**TECHNICAL BULLETIN**
DATE: NOVEMBER 1, 2020

# Benefits of Ferox Fuel Borne Catalyst on New Diesel Emissions Technologies

**The diesel engines is the most efficient power plant among all known types of internal combustion engines, have high efficiency, durability, and reliability together with their low-operating cost**. These important features make them the most preferred engines especially for heavy-duty vehicles.

**The four main pollutant emissions from diesel engines are carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM) and nitrogen oxides (NOx).**

The diesel engine sector has been one of the most active and innovative areas for technological development in the past years and **engine firms have invested enormous sums in developing new, low emissions control technologies that reduce the quantities of pollutant emissions from the tailpipe, using various combinations of the technologies available such as Diesel Oxidation Catalyst (DOC) , Diesel Particulate Filter (DPF) , Selective Catalytic Reduction (SCR), Diesel Exhaust Fluid (DEF), Exhaust Gas Regeneration (EGR) and high-pressure, common rail fuel systems (Tier 4/Euro VI).**

# BENEFITS OF USING FEROX FUEL BORNE CATALYST

Our Fuel Borne Catalyst Additives addresses emissions of hydrocarbon-based fuels at their source, **the combustion process.**

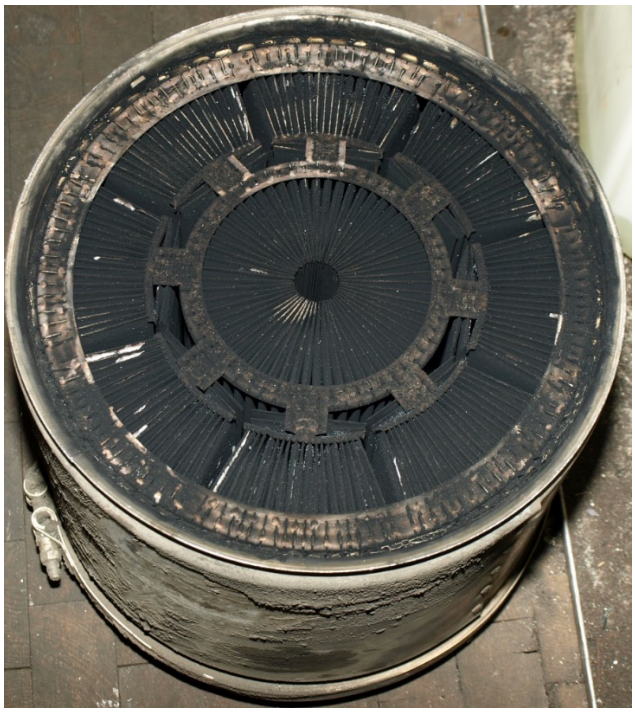
With addition of our combustion catalyst **more fuel is burnt in the engine for energy as opposed to being send out the exhaust increasing fuel economy (up to 15% or more).** This approach not only reduces harmful emissions but also results in increases in engine power and overall fuel efficiency.

From nitrogen oxides, smoke opacity to unburned hydrocarbons, various tests of **RENNSLI Fuel Borne Catalyst Additives have shown a significant correlation to decreases in harmful emissions (up to 22% of NOx, up to 51% of HC and up to 80% of PM-soot) and increase the performance and life of emission control devices (DOC, DPF, SCR, DEF, REGEN, EGR, and exhaust sensors). Our FBC are the real solution to common problems and high maintenance costs related to emissions after-treatment systems and control devices.**

## REDUCTION OF PARTICULATE MATTER EMISSIONS USING FEROX FBC

**Using Ferox highly reduce the particulate matter emissions (up to 80% ) and reduce the burning temperature of the remaining soot, this translates in less exhaust particles (PM-opacity-smoke-soot) and less time to accomplish regeneration. This exhaust particles are the root cause of most Diesel Particulate Filter (DPF) and regeneration problems (regen).**

## Your DPF will become blocked when soot builds up in it.



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## Regeneration is the process of burning off (oxidizing) the accumulated soot from the filter to keep the filter from clogging.

**There are several ways that DPF regeneration can happen:**

- **Passive regeneration**: This happens in normal operation when the engine's exhaust gets hot enough, during long drives at a high speed.
- **Active regeneration**: This happens while the vehicle is in use, when low engine load and lower exhaust gas temperatures inhibit the naturally occurring passive regeneration. The vehicle can initiate in response to a blockage, and injects diesel on the exhaust system to generate very high heat so that it ignites and burns the soot.
- **Forced regeneration**: When the filter develops too much pressure a forced regeneration must be used, the driver must pull over and proceed with a parked regen (Can take up to 30-45 minutes to complete). This can be accomplished in two ways:
    - The vehicle operator can initiate the regeneration via a dashboard mounted switch.
    - When the soot accumulation reaches a level that is potentially damaging to the engine or the exhaust system, the solution involves a garage using a computer program to run a regeneration of the DPF manually.

