

Experiences of Testing NO₂ for Diesel and NH₃ for Gasoline Cars

J. Czerwinski, P. Comte AFHB, University of Applied Sciences, Biel-Bienne, CH

A. Mayer, TTM

N. Heeb, EMPA

J. Lemaire, AEEDA

Abstract

Public concern and complaints regarding ambient air in zones of dense traffic pertains to two compounds of nitrogen, nitrogen dioxide (NO₂) and ammonia (NH₃); both are toxic and strongly irritant, such that legal limitations are under discussion. This paper contributes to measuring methods as already in part proposed by GRPE subgroup WLTP-DTP (Worldwide Light Duty Test Procedures – Diesel Test Procedures) for NO₂.

Despite legally lowered NO_x emission levels, lumping both, NO₂ and NO, levels of NO₂ have risen in cities and agglomerations as a result of both, deployed catalytic exhaust after-treatment devices and low sulphur Diesel fuels. In present tests two different combinations of NO₂ measuring methods as proposed by WLTP were checked on Diesel cars for practicability in handling and accuracy. These integral, indirect methods (NO₂ = NO_x – NO) have been found as useful tools for estimate of NO₂ and with use of appropriate analyzers a satisfactory accuracy was attained.

Furthermore, attention was brought to ammonia (NH₃) emitted by gasoline engines with three way catalysts (TWC) which ought not to be ignored while on the other hand SCR systems for Diesel engines are strictly regulated. Emission levels of more recent TWC turned out to be mostly below 20 ppm NH₃. Vehicle of older technology exhibited significantly higher levels, about 10 times more.

As chemical reactions depend on pressure and temperature (= i.e. flow condition in CVS-tunnel) as well as concentrations, doubts need to be considered on accuracy of results based on chemical reactive substances. Nevertheless, clear tendencies regarding changes of concentrations of NO₂ and NH₃ along the path-way could not be observed.

NO₂ Diesel Cars

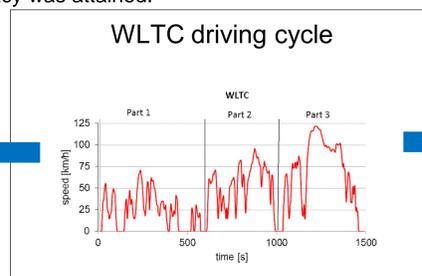
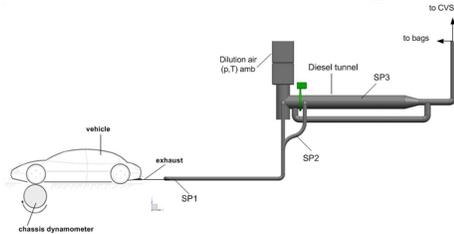
Diesel vehicles for research of NO₂



Opel (veh.1 & 2)

BMW (veh.3)

Sampling positions SP for Diesel vehicles – testing NO₂



NH₃ Gasoline Cars

Gasoline vehicles for research of NH₃

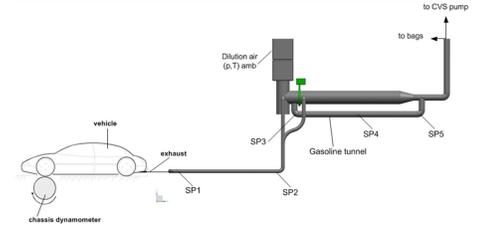


Renault (veh.4)

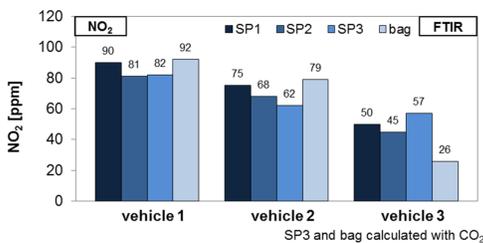
Peugeot (veh.6)

Volvo (veh.5)

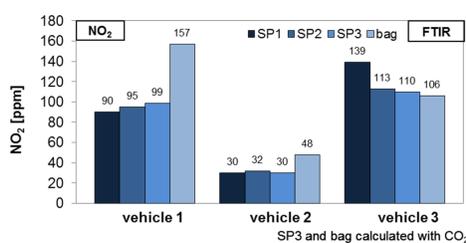
Sampling positions (SP) for Gasoline vehicles – testing NH₃



