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Size Depending Particle Losses in Sampling Lines (Poster)

DLR / FOCA Line Loss Study

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Motivation

Emission measurements at aircraft engine test rigs require long sampling lines. The typical length is between 12m and 25m. Because of safety reasons and noise level, the sampling lines cannot made shorter. For standard gas emission measurements, the line length is not a problem.
For particle measurements, the line losses can be roughly estimated. But line losses are a complex function of many parameters.

Some of these parameters are:

- line length and diameter
- line temperature
- particle diameter
- particle number concentration
- Reynolds number
- residence time
- line material
- line “ageing”
- ……

Some reasons for particle line losses are:

- wall losses (diffusion and thermophoretic)
- agglomeration → particle size up
- evaporation → particle size down
- densification → particle size down
- oxidation → particle size down
- ……

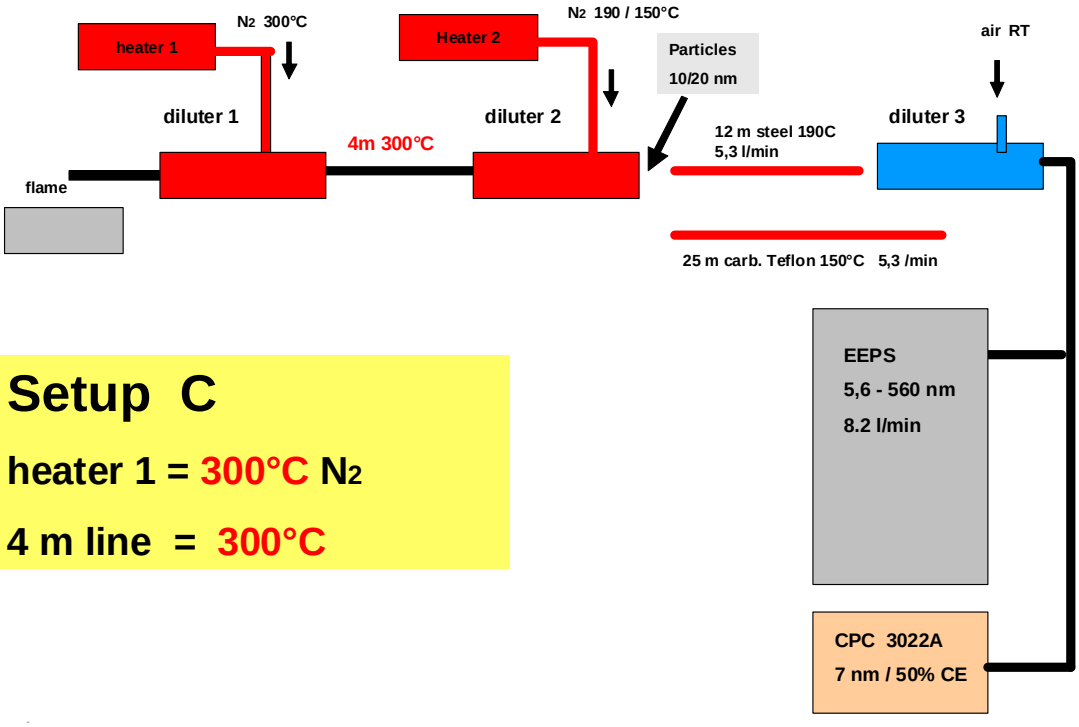
Experimental Setup

Soot source is the patented DLR –SOOT Generator. It is a stable and reliable soot particle source. Particle diameter can be set between 2nm and 200nm.

Diluter 1 is used to quench chemical reactions. The following 4m line is used to precondition the particles and to remove volatile particles. (Due to many discussions with our SAE-E31 colleagues, we improved the preconditioning section from Setup A to Setup C in order to be sure, the high losses are not caused by volatile particles).

Diluter 2 and heater 2 are used to bring the exit temperature of diluter 2 down to the temperature of the investigated sampling line (no thermophoretic effects in the sampling line!). Tested sampling lines are 1,5m / 4m / 12m stainless steel and 25 m carbon loaded Teflon®. All lines have 6mm inner diameter.

Diluter 3 is necessary to bring temperature down for EEPS and CPC.

