Emissions measurement

Combining partial flow sampling and direct exhaust flow measurement provides an ideal solution for particulate emissions measurement from light-duty vehicles

With the phase-in of LEV-3 this year targeting a 3mg/mile PM limit, followed by a 1mg/mile PM limit phasing-in by 2025, light-duty (LD) vehicle manufacturers are well aware that traditional constant volume system (CVS)-based particulate matter (PM) measurement methods are not sufficiently robust. Is an all new measurement technology required? No. It turns out that the ideal technology has been in use for decades in the heavy-duty diesel (HDD) engine industry.

The California Air Resources Board (CARB) enacted aggressive PM limits for LD vehicles in 2012 with their Low Emissions Vehicle-III (LEV-3) program. This prompted concern regarding the full dilution (CVS) based PM mass measurement, due primarily to observed hysteresis in measured PM through interaction with wall-bound PM from previous tests. This is the identical challenge faced by the heavy-duty diesel (HDD) manufacturers over a decade ago with the advent of particle trap-equipped engines.

Continuing, these spurious mass contributions affect the measurement uncertainty of PM and particle number ('PN') results. A successful replacement for CVS would produce improved uncertainty in PM results, in part through reduced PM hysteresis. However, proposed mitigation strategies for CVS include costly and time-consuming tunnel conditioning ('burn out') practices.

Sierra has launched a new evaluation program for either BG3, ExhaustTrak, or both, to qualified LD labs that may be new to the technology or are considering integration of a PFDS and direct exhaust mass flow meter into their facility

Enter partial flow dilution systems ('PFDS'), as exemplified by the technology leading Sierra BG3 Elite. BG3 PFDS technology provides virtually unlimited sampling location flexibility (pre or post-after treatment), significantly reduced physical size, operation and calibration costs, improved dilution air background levels and simplified remediation of accidental contamination. Measured PM uncertainty is improved through reduced particulate hysteresis enabled by use of the patented BG3 radial inflow dilution tunnel. Several HDD manufacturers have abandoned CVS for BG3 PFDS altogether for the reasons stated.

Furthermore, BG3 Elite can support all functions of a CVS (including enabling R49 PN) at a fraction of the cost, with improved results and with dramatically increased sampling flexibility. On January 7, 2011, the US Environmental Protection Agency (EPA) approved the use of PFDS in 40 CFR Part 1065 for engine certification on all transient cycles. This landmark decision was based on BG3 versus CVS correlation results provided to the EPA. In recent independent testing directed toward LEV-3, as part of CRC E-99, BG3 Elite provided further validation of these correlation results.

Recent breakthroughs in direct exhaust mass flow measurement have come at the right time. PFDS devices require fast responding (>10Hz recommended) engine mass flow measurement. HDD labs generally rely on engine intake airflow measurement device signals, proportional to intake mass flow rate, to enable compliant PFDS transient raw sampling proportional to engine exhaust flow. In contrast, LD engines are typically tested in-vehicle, generally precluding the use of intake airflow measurement as an exhaust mass surrogate due both to leakage through intake air components and to the lower percentage of air contributing to gasoline exhaust mass flow rate.

Using PFDS in this application requires direct measurement of exhaust flow rate. Sierra's ExhaustTrak mass flow meter features a novel Venturi design offered in either single- or dual-pressure differential pressure range options. ExhaustTrak provides near-instantaneous mass flow rate measurement of exhaust up to 850°C (1,562°F) at the emissions sample zone with <2.5% reading accuracy over a wide range of flow rates and transmits a signal proportional to mass flow to the PFDS. Recent independent on-vehicle testing has verified the accuracy of ExhaustTrak over several LD vehicle test cycles.

Furthermore, ExhaustTrak reduces concerns regarding the contribution of intake air and exhaust piping and component volumes to pneumatic capacitance-based delays for concentration-based measurements such as PN and gaseous emissions. ❮