APPENDIX E

THE INFLUENCE OF SOOT AND ASH ON NO_2 EMISSIONS

Appendix E. The Influence of Soot and Ash on NO_2 Emissions

Emissions of NO_2 from an emission control system using a platinum-based catalyst can be very sensitive to the amount of soot and ash present in the system at the time of testing. For instance, if a filter has a substantial bed of soot present, the NO_2 that forms during an emissions test would have ample opportunities to reduce to NO. If it had a substantial amount of ash, and the catalyst was on the filter itself (as opposed to in an upstream oxidation catalyst), the ash could cover active catalytic sites, thereby reducing the amount of NO_2 formed. A clean filter, however, would produce more NO_2 than is needed, resulting in elevated NO_2 emissions into the atmosphere.

The significance of the state of a filter during testing was demonstrated experimentally in a recent study by Umicore and partners (Soeger et al, 2005). A number of identical catalyzed filters were subjected to different aging environments, and their NO_2 formations were compared. A filter installed on a truck for 75,000 miles had NO_2 emissions equal to half the emissions of a new, conditioned filter. The aged filter was retested following a cleaning, and its NO_2 emissions doubled, reaching the level of the new filter. This shows that without control over the state of a system prior to emissions testing, it is possible to get a wide range of results.

A good example of how a single filter make and model can give a wide range of NO_2 fractions can be found in the EC-Diesel Technology Validation Program (LeTavec, 2000). All of the vehicles in the program were in the same emission control group. They were powered by on-road heavy-duty diesel engines certified to the 0.1 g/bhp-hr PM standard which were turbocharged and did not have EGR. In spite of having similar engines and identical retrofits, the resulting NO_2 emissions were far from consistent, as demonstrated by Figures D-1 and D-2[1].

The data are sorted by test cycle in Figure D-1 and by engine in Figure D-2. In each case, a wide spectrum of NO_2 fractions is observed, often ranging 30 to 40 percentage points for each subgroup. The spread is probably not due to variations in engine-out NO_2 emissions because data from other vehicles in the same fleets with the same engines showed a low engine-out NO_2 fraction with little absolute variation (5.0 ± 0.8 percent[2]). It is quite likely the state of the filter at the time of the testing played a significant role, as in the case of the Umicore study. All of the vehicles in the program were pulled from the field as is and tested following a 10 minute warm-up procedure (LeTavec et al, 2002). No special efforts to control the soot and ash content of the filters were made.

[1] NO_2 fractions were calculated by staff using NO and NOx emissions data from the ECD Technology Validation Program's Master Spreadsheet (Vertin, 2002).
[2] Based on data from (Vertin, 2002), as above. This result is for a 95 percent confidence interval and excludes three instances where staff found negative NO_2 fractions.

