Appendix F

Exhaust Temperature Data Analysis for Portable Diesel-Fueled Engines

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The University of California at Riverside's Center for Environmental Research and Technology (CE-CERT), working with ARB staff, recently conducted a stack-temperature profile (i.e., percentage of time at various exhaust temperatures) study to determine if passive diesel particulate filters (DPFs) are a feasible PM control technology for diesel-fueled portable engines. The success of a DPF is dependent on whether an engine achieves and maintains the minimum average exhaust temperature set by the DPF manufacturer. If engine exhaust temperatures are equal to or higher than the minimum temperatures, then passive DPFs could be considered as a potential retrofit control device. If engine exhaust temperatures are below the minimum requirements, then carbonaceous material may accumulate, increasing exhaust back pressure and possibly causing serious engine damage.

Currently, three manufacturers of passive DPFs have submitted their technology to ARB for verification for on-road diesel engine applications. These manufacturers are Johnson-Mathey, Cleair and Englehard. The required minimum average operating temperatures and duration per duty cycle vary among these DPFs. For example, the Johnson-Mathey DPF requires 270 degrees Celsius (C) for 40 to 50 percent of the duty cycle, the Cleair DPF requires 300 degrees C for 30 percent of the duty cycle, and the Englehard DPF requires an average of 225 degrees C. To date, these manufacturers have not requested ARB verification of their technologies for off-road applications, which would include portable diesel engines.

In the study, CE-CERT gathered exhaust temperatures during normal duty cycles from about 80 portable diesel engines in Northern and Southern California. The engines ranged from 77 to 2151 horsepower. The tests consisted of inserting a temperature sensor into the exhaust stream of a diesel engine, after the turbo-charger or exhaust manifold, and measuring the exhaust temperature in one-minute intervals for at least 20 hours of engine operation. Exhaust temperature data was stored on an in-line data logger. The data were downloaded from the data logger to a laptop and a frequency distribution test was applied using a spreadsheet. A frequency distribution test was used on the data to determine what temperature range each engine operated at and the percentage of time it operated within each temperature interval. The resulting data were graphed by temperature verses percent engine operation (See Figures 1-80). Table 1 is a summary of the equipment categories that were tested, the number of engines tested per category, and the percentage of those engines tested where the minimum operating temperature was high enough to install a passive DPF.

Table 1: Results of Exhaust Temperature Tests

Category	Industry	Number of Engines Tested	Passive DPF Yes
			(%)
Wood Chippers	Arborist, University, Govt.	7	43
Generators	Motion Picture, Construction, Sand & Gravel, Oil & Gas	29	73
Paint Stripers (Compressors)	Govt.	6	83
Compressors	Govt., Construction	11	55
Pumps	Govt., Oil & Gas, Agricult.	8	63
Grinders	Govt.	3	100
Grader/Shovel	Govt.	2	50
Welder	Sand and Gravel	1	100
Crane	Construction	1	0
Jet Washer	Oil & Gas	3	0
Drilling Rig	Oil & Gas	1	0
Clamshell Dredger	Construction	2	0
Bow Anchor Winch	Construction	1	0
Truck Mounted Vacuum Pumps	Govt.	5	0

The staff assumed that a minimum average operating temperature above 225 degrees C was needed to successfully retrofit with a passive DPF. The results of the test data showed that not all engines could be retrofitted with DPFs. The duty cycle appears to be the key to determining a successful retrofit of a passive DPF. Although some of the categories did show 100 percent of engines tested were capable of being retrofit with a passive DPF, Grinders and Cranes (Figures 61, 62 and 67), there wasn't enough of a population base to test and confirm if this was true for all engines in this category.

Some categories would be good candidates for a passive DPF, paint stripers for example (Figures 36-41). Paint stripers are either painting or turned off. There is a minimum amount of idling, so that the average exhaust temperatures are higher. As the data shows, 83 percent of these paint stripers could be retrofitted with a passive DPF.

In some categories retrofitting with a passive DPF is on a case by case basis. The generator category (Figures 8-35) is an example of the need to test before installing a passive DPF. From the test results, 73% could be retrofitted with a passive DPF. For the other 27%, generators appear to run at idle for long periods of time and when electrical power is needed then they are operated at full power. This appears to be the case in the movie industry, where generators of the same horsepower rating had very different duty cycles. Some had very low average exhaust temperatures while other generators maintained operating temperatures much higher than the minimum required temperature. Operators of generators would need to perform exhaust temperature tests to determine if their engine would be a candidate for a passive DPF.

Some categories would not be good candidates for a passive DPF, vacuum trucks for example (Figures 76-80). These trucks vacuum leaves and debris from storm drains, keeping storm drains clear. Data indicated that these vacuum pumps had engines that were larger and more powerful than what was needed to remove the average amount of obstruction. These trucks were designed with reserve power so that if a large amount of debris was in a storm drain it could be removed quickly. During testing, these engines never reached the minimum temperature of 225-degree Celsius for the minimum amount of time.

Based on the exhaust test results, the ARB cannot recommend the use of a passive DPF for all portable diesel engines because in many cases the duty cycle of an engine may not reach the minimum temperatures required for a passive DPF to perform its function. If an operator decides to use a passive DPF, an engine exhaust temperature study is highly recommended to determine if the average engine exhaust temperatures for individual engines do meet the minimum requirements for a passive DPF.