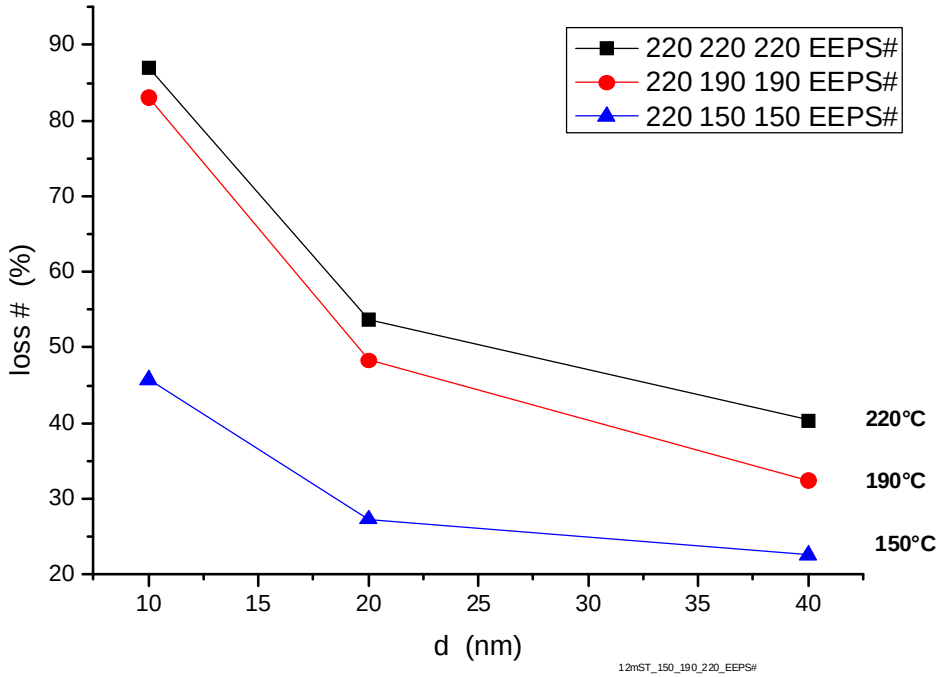


Setup C

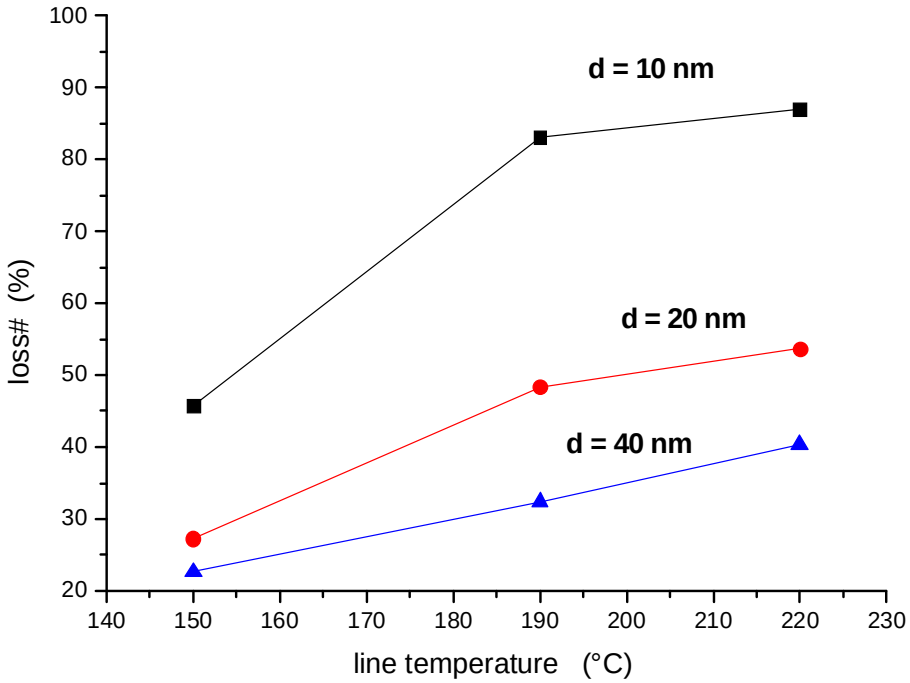
heater 1 = 300°C N_2

4 m line = 300°C

12 m stainless steel 8 x 1 mm EEPS



12 m stainless steel 8 x 1 mm EEPS



Results

- dramatic line losses are detected in “standard sampling lines”
- as expected, the losses show a clear dependence on particle size. The 10 nm particles show losses above 90% in particle number concentration.
- increasing temperature leads to increasing losses
- losses in mass are always lower, because of agglomeration
- line “aging” is not a problem
- **it is absolutely necessary to qualify sampling systems for particle line losses**

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Some of these parameters are:

- **line length and diameter**
- **line temperature**
- **particle diameter**
- **particle number concentration**
- **Reynolds number**
- **residence time**
- **line material**
- **line "ageing"**
- **……..**

Some reasons for particle line losses are:

- **wall losses (diffusion and thermophoretic)**
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- **evaporation → particle size down**
- **densification → particle size down**
- **oxidation → particle size down**
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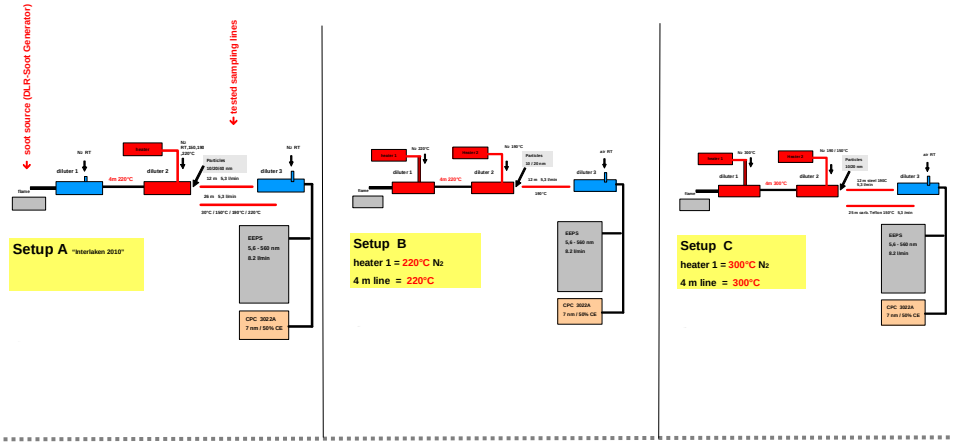

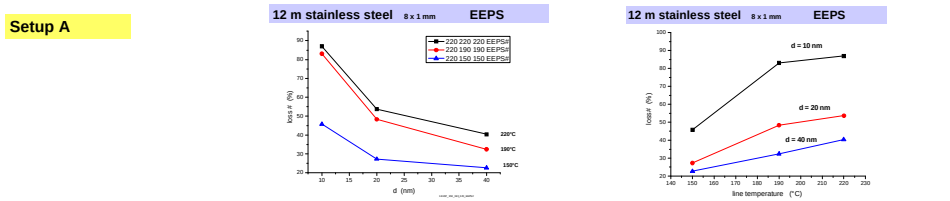

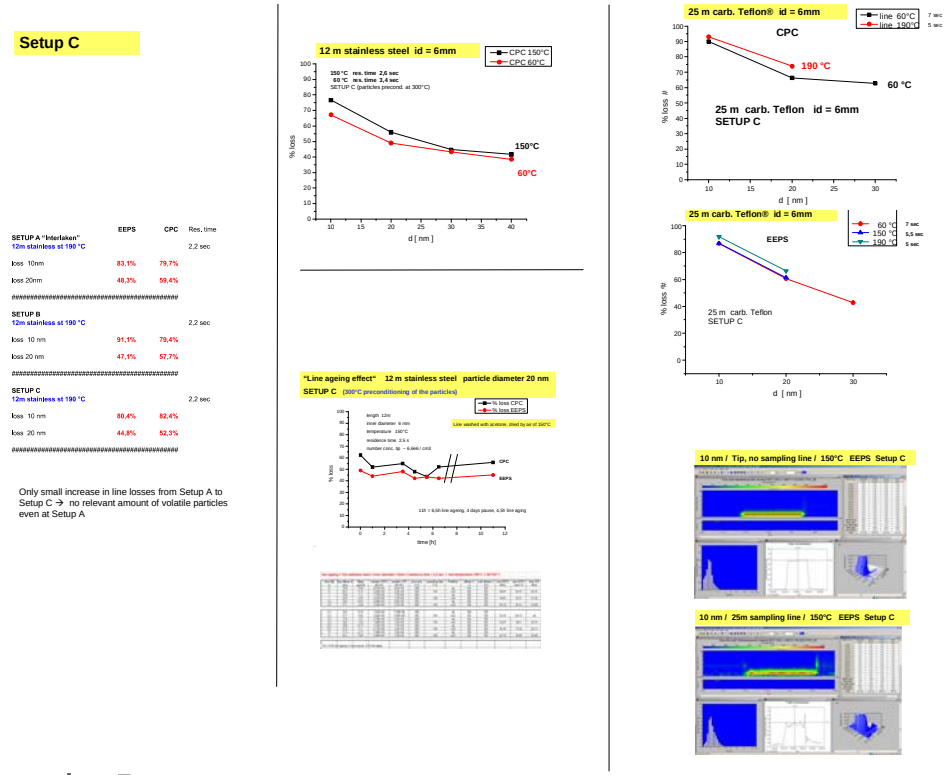

	EEPS	CPC	Res. time
SETUP A "Interlaken" 12m stainless st 190 °C			2,2 sec
loss 10nm	83,1%	79,7%	
loss 20nm	48,3%	59,4%	
##########			
SETUP B 12m stainless st 190 °C			2,2 sec
loss 10 nm	91,1%	79,4%	
loss 20 nm	47,1%	57,7%	
##########			
SETUP C 12m stainless st 190 °C			2,2 sec
loss 10 nm	80,4%	82,4%	
loss 20 nm	44,8%	52,3%	
##########			

Only small increase in line losses from Setup A to Setup C → no relevant amount of volatile particles even at Setup A

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