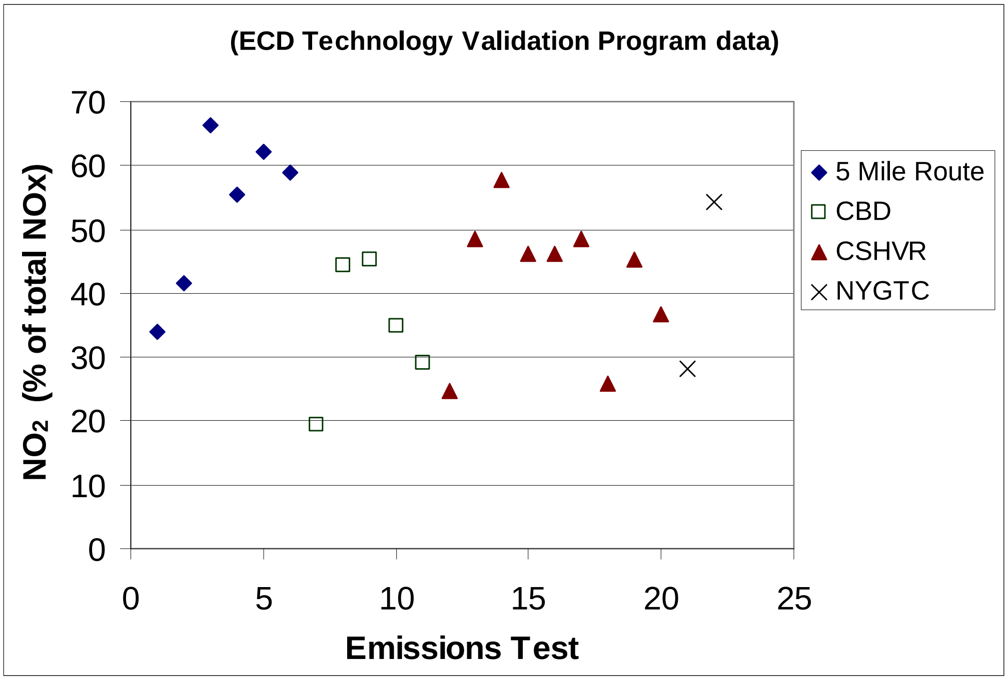

Figure D-1. DPF NO_2 fractions by test cycle
CBD = Central Business District, CSHVR = City Suburban Heavy Vehicle Route, and NYGTC = New York Garbage Truck Cycle.

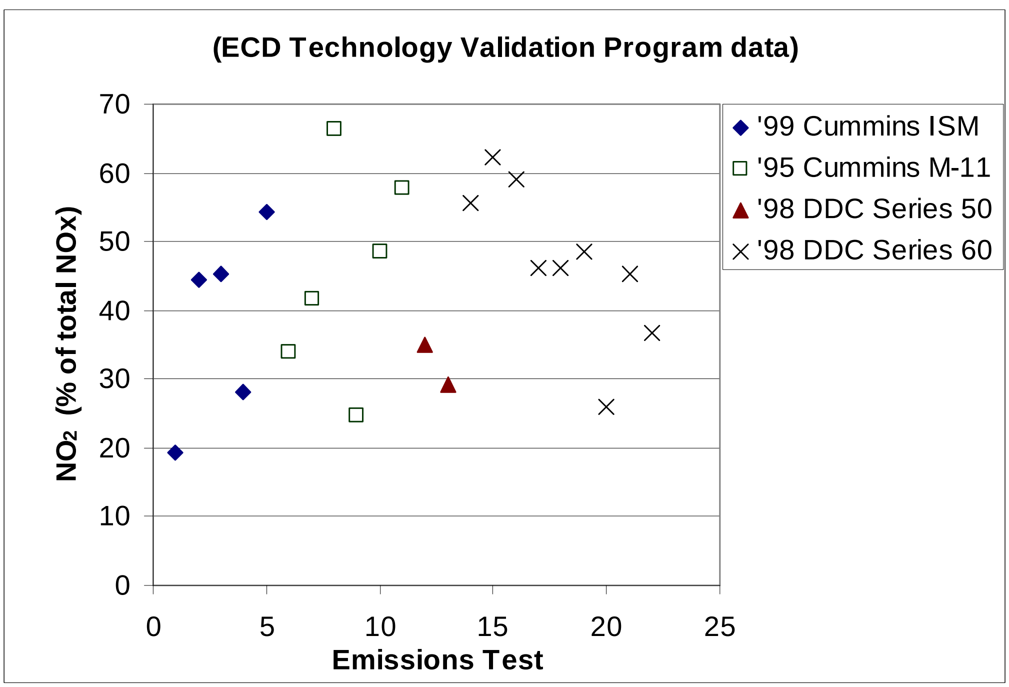

Figure D-2. DPF NO_2 fractions by engine series

References

LeTavec, C., Uihlein, J., Segal, J., and Vertin, K. “EC-Diesel Technology Validation Program Interim Report,” SAE 2000-01-1854, Society of Automotive Engineers, 2000.

LeTavec, C., Uihlein, J., Vertin, K., Chatterjee, S., Wayne, S., Clark, N., Gautam, M., Thompson, G., Lyons, D., Hallstrom, K., Chandler, K., and Coburn, T. “Year-Long Evaluation of Trucks and Buses Equipped with Passive Diesel Particulate Filters,” SAE 2002-01-0433, Society of Automotive Engineers, 2002.

Soeger, N., Mussmann, L., Sesselmann, R., Leippe, G., Gietzelt, C., Bailey, O., and Hori, M. “Impact of Aging and NOx/Soot Ratio on the Performance of a Catalyzed Diesel Particulate Filter for Heavy Duty Diesel Applications,” SAE 2005-01-0663, Society of Automotive Engineers, 2005.

Vertin, K. EC-Diesel Technology Validation Program Master Spreadsheet, Round 2. National Renewable Energy Laboratory. Updated August 21, 2002. Requests for the spreadsheet should be sent to: teresa_alleman@nrel.gov