Emergency Vehicle Emissions System Guidance Document

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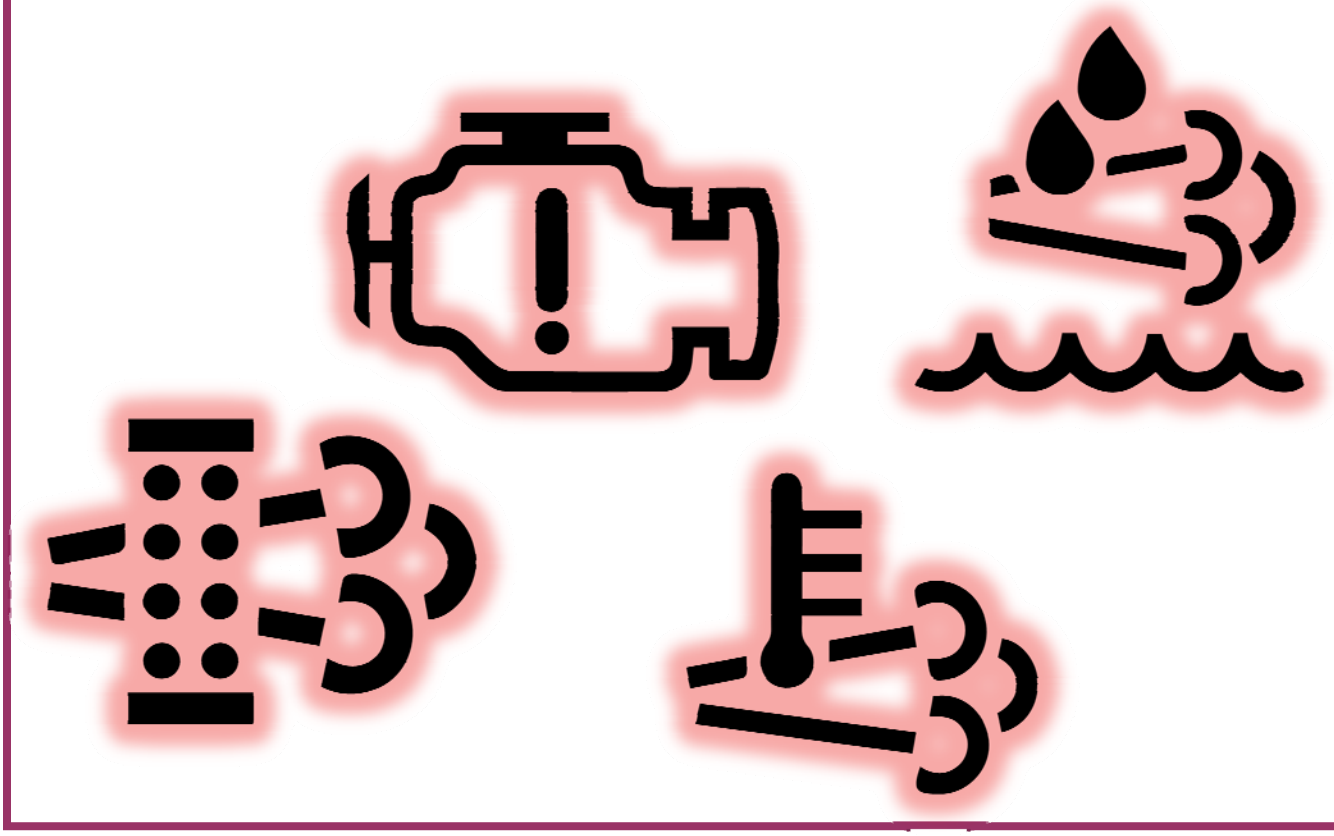
Custom Fire Apparatus



Contents

Introduction

This guide is intended to help fire service personnel understand the emissions systems on fire apparatus and to provide specific guidance on how to address emissions related concerns. The issues addressed will cover CUSTOM CHASSIS apparatus equipped with either Diesel Particulate Filters (DPF) or Selective Catalytic Reduction (SCR) aftertreatment devices.

Fire Apparatus Emissions Regulations History

Internal combustion engines have been getting cleaner for many years. This section provides a summary of the major changes that diesel engines have undergone over the past ten years.

2002

In response to the Clean Air Act, the EPA mandated improvements in diesel engine emissions beginning in 1990. The emissions limits were tightened in 1994, 1998, 2004, and 2007, with the final goal being reached in 2010. Some engine manufacturers implemented the 2004 standards two years early in 2002, while Caterpillar implemented as originally scheduled in 2004.

Exhaust Gas Recirculation (EGR)

Fire apparatus engine manufacturers other than Caterpillar introduced cooled Exhaust Gas Recirculation (EGR) beginning in 2002. EGR reduces NOx, a major contributor to air pollution, by lowering the combustion temperature inside the cylinder. The components that come with EGR include a more robust turbocharger, an exhaust gas cooler, and a system that controls the amount of exhaust that is redirected through the cooler and into the engine.

When EGR is added to an engine, it increases the total amount of heat going into the coolant. This extra heat has to be removed by the radiator. FAMA approached the EPA and was able to get some relief for fire apparatus so that radiators did not have to grow quite as much as they otherwise would have. The EPA allowed the engine manufacturers to use special engine control software features to limit the amount of exhaust gas recirculation when the fire apparatus was in extremely hot environments and/or under very heavy load. Such engine control features are termed Auxiliary Emission Control Devices (AECDs). Both Detroit Diesel and Cummins engines incorporated AECD strategies to some extent.

