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Particle number emissions from technological lubricants used in the manufacturing of the automotive exhaust system

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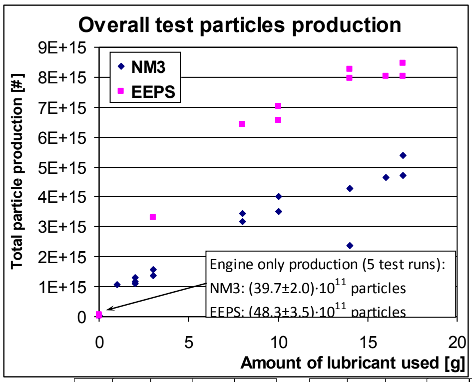
Background

- Current engine technologies allow for significant reduction of PN production.
- Other sources of traffic related PN sources (i.e. brake and tire wear) and „off-cycle" emissions are becoming significant
- Industrial lubricants are used during production process (e. g. bending) of exhaust gas components.
- These lubricants are usually not removed from the exhaust, are exposed to high exhaust gas temperatures and are undergoing thermal processes (thermal decomposition, combustion).
- Additional pollutants and specific odour are undesirably generated during first tens kilometers of operation of each such new car.

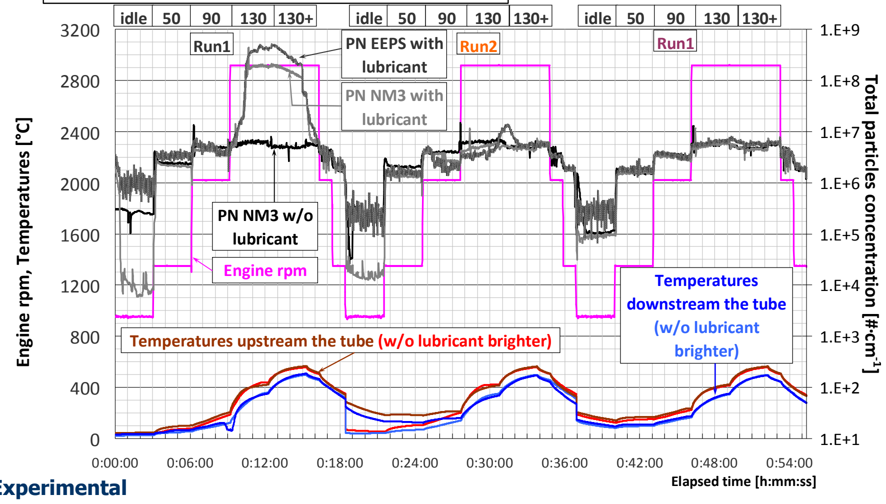


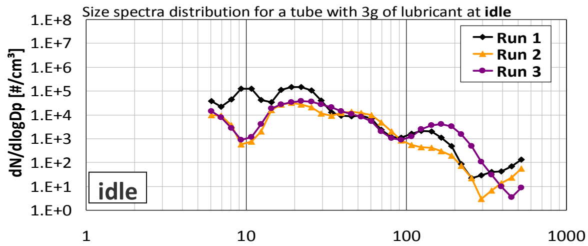
Goals:

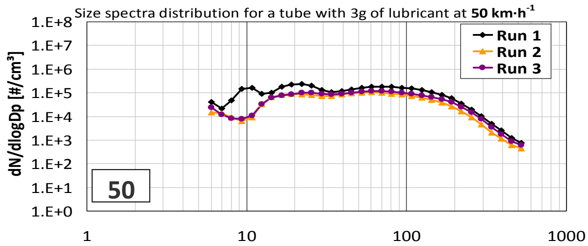
- **To characterize „excess" particle emissions originating from exhaust system technological lubricants**
- **To determine relationship between mass of lubricant used and emissions**
- **To explore changes in particle size distribution and share of particulates not detected by the PMP procedure**

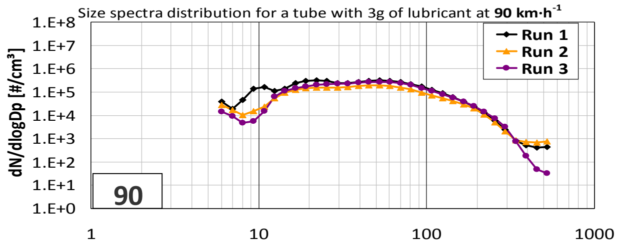
Results and Discussion

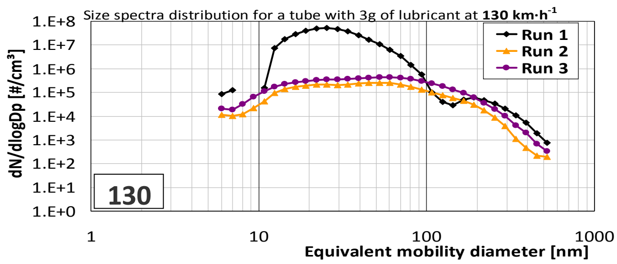
- Production of PN is increased about nearly two orders of magnitude higher when burn-off procedure is performed compared to engine out emissions only
- One pass of the procedure was enough to remove nearly all the deposited lubricants
- Lubrication burned particles are not generated before 130 km/h suggesting particles originating from lubricant are emitted predominantly during highway operation, possibly during rural and least probably during city operation
- Size distribution peak is shifted from approx. 50 nm at load corresponding to 130 km/h to about 10 nm when load increased
- 1 g of lubricant corresponds to the net production of approximately 0,3 - $1 \cdot 10^{15}$ non-volatile particles (lower values for higher lubricant amounts), which corresponds to 500-2000 times the 6 x 10^{11} particles per km Euro 5b-6 PN emission limit
- Whole exhaust contains tens of grams of lubricants in total so overall burn-off PN emissions are expected to correspond to (up to) several tens thousand kilometers of vehicle operation











Experimental

- The experiments were conducted on a state of art production three cylinder direct injection spark ignition gasoline engine mounted on a powertrain dynamometer
- Operation consisted from steady-state operating points with three minutes duration with rising load and exhaust gas temperatures: idle, steady-state operation at 50, 90 and 130 km/h at rpm and torque corresponding to actual road conditions, and 130 km/h with increased load (uphill section of a motorway)
- Multiple sets of middle part exhaust tubes were prepared, each with controlled amount of lubricants applied during manufacture
- The lubricant amount was ranging 1 – 17 g where about 10 g is technological optimum for the bending process
- Exhaust gas flow has been determined using build in MAF sensor data obtained through OBD interface
- Particle emissions were measured by Testo NanoMet3 (PN according to the PMP procedure), TSI EEPS 3090 (size distribution of all particles including volatiles, 5-560 nm), gaseous pollitants by a portable miniPEMS (NDIR for CO, CO_2, HC; chemical cell for NO_x and O_2)
- Net contribution of the lubricant to PN emissions (relative to operation with „degreened" exhaust) has been determined per test and evaluated as a function of mass of the lubricant used