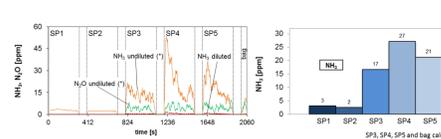
Comparison of NO₂-Results at Different SP's and 50 km/h



Comparison of NO₂-Results in WLTC at Different SP's

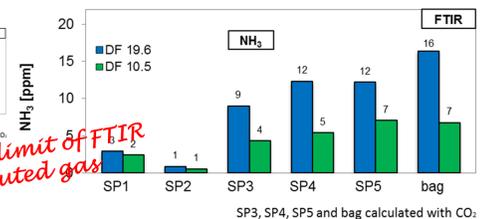


Influence of Dilution on NH₃-Emissions at Vconst 30 km/h, vehicle 5; DF: 34.1



Detection limit of FTIR in diluted gas

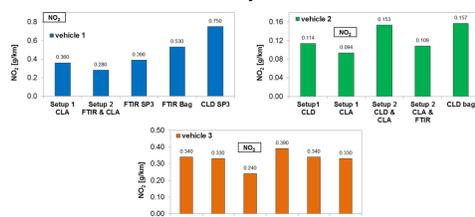
Influence of Dilution on NH₃-Emissions at Vconst 50 km/h, vehicle 5; DF: 19.6 and 10.5



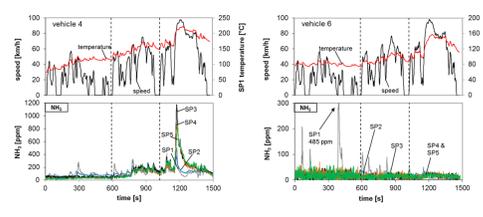
WLTP-DTP Measurement Guidelines

The guidelines proposed by WLTP for NO₂ legal measuring procedures consider the feasibility with the present installations (CVS) and analyzers. Two methods set-up #1 and #2 are possible to perform with the present equipment. They propose an indirect estimate of NO₂ by measuring continuously NO (with CLD) during the driving cycle and measuring NO_x from the bag. With the consideration of all necessary corrections NO₂ = NO_x – NO. Set-up # 1 uses for all measurements one kind of analyzer whereas set-up #2 uses two analyzers.

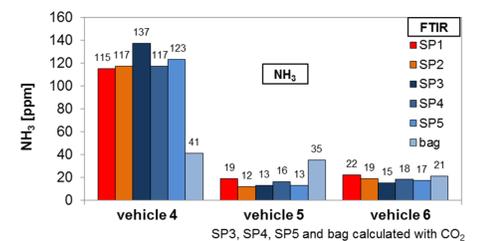
Comparison of NO₂-Results Measured According to WLTP with Different Sets of Analyzers



NH₃-Emissions in WLTC Warm



Comparison of NH₃-Results in WLTC



Conclusions

NO₂ from Diesel cars with oxidation catalyst

- At steady state operation, the NO₂-concentrations in bags are generally higher for vehicle 1 and 2 and generally lower for vehicle 3, than the tailpipe values (SP1).
- The present NO₂-results at constant speed operation do not indicate any regular, systematic changes of concentrations from SP to SP, which would indicate a chemical reactivity. Further research in this respect is recommended.
- The investigated indirect, integral WLTP – NO₂-measuring methods have been found as useful tools to estimate the NO₂-levels.
- Comparisons of NO₂-levels with other vehicles are not recommendable, since the present research was focused on the testing procedures and the NO₂-emissions of vehicles were increased by increasing the driving resistances of chassis dynamometer.

Conclusions

NH₃ from gasoline cars with TWC

- The vehicle with older technology had an approximately 10x higher NH₃-emission level, than the newer vehicles.
- In single phases of the WLTC the relationships of bag-values and the average SP-values are varying: there is a tendency of lower NH₃ in the bag for high emitting case and a tendency of slight increasing NH₃ in the bag for the low emitting cases.
- In certain acceleration events of WLTC high peaks of NH₃ emissions are observed; some of these peaks are repetitive (originating from rich Lambda-excursions) and some of them are stochastic (originating from store-release effects of NH₃).
- Emission level of newer vehicles, regarded as average of all SP's, is mostly below 20 ppm NH₃.
- The direct, undiluted measurement of NH₃ at tailpipe (SP1) can be recommended as the best variant. This direct measurement avoids the possible problems of: detection limit, contamination from dilution air, adsorption/desorption in CVS-tunnel and artefacts in the bag.