ULTIMATE SERVICE ASSOCIATES
A NORTH AMERICAN SITE SERVICES CO.

The ultimate solution for maintaining your nationwide generator network

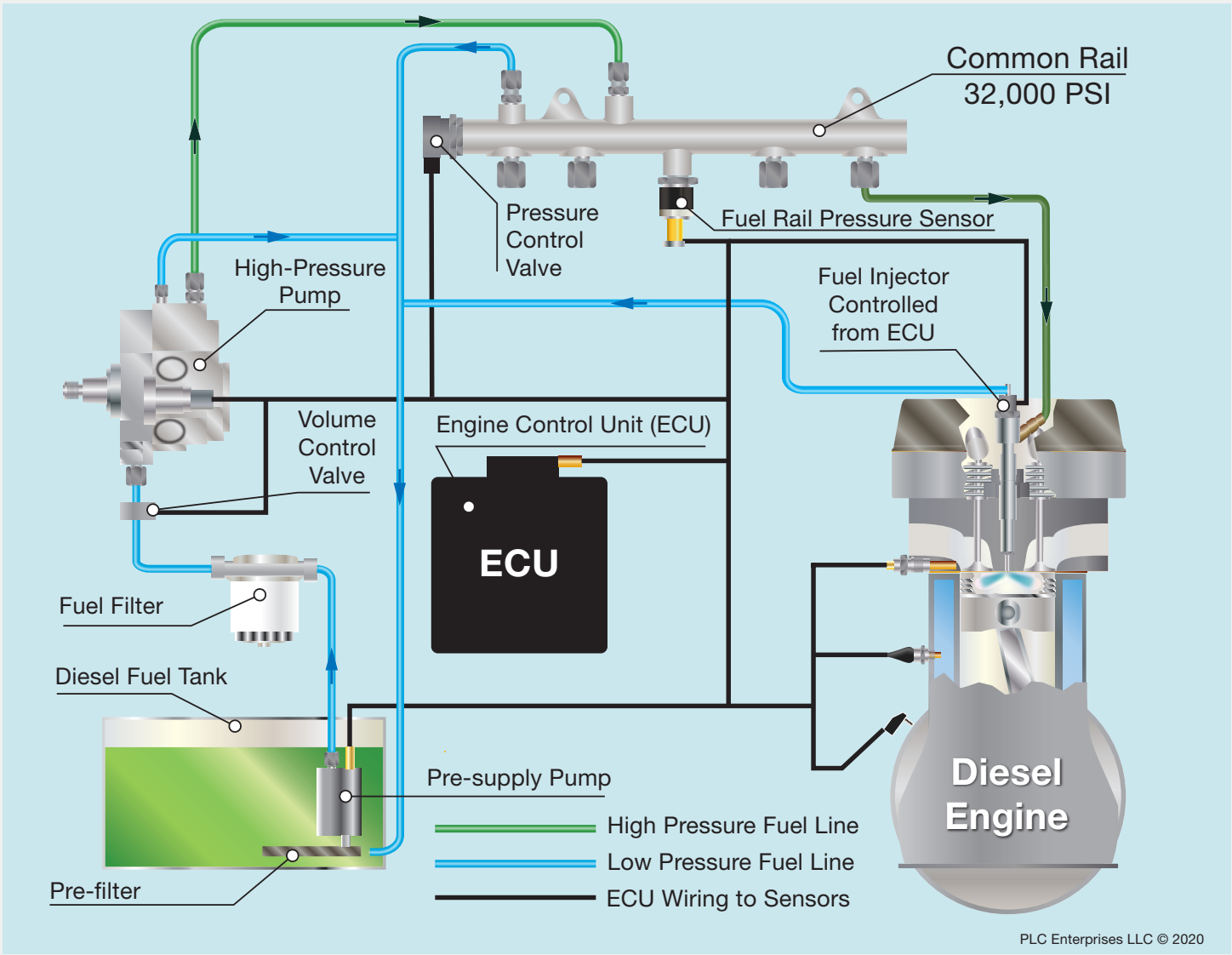
Tier 4 Certified Generator Systems Addressing PM in Cylinder

