

Comparison of the hot flue gas aerosol of 2 municipal waste incineration plants exhibiting significantly different super heater corrosion rates

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Situation

- Corrosion rate of the superheaters in MSWI can vary extremely.
Maintenance time at different (similar) plants: between approx. 1 and 10 years
- High costs due to corrosion in many plants
- Potentially influencing parameters:
 - (Solid) fuel mixture and condition
 - Operation mode / burning parameters
 - Boiler geometry and construction

Particles

Decisive impact on the corrosion process:

- Substrate of reactive compounds, like heavy metals and salts
- Corrosion is most intense at regions of thickest fouling

- ← Particle mass concentration
- ← Particle size distribution
- ← Particle chemical composition
- ← Particle deposition/adhesion

Gas phase

- Condensables
- SO₂, HCl - correlating with sulphation of the particles

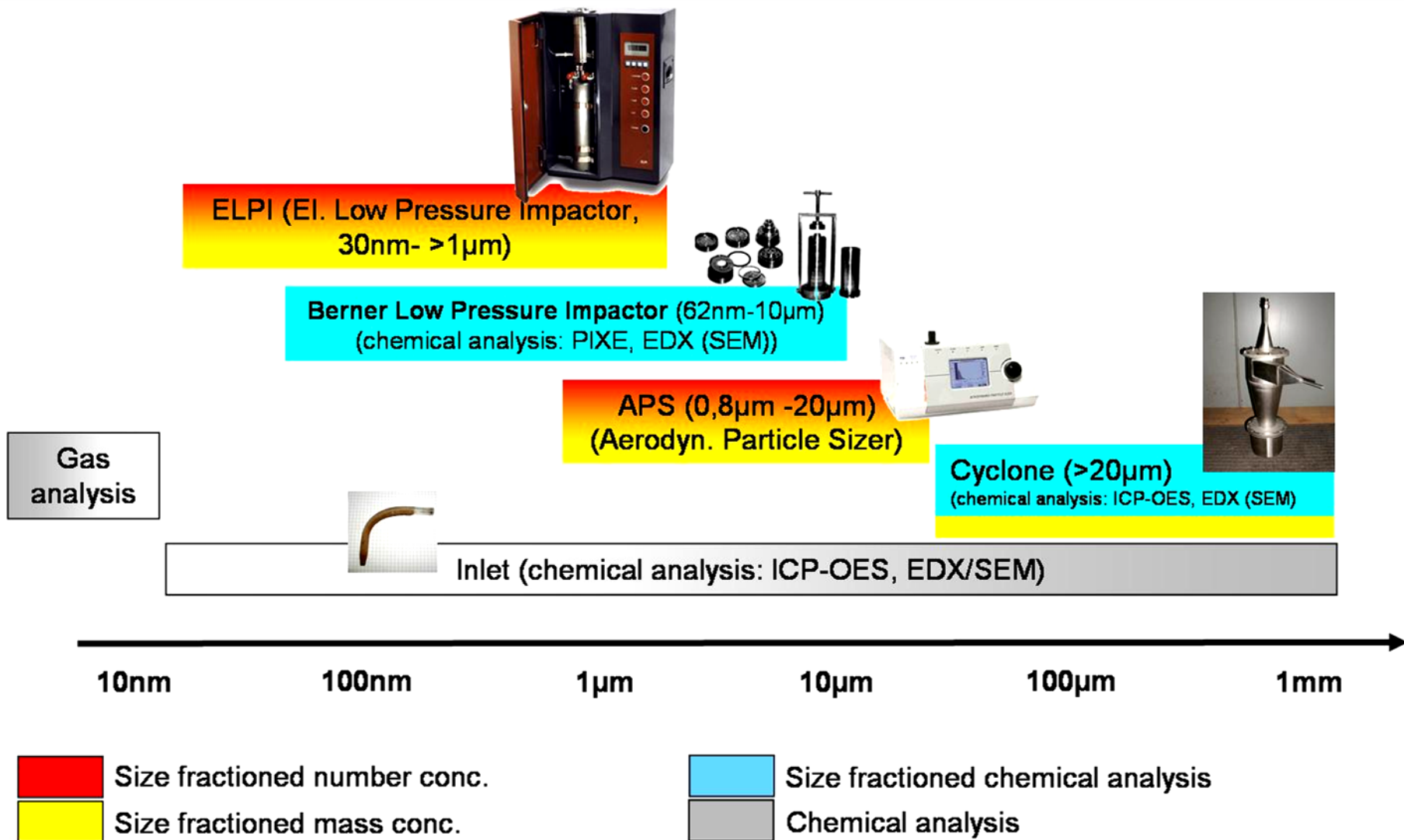
Task: Characterization of particles (30 nm – 3 mm aerodynamic diameter) and gas phase in the raw gas from the combustion chamber to the point of corrosion

Use of a Porous Tube Diluter (PTD):

