Characterization of a PTB-standard for particle number concentration of soot particles

M. Eng. Arne Kuntze, Dipl. Lök. Margit Hildebrandt, Dr. Andreas Nowak, Dr. Anke Jordan Gerkens, Dipl. -Ing.(FH) Detlef Bergman, Prof. Dr. Egbert Buhr, Prof. Dr. Volker Ebert

Introduction

Modern engines with high-pressure fuel injection which are equipped with exhaust after-treatment systems emit significantly smaller soot particles and higher number concentration with less mass concentration. In order to control automotive emissions the European Community adopted the Euro 5b and 6 standards to introduce for the first time a number-based limit. A basic requirement to ensure those limits is a system for particle number measurements. Therefore engine exhaust condensation particle counter (EECPC) were implemented in PMP conform devices to measure the particle number concentration during the type approval of Euro 5b/6 engines [1]. Currently only commercial instrument manufacturers are providing calibration services for such EECPCs. An independent validation and calibration service without commercial interest is missing. The ISO/dis 27891 provides a calibration routine for particle number concentration and counting efficiency for CPCs taking into account the UN-ECE regulation R49 and R83. [2] [3] At PTB the German National Metrology Institute a set-up for EECPC-calibration is established following the ISO recommendations.

Experimental setup

Development of soot aerosol conditioning

- The PTB soot standard generates aerosols with monodisperse particle number concentrations from $10^4$ to $10^7$ cm$^{-3}$ and a mean particle number size distribution from 12 to 105 nm with mean width of 1.3 to 1.5
- Ultrasonic differential mobility particle size for selecting of monodisperse particles (non-commercial)
- Electrode as traceable reference system (TS: 3068 FCA)
- Condensation particle counter as secondary standard (TS: 3772 CPC)
- Engine exhaust condensation particle counter (TS: 3790 EECPC)

Burner-characterization: Longterm stability

Distribution unit

Scheme of distribution unit: Dilution of monodisperse CAST-Aerosol to adjust the concentration

- 23 nm CAST-aerosol without thermal treatment
- 23 nm CAST-aerosol with thermal treatment

Testing of stable conditions at eight different parts of the distribution unit using a particle number concentration at 23nm of 2000 /cm$^3$

Conclusion and outlook

- The PTB infrastructure is based on a miniCAST soot aerosol generator running on propane, which is able to generate soot well defined and stable with diffusion flames.
- The infrastructure at PTB is intended to ensure a highly stable, accurately characterized soot aerosol generator that allows well defined particle parameter variations.
- Calibration and standardization procedures are developed to allow valid comparisons between different types of particle counters, and to reliably determine uncertainties.
- The final step will be transferring the current soot aerosol generator into a soot aerosol standard in terms of uncertainty budget for particle number concentration.