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Plug-In Hybrid Light-Duty vehicle emission measurements over custom RDE test cycle on the road and in the various laboratory conditions

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INTRODUCTION

Real Driving Emissions (RDE) methods are essential for assessing the environmental performance of Plug-In Hybrid Electric Vehicles (PHEVs), which differ significantly from Internal Combustion Engine (ICE) vehicles due to their dual powertrain systems. These systems have different operating modes, either prioritizing electric power (in this case Automatic mode) or balancing ICE use to maintain battery state of charge (SOCH; here Hybrid mode), which influence emission profiles. Such distinctions necessitate tailored RDE testing to capture emissions under real-world conditions accurately.

This study focuses on two PHEVs: one equipped with a gasoline engine (PHEVG) and the other with a diesel engine (PHEVD).

Gaseous and particulate emissions were quantified to assess the effects of temperature, powertrain type, and driving mode.

METHODS

Emissions of gaseous compounds—carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), total hydrocarbons (THC), and particle number (PN)—were measured in both on-road RDE and laboratory conditions. Tests were conducted at -9°C, 23°C, and 35°C to simulate varying driving environments. To ensure comparable testing, a "golden" on-road RDE test was used to develop the laboratory-based RDEsim cycle. This custom cycle was executed on a chassis dynamometer. The study investigated PHEVG and PHEVD, capturing emissions in both AUTOMATIC and HYBRID driving modes for PHEVG and COMFORT mode for PHEVD under consistent SOCH levels.

RESULTS

Emission patterns varied significantly between the two PHEVs under different temperatures and driving modes. CO_2 emissions increased at -9°C, with PHEVD consistently achieving lower levels due to the efficiency of the diesel technology. AUTOMATIC mode for PHEVG emphasized electric power, reducing fuel consumption but increasing energy use, while HYBRID mode prioritized SOCH stability with more frequent internal combustion engine usage. NO_x emissions were minimal for PHEVG but rose for PHEVD in colder conditions. Both vehicles showed elevated THC and PN emissions at -9°C, with diesel-powered PHEVD maintaining lower PN levels overall due to advanced filtration systems. These results underscore the impact of driving modes and environmental conditions on emission behaviours.

CONCLUSIONS

This study demonstrates the distinct emission characteristics of PHEVG and PHEVD across varying conditions. AUTOMATIC mode favored electric power utilization, leading to reduced tailpipe emissions but increased electric energy consumption. HYBRID mode offered consistent SOCH management, relying more on the internal combustion engine, which increased emissions.

Colder temperatures (-9°C) had the most pronounced effect, significantly elevating CO_2, NO_x, and THC emissions for both vehicles. Diesel-powered PHEVD consistently outperformed PHEVG in CO_2 and PN emissions, showcasing the advantages of diesel technology under diverse conditions.

The findings underscore the need for tailored RDE testing methods to reflect the unique operational behaviours of PHEVs. By accounting for driving mode, temperature, and powertrain type, this study contributes to improving emission standards and ensuring accurate assessment of plug-in hybrid vehicles in real-world scenarios.

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