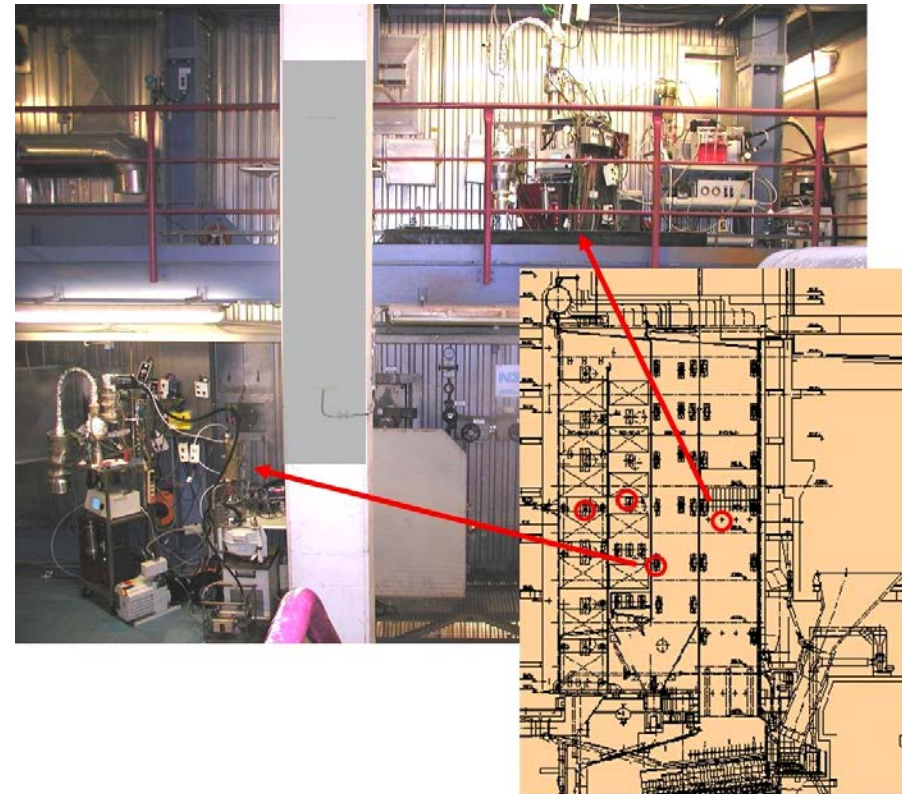
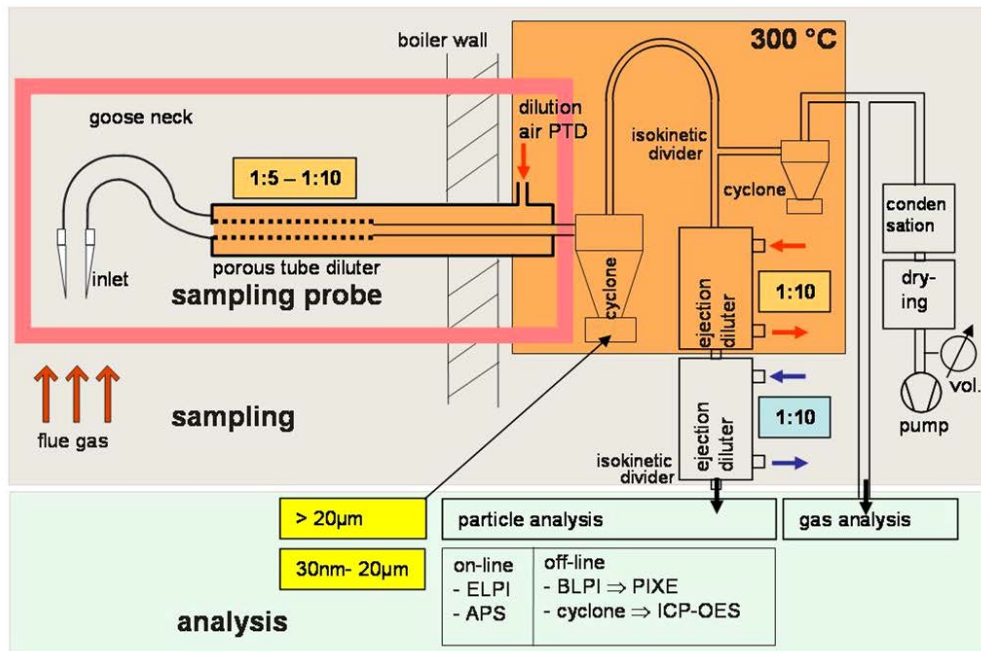
- ❑ Rapid dilution of the raw gas (5x-10x)
- ❑ Rapid cooling to $T = 300 \text{ }^{\circ}\text{C}$
- ➔ Minimize further chemical reactions
- ➔ Minimize coagulation, nucleation, condensation
- ➔ Minimize thermophoretic and inertial impaction



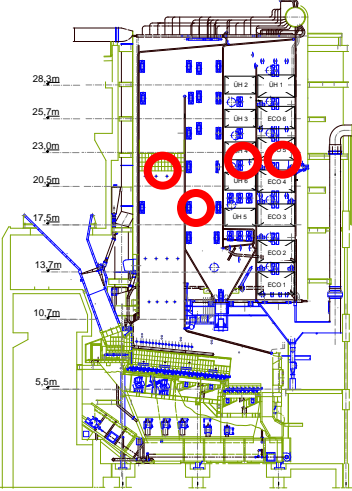
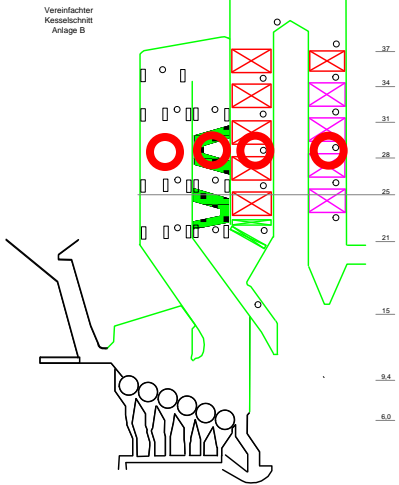
Total length: approx. 1500 mm, diameter: approx. 55 mm



- Synchronous sampling of gaseous and particulate matter
- Each measurement was carried out by 2 sampling systems running in parallel:
 - 1) reference point: 2nd pass
 - 2) further pass