2004

Caterpillar ACERT

Caterpillar did not adopt EGR in 2004, but introduced a strategy they termed Advanced Combustion Emissions Reduction Technology (ACERT). They added a second turbocharger and employed electronically controlled fuel injection to meet the emissions criteria. The higher turbocharger pressures increased the heat of the charge air, requiring larger radiators and charge air coolers just as EGR did.

2007

The 2007 regulations tightened the criteria for NOx emissions, and instituted a 90% reduction in particulate matter, or soot.

More EGR

To meet the more stringent NOx criteria, Detroit Diesel, Cummins, and most other U.S. on-road engine manufacturers increased their reliance on EGR. This strategy also increased the amount of heat going into the cooling system and required apparatus manufacturers to increase the size of their radiators and charge air coolers. To gain a comfortable margin, many chassis cabs increased in width from 96 to 102 inches, allowing them to maintain driver and officer space while providing room for a larger radiator.

Diesel Particulate Filters

To meet the particulate matter regulation, the only method available was to add a Diesel Particulate Filter (DPF). The most common DPFs uses what is call a wall-flow substrate, typically made of porous ceramic media that capture exhaust gas and remove PM or soot particles. A typical filter consists of an array of small channels for exhaust gas to flow. Adjacent channels are plugged at opposite ends, forcing the exhaust gas to flow through the porous wall, capturing the soot particles on the surface and inside pores of the media. As soot accumulates in the filter, a regeneration event will provide sufficient heat to oxidize the soot.

DPF Regeneration

The heat required to burn off the soot in the DPF can be generated naturally when the engine is under a significant load. For over-the-road truck applications the engine will oftentimes be sufficiently loaded as it is driving down the road.

For fire apparatus that only take short runs and idle for hours at a time, the engine may never create enough exhaust heat for a long enough time to complete the soot oxidation. For this reason, engine manufacturers need a method of adding heat to the exhaust. All engine OEMs other than

Caterpillar chose to do this by adding a Diesel Oxidation Catalyst (DOC) ahead of the DPF.

The DOC oxidizes hydrocarbons (the main constituent of diesel fuel) and in the process produces heat. When the emissions system senses that the DPF is sufficiently full of soot, a charge of fuel is introduced into the exhaust stream. As it passes through the DOC, the fuel is oxidized and the exhaust is heated to a temperature that will burn off the soot in the DPF. This process is termed “active regeneration”.

Active regeneration can either take place automatically under normal engine operation, or it can be initiated manually at the direction of the operator.

DPF Ash Cleaning

Soot (mostly carbon) can be burned off in the DPF, but there are also particles that cannot be burned and remain trapped in the filter. This remaining ash must eventually be mechanically removed from the filter by removing it and having it professionally cleaned by an authorized service center. This cleaning should not be required for several hundred thousand miles of service, so most fire apparatus will likely never need the DPF cleaned over the life of the vehicle.

Caterpillar Clean Gas Recirculation

To meet the 2007 particulate regulations Caterpillar added a DPF to their emissions system. To meet the NOx regulations, they took a slightly different approach, calling it Clean Gas Recirculation (CGR) instead of EGR.

While CGR has the advantage of introducing cleaner exhaust back into the cylinders, it requires some additional accommodations. Traditional EGR systems use the engine coolant to remove heat from the exhaust. CGR draws the exhaust gas from downstream of the DPF, after the particulates have been removed from the exhaust. While this gas has very little soot remaining, it does include moisture that can condense in the charge air cooler, where trace amounts of sulfur can create an acidic mix. For this reason 2007 emissions Caterpillar engines use stainless steel charge air coolers that resist corrosion.

Another unique feature of the Caterpillar engine is the method used for active regeneration of the DPF. The CAT DPF does not include a DOC. Instead, the Caterpillar system uses a fuel injector and igniter located in the exhaust just downstream of the turbocharger outlet. This method directly heats up the exhaust gas. It is a very tricky process as the exhaust is depleted of oxygen and flowing very rapidly. The igniter must keep the flame alive in this very chaotic environment. For this reason it is

critical that the injector and igniter be maintained in peak condition for the regeneration process to work effectively.

2010

The EPA's latest move to clean up diesel emissions came in 2010. Particulate matter limits were unchanged, but the NO_x limit dropped another six-fold from the 2007 limits. Caterpillar decided to drop out of the on-road engine market, leaving only Cummins, Detroit Diesel, and Navistar as viable options for custom fire apparatus.

EGR + DPF + SCR

Detroit Diesel and Cummins both chose to adopt Selective Catalytic Reduction (SCR) as their means to meet the new NOx limits. SCR systems add a catalyst canister in conjunction with a liquid called Diesel Exhaust Fluid (DEF), also known as urea. When injected into the exhaust stream, the DEF is transformed into ammonia which works with the SCR catalyst to convert the NOx into nitrogen and water. This process is very effective at eliminating NOx from the exhaust. An SCR equipped engine can therefore be tuned to improve fuel economy and reduce soot while still meeting stringent emissions criteria.

Maxxforce Extreme EGR + DPF

The only U.S. engine OEM that did not initially embrace SCR was Navistar. Their Maxxforce engines increased the use of EGR, increased injection pressure, and otherwise modified the combustion chamber to drive down NOx emissions. This did not get them all the way so they used emissions credits to make up the compliance deficit.

Navistar has abandoned this strategy, and beginning in 2013 will be using Cummins SCR technology on their diesel engines.