1.0 Introduction:

All diesel generator systems manufactured for the US market have to be certified to the emission Tier as defined by the Environmental Protection Agency (EPA). The standards were first introduced in 2005 and phased in completely by 2015. To improve exhaust emissions from reciprocating, combustion pressure ignited diesel engines, a primary source of power for generator system, the EPA regulated four key components of exhaust gas; Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Monoxide (CO), and Non-Methane Hydrocarbons (NMHC or simply HC). Traditionally diesel engines have emitted higher levels of PM than gaseous fueled engines. High levels of PM are known to be a health hazard in both on and off-highway diesel engine powered systems. Many engine manufacturers started to fit their engines with Diesel Particulate Filters (DPF) to meet the appropriate emission levels set for PM.

This Information Sheet discusses the disadvantages of generator systems fitted with a DPF system, and alternative technology incorporated into the latest diesel engine designs to reduce PM and eliminate the need for DPF.

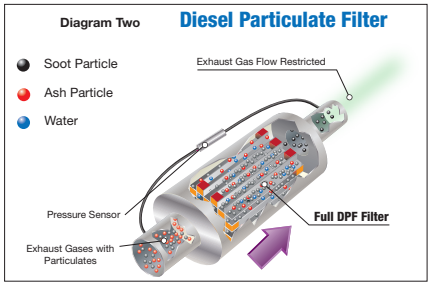
Diagram One - Common Rail High Pressure Fuel Injection System to Reduce In-Cylinder PM



To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

1.0 Disadvantages of Diesel Particulate Filters:

DPFs as a filter, collect Particulate Matter (PM) as part of an after exhaust treatment process before the exhaust is emitted into the surrounding ambient air. As a filter, it is designed to collect PM, and like any filter only has a limited capacity to gather the PM being collected. This in itself becomes a maintenance issue with two principal disadvantages:



1.1 DPF Cost - The first cost is the requirement to fit DPF for the diesel generator system. In addition to the cost of the item itself, it is another component that has to be mounted and can increase the overall envelop of the diesel power unit and some case the size of the generator enclosure.
The second cost is maintenance. DPF becomes an additional maintenance item in planned maintenance programs. After several hours of running, as defined by the diesel engine manufacturer, the DPF has to be removed and put through a regenerator to remove the exhaust particulate matter that has accumulated. ***See diagram two***

1.2 Hours Run Limiting Factor - A diesel engine fitted with DPF will only be able to run for a certain time before the filter has to be regenerated or cleaned. Apart from the maintenance expense this can be a reason for the generator system going off-line.

2.0 Eliminating the Requirement for DPF:

Many diesel engine manufacturers concentrated on making sure their diesel engines met the emission limits, set by the EPA emission levels leading up to Tier 4 final, by adding Exhaust Aftertreatment to existing engine platforms which included items such as DPF. Other manufacturers that were developing the next generation of diesel engine platforms, such as Kohler with their KD series, looked into combustion technology that emitted less of the exhaust emission components as defined by the EPA.

3.0 The Advantages of Eliminating the Requirement for DPF:

Removing the requirement for DPF provides the following advantages to users and the environment:

3.1 Reduced Maintenance Cost - Eliminating DPF removes an expensive maintenance item, with less downtime for planned maintenance programs by removing the time and cost to regenerate a DPF.

3.2 Higher Reliability - Eliminating DPF removes a component that can fail and shut down the diesel engine after a limited time.

3.3 Cleaner Exhaust Emissions - When an engine emits less PM less exhaust aftertreatment is required because you have a cleaner exhaust.

