GET REAL! – PEMS ENABLES REAL-WORLD DRIVING EMISSIONS TESTING IN NEW ZEALAND

It is becoming recognised internationally that 'real-world' driving emissions results measured using portable emissions monitoring systems (PEMS) are sometimes three times higher than traditional rolling road dynamometer test results. While both test methods have their place, there has been an increasing focus in recent years on real-world automotive emissions testing because the results align better with other scientific observations. For example, monitoring of ambient air quality in urban centres has found concentrations of nitrogen dioxide (NO_2) that were much higher than the estimated contribution from the vehicle fleet, as calculated from rolling road test data.

The implications here are not trivial for society. The 2012 health and Air Pollution in New Zealand (HAPINZ) report declared that harmful vehicle emissions, such as NO_2 were responsible for 256 premature deaths. When compared to the 308 people who died in road accidents that same year, the number is staggeringly high and justifies all reasonable efforts to reduce these tragic fatalities.

Taken from another perspective, the emissions monitoring scandal that impacted VW in Germany was responsible for wiping 35 billion Euro from the value of the VW group. That would be approximately 20% of New Zealand's GDP! Clearly, the importance of good science in vehicle emissions measurement, is critical. PEMS has an important role to play and will ensure that car makers can employ technology to achieve genuine emissions reductions.

Good science

To understand how best practices are being applied in automotive emissions measurement, let's turn to Paul Baynham, Senior Scientist at Mote Limited (formerly AirQuality Limited) in Auckland. "When it comes to PEMS, we have worked with national government transport agencies, local regulators and fleet operators. Our industrial and regulatory clients increasingly require realistic, accurate data on which to base their decisions. This means that real-world emission monitoring using PEMS is on the increase. In some cases, this is to verify the claims of manufacturers and fleet operators that their vehicles meet emissions requirements or contractual terms. In other cases, it is used to understand that unique emissions characteristics of individual vehicles that make up the vehicle fleet in a particular urban centre."

Since the traditional rolling road chassis dynamometer will still have a role to play in the future is essential that there is a clear correlation between real driving emissions measurements using PEMS and the rolling road in the laboratory. Baynham explains how this link is made: "we have performed concurrent vehicle emission testing on a rolling road dyno then repeated the drive cycle on a similar real-world route to compare the results. This approach has underpinned our PEMS calibration and evaluation process."

The foundation of the testing must be national and international standards and Baynham explains how this is achieved at Mote: "we have used the World Harmonised Light Vehicle Test Procedure (WLTP) as the basis for laboratory testing. However, we generally

develop our Real Driving Emissions (RDE) route using Commission Regulation (EC) 2016/427 with (EC) 2016/646 as guidance. We also try to incorporate characteristics which mimic either the vehicle fleet or the driving style of the vehicle we are testing."

Do sensors make sense?

Sensors are increasingly used for the measurement of gases across a range of applications. In safety equipment they detect toxic gases such as H_2S. They also proliferate in the measurement of indoor CO_2 levels to determine the presence of humans in a room and activate the air-conditioning system, thus combining comfort and energy efficiency. Their application is widespread due to their low cost and small size.

Gas sensors, such as the Lambda Sond oxygen sensor for air / fuel injection ratio control, have also been used for decades in automotive engine management systems. More recently, both NOx and NH3 sensors are being used in heavy duty vehicles to monitor and adjust AdBlue® dosing to the SCR unit that is responsible for NOx emissions reduction.

The US EPA have also recently tested automotive emissions using sensors and evaluated the results against PEMS systems employing analytical instrumentation. The sensors certainly are the more practical technology when it comes to motorbike emissions testing, where the use of instrumentation for PEMS would completely change the aerodynamics of the bike and the weight distribution. It would therefore move the test too far from "real-riding", conditions. So, sensors are knocking on the door of this motor vehicle emissions testing application also.

Paul Baynham sums it up like this: "in terms of suitability, the use of sensors vs analytical instrumentation really depends upon what question you are trying to answer. We are fortunate that our team at Mote have extensive experience with gas sensor use and evaluation through our operation of low cost ambient air quality sensor networks. We have found that for some gas sensors there is considerable variability, due to the presence of interferences such as humidity and temperature. While we can control these to some extent, some gas sensors are also sensitive to specific hydrocarbons which may be present in engine exhaust gases. Our conclusion was that where size and weight limitations prevented a full PEMS system being used (such as motorbikes) then use of gas sensors may be appropriate, provided it is understood that this comes at the cost of reduced accuracy."

Tried and tested

Established practice in PEMS is to use analytical instrumentation, like that used with the rolling road in the engine emissions laboratory. At Mote, that breaks down to mean that: "We selected the Ecophysics CLD66 chemiluminescence monitor for NOx and NO_2 which enables us to measure in the concentration range from 0.5 ppb to 1,250 ppm. We chose to use the Teledyne T360 IG gas filter correlation analyser to measure CO_2 and the similar Teledyne T300 to measure CO. We have also performed some SO_2 measurement and selective monitoring for specific VOCs. Our testing also includes particulates such as PM2.5 and on occasions, PM1 or PM10. The particulate range we monitor varies from 1 $\mu g/m^3$ to 3,500 mg/m^3."

Baynham is acutely aware that the sensor option is a cost competitive benchmark. With selection of equipment that was fit for purpose, and the customisation of the measurement suite to focus on the requirements of the tests required in the market, Mote were able to build a PEMS system that was a fraction of the cost of the best commercially available systems. Despite this tremendous cost advantage, Mote continue to focus on using their system to deliver good science and accurate emissions data rather than market their hardware technology for sale. The low cost of their PEMS equipment means that their studies have a winning combination of accuracy and cost competitiveness.

Chain of dominoes

According to the principles of measurement uncertainty, the accuracy of the analytical instrumentation can only be as good as the calibration. For this reason, use of the highest accuracy calibration gas mixtures which are traceable to national and international standards is essential. This chain of dominoes ensures that measurement around the world is harmonised and can be traced to SI standards.

Changes in the classification of calibration gas mixtures have taken place recently and it is now accepted that selection of reference materials produced under a scheme of accreditation according to ISO 17034:2016 is best practice. Finding a specialty gases supplier that can comply with these requirements is no simple matter and despite excellent capabilities in Asia, some mixtures are imported from the USA. Despite the challenges, Coregas, with their production centre in Yennora, close to Sydney, have kept up with the changes. They were awarded the gold seal of metrology recently when they achieved ISO 17034:2016 accreditation for production of automotive emissions testing calibration gas mixtures. Their gaseous reference materials contain ppb and ppm levels of NOx, SO_2, CO and CO_2, amongst other typical transport emissions species.

Victor Chim, Business Development Manager at Coregas speaks with confidence about the recent developments, "the world keeps changing and at Coregas we want to be ready to offer customers products that the latest standards are pulling for. That's why we set out to achieve the ISO 17034:2016 accreditation from NATA as soon as the new standard was written. It is only due to the complexity of implementation and the requirement for long term stability testing of our gas mixtures, which proves their accuracy over a multi-year shelf life period, that it has taken us until 2018 to achieve this coveted accreditation. Despite this two-year implementation period, we were the first specialty gases supplier in the APAC region to achieve this goal and that makes us feel enormously proud".

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