DPF Emissions Problems Unique to Fire Apparatus

Manual Regeneration Process

Most over-the-road trucks will often times burn off the soot captured in the DPF through the heat produced naturally from high engine loads over hours of regular operation. Unfortunately many fire apparatus make frequent short runs and may not get the exhaust hot enough to keep the DPF burning off the soot efficiently.

Build up of soot in the DPF is indicated by a series of warning lights on the dash. The typical sequence begins with the illumination of the DPF lamp. When the DPF lamp comes on it means that the filter has loaded up with soot to a point that an intervention by the operator is necessary. The apparatus needs to be operated at higher load (by driving or pumping), or a manual regeneration needs to be performed. If action is not taken and soot continues to build up, the DPF lamp may begin to flash, followed by a check-engine lamp, and eventually a stop-

engine lamp. Consult your operator manual for the exact sequence for your particular apparatus and engine.

Frequent need for regeneration has by far been the most common emissions related complaint with fire apparatus. While many departments report that they have had little or no difficulty, there was a sufficient level of frustration in the industry to get the attention of leaders in the EPA. EPA scientists interviewed fire chiefs and made on-site visits to assess the situation. Based on their investigation, the EPA proposed and then instituted regulatory changes meant to help reduce any negative consequences of emissions system operation.

Regeneration Guidelines

Given the technology required to meet the EPA regulation and the typical fire apparatus duty cycle, it is unlikely that departments operating 2007 and later emissions systems will be able to entirely avoid the need to perform manual regenerations. FAMA has the following recommendations to minimize both the number of manual regenerations and the impact on fire service operations:

Keep the Apparatus In-Service during Manual Regen

A common misconception is that the apparatus must be taken out of service during a parked regeneration. This is not the case. If the DPF lamp is illuminated, park the apparatus outside on a level surface with the parking brake applied and the transmission in neutral. Engage the manual regeneration switch. The engine will begin the active regeneration process once the exhaust temperature is hot enough and will continue until the soot in the DPF has been burned off. Expect this process to take between 20 and 40 minutes.

If a call comes in before the regeneration process is complete, simply operate the apparatus as you would in any normal call. The regeneration process will be interrupted by tapping the service brakes or by releasing the parking brake. If the DPF lamp is still illuminated when you return from the call, park the apparatus and engage the manual regen switch as before. The process will begin again from where it left off. If the DPF lamp has gone out, it is probably because the duty cycle involved in the call continued to regenerate the DPF and the remaining soot was burned off naturally

Limit the Use of the Regen Inhibit Switch

Most apparatus are equipped with a regeneration inhibit switch. The regen inhibit switch is meant to be used sparingly, only if the apparatus is operating near a hazardous source of combusion. Inhibiting the automatic regeneration process may cause the DPF to load up with soot beyond its design limit, eventually leading to decreased engine performance. Continued use may lead to engine and emission system damage. Train your drivers to use the inhibit function only when absolutely necessary.

Don't Inhibit Regeneration While Pumping

There is a common misconception that regeneration will adversely affect pump operation. This is not the case. Any time the DPF lamp is illuminated the engine ECM is looking for minimum engine temperature and engine speed criteria to initiate active regeneration on its own. If the PTO is engaged, the ECM will not affect the PTO speeds, but regen will take place if the required minimums are met.

Update Engine ECM Programming Regularly

Engine manufacturers continuously learn more about how the emissions components work together. As they learn, they update and improve the engine ECM programming. Some of these programming updates may help your DPF regenerate less often or more efficiently. Consult with your local authorized service facility to see if any software changes are applicable to your apparatus to improve functionality. Add this to the service checklist so that future updates are uploaded on a regular schedule.

Use only ULSD Fuel and Approved Additives

In 2007, US oil companies were required to switch to ultra-low sulfur diesel (ULSD) fuel to limit the amount of ash that will build up in the DPF. Using any other fuel can increase the amount of soot and ash load on the DPF. Make sure you are not using any fuel other than ULSD with a maximum of 15 ppm of sulfur. Do not use fuel additives unless prescribed by the engine OEM. Do not use agricultural fuel, heating oil, Jet A, Kerosene, or any unapproved BioDiesel blends.

Maintain Exhaust Insulation

Hot exhaust temperature is essential to maximize the efficiency of the DPF in oxidizing the soot. If your apparatus was delivered with exhaust pipe insulation between the engine and the DPF make sure your insulation is not damaged or missing.

Don't Modify Exhaust Systems

Modern exhaust systems are highly engineered components designed to work in conjunction with the diesel particulate filter and other components of the engine emissions system. Re-routing or changing size of exhaust system piping could affect the performance of these components. Contact your apparatus manufacturer before making any changes to the exhaust system.

Use Only CJ-4 Engine Oil

To meet 2007 emissions requirements and improve reliability, engine oil manufacturers have developed the CJ-4 oil standard. CJ-4 has lower levels of phosphorous, ash, and sulfur. If the wrong oil is used in 2007 and newer engines, compounds in the oils will prematurely plug up the diesel

particulate filter (DPF). Check your maintenance shops to make sure you are using CJ-4 oil.

Monitor Engine Coolant Levels Carefully

Cummins, Detroit Diesel, and Navistar engines use engine coolant to cool the exhaust before it is introduced in the in intake manifold. This cooler is a highly stressed component, subject to changing pressures and temperature extremes. If the cooler leaks internally, coolant will pass into the air-intake stream and will be consumed in the cylinders. This creates additional deposits that will put an extra load on the EGR system and the DPF. Watch your coolant level carefully. If coolant levels are dropping without evidence of external leaks, you may be burning it in the engine. If coolant levels are dropping the problem should be diagnosed and the system repaired immediately.

