Clean Air Facts

Emission Control Retrofit of Existing Diesel Engines

Resources

Many useful resources on diesel retrofit are currently available. For more information on diesel retrofit technology, funding opportunities and other information related to diesel retrofit, please visit MECA's diesel retrofit website: www.dieselretrofit.org.

Background

- Over the past decade, air quality officials have expressed increasing concern over the health effects of diesel emissions.
- While diesel engines provide many advantages, they also have the disadvantage of emitting significant amounts of particulate matter (PM) and nitrogen oxides (NOx) along with hydrocarbons (HC), carbon monoxide (CO), and toxic air pollutants.
- 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 catalyst-based 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. Additionally, DOCs can reduce soluble organic fraction of the particulate by 90 percent under certain operating conditions.

- Retrofit of DOCs has been taking place for well over 30 years in the off-road vehicle sector, particularly in the mining and materials handling vehicles, with over 250,000 off-road engines retrofitted.

- Oxidation catalysts have been retrofitted on over 750,000 on-road and off-road vehicles worldwide. The earliest installations have accumulated well over 150,000 km and have proven to be virtually maintenance free.

- Over 8,000 trucks and buses have been retrofitted in Mexico.

- Hong Kong recently completed a large retrofit program that involved 2,000 urban buses and more than 40,000 medium-heavy diesel vehicles.

<u>Diesel Particulate Filters</u>

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. Today, the most common DPF used in retrofit applications is a highly efficient, ceramic wall-flow filter.

- 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. One 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.

- Flow-through filter technology is a relatively new method of reducing diesel PM emissions that unlike a high efficiency DPF, does not physically “trap” and accumulate PM. Instead, exhaust flows typically through a catalyzed wire mesh or a sintered metal sheet that includes a torturous flow path, giving rise to turbulent flow conditions. Any particles that are not oxidized within the flow-through filter flow out with the rest of the exhaust.

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.

- The number of vehicles retrofitted, the number of programs, and the interest in new DPF programs has grown significantly over the past few years with more than 200,000 DPFs installed as retrofits to date in variety of world markets.

- Transit bus retrofits using DPFs have occurred in many urban fleets across the U.S., including New York City, Boston, Philadelphia, Washington, D.C., Seattle and many transit fleets in California.

- Sweden's Environmental Zones program resulted in the commercial introduction of DPFs in urban buses operating in Sweden's major cities. More than 4,000 buses have been retrofitted with a passive, high efficiency filter system.

- DPFs have also been retrofitted on heavy-duty vehicles in Great Britain, Germany, Finland, Denmark, Mexico, Switzerland, Austria, Japan, and France.

- In off-road applications, over 20,000 active and passive DPF systems have been installed as either original equipment or as retrofit worldwide.

Selective Catalytic Reduction

Operating Characteristics

- Selective Catalytic Reduction (SCR) systems are similar to DOCs except that a reductant is added to the exhaust stream in order to help convert NOx 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 NOx 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 to 90 percent NOx, 50 to 90 percent HC, and 20 to 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.

- Over 50 mobile SCR systems have been operational in U.S. since 1995 and several hundred have been installed in Europe.

- A program conducted in Germany where 30 line-haul trucks were fitted with SCR systems achieved the performance targets of approximately 70 percent NOx, 80 percent HC, and 30 percent PM reduction. The fleet accumulated a combined 4,200,000 miles of operation, with several vehicles operating over 360,000 miles with excellent results.

Exhaust Gas Recirculation

Operating Characteristics

- Exhaust Gas Recirculation (EGR) system involves recirculating a portion of the engine's exhaust

back to the charger inlet or intake manifold, n the case of a naturally aspirated engines. The cooled recirculated gases, which have a higher heat capacity than air and contain less oxygen than air, lower combustion temperature in the engine and reduce NOx formation.

- Low pressure EGR systems are used for retrofit applications in conjunction with high efficiency DPFs. In a low pressure EGR system, the recirculated exhaust is taken from downstream of the high efficiency DPF.

- EGR systems are capable of achieving NOx reductions of more than 40 percent.

Experience

- Over 600 EGR systems have been installed on bus engines in Europe.

- EGR systems are now being installed in the U.S. on solid waste collection vehicles, buses and some city-owned vehicles.

Lean NOx Catalyst

Operating Characteristics

- Lean NOx catalyst removes NOx in a lean (i.e., oxygen-rich) exhaust environment.

- Lean NOx catalyst systems generally inject diesel fuel or other reductant into the exhaust that serves as a reducing agent for the catalytic conversion of NOx to N_2.

- Lean NOx catalyst systems reduce NOx by 10 to 20 percent.

Experience

- There are more than 1,000 lean NOx catalyst systems in service in U.S. These systems combine a lean NOx catalyst with a high efficiency DPF.

Combined Emission Control Systems

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

Experience

- Systems can combine DPFs or DOCs with lean NOx catalyst technology to provide not only reductions in PM, CO, and HC emissions but also NOx emission reductions.

- An emerging retrofit strategy is the use of EGR and DPFs for simultaneous reductions of PM and NOx emissions, as well as HC and CO emissions.

- DOC and DPFs can be combined with SCR catalysts for controlling PM and NOx emissions

Emission Control Retrofit Programs

U.S. EPA Urban Bus Retrofit/Rebuild Program

- Begun in 1993, the program required 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 DOCs, or be rebuilt using certified low emission components at the time of engine

overhaul.

- Over 20,000 urban buses have been retrofitted or rebuilt as a result of the program.

U.S. EPA Voluntary Diesel 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 equipments.

- EPA met its initial goal of securing commitments to retrofit 10,000 trucks, buses, and construction vehicles with commercially available emission control technologies by March 2001. EPA received 160,000 retrofit commitments as of February 2005. EPA has set the goal of retrofitting, replacing, or repowering all 11 million in-use diesel engines by 2015.

- EPA has created a web site at www.epa.gov/otaq/retrofit to provide more information on its voluntary diesel retrofit program.

- EPA has established a verification protocol for establishing the performance and durability of diesel retrofit technologies. Information on the verified technologies is available at: http://www.epa.gov/dieselretrofit/retroverifiedlist.htm.

U.S. EPA National Clean Diesel Campaign

- Building on the successes of EPA's regulatory and voluntary efforts to reduce emissions from diesel engines, EPA created the National Clean Diesel Campaign (NCDC).

- The Campaign works aggressively to reduce pollution emitted from diesel engines across the country through the implementation of varied control strategies and the aggressive involvement of national, state and local partners.

- More information on the National Clean Diesel Campaign is available at: http://www.epa.gov/cleandiesel/index.htm.

California Air Resources Board (ARB) Diesel Risk Reduction Plan

- In 2000, ARB adopted a comprehensive plan to reduce the risk of exposure to diesel PM from on-road, off-road, and stationary diesel engines. The plan calls for diesel PM emissions to be reduced statewide by 75 percent in 2010 and 85 percent in 2020.

- A key element of the program is a comprehensive retrofit program. ARB has already established PM retrofit requirements for urban buses and is developing requirements for a variety of other diesel engine applications, including solid waste collection vehicles and fuel transport trucks. ARB has created a web site at www.arb.ca.gov/diesel/dieselrrp.htm to provide more information on its heavy-duty retrofit program.

- ARB has established a verification protocol for establishing the performance and durability of diesel retrofit technologies. More information on the verified technologies is available at: http://www.arb.ca.gov/diesel/verdev/verdev.htm.

For more information:

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