



Technical Highlights

Diesel Oxidation Catalysts: Informational Update

The U.S. Environmental Protection Agency (EPA) is providing this information to help explain the operation of diesel oxidation catalysts (DOCs) used for retrofit purposes and address questions about emissions of NO2 and ultrafine particles. EPA may prepare similar updates for other retrofit technologies. For further information visit EPA's National Clean Diesel Campaign.

- Diesel oxidation catalysts verified by EPA and/or the California Air Resources Board (CARB) are available for nonroad and highway diesel engines from a wide range of model years. See the list of technologies verified by EPA and those verified by CARB. EPA and CARB have a reciprocity agreement, under which EPA accepts and permits the nationwide use of retrofit technologies that are verified by CARB.

- Diesel oxidation catalysts verified by EPA and/or CARB are typically effective at removing 20-40 percent of the total particulate matter (PM) mass. The PM removed by DOCs is largely the soluble organic fraction (SOF or organic material) that comes from unburned fuel and lube oil.

- While available data show that DOCs do not remove elemental carbon PM, they remove many other particles and components including substantial organic hydrocarbons, many PM precursors and many toxics including polyaromatic hydrocarbons. For example, in a study performed by the Manufacturers of Emission Controls Association (MECA), DOCs removed 54-68 percent of 18 polyaromatic hydrocarbons, 68-91 percent of total hydrocarbons and a similar amount of carbon monoxide (CO).[1]

[1] MECA Report: Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Low Emission Levels (June 1999) www.meca.org/galleries/default-file/SwRIHDE.pdf

EPA United States Environmental Protection Agency

Office of Transportation and Air Quality
EPA-420-F-07-068
November 2007

Technical Highlights

- The PM removed by DOCs contributes to ambient $PM_{2.5}$ levels and the hydrocarbons removed contribute to ozone formation. Retrofit projects with DOCs can begin reducing emissions immediately and can help state and local governments reduce emissions of $PM_{2.5}$ and VOCs in the near term. These reductions can play an important role in reducing air pollution and helping nonattainment areas meet the National Ambient Air Quality Standards for Ozone and $PM_{2.5}$.

- EPA is aware of concerns that DOCs may produce some ultrafine particulates. Such concerns are associated with sulfur levels in diesel fuel and the potential for sulfur to accumulate in the DOC and then be released as sulfate particles (sulfates). EPA now requires highway diesel fuel to be ultra-low sulfur diesel fuel (ULSD) which contains 15 ppm sulfur or less. When used with ULSD, EPA does not believe DOCs increase ultrafine PM. Additionally, a DOC may be formulated to help reduce the potential to create sulfate particles. Because nonroad diesel fuel is not required to meet ULSD sulfur levels until 2010, nonroad equipment equipped with DOCs should be fueled with highway fuel or the DOCs should be properly formulated to reduce the potential for sulfate make.

- EPA is also aware of concerns that DOCs may increase the NO_2 fraction of total NOx emissions. The NO_2 produced by a DOC is dependent on the catalyst formulation. CARB has established a limit on incremental NO_2 from diesel retrofit devices and all DOCs on its list of verified products comply with this limit. Data EPA has reviewed to date indicate that EPA verified DOCs also comply with the CARB limit. Data supplied by DOC manufacturers to both CARB and EPA show that, for some verified DOCs, the NO_2 fraction of total NOx actually decreases slightly. DOCs do not raise total NOx levels. EPA is continuing to analyze NO_2 data from verified technologies and is looking to implement an NO_2 requirement for verified technologies that would maintain harmonization with California.

- DOCs can be a cost effective way to remove PM from diesel exhaust on both highway and nonroad vehicles. Cost effectiveness is influenced by such factors as vehicle age, remaining vehicle life and vehicle usage. EPA's highway cost effectiveness study showed a range of about $11,000 to $50,000 per ton of PM removed for school buses and Class 8b trucks. For 10 year old school buses or Class 8b trucks, the cost effectiveness was about $30,000 per ton.[2] Cost effectiveness ranges for a variety of nonroad vehicles can be found in EPA's non-road cost effectiveness study.[3]

- Total PM removal by DOCs (or other exhaust aftertreatment devices) can be augmented by the addition of a closed crankcase ventilation (CCV) system. A number of CCV

[2] Technical Report: An Analysis of the Cost Effectiveness of Reducing Particulate Matter Emissions from Heavy-duty Diesel Engines Through Retrofits, EPA420-S-06-002, March 2006. www.epa.gov/cleandiesel/documents/420s06002.pdf

[3] Technical Report: An Analysis of the Cost Effectiveness of Reducing Particulate Matter and Nitrogen Oxides Emissions from Heavy-Duty Nonroad Diesel Engines Through Retrofits, EPA420-R-07-005, May 2007. www.epa.gov/cleandiesel/documents/420r07005.pdf

systems have been verified by EPA and CARB. CCV systems remove additional HC and CO emissions by routing crankcase blowby gases back into the engine intake. They also reduce oil consumption and oil spotting by separating liquid oil from the gases and returning it to the crankcase.

- EPA National Ambient Air Quality Standards establish mass based emission standards for $PM_{2.5}$. The ambient $PM_{2.5}$ has many components including sulfates, nitrates, and carbonaceous compounds. EPA's various diesel exhaust emission standards are based on the total mass of diesel particulate which is almost entirely carbonaceous and includes both organic and elemental components. Ongoing research is evaluating the relative health effects of the different components of ambient PM. This work will show which components of ambient PM (and possibly which components of diesel PM) are important to control.

- While DOCs can play a very important role for many engines and may be the only option for certain older or high emitting engines, EPA encourages selection, when feasible, of technologies that yield greater PM control such as diesel particulate filters and partial-flow filters. These devices are more effective at reducing diesel particulates of all sizes and composition. In selecting a retrofit technology, the intended application should be carefully evaluated for such factors as exhaust temperature, duty cycle, engine condition and past and future maintenance practices. These parameters are important in determining whether a vehicle or piece of equipment can support a particular retrofit technology.