})^2$**
- **The authors prefer the formula:**

- **Leith and Licht then Koch and Licht propose another efficiency expression and the loss of dust collector charge based on the radial rétromélange concept of non-collected particles**
  - **The given efficiency for dust collectors of optimized dimensions as those represented on the previous transparency contingent on parameter C**
  - **C varies between 50 and 200. C weakly corresponds to the weak loss of charge but also to a low-level of efficiency**

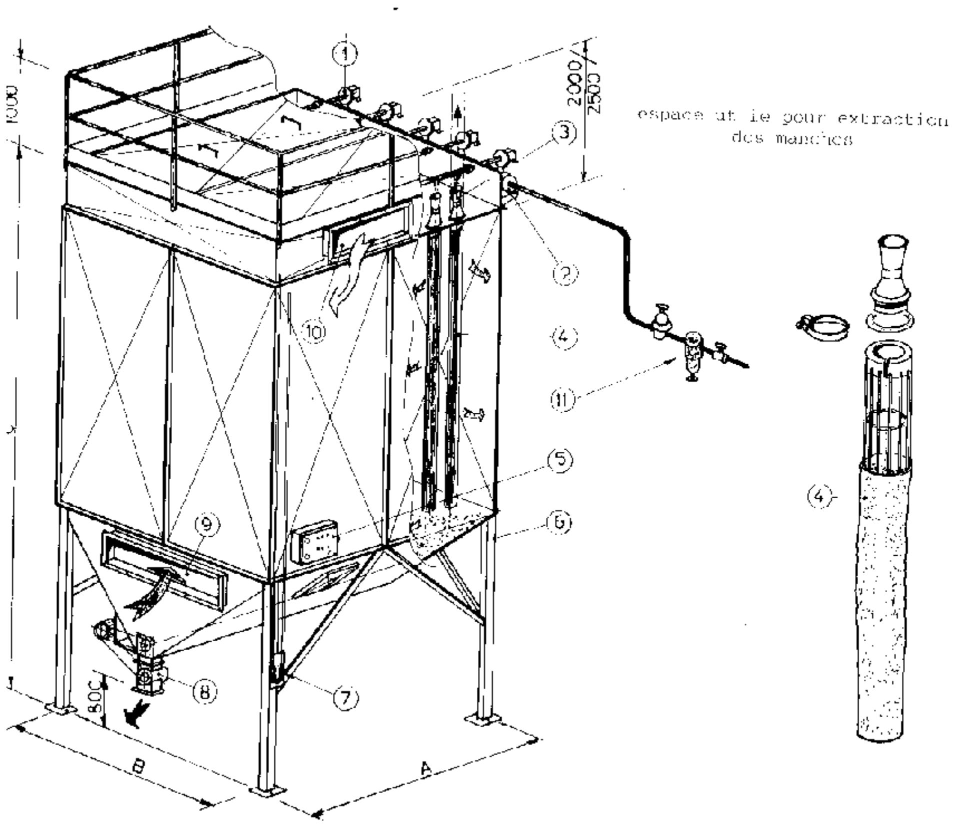
- **The dust collectors are well adapted to small installations with particles having a size greater than a few μm**

Dust removal: example of multi-dust collector

Dust removal: bag filters

- The gas charged in particles passes from the exterior to the interior of the sleeve through a filtrating cloth
- The particles rest on the cloth and form a cake which also contributes to the filtration: the smallest particles that the pores of the fabric are able to retain
- The cleaning of the cloth is done sequentially by:
    - vibration
    - Air circulation against the current (by module)
    - injection of compressed air against the current (pulses of 30 to 600ms under 5 to 7 bar, 0,15 m3/h/m2 of cloth)
- the frequency of cleaning is adapted to the charge of the gas
- The choice of the cloth is contingent on the gas and the particles: certain ones can function at more than 200°C (glass fibers)
- Loss of charge variable to thickness of gateau: 1000 to 2500Pa
- Very efficient, even for small particles (dry gases)

Dust removal: example of bag filters



LEGENDE

1	ELECTROVALVE
2	TUBE POUMON
3	TUBE DE VENTURI
4	GROUPE FILTRANT
5	TABLEAU DE COMMANDE ELECTROVALVES
6	CORPS FILTRANT
7	MANOMETRE DIFFERENTIEL
8	EVACUATION POUDRE
9	ENTREE AIR POUSSIEREUX
10	SORTIE AIR FILTRE
11	ARRIVEE AIR COMPRIME

d'après Ventilazione Industriale

Dust removal: scrubbers and venturis

- **The gas must be saturated in water before washing**
- **The water is sprayed finely and dispersed within the gas; the droplets capture the dust**
- **The efficiency depends on the energy brought into play in order to carry out the mixture (speed of gas and water, size of droplets)**
- **In a venturi, the large gap between the speed of the gas and the liquid improves the capturing of fine particles by droplets**
- $\Delta p = \xi \frac{1}{2} \rho V^2$ with $\xi = 0{,}435 + k \, Q_l / Q_g$

  $k = 0{,}786 + 0{,}878.10^{-2} \, V_{g,col}$
- **Vgaz = 50 to 150 m/s and Dcol = 100 to 120 mm**
- **Anticipate a separation of gas/droplets the particles are extracted in the form of sludge and the water can be recycled.**
- **Various gaseous pollutants can also be stuck; the water must therefore be treated**

Dust removal: electro filters

- Corona effect: the resulting electric field from the high voltage ionizes the gases to the vicinity of the emissive electrode
- The ions, during their displacement, create others by the drawing of electrons to molecules
- The ions bind to the particles qui which then migrate toward the electrodes under the effect of the 2 electric and vapor forces:

$$F_e = -T \qquad F_e = qE \qquad T = 3\pi d_p \mu w \qquad w = \frac{qE}{3\pi d_p \mu}$$

- Transference time is $\tau_m = \frac{l}{2w}$
- Transit time is $\tau_s = \frac{L}{V_g}$
- The collecting efficiency is contingent on the relationship of these 2 times : DEUTSCH's equation

$$\eta(d_p) = 1 - \exp\left(-\frac{\tau_s}{\tau_m}\right) = 1 - \exp\left(-\frac{Sw}{Q}\right)$$

- Resistance of the gas and particles have a large influence on q et therefore w

Conditions of use of electro filters

Gas velocity	m/s
Gas temperature	120 à 150°C (even more)
Gap between lectrodes	200 à 400 mm
Collection specific surface area	20 à 200 m2 par m3/s
Pressure drop	10 à 200 Pa
electricity	20 à 120 kV
Restivity of particles	10^{6} à 10^{10} Ωcm
intensity	0,1 à 0,5 mA /m2
Power consumption	0,1 à 1 kW pour 1000m3/h