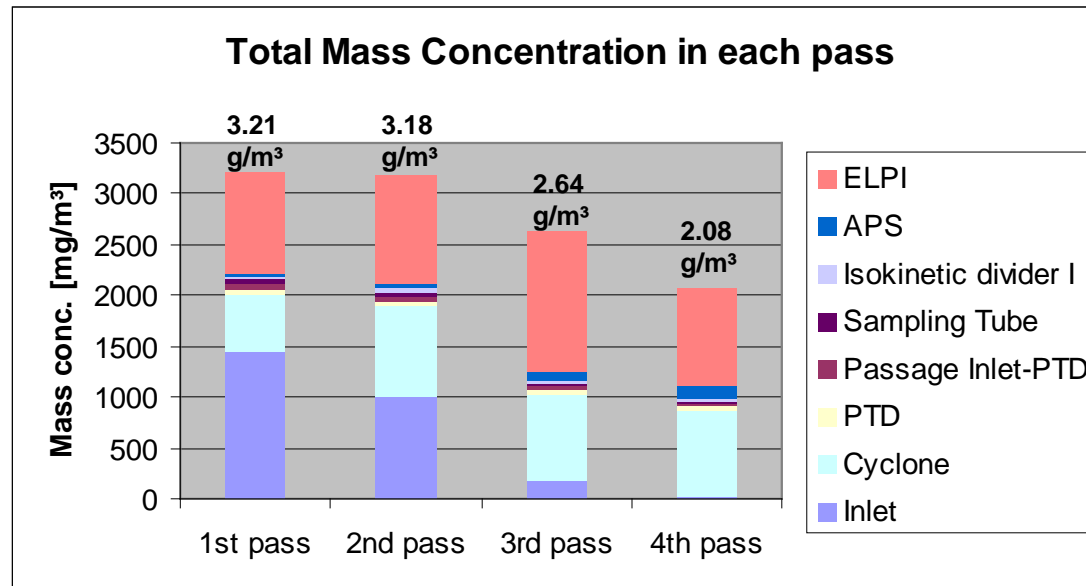


Plant A: 0.33mm/1000h; several measurement campaigns since 2005
Plant B: < 0.05 mm/1000h; 2-week measurement campaign in 2007

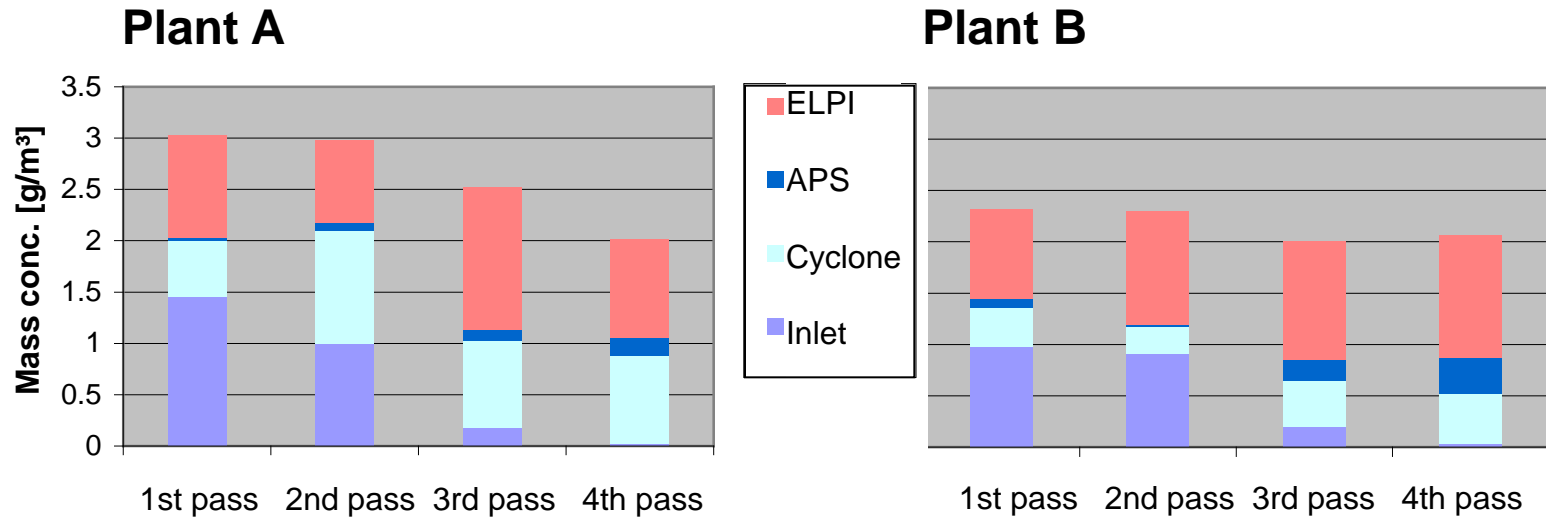
	Plant A	Plant B
Heat power	20 MW	40 MW
Steam parameter	65 bar / 435 °C	40 bar / 400°C
Boiler construction	 <p style="text-align: center;">4 pass, vertical</p>	 <p style="text-align: center;">4 pass, vertical</p>
Grate, fire zone	co-current reciprocating grate, first pass at grate front	rotating rollers, first pass at grate end
Corrosion rate (SH)	0.33 mm / 1000 h	< 0.05 mm / 1000 h

Measuring Points

Plant A



- Total dust mass annualized from particle measurements: 840 t/a
(7490 operation h/a, 7250 kg waste/h, 4500 m³N/t waste)
- Total dust mass according to operator's (GKS) data: 915 t/a
(deviation: 8 %)