Don't Ignore the Low Coolant Lamp

The coolant level sensor is one of the inputs required by the engine ECM before active regeneration is permitted. If the coolant level is low or the sensor has failed, you will not be able to perform a manual regen. Don't ignore a low coolant indicator. Determine the root cause of low coolant indication and have it repaired immediately.

Don't Ignore Leaking Fuel Injectors

Leaking injectors will cause poor engine performance and increased soot levels resulting in the need for more frequent regenerations. They can also pass fuel into the cylinder heads after the engine is shut down. This fuel will flow past the rings and into the crankcase. This is termed "making oil". The crankcase oil will be diluted which may lead to excessive engine wear and increased soot levels in the exhaust. Extra soot will increase the required frequency of regenerations.

Apparatus without Split-Shaft Driven Pumps

NFPA requires the speedometer to measure 5 mph before an automatic regeneration can be activated. If the apparatus is equipped with an engine-driven split-shaft water pump, the speedometer will register vehicle speed during pumping and an automatic regeneration can take place.

If the apparatus is not pumping, if the pump is driven off a power take-off (PTO), or if the apparatus has no pump, the 5 mph interlock will prevent automatic regeneration. This 5 mph criteria can be removed by reprogramming the engine ECM so that the system can perform an automatic regeneration any time the vehicle is running and stationary. This will increase the opportunity the DPF has to automatically regenerate, and reduce the possibility of a soot-load related maintenance event.

Navistar and Mid-Range Cummins Engines

Limit Unnecessary Regeneration

All Navistar engines except the Maxxforce 13L as well as Cummins ISB, ISC, and ISL engines dose fuel directly into the engine cylinders rather than after the turbocharger in the exhaust stream. If you regenerate too frequently with these engines the fuel in the cylinder can damage the engine by leaking into the crankcase and diluting the oil. In general, FAMA recommends that you wait until the DPF light comes on before you perform a manual regeneration. If you are a department that has determined that you need to perform more frequent or scheduled regens then you should sample your oil regularly to ensure that oil dilution is not taking place. Consult with your authorized repair facility to determine if your regeneration frequency is normal for your apparatus.

Engine Surging

Some departments have reported problems with the engine surging or hunting if the apparatus is pumping and the DPF is regenerating at the same time. This complaint appears to be isolated to mid-range diesel engines and sometimes can be resolved by a change to the ECM programming. Consult your authorized apparatus or engine service provider if you experience this issue.

Caterpillar Engine ARD

2007 Caterpillar engines use an Aftertreatment Regeneration Device (ARD), a unique method of heating the exhaust to produce an active regeneration. The ARD consists of a fuel injector and igniter downstream of the turbocharger. The flame produced by the ARD adds the necessary heat to the exhaust to initiate regeneration. Caterpillar engineers spent considerable effort designing just the right configuration of injector, igniter, and combustion chamber to ensure that the flame would stay lit in high exhaust stream velocities. The ARD is susceptible to malfunction if the system is not maintained in peak condition. The injector can become clogged, reducing the flame temperature and the effectiveness of the regeneration. Schedule regular inspection of the injector and repair or replace as needed.

EPA Regulation Changes Related to DPFs

In August, 2012, the EPA approved a rule change that gives emergency vehicle engine manufacturers more flexibility in how they meet diesel emissions standards in the future. This flexibility is meant to minimize the risk of emergency vehicle engines losing power or shutting down as a result of the emission control system performance.

There is a common misconception in the fire service that this regulatory change exempts emergency vehicles from pollution control devices. This is not the case as this change DOES NOT allow for any EXEMPTIONS or removal of aftertreatment (pollution control) hardware. It is also important to note that the rule change is voluntary in nature and it is up to each engine manufacturer to develop appropriate strategies. This rule change also allows engine manufacturers the option of updating units already in service, but in no way requires it.

Any approach will need EPA review and approval, but the rule is written in a manner that leaves the door open for other approaches that would meet the intent of emissions regulation while reducing the risk to operations. The EPA is suggesting three approaches that they would likely approve.

DPF Regeneration Allowed More Frequently

Some engine programming restricts the amount of active automatic or manual regeneration that takes place. This delays regeneration action until soot levels have built up to higher levels. EPA proposes to allow the engine to regenerate at lower soot loads, allowing more frequent active regeneration, and thereby reducing the risk of soot-loaded DPFs affecting power or causing the engine to shut down.

Allowing Engines to Produce Less Soot

Engine calibration that reduces NOx pollutants tends to increase soot production. EPA proposes to allow engine calibration changes that will reduce soot production even though NOx levels may rise. This will reduce the load on the DPF and increase the time between required regeneration.

DPF Bypass Device

If soot levels in the DPF get to critical levels, the engine will shut down. This is a safety measure to prevent the DPF from entering a state where the soot begins to burn uncontrollably with massive amounts of heat that will destroy the DPF and create a fire hazard on board. EPA proposes to allow a bypass device that would direct exhaust around the DPF to avoid shutting the engine down if critical soot levels develop. This approach would be very impractical for, particularly for retrofit on in-service apparatus.

At time of publication, engine manufacturers are evaluating their options, submitting proposals to EPA, and developing plans to implement EPA approved changes as development and production schedules permit.