4.0 Adopting More Advanced Exhaust Emission Technology Designs:

The solution to less PM in the exhaust is to control the problem within the combustion process. Engine developers looked into the factors that were causing PM emission in the exhaust and it came down to several issues within the combustion process:

4.1 Fuel Injection - Could there be a better way to inject fuel into the cylinder?

4.2 Combustion - Could the power stroke in the cylinder when the air fuel mixture burns be more efficient?

4.3 Cleaner Fuel - Was there material in the fuel that was producing more PM?

5.0 Addressing PM In-cylinder:

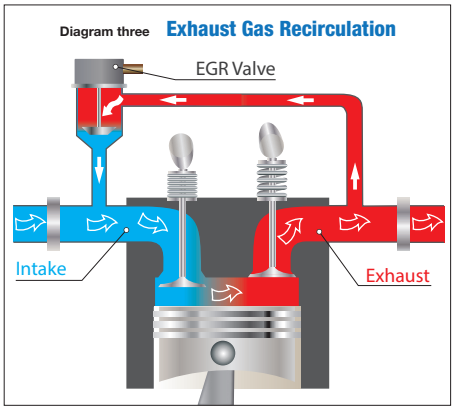
Currently the most advanced emission technology adopted by diesel engine manufacturers addresses the problem of PM in-Cylinder. Methods for controlling PM in-cylinder and producing more efficient, cleaner burn diesels are:

5.1 Fuel Injection - Diesel engines are compression ignited engines. As the piston rises and compresses the fuel air mixture, the temperature of the compressed mixture increases to ignite the mixture for it to burn and pushes the piston down converting fuel energy to mechanical energy. The fuel is injected into the combustion chamber in a very fine spray to mix better with the air drawn in. However, older engine technology utilized much lower fuel injection pressure.

5.2 High Pressure Fuel Injection - One of the greatest sources of PM was the result of not all the fuel been effectively burnt. Diesel engine designers determined if the fuel could be sprayed into the engine at much higher pressure there would be greater atomization of the fuel air mixture resulting in a more complete burn and less PM in the exhaust gas.

5.3 Common Rail High Pressure Fuel Injection - As exhaust emissions regulations started to set much lower PM targets for exhaust gases, as defined in Tier 4 Final, fuel injection specialists started addressing another reason for PM. More fuel being injected than was required through the burn on the power stroke. Common rail high pressure fuel injection combines high pressure and very accurate control of the amount of fuel required on the power stroke. ***See diagram one page-1***

Fuel is pumped into a rail (see Diagram one) at a much higher pressure than prior fuel injectors, in the case of the Kohler KD series 32,000 PSI. An Engine Control Unit (ECU) controls the fuel injection into the individual cylinder combustion chambers via solenoids that open at precisely the right time to inject a much more efficient air to fuel mixture. This results in very high level of atomization of the fuel mixture for a much more complete burn, and a more precise control of the fuel required. Both of these advanced emission control technologies reduce exhaust PM.



5.4 Combustion Chamber Design - Latest emission technology also addresses the design of the combustion chamber for a better mixture of the fuel/air leading to more complete combustion. In addition to improved emissions the engine has greater fuel efficiency.

5.5 Exhaust Gas Recirculation - Some engine combustion systems also utilize Exhaust Gas Recirculation (EGR). This system works by recirculating some of the exhaust gases back into the air inlet stream (see diagram two). By using this method not all the burnt fuel is exhausted with some of it returned to the inlet to further burn any unused fuel to lower PM. It also increases combustion temperatures for a more complete burn. The KD series achieved Tier 4 Final without EGR. ***See diagram three***

5.6 Lower Sulfur In Diesel Fuel - Another reason for PM in the exhaust gas was the high sulfur content of diesel fuel. Most engine manufacturers now recommend low sulfur content diesel to achieve the latest EPA Tier emission levels.

USA ULTIMATE SERVICE ASSOCIATES A NORTH AMERICAN SITE SERVICES CO.

Ultimate Service Associates, LLC.
5514 South Lewis Ave.
Tulsa, OK 74105

Ph: 918.836.8701
Fx: 918.835.2748

www.usa-svc.com

MEMBER EGSA Electrical Generating Systems Association