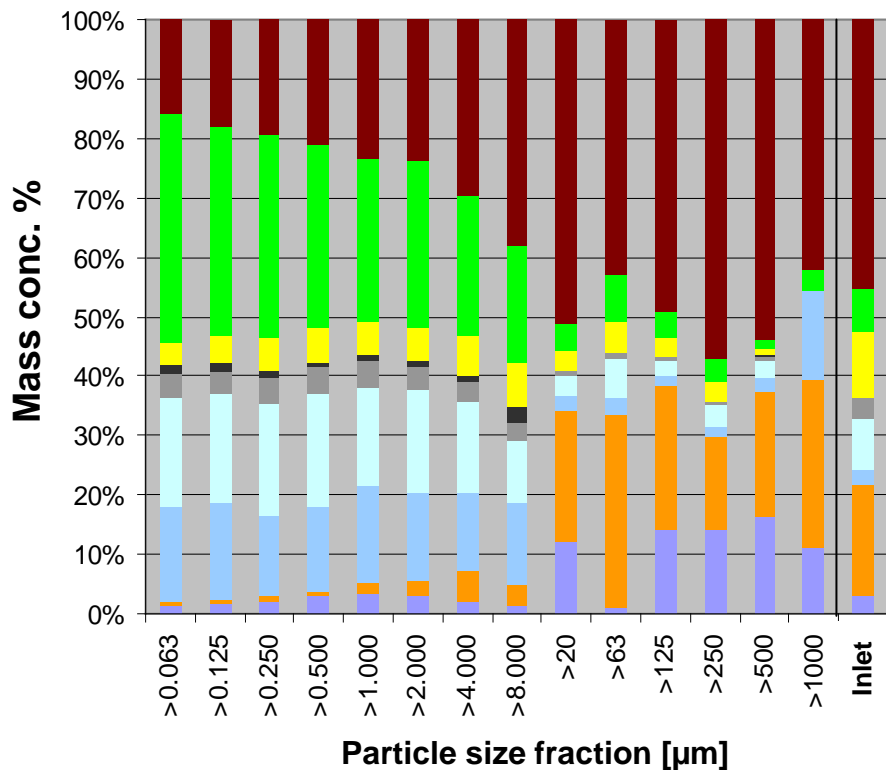
- **Plant B**

→ Significantly lower total mass concentration

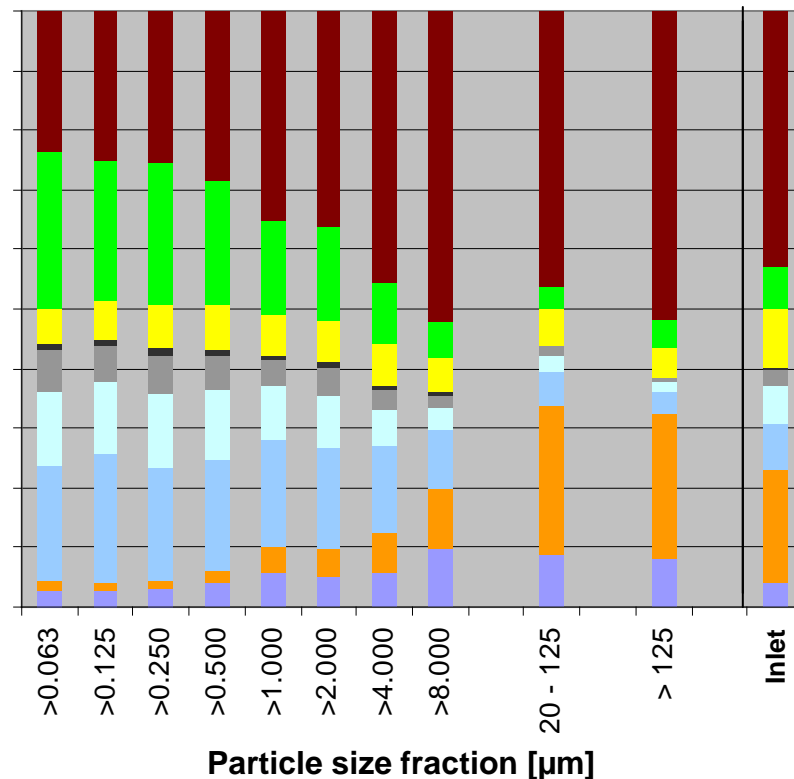
→ Less reduction through the boiler

(corresponds with the observed lower tendency for fouling)

Plant A



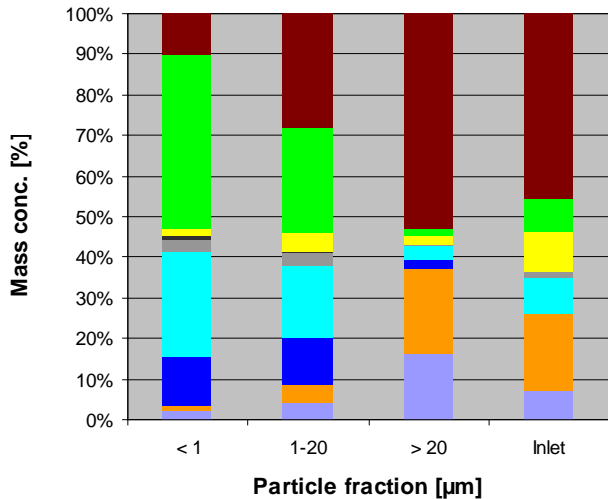
Plant B



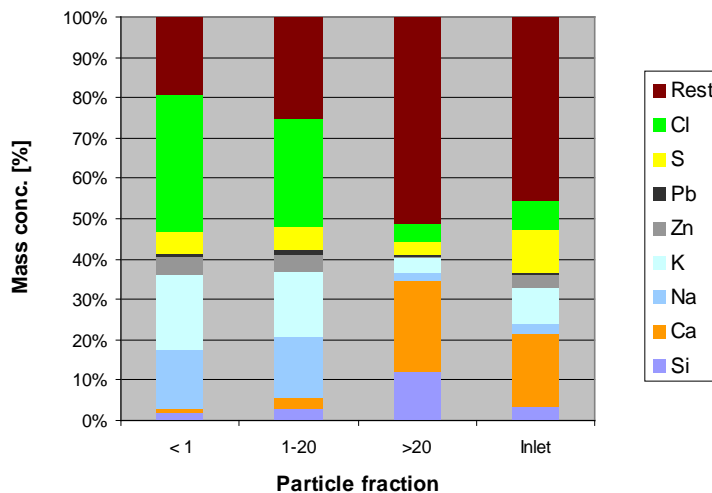
Fine fraction (secondary particles): A: (Na, K, Cl) B: more non-Na/K/Cl (more Na, less K/Cl)
Coarse fraction (primary particles): A/B: Ca, Si, High "Rest"