## FEROX Fuel Borne Catalyst Improves DPF (Diesel Particulate Filter) Regen Performance, increasing the operating window for passive regeneration and reducing the time and diesel consumption for active regeneration.

# REDUCTION OF NITROGEN OXIDES (NOx) EMISSIONS USING FEROX FBC

**The formation of $NO_x$ appears to take place late in the combustion process during the exhaust phase and is influenced by available excess oxygen, high temperatures and time duration.**

**One of the results observed while monitoring the effects of Ferox on general emissions is wide fluctuations in the amount of $NO_x$ produced. Over time these fluctuations have always shown a downward trend that correlates to the removal of deposits. The fact that deposits directly affect the factors responsible for the formation of $NO_x$ support a direct connection between $NO_x$ emissions and deposits. This connection is further supported by the fact that a clean engine running on Ferox treated fuel produces very low amounts of $NO_x$.**

The process by which Ferox inhibits the formation of $NO_x$ is a direct result of the process by which it destroys and inhibits the formation of deposits, namely through the promotion of $CO_2$ production. The following is a general explanation of how Ferox affects the three main factors that promote the formation of $NO_x$.

**Fuel has a limited amount of energy that is released through the production of $CO_2$. Ferox promotes the formation of $CO_2$ during the combustion phase.**

**If more $CO_2$ or energy is released during the combustion phase then less is available to be released during the exhaust phase. The difference in the amount of energy released during the two phases correlates to a temperature difference. This temperature difference, its magnitude and cause are important for three reasons.**

**First, cooler exhaust**. If the temperature of the combustion phase rises due to increased $CO_2$ production then the temperature of the exhaust phase will go down due to a decrease in $CO_2$ production. This denies the nitrogen molecules the high temperatures needed to form $NO_x$ compounds during the exhaust phase of the combustion process.

The lower temperatures slow the production of $NO_x$ by requiring more time for the reactions to take place. The greater the difference in the energy released and the associated temperature difference, the cooler the exhaust and the slower the rate of $NO_x$ production.

**Second, a quicker heat transfer time.** The greater the magnitude of the temperature difference the quicker the heat transfer time becomes. This allows more of the heat to be transferred to the surrounding engine components in a given moment and in and of itself will contribute to lower exhaust temperatures as discussed above. More importantly this decreases the time duration in which high temperatures are available for the conversion of nitrogen to $NO_x$ compounds. The shorter the time duration the lower the $NO_x$ emissions.

**Third, the cause of the first two, namely the production of $CO_2$, uses up more of the available oxygen**. Due to the fact that Ferox promotes the production of $CO_2$ during the combustion phase, less oxygen is available for $NO_x$ reactions during the exhaust phase. Less available oxygen results in lower $NO_x$ emissions.

The combination of lower exhaust temperatures, quicker heat transfer and less available excess oxygen along with the removal of deposits, causes a noticeable reduction in the amount of $NO_x$ emissions produced.

# REDUCTION OF NITROGEN OXIDES (NOx) EMISSIONS USING SCR

**Selective Catalyst Reduction (SCR) is based in Hydrolysis, the chemical breakdown of a compound due to reaction with water.**

**The Diesel Exhaust Fluid (DEF) is an aqueous urea solution made with 32.5% urea & 67.5% deionized water, is used as a consumable in Selective Catalytic Reduction (SCR) in order to lower NOx concentration in the diesel exhaust emissions.**

**Selective Catalytic Reduction (SCR) and Diesel Exhaust Fluid (DEF) sets off a chemical reaction that converts nitrogen oxides (NOx) into nitrogen, water and tiny amounts of carbon dioxide (CO2), natural components of the air we breathe, reducing nitrogen oxides (NOx) to NEAR ZERO LEVELS.**

**The system will consume approximately 2% DEF consumption to fuel consumption (Every 50 gallons of fuel use 1 gallon of DEF)**

## FEROX Fuel Borne Catalyst reduces Nitrogen Oxides (NOx) Emissions, as a benefit the Selected Catalyst Reduction (SCR) lowers the utilization of DEF (Diesel Exhaust Fluid).

