



Frequently Asked Questions

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Frequently Asked Questions about the Installation of Emission Control Technology on Existing Diesel Engines

Today, emission control systems are commercially available that greatly reduce the air pollutants emitted from in-use diesel engines. These systems can be retrofitted on trucks and buses, off-highway vehicles, and stationary diesel engines. Modern diesel emission controls can reduce carbon monoxide, hydrocarbons, particulate matter, oxides of nitrogen, and toxic air pollutants. Widespread use of these control systems can significantly improve air quality. This document answers some of the frequently asked questions about diesel retrofit – the installation of emission control systems on existing diesel engines.

Why should I install a diesel retrofit emission control system?

The primary reason for installing diesel emission controls is to protect human health. Studies have shown that diesel exhaust poses a public health concern. Retrofit emission controls offer an effective means of reducing the air pollution emitted from an in-use diesel engine. Controlling harmful emissions is especially important when diesel engines are operated in confined or restricted space where workers may be exposed to high exhaust concentrations. Controlling emissions in urban environments is also important where inhabitants may be exposed to elevated concentrations over long periods. Cleaning up diesel engine exhaust can also help reduce soiling of buildings and improve visibility.

Am I required to retrofit my diesel engine with an emission control system?

In the U.S., there are no federal requirements to reduce emissions from in-use diesel engines. The U.S. EPA, however, has implemented a voluntary diesel retrofit program as part of its National Clean Diesel Campaign to encourage the installation of emission control devices on in-use diesel engines. In California, where the state is implementing a Diesel Risk Reduction Plan, many diesel vehicle fleets are or will be required to reduce their diesel PM emissions. One option for complying with these California regulations is to install diesel retrofit technology. Many school buses, transit buses, solid waste collection vehicles, on-road vehicles, stationary engines, and off-road vehicles have installed or will need to install diesel retrofit technology to comply with the California requirements.

In New York, New York City passed Local Law 77 in 2003 to require the use of ultra-low sulfur diesel (ULSD) fuel and best available retrofit control technologies to reduce emissions from nonroad equipment used in city construction projects. Subsequent to this rulemaking, the city passed bills requiring public on-road diesel vehicles, vehicles used in solid waste and recycling contracts, buses used by sightseeing companies, and public school buses to also use ULSD and retrofit technology. New Jersey adopted regulations in 2005 that will require publicly owned fleets to apply the best available retrofit emission controls to existing heavy-duty diesel vehicles. In the future, other states may consider mandatory diesel retrofit requirements as they develop plans for complying with new federal ambient air quality standards for particulate matter.

Although there are no federal requirements to reduce emissions from in-use diesel engines, it is important to note that many cities and businesses have voluntarily retrofitted their vehicles to reduce air pollution and protect human health.

What kind of retrofit emission control systems exist for in-use diesel engines?

Diesel emission control systems are installed on vehicles or equipment to reduce unwanted emissions. The system may involve a device or component such as a catalyst or a filter. The device may or may not be used in conjunction with a fuel-borne catalyst or a special fuel. (Note: All catalyst-based retrofit emission control technologies are adversely affected by sulfur in the fuel, so it is important to work with the supplier of a particular technology to determine exactly what type of fuel is required.) Diesel emission control devices can be installed on a wide variety of in-use vehicles, including on-highway trucks and buses, off-road construction equipment, mining and material handling equipment, stationary engines, and many other applications.

Depending on the type of emission control technology, retrofit control devices can significantly reduce carbon monoxide (CO), hydrocarbons (HCs), particulate matter (PM), and oxides of nitrogen (NOx) in diesel exhaust. Diesel oxidation catalysts (DOCs) oxidize CO, gaseous HCs, and soot particles, while reducing smoke and the characteristic pungent diesel odor. Diesel particulate filters (DPFs) physically trap particles in the engine exhaust before they leave the tailpipe. Filter systems may also be added to an engine's crankcase system to reduce PM emissions associated with them. Devices that use a process called selective catalytic reduction (SCR) use a catalyst and a liquid reagent to reduce the oxides of nitrogen (NOx) produced by the engine. Exhaust gas recirculation (EGR) recycles a portion of the engine exhaust to reduce NOx emissions. Lean NOx catalysts use catalytic processes and a reductant to lower NOx emissions.

How do diesel retrofit emission control technologies work?

As part of an overall engine exhaust system, emission control devices convert or capture pollutants before they leave the tailpipe. The two most common types of retrofit devices are diesel oxidation catalysts and diesel particulate filters.

Diesel Oxidation Catalysts (DOCs) – A typical diesel oxidation catalyst is a stainless steel canister installed in the exhaust system much like a muffler. The canister contains a honeycomb-shaped substrate that is coated with catalytic metals such as platinum or palladium. There are no moving parts in the canister, just a large amount of surface area coated with a catalyst. As exhaust gases pass through the honeycomb structure, pollutants and particulate matter are chemically oxidized to harmless gases. Diesel oxidation catalysts can reduce PM emissions by 20 to 50 percent, toxic hydrocarbon emissions by greater than 70 percent, and carbon monoxide and hydrocarbon emissions by greater than 90 percent. DOCs can also significantly reduce or eliminate the smoke, soot, and odors associated with diesel engine operation.