SCR Emissions Problems Unique to Fire Apparatus

The 2010 SCR emissions system works if it is provided with a source of Diesel Exhaust Fluid (DEF). To make sure that the operator maintains adequate DEF

tank levels, the EPA mandated driver inducement strategies. As the DEF tank level drops, a series of inducements occur that first reduces power or torque and ends with a 5 mph vehicle speed limit. FAMA worked with the EPA to allow less severe driver inducements for emergency vehicles. The final inducement with the emergency vehicle strategy is a vehicle speed limit of 25 mph. This strategy was installed on Cummins engines produced beginning in July of 2011.

There are also provisions in the EPA standard that require engine manufacturers to guard against emissions systems tampering and ensure the proper repair of critical component failures.

To make sure that the apparatus emission levels remain within the limits and that engine performance is not compromised, FAMA recommends the following practices:

Rotate DEF Supplies

DEF has a shelf life of approximately two years if stored in controlled temperatures between 10 and 90 deg F. If stored outside these temperatures it will last at least one year. Whether you purchase DEF in bulk or in jugs, rotate your DEF stock to ensure proper emissions system efficiency.

Carry Spare DEF

Engine derate or vehicle speed limits are initiated as the DEF tank level drops. Train your drivers to top off the DEF tank every time they fill with fuel, monitor the DEF gauge, and carry spare DEF on the apparatus.

EPA Regulation Changes Related to SCR

DEF Inducements

One of the EPA regulation changes allows for the removal of driver inducements. It is anticipated that inducement-free strategies for emergency vehicles will be available in the future for both new and in-service apparatus.

DEF Tank Size

In a separate but parallel rule-making, EPA will require that DEF tanks be sized to provide an operational range equivalent to no less than two tanks of diesel. This proposal is part of a Notice of Proposed Rulemaking that will take effect at some future date with sufficient time for manufactures to react, and will not be retroactive to in-service vehicles.

General Service Suggestions

OEM Programmable Parameters

Engine emissions systems are complicated and some aspects of the system are programmable by the custom chassis OEM. Mechanics should be aware that emissions systems may be programmed differently from apparatus to apparatus and from engine to engine. Be cautious about applying what you think you know on one apparatus or engine to another apparatus or engine. Always refer to the manuals, and consult your authorized service facility if you have questions.

Engine Service

Given the complex nature of engine systems it is essential that service be obtained from OEM authorized service centers only. They will have the proper equipment, training, and software to troubleshoot any issues.

Appendix A - Abbreviations

DPF	Diesel Particulate Filter	An emissions component that traps soot particles left over from the combustion process and holds them while they continue to oxidize (burn) into carbon dioxide and water.
Passive Regen	Passive Regeneration	An ongoing chemical process inside the DPF that oxidizes (burns) carbon during a vehicle's normal operation. "Self-Cleaning"
Active Regen	Active Regeneration	A process that increases heat in the exhaust to oxidize (burn) excess carbon in the DPF.
SCR	Selective Catalytic Reduction	A method of reducing the oxides of nitrogen (NOx) in the exhaust through a chemical reaction with ammonia.
ECM	Electronic Control Module	The computer module that controls the functions of the diesel engine.
DOC	Diesel Oxidation Catalyst	An emissions component that oxidizes unburned hydrocarbons in the exhaust and provides a method of increasing exhaust system heat.
CGR	Clean Gas Recirculation	A term coined by Caterpillar to describe their unique method of EGR.
ARD	Aftertreatment Regeneration Device	Caterpillars name for their device that burns fuel in the exhaust to regenerate the DPF.
DEF	Diesel Exhaust Fluid	Liquid Urea. Also known in Europe as AdBlue.
AECD	Auxiliary Emission Control Device.	Anything used by engine manufactures that modifies the emissions outside their normal parameters. Normally this is a piece of engine ECM software code. Must be approved by the EPA for each engine.
ULSD	Ultra-Low-Sulfur Diesel	Diesel fuel with 15 parts per million or less of sulfur content.
NOx	Oxides of Nitrogen	Mostly consisting of NO and NO_2, these compounds react with sunlight to form pollutants.
Manual Regen	Manual DPF Regeneration	The term "Manual Regen" used in this document refers to the process of performing an active regeneration while the vehicle is parked (also called a Parked Regeneration, Forced Regeneration, or Stationary Regeneration)

Appendix B - Training Checklist

To ensure peak performance from your 2007 or 2010 emissions apparatus, drivers must be trained on the service requirements of their emissions system and how to respond to the information provided by the indicator lamps. This training must be specific to the particular apparatus and engine and should include the information in this document, your apparatus operator and service manuals, and your engine operator and service manuals. Drivers should have specific knowledge on the following emissions systems topics:

- Proper identification of emissions system on the apparatus using one of the following methods.
  - Engine serial number:
    - Date of manufacture.
    - Emissions certification level.
  - Identification of engine emissions strategy (ie, DPF only, EGR only, DPF with SCR, etc...).

- DPF functions
  - Regeneration process.
    - Dash lamps associated with DPF (DPF, HEST, Check Engine, Stop Engine).
    - Possible inducements based on system installed.
    - Exhaust tubing insulation and importance of keeping insulation intact.
    - Location of tail pipe.
    - Tail pipe heat diffuser.
    - Active verses Passive Regeneration.
      - Passive regeneration (occurs naturally while driving or working an engine under a load).
      - Active regeneration.
        - Manual / Stationary regeneration process.
          - Identify switch location.
          - Parameters necessary for manual regeneration (brake set, clear tail pipe area of debris, etc…).
        - In PTO mode.
  - Purpose of and correct use of inhibit switch.
    - Limit the use of the inhibit switch.
    - Don't inhibit regeneration while pumping.