## OTHER EMISSIONS AND CONTROL SYSTEMS

**First diesel engines emit less hydrocarbons (unburned fuel) and carbon monoxide (CO) than gasoline engines, but produce more noxious gases (NOx) and significantly more particulates (PM).**

### 2003-2007 – EGR

### 2008-2010 - EGR + VGT + DOC + DPF

### 2011-2018 - EGR + VGT+ DOC + DPF + SCR

**Exhaust Gas Recirculation (EGR) is a valve mounted on the exhaust manifold, this valve regulates exhaust gases that go into the engine, is an effective strategy to control NOx emissions from diesel engines. The EGR reduces NOx through lowering the oxygen concentration in the combustion chamber, as well as through heat absorption.**
**From 2008 the EGR system works with the VGT (Variable Geometry Turbo) operation to create the right turbo drive pressures for the right amount of EGR Flow.**

**The exhaust after-treatment devices that are applied to vehicles are Diesel Oxidation Catalysts (DOC), Diesel Particulate Filters (DPF) and Selective Catalytic Reduction (SCR) catalysts.**

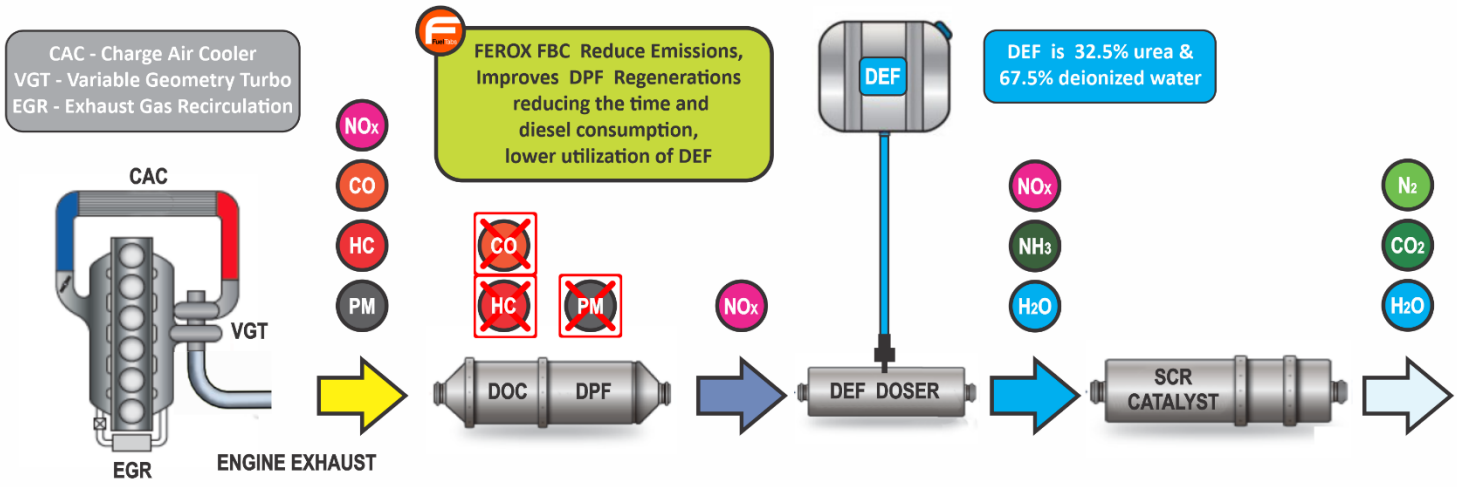
**The Diesel Oxidation Catalyst (DOC) is the first device in the after-treatment system. It is a flow through filter that contains precious metals to start the oxidation of hydrocarbons, carbon monoxide and unburned fuel and oil to water and carbon dioxide. Both the DOC and the DPF are honeycomb ceramic filters.**

**However, unlike the DOC, the DPF is a wall-flow filter that traps any remaining soot that the DOC couldn't oxidize. The soot remains in the DPF until it is regenerated and eliminated.**

**Using FEROX Fuel Borne Catalyst removes and prevent carbon deposits from forming in the combustion chamber and fuel injector, removing the coking deposits from injector is critical to ensuring optimal fuel "atomization" and fuel injector spray patterns into the cylinder, this contributes so that more fuel is burned in the engine and fewer emissions are generated in the exhaust.**

**FEROX Fuel Borne Catalyst removes and prevents carbon deposits, hydrocarbons (HC), unburned fuel and carbon monoxide (CO) prolonging the life of DOC, EGR, VGT**

# DIESEL EMISSIONS TECHNOLOGY




## ENGINE
**WITH EGR**
**PRE - 2007**

## PARTICULATE REDUCTION
**EPA 2007 - EGR + Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF)**

Diesel Oxidation Catalyst (DOC) is designed to convert carbon monoxide (CO) and hidrocarbons (HC) into carbon dioxide (CO2) and water.
Diesel Particulate Filter (DPF) is designed to remove 98% or greater of the Particulate Matter (PM) or soot where is trapped. This must eventually be removed to keep the filter from clogging.
The process of burning the soot in the filter is called REGENERATION

## NOx REDUCTION
**EPA 2010 - Reduced EGR + DOC & DPF + Selective Catalyst Reduction (SCR)**

Selective Catalyst Reduction is based in Hydrolysis, the chemical breakdown of a compound due to reaction with water.
The DEF sets off a chemical reaction that converts nitrogen oxides (NOx) into nitrogen, water and tiny amounts of carbon dioxide (CO2), natural components of the air we breathe, reducing nitrogen oxides (NOx) to NEAR ZERO LEVELS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