



# Tech Tip

Diesel Exhaust 172

## DIESEL EXHAUST TREATMENT Taking the Mystery Out of Diesel Exhaust Regeneration

**C**leaning up the exhaust on a diesel application has been a challenge for the vehicle manufacturers. Much progress has been achieved with new fuel injection technology and the addition of a three stage catalytic converter to control hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and a diesel particulate filter (DPF) that collects the soot/carbon particles from the combustion process. The soot/carbon collected in the DPF is later consumed by a burn-off process called regeneration.

The regeneration process has created some chatter in the industry and false claims have been made on how the system functions, and more specifically what allegedly initiates the regeneration process.

For example: How would you handle a customer that shows up at your shop with a repair ticket from a vehicle dealer stating that the air filter you installed in their vehicle rendered the catalytic converter inoperative? The vehicle was a Chevy Silverado equipped with a 6.6L turbo diesel. The technician claimed that the aftermarket air filters do not have enough restriction, resulting in an inoperative DPF regeneration cycle. Further, it was stated that the aftermarket filter caused certain exhaust sensors to be fooled, preventing the system from activating the regeneration cycle to burn off the soot/carbon. If you are not familiar with the diesel exhaust system and how and when regeneration occurs, you may feel obligated to pay the repair bill. Following are some facts about the exhaust system, how it functions, and the conditions required for DPF regeneration. It is imperative that you familiarize yourself with the system so you can offer an explanation to your customer when confronted with disparaging statements.

### THREE STAGE PROCESS

The diesel exhaust aftertreatment system functions via a three stage process:

- 1) In the first stage, the diesel oxidation catalyst (DOC) removes the exhaust hydrocarbon (HC) and carbon monoxide (CO) through an oxidation process.
- 2) In the second stage, the Selective Catalytic Reduction (SCR) system reduces the high levels of oxides of nitrogen (NOx), which is especially a problem with the diesel engines due to the high compression characteristics of the engine. The system injects a mixture of diesel exhaust fluid (DEF) into the exhaust system upstream of the SCR catalyst where it vaporizes, forming ammonia and carbon dioxide. The ammonia, in conjunction with the SCR catalyst, converts the NOx into harmless nitrogen and water vapor. The DEF fluid is a non-toxic solution comprised of 67.5% deionized water and 32.5% high urea. Urea is a compound of nitrogen that turns to ammonia when subjected to the intense heat. The fluid is commonly used in the manufacture of agriculture fertilizer, waste water treatment and the manufacture of some pharmaceuticals.
- 3) The third stage involves a diesel particulate filter (DPF), which traps the soot/carbon resulting from the combustion process, preventing the contaminants from being released into the atmosphere. The particulates are trapped in thousands of porous cells that have the capacity to trap more than 90% of the soot/carbon carried by the exhaust gases.

### NORMAL DPF REGENERATION

The inlet and outlet of the DPF is monitored by a differential pressure sensor (DPS) that measures any pressure drop across the DPF filter. When the soot/carbon begins to collect in the porous cells, the pressure drop will be increased. The amount of contamination is in relation to the power demands placed on the engine. Without a DPF clean-up (regeneration), the increased backpressure will create driveability issues. When the DPS senses a pressure drop across the DPF, it provides the electronic control module (ECM) with a signal that indicates contamination build-up in the DPF. Once this contamination reaches a certain level, the ECM will command a regeneration event to burn off the soot/carbon during normal vehicle operation. The

regeneration events that occur during vehicle operation are known as normal regenerations, and they can occur without the knowledge of the driver. To perform this regeneration event the vehicle will have to operate continuously at speeds above 30 mph for approximately 20–30 minutes to achieve a full regeneration of the DPF filter. The frequency of normal regeneration is determined by engine run time, miles driven and fuel consumed since the last regeneration. ***The regeneration cycle has nothing to do with the flow characteristics of the air filter.*** To create the necessary heat to burn off the soot/carbon, the ECM commands a fuel injector mounted forward of the DOC to inject fuel upstream of the catalyst. During the regeneration cycle exhaust temperatures may exceed 1,000 degrees F, as the system burns off the soot/carbon. If the vehicle speed is reduced to an idle speed during a normal regeneration, the engine may maintain an idle speed of 800 RPM until the DPF is cooled to a given temperature. If the sensors indicate that the temperature has exceeded a given threshold, regeneration will temporarily be discontinued until the sensors return to a normal value. If the regeneration temperature falls below a set value, the regeneration event is canceled and a diagnostic trouble code is set in the ECM memory.

Most of the problems with the system involve vehicles that are operated continuously at slow speeds, low loads, or spend a lot of time idling. During this mode of operation normal regeneration does not occur, resulting in heavy soot/carbon load conditions. When the DPS detects an increased pressure drop across the DPF, the ECM will illuminate the DPF lamp in the instrument cluster and a Clean Exhaust Filter message will appear in the driver information center. The owner's manual illustrates how the vehicle should be driven to establish normal regeneration. It is important that the vehicle be driven at speeds that allow normal regeneration on a routine basis. This can prevent high soot/carbon load build-up, which can damage the DPF due to excessive temperatures during a heavily contaminated burn-off cycle.

## **SERVICE REGENERATION**

If the vehicle is not driven under the conditions necessary to initiate a normal regeneration cycle, the ECM will illuminate the Service Engine light and display a Reduced Engine Power message on the driver information center when the DPF soot accumulation exceeds a set value. The engine will remain in the reduced power mode until the service regeneration is performed. This procedure is necessary, as the soot build-up is at a level that could cause thermal damage to the DPF.

The technician can activate the service regeneration mode with a scan tool. Once this mode is selected, the ECM will take control of the engine operation until the process is completed. The ECM uses exhaust gas temperature sensors to monitor the inlet and outlet temperature of the DPF to prevent damage to the system from excessive temperature and to insure complete regeneration. This regeneration process is usually completed within 30 minutes. The regeneration event can be terminated by applying the brake or commanding it to stop via the scan tool. Some vehicles are equipped with a dash mounted regeneration switch and a sequence of steps to activate the service regeneration mode. The required procedure is illustrated in the owners/operators manual.

## **SERVICE PRECAUTIONS**

- 1) Exhaust temperatures at the tailpipe may exceed 600 degrees F during regeneration.
- 2) The technician must not leave the vehicle during the regeneration process.
- 3) Make certain the tailpipe exhaust cooler is free of obstruction, as air must pass freely through the cooler to dissipate the extreme heat generated during the regeneration or burn-off process.
- 4) There should be a minimum of 10 feet clearance on all sides of the vehicle and the hood should be raised.
- 5) The service regeneration should be performed outdoors, as most exhaust hoses cannot withstand the excessive heat.
- 6) Combustible material or other vehicles should not be in close proximity.

Ash build-up in the DPF is a long term concern for the system. The ash is non-combustible and will not burn off during the regeneration process. It occurs from normal oil consumption. Use only the vehicle manufacturer's recommended oil for the diesel application, as it will specify low ash content. Heavy accumulations of ash deposits will require replacement of the DPF.

The information contained in this writing should provide you with the necessary information to address those false statements concerning the air filter and the regeneration process.

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