- SCR functions.
  - DEF tank and importance of maintaining correct fluid and tank level.
  - Dash lamps associated with SCR (DEF, Check Engine, Stop Engine).

- Location of DEF Level Indicator.
- Possible inducements based on engine manufacturer and system installed.

- On Board Diagnostics system.
  - MIL Lamp.

- Review chassis reference material.
  - Chassis operator’s manual regarding engine and exhaust system.
  - In-vehicle placards if present.

- Review engine reference material.
  - Engine operator’s manual regarding engine and exhaust system.
  - Engine manufacturer's reference materials (see Appendix D).

Appendix C - Manufacturer Contacts

For further information contact the following FAMA companies

Custom Apparatus Manufacturers

American LaFrance	843-486-7400	customersupport@americanlafrance.com
E-One	352-237-1122	info@e-one.com
Ferrara	800-443-9006	charlieg@ferrarafire.com
HME	616-534-1463	info@hmetruck.com
KME	800-235-3928	kme@kovatch.com
Pierce	888-974-3723	contactcenter@piercemfg.com
Rosenbauer	605-543-5591	info@rosenbaueramerica.com
Seagrave	800-732-4728	service@seagrave.com
Spartan	800-543-5008	firetruckservice@spartanmotors.com
Sutphen	866-287-5549	

Engine Manufacturers

Caterpillar	800-447-4986	Truck_Engine_Call_Ctr@cat.com
Cummins	800-343-7357	cumminsengines.com
Detroit Diesel	800-445-1980	
Navistar Maxxforce		www.maxxforce.com

US EPA

Lauren Steele	734-214-4788	steele.lauren@epamail.epa.gov

Appendix D – Engine Reference Documents

Caterpillar

Driver Guidelines

The DPF Regeneration Quick Reference Card

CATERPILLAR®

Regeneration Lamps	Activity	Driver Action
DPF Lamp	Flashing	Insure DPF inhibit switch is in the "automatic / not inhibited" position. If in "automatic" continue driving.
DPF Lamp	Solid	Continue Driving.
DPF Lamp + Check Engine Lamp	Solid	Perform a stationary regeneration as soon as possible. If regeneration is unsuccessful, call for service. NOTE: Continued running of the engine, if regeneration was unsuccessful, will cause automatic derating of power and may cause permanent damage to emissions control system.
HEST Lamp	Solid	Informational Lamp, exhaust system is hot and vehicle speed is less than 5 mph. No action is required.

*Note: For a complete description of DPF Regeneration please review "The DPF Regeneration Lamps, Switches and Driver Tips" brochure LEDT 7022.

For questions contact the Caterpillar Truck Engine call center 1 (800) 447- 4986

Cummins

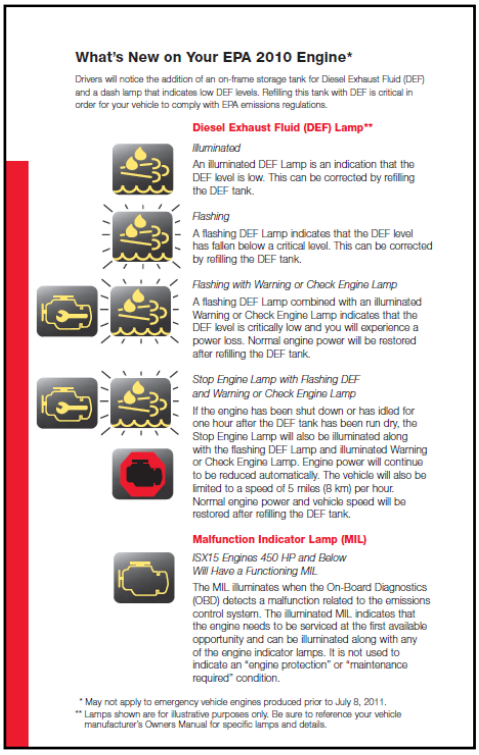
References

Diesel Particulate Filter for Emergency Vehicles
http://cumminsengines.com/assets/pdf/4971356.pdf

Driver Tips for Fire & Emergency Vehicles (shows the different DEF derates based on when your engine was built)
http://cumminsengines.com/assets/pdf/4971316.pdf

VIDEO: 2010 Cummins Aftertreatment System Overview For Fire Trucks
http://www.youtube.com/playlist?list=PL82D6C0E1AEECBFDB&feature=plcp

Driver Guidelines



What's New on Your EPA 2010 Engine*

Drivers will notice the addition of an on-frame storage tank for Diesel Exhaust Fluid (DEF) and a dash lamp that indicates low DEF levels. Refilling this tank with DEF is critical in order for your vehicle to comply with EPA emissions regulations.

Diesel Exhaust Fluid (DEF) Lamp**

Illuminated
An illuminated DEF Lamp is an indication that the DEF level is low. This can be corrected by refilling the DEF tank.

Flashing
A flashing DEF Lamp indicates that the DEF level has fallen below a critical level. This can be corrected by refilling the DEF tank.