Inlet: A/B: mixture of all fractions

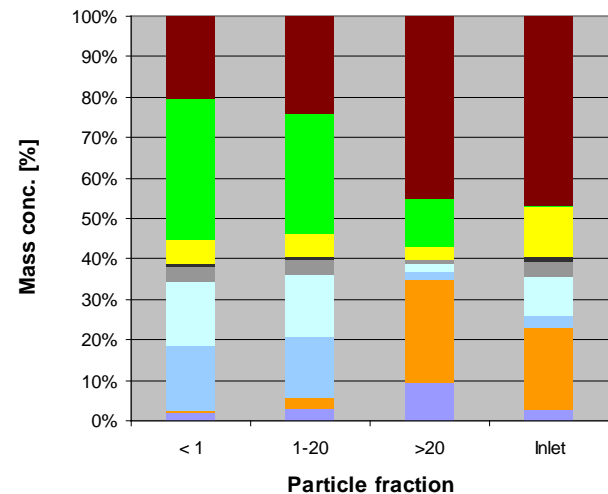
Chemical Composition – 1st pass



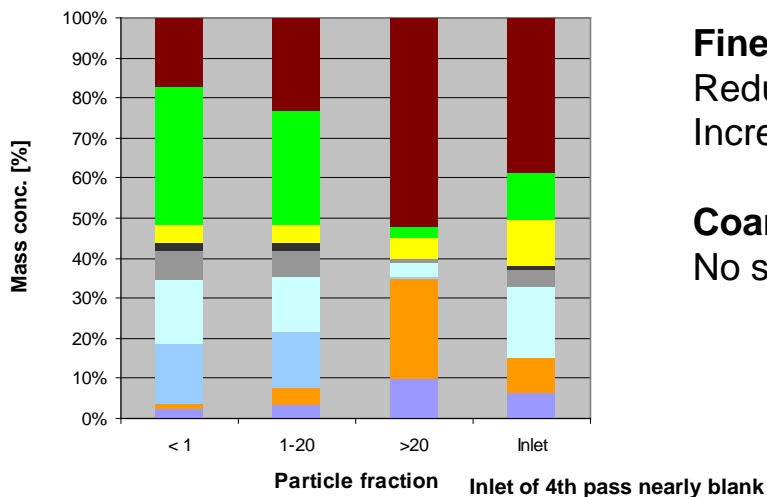
Chemical Composition – 2nd pass



Chemical Composition – 3rd pass



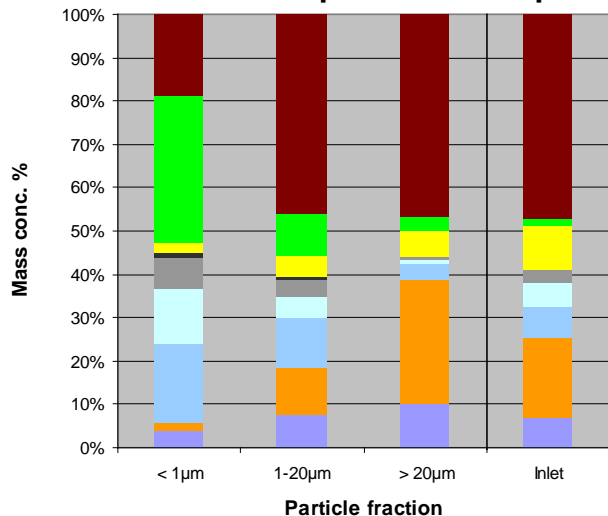
Chemical Composition – 4rd pass



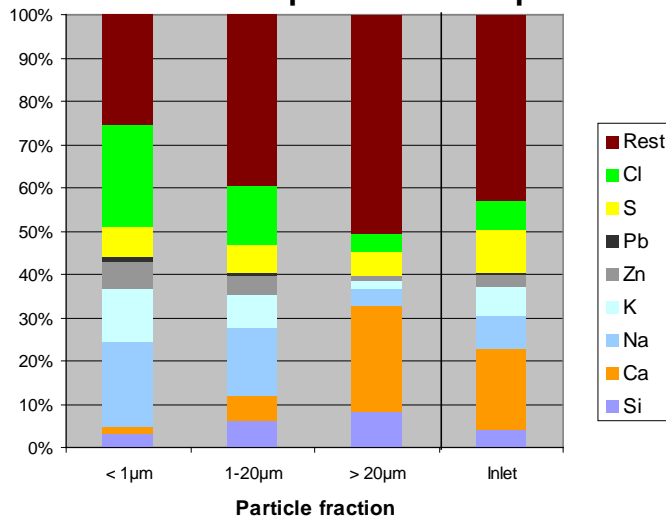
Fine fraction:
Reduction of Cl (1 → 2)
Increase of S (1 → 2)

