Conformity of Production Testing for Particle Traps - a Model Experiment

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Currently, Type Approval of new DPF systems is covered by acknowledged standards, such as the VERT protocol or the CARB certification procedure. While Type Approval demonstrates the quality of a single product sample (or a very limited number), it remains the manufacturer's responsibility to ensure that mass-produced units have - within narrow limits - exactly the same properties as the approved specimen. The conformity of DPF substrates with their Approved Type is best demonstrated with a measurement of particle precipitation efficiency.

For this purpose, a model set-up for conformity of production (CoP) testing was realised, consisting of a soot particle generator and several particle measuring instruments; two light-duty particle traps were mounted onto this model test rig and characterised. Measurements were carried out before and after DPF regeneration; then, holes were drilled into the plugged filter channels to simulate defects.

Particle concentrations downstream of the DPF units were found to be far below ambient concentrations as long as the filters were intact. After regeneration, particle emissions were observed to shortly increase by approximately two orders of magnitude, but they returned to low levels within a few minutes. With a defect of less than 1 mm2 in place, the filtration efficiency dropped from >99.995% to ~99%, further dropping as the size of the defect was increased, but independent of exhaust gas flow direction.

The model experiment demonstrates the applicability of particle based measuring methods to the challenge of CoP testing for DPF substrates.

Matter Engineering
Nanoparticle Management

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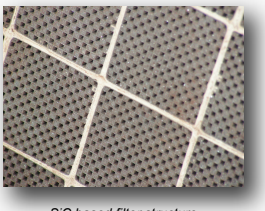
background

- DPF type approval established (e.g. VERT)
- DPF market and production grow fast
- quality control at end of production needed
- conformity of production with approved specimen required (e.g., 2007 FOEN Filter List)

- CoP testing should use diesel-like particles
- particle measurement must be reliable even at post-DPF concentrations
- CoP method must be simple, reproducible, reliable



SiC based filter structure

Reproducible EXhaust Simulator - REXS

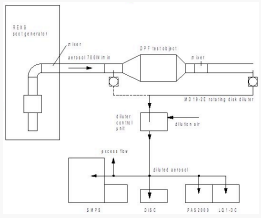
- combustion soot generator
- 1.5 g/h @ 80 nm / 700 l/min
- 65 / 80 / 100 nm mode
- backpressure proof up to 500 mbar

CoP test set-up

- REXS soot generator

- MD19-2E diluter
- SMPS, DiSC, PAS, DC

- DPF samples

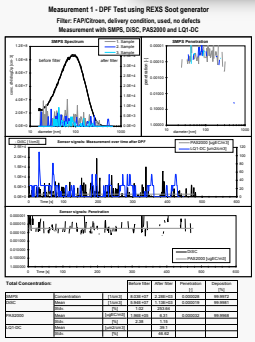


Diffusion Size Classifier - DiSC

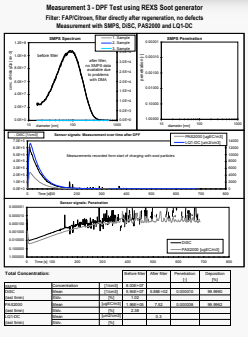
- on-line measurement of number and size
- size range 10-300 nm
- portable, 10 hrs battery operation
- USB or bluetooth connectivity

results - DPF ok

- DPF in normal condition: used, no defects
- particle penetration < 0.001%

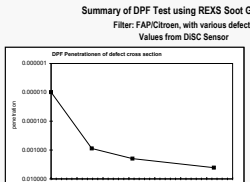


- DPF in normal condition: regenerated, no defects
- particle penetration < 0.001%
- note "refill" period (3 min)!



summary

- CoP testing possible with compact set-up
- typical DPF penetration < 0.001%
- measurable with nanoparticle (standard) equipment
- even small defects increase penetration significantly
- particle penetration increases almost linearly with leak cross section area
- no effect of leak location in DPF sample
- distinction of smallest defects in new DPF substrate?



	Defect [mm2]	Penetration [-]	Deposition [%]	Number concentration [1/cm3]
No defect	0.00	0.0000099	99.9990	5.88E+02
1 defect channel	0.79	0.0009823	99.9118	5.25E+04
2 defect channels	1.57	0.0019846	99.8015	1.18E+05
4 defect channels	3.14	0.0040919	99.5908	2.43E+05

acknowledgment

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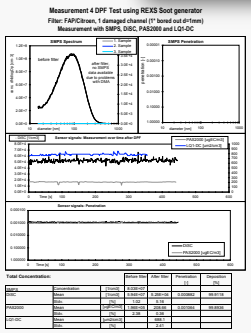
results - DPF leaky

- leaky DPF: defect simulated by one 1 mm hole
- particle penetration > 0.1%



- leaky DPF: defect simulated by four 1 mm holes
- exhaust flow direction reversed
- particle penetration > 0.5 %