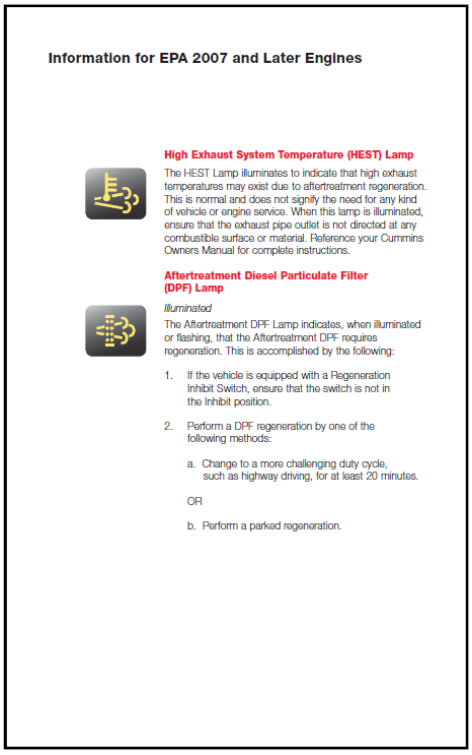
Flashing with Warning or Check Engine Lamp
A flashing DEF Lamp combined with an illuminated Warning or Check Engine Lamp indicates that the DEF level is critically low and you will experience a power loss. Normal engine power will be restored after refilling the DEF tank.

Stop Engine Lamp with Flashing DEF and Warning or Check Engine Lamp
If the engine has been shut down or has idled for one hour after the DEF tank has been run dry, the Stop Engine Lamp will also be illuminated along with the flashing DEF Lamp and illuminated Warning or Check Engine Lamp. Engine power will continue to be reduced automatically. The vehicle will also be limited to a speed of 5 miles (8 km) per hour. Normal engine power and vehicle speed will be restored after refilling the DEF tank.

Malfunction Indicator Lamp (MIL)

ISX15 Engines 450 HP and Below Will Have a Functioning MIL
The MIL illuminates when the On-Board Diagnostics (OBD) detects a malfunction related to the emissions control system. The illuminated MIL indicates that the engine needs to be serviced at the first available opportunity and can be illuminated along with any of the engine indicator lamps. It is not used to indicate an "engine protection" or "maintenance required" condition.

* May not apply to emergency vehicle engines produced prior to July 8, 2011.
** Lamps shown are for illustrative purposes only. Be sure to reference your vehicle manufacturer's Owners Manual for specific lamps and details.



Information for EPA 2007 and Later Engines

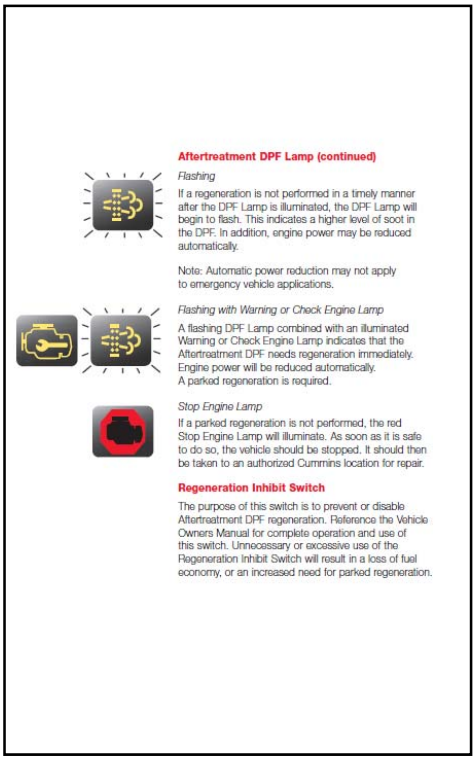
High Exhaust System Temperature (HEST) Lamp

The HEST Lamp illuminates to indicate that high exhaust temperatures may exist due to aftertreatment regeneration. This is normal and does not signify the need for any kind of vehicle or engine service. When this lamp is illuminated, ensure that the exhaust pipe outlet is not directed at any combustible surface or material. Reference your Cummins Owners Manual for complete instructions.

Aftertreatment Diesel Particulate Filter (DPF) Lamp

Illuminated
The Aftertreatment DPF Lamp indicates, when illuminated or flashing, that the Aftertreatment DPF requires regeneration. This is accomplished by the following:

1. If the vehicle is equipped with a Regeneration Inhibit Switch, ensure that the switch is not in the Inhibit position.
2. Perform a DPF regeneration by one of the following methods:
   a. Change to a more challenging duty cycle, such as highway driving, for at least 20 minutes.
   OR
   b. Perform a parked regeneration.



Aftertreatment DPF Lamp (continued)

Flashing
If a regeneration is not performed in a timely manner after the DPF Lamp is illuminated, the DPF Lamp will begin to flash. This indicates a higher level of soot in the DPF. In addition, engine power may be reduced automatically.

Note: Automatic power reduction may not apply to emergency vehicle applications.

Flashing with Warning or Check Engine Lamp
A flashing DPF Lamp combined with an illuminated Warning or Check Engine Lamp indicates that the Aftertreatment DPF needs regeneration immediately. Engine power will be reduced automatically. A parked regeneration is required.

Stop Engine Lamp
If a parked regeneration is not performed, the red Stop Engine Lamp will illuminate. As soon as it is safe to do so, the vehicle should be stopped. It should then be taken to an authorized Cummins location for repair.

Regeneration Inhibit Switch
The purpose of this switch is to prevent or disable Aftertreatment DPF regeneration. Reference the Vehicle Owners Manual for complete operation and use of this switch. Unnecessary or excessive use of the Regeneration Inhibit Switch will result in a loss of fuel economy, or an increased need for parked regeneration.