Diesel Particulate Filters (DPFs) – Diesel particulate filters are filters that physically trap particles in the engine exhaust before they leave the tailpipe. Typically, filters are muffler-like devices installed in the engine exhaust system. They are made of cordierite, silicon carbide, aluminum titanate, metal foils and meshes, or other material. As exhaust gases pass through the filter, particulate matter is trapped. Removing particulate matter deposited in the filter is accomplished by several means. Today, in many on-road applications, filters are regenerated through catalyst-assisted means. In catalyst-assisted filter regeneration, particles trapped on the filter are oxidized to carbon dioxide and water when exhaust gases reach manufacturer recommended temperatures. The catalyst, installed upstream of the filter or coated on the filter substrate, form chemical species that oxidize accumulated particulate matter. Fuel-borne catalysts can also be employed to reduce the regeneration temperature of the filter. In applications where exhaust temperatures are not high enough to allow catalyst-assisted regeneration, thermal management strategies or an auxiliary heat source such as an electric heating element or fuel burner can be used to regenerate the filter. In some applications, a filter may be removed from the vehicle and actively regenerated while the vehicle is out of service. High-efficiency wall-flow DPFs can reduce PM, CO, and HC and toxic HC emissions by up to 90 percent or more.

Flow-Through Filters (FTFs) – Flow-through filters employ catalyzed metal wire mesh structures or tortuous flow, metal foil-based substrates with sintered metal sheets to reduce diesel PM. Technologies verified to date employ catalysts and/or fuel-borne catalysts to oxidize diesel soot as the exhaust flows through these more turbulent flow devices. Flow-through filters are capable of achieving PM reductions in the range of 30 to 75 percent depending on engine operating characteristics.

Exhaust Gas Recirculation (EGR) – As the name implies, EGR involves recirculating a portion of an engine's exhaust back to the charger inlet (or intake manifold in the case of a naturally aspirated engines). In most systems, an intercooler lowers the temperature of the recirculated gases. 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 NO_x formation. Low-pressure EGR systems are used in retrofit applications. Diesel particulate filters are always used in a low-pressure EGR system, ensuring that large amounts of particulate matter are not recirculated to the engine. Retrofit EGR systems are capable of achieving NO_x reductions of more than 40 percent.

Selective Catalytic Reduction (SCR) – An SCR system uses a metallic or ceramic washcoated catalyzed substrate (or a homogeneously extruded catalyst) and a chemical reductant to convert nitrogen oxides to molecular nitrogen and oxygen in oxygen-rich exhaust streams like those encountered with diesel engines. In mobile source applications, an aqueous urea solution is usually the preferred reductant. As exhaust and reductant pass over the SCR catalyst, chemical reactions occur that reduce NO_x emissions. In typical on-road heavy-duty applications, an SCR catalyst is usually combined with a DOC or a DPF for reductions in both diesel PM and NO_x. SCR can reduce NO_x emissions up to 70 percent or more.

Lean NO_x Catalysts (LNCs) – Lean NO_x catalysts have similarities with diesel oxidation catalysts in that the converter canister contains a substrate coated with catalytic materials. A liquid reagent or reductant introduced upstream of the converter allows the catalyst to reduce NO_x emissions. Typically, the diesel fuel itself is used for this purpose. The fuel is sprayed into the exhaust stream using a specially mounted fuel injector. The amount of fuel injected is controlled by an electronic control module. NO_x reductions of up to 25 percent have been demonstrated. Lean NO_x catalysts can also be combined with diesel particulate filters to simultaneously reduce both NO_x and PM emissions.

Do diesel retrofit emission controls require a special fuel?

All retrofit devices work better and achieve lower emission reductions when used with ultra low-sulfur diesel (ULSD) fuel (diesel fuel containing 15 parts per million of sulfur or less). (Note: As of October 2006, all highway diesel fuel sold in the U.S. is required to be ULSD.) Catalyst-based DPFs are particularly sensitive to fuel sulfur levels. These devices work at peak effectiveness when used with ULSD fuel. Some retrofit devices are less affected by fuel sulfur levels than others. DOCs and uncatalyzed DPFs can be used with fuels with sulfur levels higher than 15 ppm (e.g., nonroad diesel fuel) and still effectively reduce harmful emissions. Vehicle owners or operators should determine in advance the fuel quality requirements of a particular emission control system before installing the device.

How do I know if a diesel retrofit device will work as advertised?

Both the U.S. EPA and the California Air Resources Board (ARB) verify the performance of diesel retrofit devices through a verification process. The goal of the verification process is to ensure that emission control systems perform as a manufacturer claims. EPA maintains a list of verified technologies on their website at: www.epa.gov/otaq/retrofit/retroverifiedlist.htm. ARB's list of verified technologies can be found at: www.arb.ca.gov/diesel/verdev/vt/vt.htm.

