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Retrofitting Diesel Engines: Reducing the Emissions of Our Ideal Power Source

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Over the past several years, Avogadro Environmental has been working with a number of clients to develop proactive environmental programs as part of their EPA Performance Track and ISO 14001 management systems. Many client companies that are proactively implementing measures to reduce their environmental footprint are looking for ideas. Diesel engine retrofits for off-road stationary and mobile equipment may provide new opportunities to reduce footprint looking beyond manufacturing processes and traditional control and P2 options. For example, many pieces of equipment, such as quarry cranes and conveyance systems, have been in place for decades. They are often well maintained and continue to serve operations well. However, retrofit may provide a cost effective, low-capital investment, versus replacement, to assure that these kinds of equipment have been addressed before further regulation from state agencies addressing particulate non-attainment force the issue.

In researching options for one such client recently, we compiled the following summary of diesel retrofit technologies that are currently available through a variety of vendors. In some cases, there may be external funding options available and possibly new funding options as regulations get tighter.

Generally, retrofit technologies refer to 5 emission-reducing strategies. These strategies are proven to improve emission performance of diesel engines by reducing particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), and hydrocarbons (HC). More specifically, these 5 strategies are known as refuel, retrofit, repower, replace and rebuild.

1. Refuel
Using more advanced cleaner fuels; such as low-sulfur fuels and emulsified diesel, will reduce emissions. Fuels that contain low amounts of sulfur reduce PM by 5-9%. Emulsified diesel, fuel that is combined with water and other additives, lowers combustion temperatures, reducing PM 16-58% and NOx pollutants 9-20%. PM, NOx, HC and CO can also be reduced when diesels are replaced by electric, hybrid or alternative fuel equipment, such as Liquefied Natural Gas (LNG), Compressed Natural Gas (CNG) and Propane.

2. Retrofit
Retrofit refers to emissions reduction technologies, such as filters and catalysts that can be installed on an engine. There are a number of technologies to choose from when retrofitting off-road diesel engines.

Diesel Particulate Filters (DPFs) are honeycomb or mesh devices that are placed within the exhaust stream of the diesel engine. These devices physically trap and oxidize PM and result in a 55-90% reduction of PM, HC and CO. When using a DPF be sure to use low-sulfur fuels.

Diesel Oxidation Catalysts (DOCs) are generally packaged with the engine muffler. These devices oxidize pollutants in the exhaust stream, converting pollutants to water and CO2. DOCs reduce PM by 10-50% and HC and CO by 50%.

DOCs can be coupled with Closed Crankcase Ventilation (CCV). CCV captures returning oil in blow-by gasses to the crankcase, directing NOx, HC and toxics to the intake system for recombustion. PM is collected in a filter and removed from crankcase vapors, resulting in a 10% reduction in PM pollutants. Some advantages of CCV include: improved vehicle/equipment reliability and maintenance, clean engine compartment and components and reduced oil usage and operating costs.

Selective Catalytic Reduction (SCR) Systems provide a 25% PM reduction and a 60% NOx reduction by injecting a form of ammonia (ie: urea) into the exhaust stream of the engine. The ammonia reacts over a catalyst to reduce emissions. SCR systems work best on stationary equipment.

Exhaust Gas Recirculation (EGR) devices recirculate portions of engine exhaust back into the engine. This recirculation cools peak combustion temperatures, reducing NOx pollutants 25-50%. When coupled with a DPF, PM reduction can also occur.

Lean NOx Catalyst (LNC), when paired with a DPF, promotes the reduction of NOx by using hydrocarbons as a reducing agent. This catalyst reduces up to 90% of PM, 25% of NOx, and 60-90% of HC and CO pollutants.

3. Repower
Repowering involves replacing uncontrolled engines found in pre-1996 off-road equipment with newer engines. The benefits of repowering includes better fuel efficiency, more reliability, reduced maintenance costs and NOx, PM, HC and CO reductions.

4. Replace
Replacing older equipment with newer and cleaner equipment provides the same benefits as the previously discussed repowering technologies. However, replacing older

equipment is sometimes more cost effective than repowering.

5. Rebuild
It is suggested that an engine needs an upgrade every 3-4 years. It is suggested to rebuild core engine components to ensure they meet the manufacturer's original specifications. Furthermore, some manufacturers now provide options that can improve engine emissions beyond previous performance standards.

Another proposed way of reducing emissions is to reduce the idling time of equipment. Anti-idling regulations have been in effect since the 1970s; however, these regulations were not always enforced. In 2005 the State of New Jersey's Air Quality Work Group implemented NJAC 7:27-14. NJAC 7:27-14 limits the idling time of diesel engines to no more than 3 minutes. If idling time is not limited to 3 minutes, violators could be fined anywhere from $200-$3,000 (see Avogadro Advisor July 2005 for more information on NJAC 7:27-14 at http://www.avogadro.net/downloads/advise0705.pdf).

Pennsylvanian legislatures are also aware of the effect that diesel engines have on our environment and are especially interested in the reduction of idling time. Currently, the Pennsylvania Legislature is reviewing proposals similar to NJAC 7:27-14 (see Avogadro Advisor July 2007 at http://avogadro.net/downloads/Avogadro%20Advisor%20Newsletter%20-%20July%202007.pdf).

Maintenance is also a key factor when reducing emissions. The EPA cited the following as common maintenance issues that could increase emissions:

- Restricted air filters
- Improper engine timing
- Clogged worn or mismatched fuel injectors
- Faulty fuel injection pumps
- Defective or maladjusted puff limiters
- Low air box pressure
- Improperly adjusted valve lash or governors
- Maladjusted fuel racks
- Defective air fuel quality
- Improper driving gear and air intake manifold links

Avogadro Environmental has extensive experience working with clients addressing regulatory matters for engines including permitting options, source testing, and emissions control options. Contact us today for more information on how we may be of further assistance addressing these needs.