Detroit Diesel

Driver Guidelines

DETROIT DIESEL
DEMAND PERFORMANCE™

DRIVER NOTIFICATIONS, DESCRIPTIONS AND ACTIONS

NOTIFICATION AND DESCRIPTION	DRIVER ACTION
High Exhaust System Temperature Lamp (HEST) • **Solid**: Exhaust is at **high** temperature and vehicle is at **low** speed or parked. • **Flashing**: A parked regeneration is in process and the system is not up to temperature.	No change in driving style is required. When parked, keep vehicle at a safe distance from people and flammable materials or vapors
Malfunction Indicator Lamp (MIL) • Indicates a failure of an Emission Control Device. May illuminate at the same time as the Check Engine Lamp.	Vehicle can be driven to end of the shift. If the MIL remains on after 3 drive cycles, call for service.
DPF Regeneration Lamp • **Solid**: Indicates that a parked regeneration may be needed. • **Flashing**: Indicates that a parked regeneration is required as soon as possible. • Diesel Particulate Filter reaching system limits.	Perform a parked regeneration OR bring vehicle to highway speeds to enable Automatic Regeneration of the filter.
Flashing CHECK ENGINE **DPF Regeneration Lamp / Check Engine Lamp** **ENGINE DERATED** • Indicates the Diesel Particulate Filter has **reached** system limits.	A parked regeneration **must** be performed. If the parked regeneration exits and the lamps remain on, repeat the parked regeneration. If the second attempt fails call for service.
Flashing CHECK ENGINE STOP ENGINE **DPF Regeneration Lamp / Check Engine Lamp** **Stop Engine Lamp** **ENGINE SHUTDOWN** • Indicates the Diesel Particulate Filter has **exceeded** system limits.	A parked regeneration **must** be performed. If the parked regeneration exits and the lamps remain on, repeat the parked regeneration. If the second attempt fails call for service. **Note**: Engine can be restarted but a parked regeneration must be initiated within 30 seconds or the engine will shutdown.

PARKED REGENERATION PROCEDURE

1. Keep engine at slow idle (cannot be in PTO mode).
2. Transmission in neutral with park brake ON.
3. Cycle the park brake OFF to ON.

4a. If equipped with clutch pedal, Press and release clutch pedal.

4b. If not equipped with clutch pedal, cycle transmission to DRIVE and back to NEUTRAL.

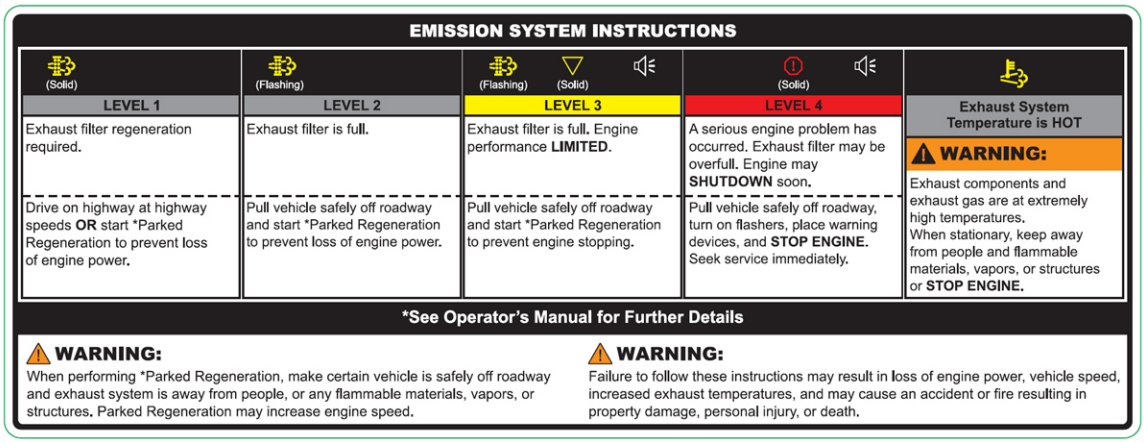
5. Hold DPF Switch to the ON position for five (5) seconds, then release (engine speed will increase and DPF Lamp will go out).

- The parked regeneration may take up to 40 minutes.
- The parked regeneration is completed when the engine returns to low idle and the DPF Lamp remains off. The HEST light may remain on but the vehicle can be driven.
- A parked regeneration will stop if the key is turned to the OFF position, clutch is depressed, the truck is put into gear or the parking brake is released.

BLUETEC EMISSIONS TECHNOLOGY

Navistar Maxxforce

Driver Guidelines



EMISSION SYSTEM INSTRUCTIONS

(Solid)	(Flashing)	(Flashing) (Solid)	(Solid)	
LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**	**Exhaust System Temperature is HOT**
Exhaust filter regeneration required.	Exhaust filter is full.	Exhaust filter is full. Engine performance **LIMITED**.	A serious engine problem has occurred. Exhaust filter may be overfull. Engine may **SHUTDOWN** soon.	**WARNING:** Exhaust components and exhaust gas are at extremely high temperatures. When stationary, keep away from people and flammable materials, vapors, or structures or **STOP ENGINE.**
Drive on highway at highway speeds **OR** start *Parked Regeneration to prevent loss of engine power.	Pull vehicle safely off roadway and start *Parked Regeneration to prevent loss of engine power.	Pull vehicle safely off roadway and start *Parked Regeneration to prevent engine stopping.	Pull vehicle safely off roadway, turn on flashers, place warning devices, and **STOP ENGINE.** Seek service immediately.	

***See Operator's Manual for Further Details**

WARNING:
When performing *Parked Regeneration, make certain vehicle is safely off roadway and exhaust system is away from people, or any flammable materials, vapors, or structures. Parked Regeneration may increase engine speed.

WARNING:
Failure to follow these instructions may result in loss of engine power, vehicle speed, increased exhaust temperatures, and may cause an accident or fire resulting in property damage, personal injury, or death.