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Recommended Citation

Liu, Y.,& Mak, M. (2023). Investigation on Performance of a Converted Remote Sensing System for Diesel Tailpope Emissions Monitoring. Retrieved from https://repository.vtc.edu.hk/thei-dcee-sp/2

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Investigation on Performance of a Converted Remote Sensing System for Diesel Tailpipe Emissions Monitoring

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Abstract. Roadside remote sensing (RS) has been adopted by the environmental protection department of Hong Kong as a tool for controlling urban air quality issues induced by on-road vehicles. The technology provides the unique advantage of being able to scan a large number of vehicles without interfering the traffic. The horizontal or cross-road RS (HRS) devices in used today are mostly tailored for single-lane applications, where the path of the RS light beam is parallel to the road surface, and emission scanning are limited to some segments of the roadway network. Vertical remote sensing (VRS) that scans an exhaust plume with a light beam perpendicular to the road surface has been proposed for multiple-lane applications but published results are scarce. VRS offers the advantage of being able to distinguish the plumes of different vehicles [1] but comes with some snags associated with installation, protection, and maintenance of the ground unit. A diagonal remote sensing (DRS) system is a modified version of the conventional RS with the light source and the detector unit (the main unit) lifted and tilted to scan the exhaust plume of a passing car diagonally and the ground unit titled to deflect the light back to the main unit. Such setup could prevent the ground unit being drove over and, therefore, reduce the needs to protect and maintain the ground unit. Plume dispersion models of box trailer trucks revealed that an area of recirculation appear at the close vicinity of the back of the trucks [2, 3]. The tilt angle of the DRS could be adjusted to scan the recirculation pockets of different types of vehicle.

This study aims at evaluating the performance of a DRS prototype system that was converted from conventional RS devices in detecting exhaust emissions from a diesel truck, comparing the performance of DRS to those of HRS and VRS, and determining the feasibility of deploying DRS in single-lane applications. The RS systems measured the tailpipe emissions from a designated diesel vehicle equipped with portable emission measurement systems (PEMS) under a range of loading and driving conditions (i.e., 0 – 50% load and 10 – 30 km/h). The average NOx to CO2 ratio recorded by the HRS, VRS, and DRS systems were 44% (± 6%), 32% (± 4.5%), and 36% (± 5.7%) of the PEMS equivalent measurements, respectively. The linear regression analyses of the HRS-PEMS pair, VRS-PEMS pair, and DRS-PEMS pair in terms of NOx/CO2 revealed that the correlation between HRS-PEMS is the most significant followed by VRS and DRS. The average NOx signal magnitude of the HRS, VRS, and DRS systems were 0.52, 0.61, and 0.21, respectively. It is concluded that the performance of the proposed DRS system is comparable to the performances of the HRS and VRS systems and DRS could be an opportunity to expand the role of RS in urban air quality control.

The work described in this study was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. UGC/IDS(c)25/E02/19).

Keywords: horizontal remote sensing, vertical remote sensing, diagonal remote sensing

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