Coarse fraction/Inlet:
No significant changes

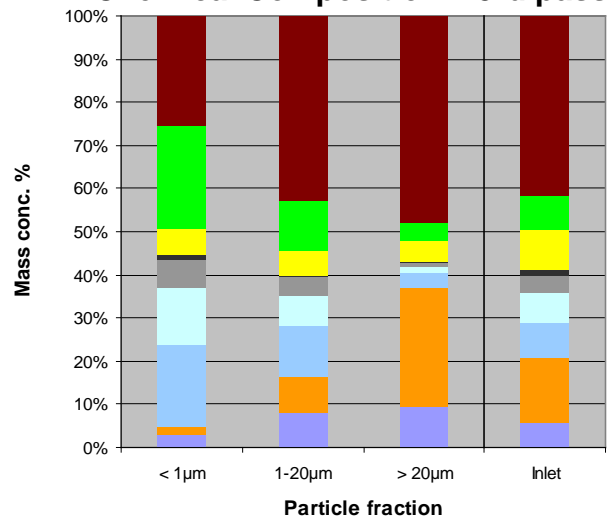
Chemical Composition – 1st pass



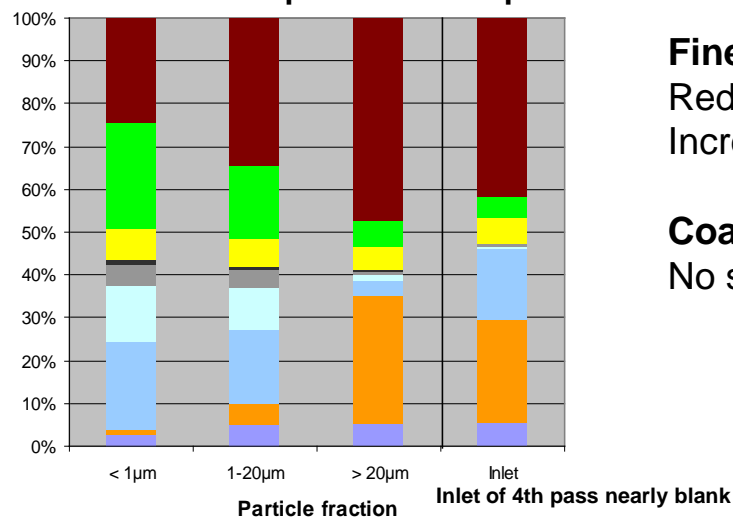
Chemical Composition – 2nd pass



Chemical Composition – 3rd pass



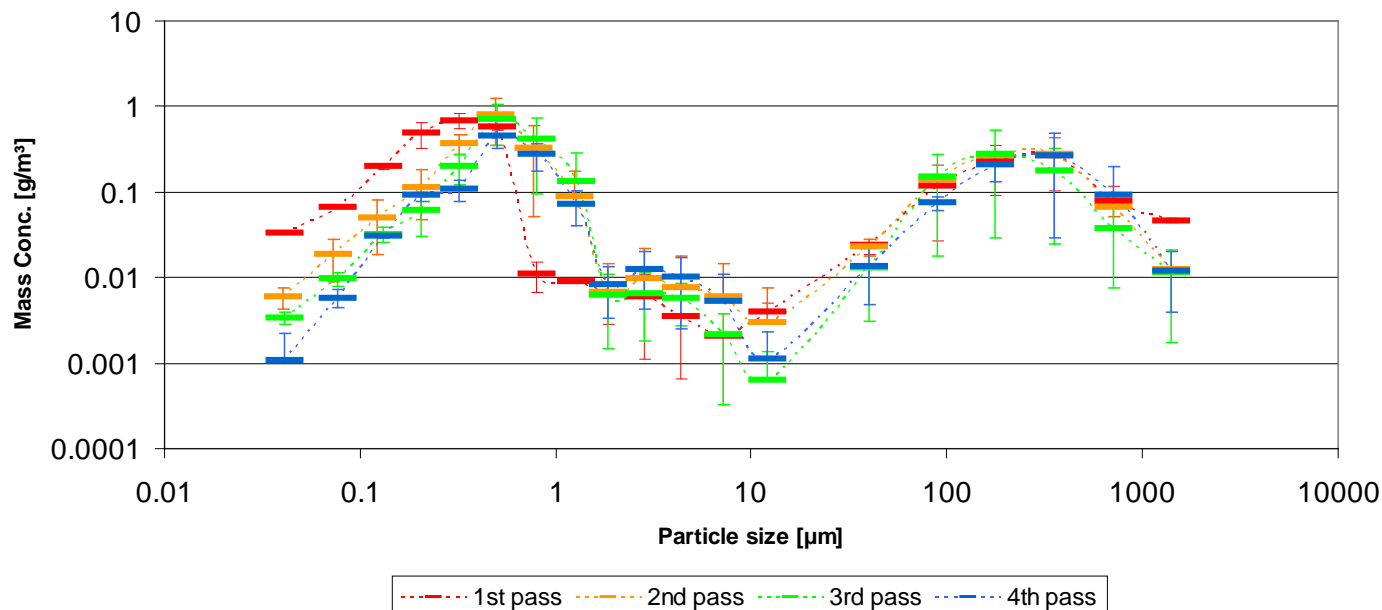
Chemical Composition – 4rd pass



Fine fraction:
Reduction of Cl (1 → 2)
Increase of S (1 → 2)

Coarse fraction/Inlet:
No significant changes

Plant A - Mass Concentration, 1st - 4th Pass (mean values)



Bimodal distribution:

1st mode: secondary particles (nucleation, condensation). Maximum shifts to slightly higher values (coagulation, condensation), nearly no reduction.

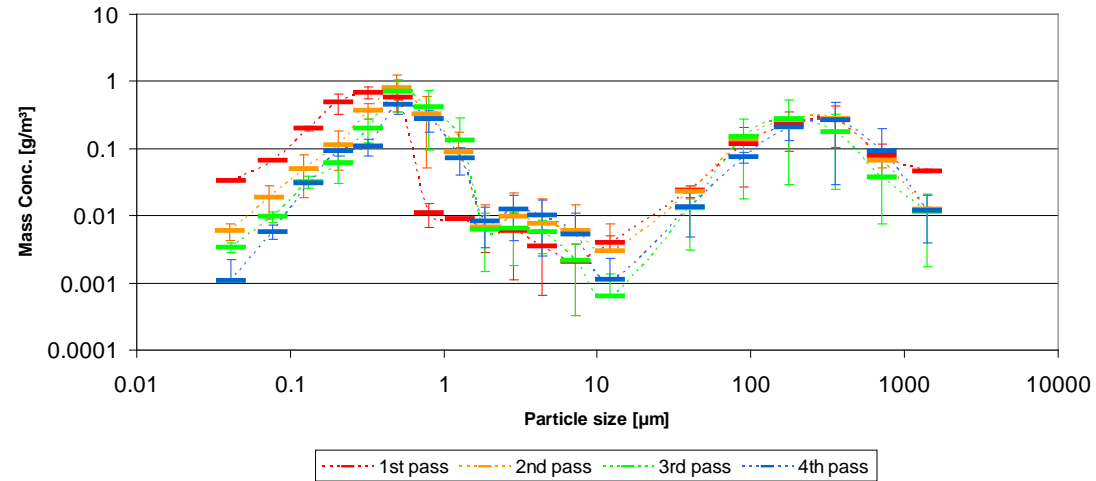
2nd mode: primary particles (ashes, calcium oxide spherules). Similar particle mass conc. as 1st mode; however, more reduced along the flue gas duct (impaction).

