

A Study on Changes in Exhaust Gas Performance During the Use Process of Heavy-Duty Trucks Equipped with Urea SCR System

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It is difficult to achieve the payload capacities and transport distances required for diesel freight vehicles in the over-10-ton class through electrification; therefore, a rapid transition to electric vehicles or similar alternatives is considered challenging. Therefore, measures to reduce NOx emissions from diesel engines will continue to be important. The urea SCR system, currently the mainstream countermeasure, is a catalytic system composed of components such as a selective catalytic reduction (SCR) catalyst. It is known that SCR catalysts undergo performance degradation due to factors such as hydrothermal aging caused by exposure to high-temperature, high-concentration water vapor and sulfur poisoning. It is presumed that the frequency with which the SCR catalyst is exposed to exhaust gas conditions leading to such performance degradation increases as the accumulated mileage rises. Currently, the accumulated mileage of heavy-duty vehicles can exceed one million kilometers; while ensuring exhaust emission purification performance during actual road operation is becoming increasingly important, there is limited knowledge regarding performance degradation and other issues associated with urea SCR systems during use.

Against this background, this study collected emission data by periodically conducting CD tests (such as WHVC mode tests) on a specific test vehicle—a heavy-duty truck compliant with 2016 regulations, with a gross vehicle weight of 25 tons and equipped with a copper-based SCR catalyst—as its accumulated mileage increased from 150,000 km to 500,000 km, in order to understand changes in exhaust gas performance during actual use. Based on this data, we analyzed the gradual increase in NOx emissions and the fluctuations in PM emissions during the use process, and demonstrated that these phenomena may be attributable to a drop in SCR catalyst temperature (a decrease of approximately 25°C to 30°C) during use. (Refer to Figures 1 and 2)

The details are summarized below.

- (1) Although NOx emissions increased gradually as the accumulated mileage increased, they remained below the regulatory limits for NOx emissions in certification testing—an average of 0.4 g/kWh and a maximum of 0.7 g/kWh (weighted average under the WHTC mode)—and it was found that NOx emissions were sufficiently controlled at 500,000 km of accumulated mileage. In this case, the gradual increase in NOx emissions was attributed to the NOx purification reaction becoming less active as the SCR catalyst temperature dropped to around the catalyst activation temperature of 230°C, resulting in higher NOx emissions.
- (2) PM emissions fluctuated with increasing accumulated mileage, and at 430,000 km, the results exceeded the regulatory upper limit of 0.013 g/kWh. Based on observations of the color of the PM collection filters, it was inferred that this increase in PM emissions was due to an increase in urea-derived PM (solid urea, cyanuric acid, etc.). It was considered possible that, as the accumulated mileage increased, the temperature range above 300°C for the SCR catalyst during test mode operation narrowed, inhibiting the decomposition of urea-derived PM and leading to an increase in PM emissions.

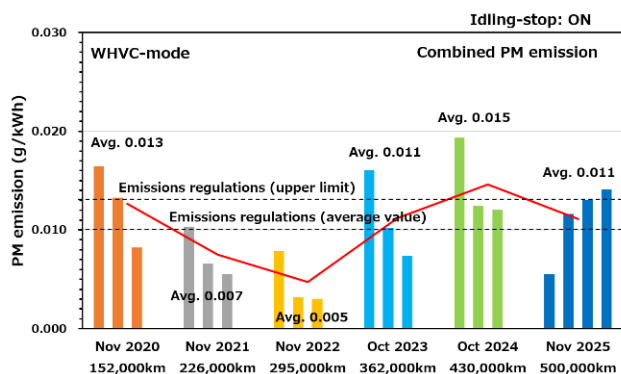


Fig. 1 Changes in PM emissions with increasing accumulated mileage of test vehicle

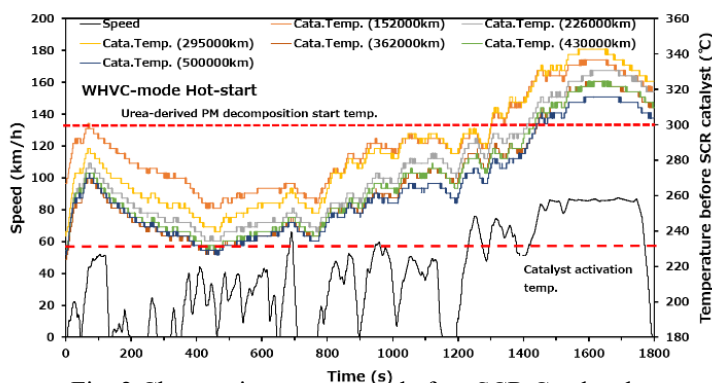


Fig. 2 Changes in temperature before SCR Catalyst by accumulated mileage during hot-start in WHVC-mode