



Clean Air Facts

Emission Control Retrofit of Existing Diesel Engines

Background

- Over the past decade, air quality officials have expressed increasing concern over the health effects of diesel emissions.
- Each year, diesel engines contribute millions of tons of soot, smog-forming pollutants, and air toxic pollution that health experts have agreed can cause adverse health effects such as lung damage, respiratory problems, and cancer.
- The U.S. EPA estimates that retrofitting 10,000 engines would eliminate roughly 15,000 tons of harmful pollution each year.
- Achieving emissions reductions from in-use diesels is needed because older engines pollute at much higher rates than newer ones and remain on the road for decades.
- The U.S. EPA believes that in-use diesel emission control programs need to be available now so that areas can use them to meet their immediate nonattainment goals, as well as address ongoing public complaints about dirty diesels.

Available Emission Control Technologies

All retrofit emission control technologies are adversely affected by sulfur in the fuel. When considering retrofitting existing diesel engines, it is important to work with the supplier of a particular technology to determine exactly what type of fuel is required.

Diesel Oxidation Catalysts

Operating Characteristics

- A diesel oxidation catalyst (DOC) consists of a porous, active catalyst layer applied to a high geometric surface area, honeycomb-like structure called a substrate or catalyst support. The catalyst layer contains a small, well-dispersed amount of precious metals such as platinum.
- The catalyst oxidizes carbon monoxide (CO), gaseous hydrocarbons (HCs), and the liquid hydrocarbon particles, while reducing smoke and the characteristic pungent diesel odor.

Experience

- DOCs equipped on an engine fueled with sulfur levels at or below 0.05 percent sulfur have achieved reductions of 20-50 percent for PM, as well as 60-90 percent for HCs (including those HC species considered toxic) and CO, and eliminate the offensive odor coming from diesels.
- Retrofit of DOCs has been taking place for well over 20 years in the off-road vehicle sector, particularly in the underground mining industry, with over 250,000 off-road engines retrofitted.
- Since 1995, over 20,000 systems have been retrofitted on buses and highway trucks in the U.S. and Europe.

- Over 3000 trucks and buses have been retrofitted in Mexico.
- Hong Kong has begun to retrofit thousands of urban buses with DOCs.

Diesel Particulate Filters

Operating Characteristics

- The diesel particulate filter (DPF) system consists of a filter positioned in the exhaust stream designed to collect a significant fraction of the particulate emissions while allowing the exhaust gases to pass through the system.
- Since the volume of particulate matter generated by a diesel engine is sufficient to fill up and plug a reasonably sized filter over time, some means of disposing of this trapped particulate must be provided. The most promising means of disposal is to burn or oxidize the particulate in the filter, thus regenerating, or cleansing, the filter. This is accomplished through the use of a catalyst placed either in front of the filter or applied directly on the filter, a fuel-borne catalyst, or burners which are used to oxidize or combust the collected particulate.
- In select nonroad applications, a disposable filter system has also been used. The disposal filter is sized to collect enough particulate for a working shift or two of operation while remaining within the engine manufacturers backpressure specification and then it is removed and properly disposed.

Experience

- Particulate collection efficiencies of these filters are up to 90 percent or more.
- DPFs also can be designed to reduce up to 90 percent of HCs (including air toxics) and CO, as well as eliminate diesel smoke and odor.
- In Sweden, over 6500 buses have been equipped with a passive filter system.
- DPFs have also been retrofitted on heavy-duty vehicles in Great Britain, Germany, Finland, Denmark, and France.
- In off-road applications, over 10,000 filter systems have been retrofitted on diesel engines over the past 10 years.
- In the U.S., diesel filter retrofit programs are underway in California and in New York City where the city plans to retrofit 3,500 buses with diesel particulate filters.
- A recent off-road equipment demonstration program conducted in Massachusetts achieved an 81 percent reduction and 96 percent reduction in PM, respectively, on two front-end loaders.

Selective Catalytic Reduction

Operating Characteristics

- SCR systems are similar to DOCs except that a reductant is added to the exhaust stream in order to help convert NO_x to nitrogen and oxygen in an oxidizing environment.
- The reductant in mobile source applications is normally a urea solution. The urea solution is metered into the exhaust stream and passes through the SCR catalyst where NO_x is reduced and HC emissions and a portion of the PM emissions are oxidized.
- SCR also reduces the characteristic odor and smoke produced by a diesel engine.

Experience

- SCR using urea as a reducing agent has been retrofitted to diesel-powered vehicles providing simultaneous reductions of 75-90 percent NO_x, 50-90 percent HC, and 30-50 percent PM.
- Diesel engines used on marine vessels, ferries, and locomotives have also been retrofitted. Some have over 8 years of satisfactory operating service.
- Currently, over forty diesel engines have been retrofitted with SCR in Europe.
- A program conducted in Germany where 22 line-haul trucks were fitted with SCR systems achieved the performance targets of approximately 70 percent NO_x, 80 percent HC, and 30 percent PM reduction. The fleet accumulated a combined 3,600,000 miles of operation, with several vehicles operating over 250,000 miles with excellent results.

Combined Emission Control Systems

Operating Characteristics

- New systems which combine catalysts, filters, air enhancement technologies, thermal management technologies and/or engine adjustments and components are emerging as retrofit options.

Experience

- A combined emission control system using ceramic engine coatings combined with fuel injection timing retard and an oxidation catalyst has demonstrated over a 40 percent NO_x reduction while maintaining very low particulate emissions. The system has been approved under the U.S. EPA's urban bus rebuild/retrofit program.
- Another system combines diesel particulate filters or oxidation catalysts with lean NO_x catalyst technology including a heat recuperator in the exhaust stream to provide not only reductions in PM, CO, and HC emissions but also NO_x emission reductions.
- A system which provides substantial PM emission reductions employs a proprietary cam shaft in combination with an oxidation catalyst. The system has recently been approved by the U.S. EPA under the Agency's urban rebuild/retrofit program.
- In 1998, a 0.10 g/bhp-hr PM kit with a combined electronic supercharger and oxidation catalyst was certified under the EPA's urban bus retrofit/ rebuild program and has so far been retrofitted on more than 250 urban bus engines, accumulating over 5 million miles of operation. These components have also been retrofitted on refuse trucks, line-haul trucks, and water tankers. In the combined system, the electronic supercharger, which exhibits minimal degradation, improves in-cylinder combustion, thereby reducing engine-out emissions to the oxidation catalyst. Visible smoke is also reduced.
- An emerging retrofit strategy is the use of exhaust gas recirculation (EGR) and DPFs for simultaneous reductions of PM and NO_x emissions, as well as HC and CO emissions.

Emission Control Retrofit Programs

U.S. EPA Urban Bus Retrofit/Rebuild Program

- Begun in 1993, the program requires that urban buses operating in metropolitan areas with

populations over 750,000 be equipped with U.S. EPA-certified retrofit pollution control devices, such as oxidation catalysts, or be rebuilt using certified low emission components at the time of engine overhaul.

- To date, well over 20,000 urban buses have been retrofitted or rebuilt as a result of the program.

U.S. EPA Voluntary Heavy-Duty Retrofit Program

- Announced on March 22, 2000, the objective of the voluntary initiative is to clean up in-use diesel engines in trucks, buses, and construction equipment.
- EPA's initial goal is to get commitments from owners by the end of the year to retrofit 10,000 older heavy-duty diesel engines over the next two years.
- EPA has created a web site at www.epa.gov/otaq/transp/vmweb/vmhvydty.htm to provide more information on its voluntary heavy-duty retrofit program.

For more information:

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