Fine fraction:
($< 1 \mu\text{m}$):
nearly equal

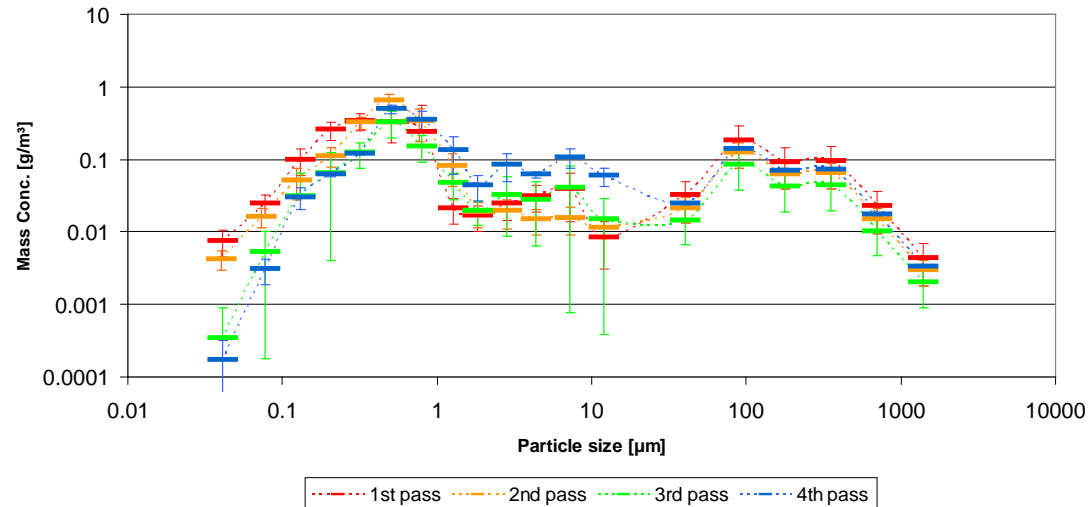
Midsized fraction
($1\text{-}20 \mu\text{m}$):
more at plant B!

Coarse fraction
($> 20 \mu\text{m}$):
less at plant B

Plant A - Mass Concentration, 1st - 4th Pass (mean values)



Plant B - Mass Concentration, 1st - 4th Pass (mean values)

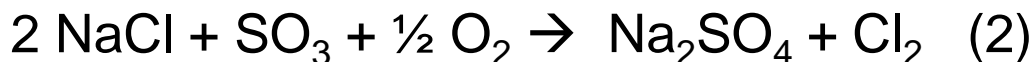


Sulphation of the chlorides is supposed to play a key role in corrosion processes of MSI super heaters.

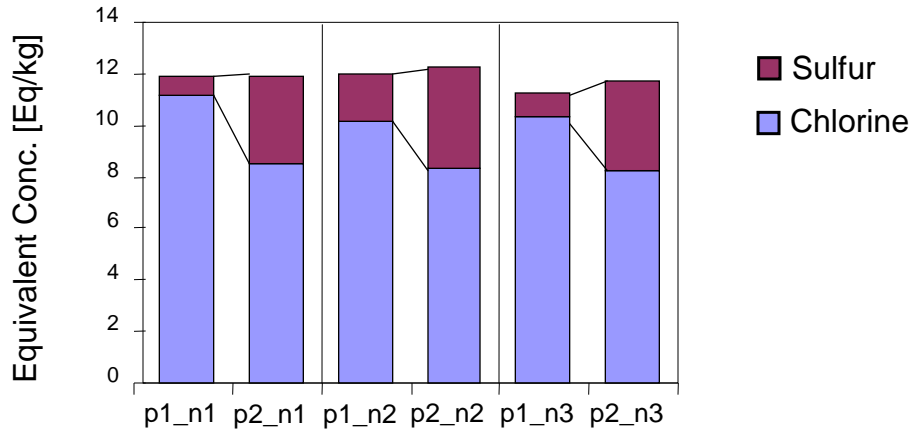
If sulphation occurs during the flight of chloride containing aerosol particles, chlorine is released mainly as indifferent HCl, as concerning corrosion:



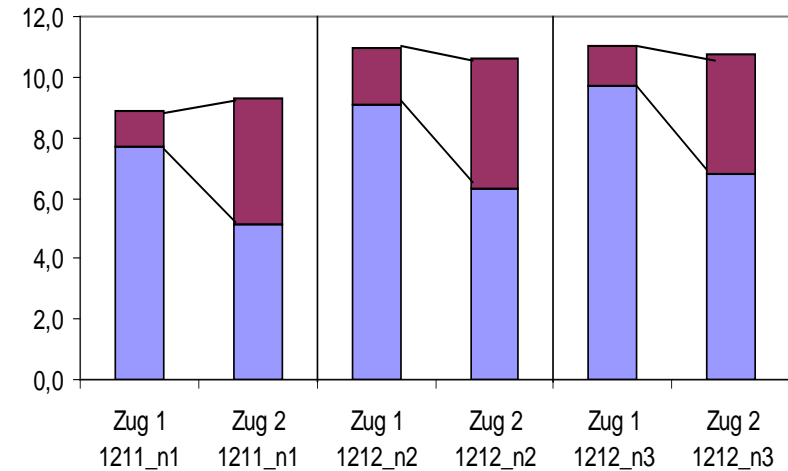
The sulphation of particles already deposited on superheater tubes is supposed to result in the formation of “active” chlorine that subsequently reacts with the iron of the tube steel:



Plant A



Plant B



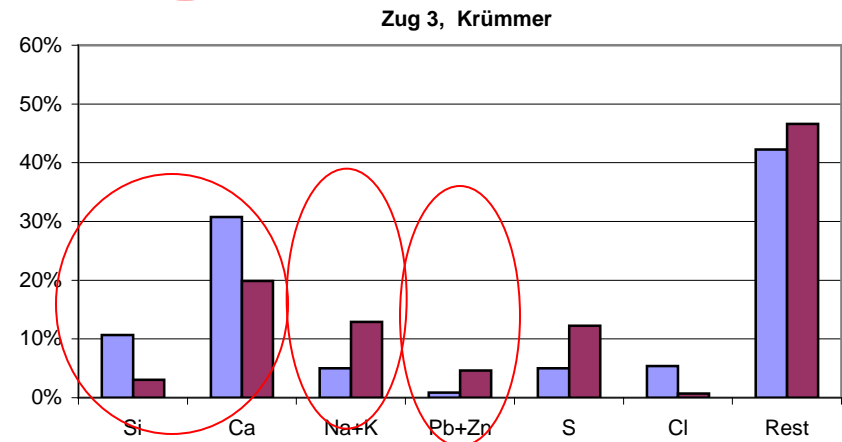
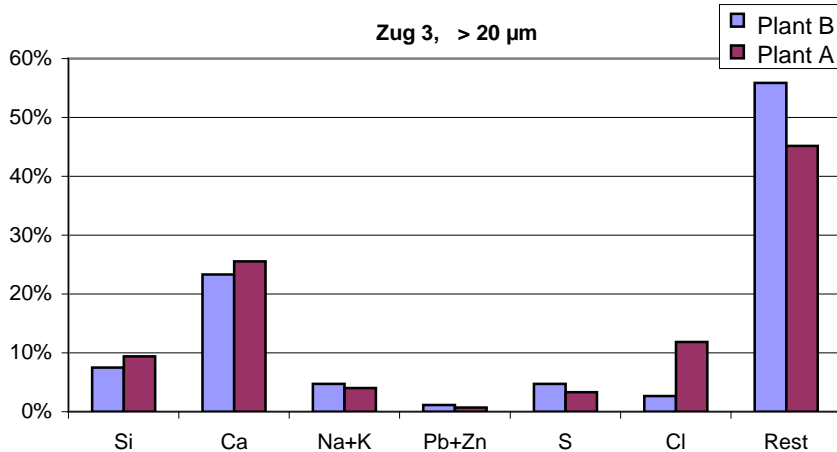
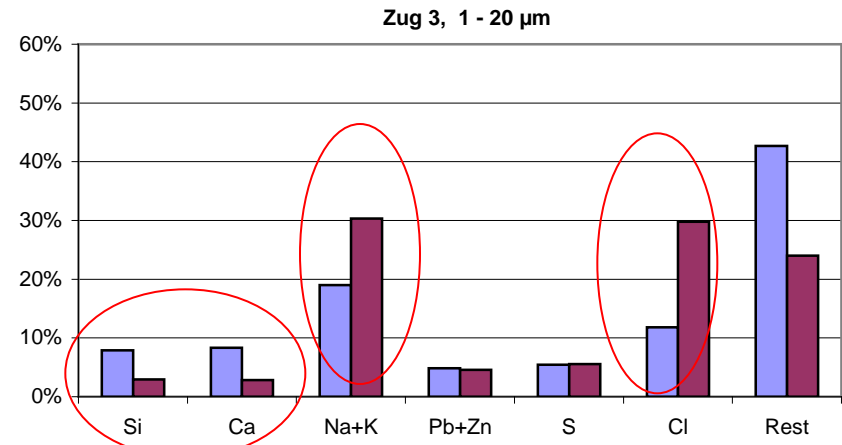
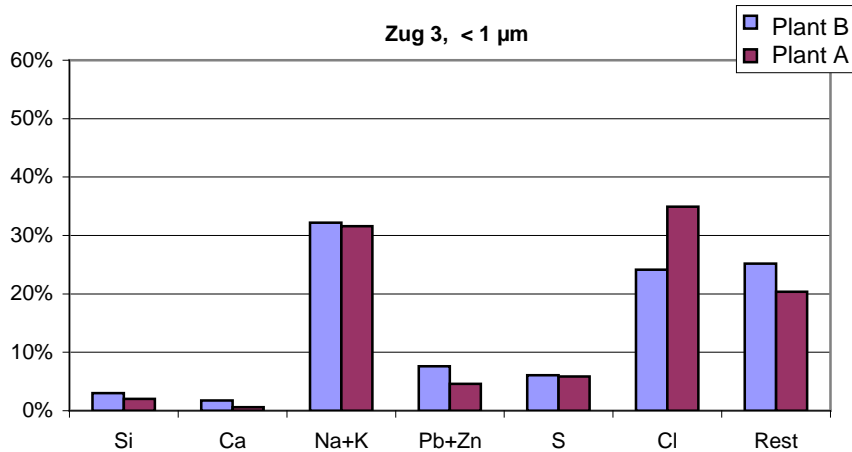
→ Plant A: Sulphation of approx. **20%** of the chlorides along the flight before reaching the SH

→ Plant B: Sulphation of approx. **30%** of the chlorides along the flight before reaching the SH

This conversion corresponds with an increase of the hydrogen chloride content of the raw gas.

Nordsieck et al., 2008

- 3rd pass: Comparison of chemical composition of 4 fractions – 2nd look



Nordsieck et al., 2008

Comparison of plant A (high corrosion rates) and plant B (low corrosion rates):

Plant B:

- Total mass concentration (TMC) is lower, especially the coarse fraction portion
 - Lower reduction of TMC along the boiler passes
 - Higher Sulphation achieved before particles reach the superheaters
 - Probably less stickiness of mid and coarse size particles (different chemical composition, mid fraction stays higher until boiler end)
- ➔ High temperature aerosol analysis has discovered several corrosion-triggering properties which all are suitable to amplify corrosion at plant A.

With this set of indicators it should be possible to directly control (and later perhaps even quantify) the real effect of actions undertaken to reduce corrosion at the measured or at any other plant.



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