In 2004, EPA and ARB signed a Memorandum of Agreement (MOA) for the Coordination and Reciprocity in Diesel Retrofit Device Verification. The MOA establishes reciprocity in verifications of

hardware or device-based retrofits. This agreement commits EPA and ARB to work toward accepting PM and NOx verification levels assigned by the other's verification program.

How do I install and maintain a diesel retrofit emission control system?

Companies that manufacture diesel retrofit emission control systems, their service providers and exhaust system specialists, and other vehicle maintenance providers can install diesel retrofit devices. Large fleets with in-house maintenance capability may also install diesel retrofit devices. To ensure an appropriate system is installed, emission control manufacturers work with vehicle owners and fleet managers to determine the system and fuel that will work best with the vehicles being retrofitted. Emission control manufacturers need accurate information on how vehicles are operated to select and size a retrofit device. They may want to install sensors and data-logging equipment on candidate vehicles for several weeks to gather accurate and complete exhaust temperature data for the vehicles. After fleet assessment, the emission control manufacturer will work with the fleet or vehicle owner and the system installer to recommend the best retrofit solution for the customer.

Maintenance requirements depend on the type of retrofit technology used, the age and performance of the engine, the engine oil used, the vehicle's duty cycle, and time between engine service events. As part of any sale, control system manufacturers provide recommendations on the care and maintenance of their products. For example, diesel particulate filters should typically be inspected and cleaned annually or every 60,000 miles, whichever comes first. (Note: More information on DPF maintenance practices can be found in MECA's technical document, *Diesel Particulate Filter Maintenance: Current Practices and Experience*. The document can be downloaded from MECA's diesel retrofit website at: www.meca.org/galleries/default-file/Filter_Maintenance_White_Paper_605_final.pdf.) Additionally, on-board monitor systems are typically provided with retrofit technologies. These monitors typically provide the end-users with diagnostic, data-logging, and retrofit maintenance-related information, such as engine back pressure and exhaust temperature.

Will using a diesel retrofit device void the engine warranty?

No. Under the Magnuson-Moss Warranty Act, a manufacturer (an engine manufacturer) cannot void a warranty (an engine warranty) based on the use of non-OEM parts (such as a third-party diesel retrofit emission control device) unless it is specifically prohibited in the warranty and the manufacturer must be able to show a valid reason for the prohibition. In other words, the engine manufacturer must be able to prove that the diesel retrofit device caused/will cause a failure. If this cannot be shown, the warranty must be honored as written.

Will using a diesel retrofit device affect an engine's performance?

Emission control manufacturers work closely with engine manufacturers and vehicle owners/operators to ensure control systems do not affect vehicle performance. In some situations, installation of a DPF system on a vehicle may cause a very slight fuel economy penalty (about 1 percent) due to the backpressure of the filter system.

How much do diesel retrofit devices cost?

For a typical on-road heavy-duty engine, the average diesel oxidation catalyst cost ranges from \$500 to \$2,000 per vehicle. Wall-flow diesel particulate filters are currently being sold for about \$7,000 to \$10,000 per filter. The cost of selective catalytic reduction devices range from \$12,000 to \$20,000 with an oxidation catalyst, and \$15,000 to \$25,000 with a diesel particulate filter. A low-pressure exhaust gas recirculation system with a diesel particulate filter costs in the range of \$18,000 to \$20,000. A system combining a lean NOx catalyst with a diesel particulate filter costs from \$15,000 to \$20,000. It is important to note that over time higher volumes will tend to bring these costs down. For larger diesel engines (e.g., engines used in construction equipment), retrofit costs can be higher than noted above. To determine the exact cost of a particular retrofit emission control system for a specific vehicle or fleet,

please consult directly with an emission control technology vendor (for a list of vendors, go to MECA's diesel retrofit website at:

www.meca.org/cs/root/diesel_retrofit_subsite/manufacturers/list_of_manufacturers).

Is funding available for the purchase of diesel retrofit devices?

Federal agencies, state air quality agencies, and local environmental agencies provide funding for diesel retrofit projects, which can help fund the purchase of diesel retrofit devices. The U.S. EPA has formed seven regional diesel collaboratives across the U.S. (www.epa.gov/cleandiesel), which work to identify, fund, and implement diesel emission reduction projects. Individual state and local air quality officials may assist in identifying funding sources for retrofit projects even if they cannot offer funding themselves. Examples of federal funding for diesel retrofit projects include the U.S. EPA's Clean School Bus USA program (www.epa.gov/otaq/schoolbus/) and the Federal Highway Administration's Congestion Mitigation and Air Quality (CMAQ) program (www.fhwa.dot.gov/environment/cmaqpgs/). Examples of state funding programs include California's Carl Moyer Program (www.arb.ca.gov/msprog/moyer/moyer.htm) and the Texas Emissions Reduction Plan (TERP) (www.terpgrants.org).

How do I get more information on diesel retrofit technologies?

For additional information on diesel retrofit, including technical information on diesel retrofit technologies, funding opportunities, and current news, please visit MECA's diesel retrofit website at: www.dieselfretrofit.org or contact MECA's Antonio Santos at: asantos@meca.org.

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