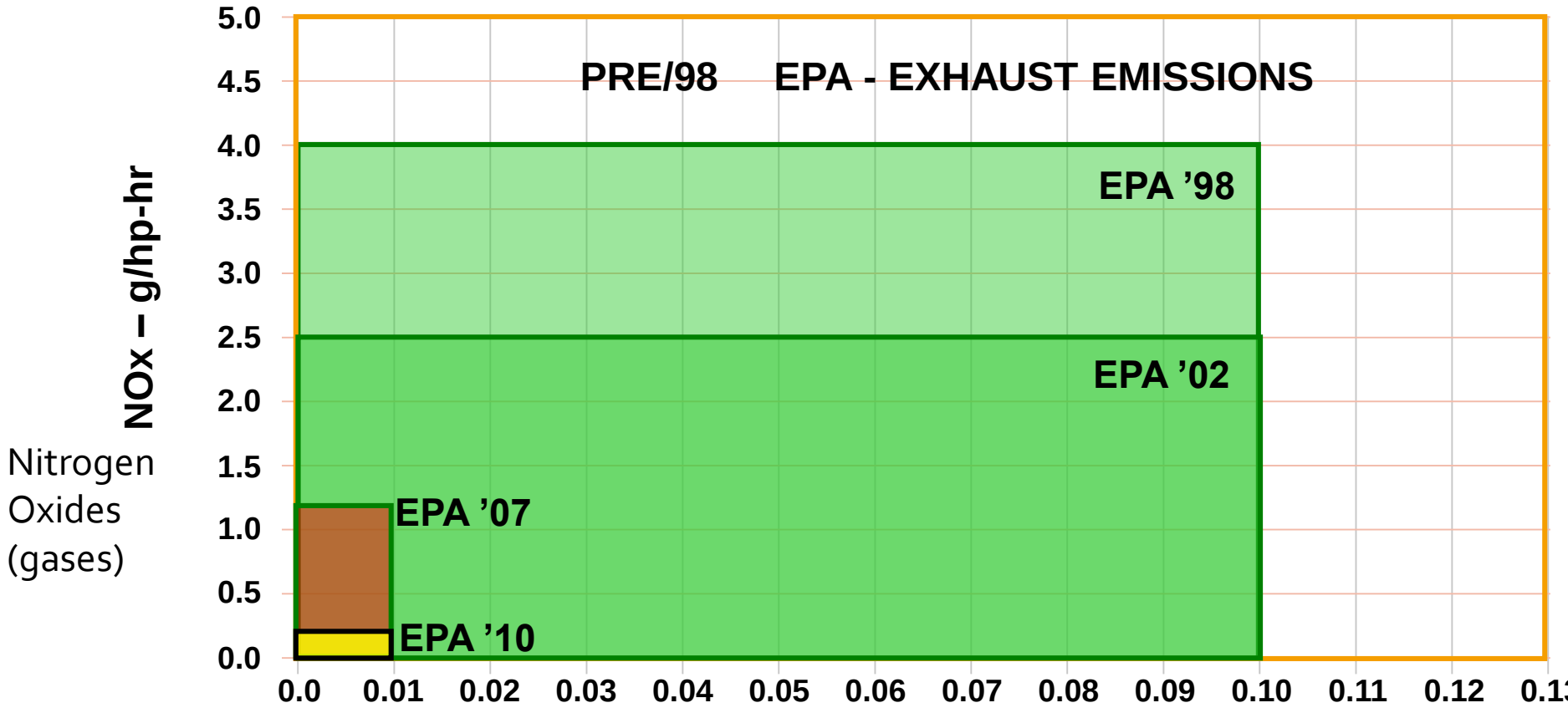
A TRUCKER'S GUIDE

TO
COMPLIANT TRUCK TECHNOLOGY
BEST PRACTICES, MAINTENANCE AND CARE OF AN ENGINE'S EMISSION SYSTEM

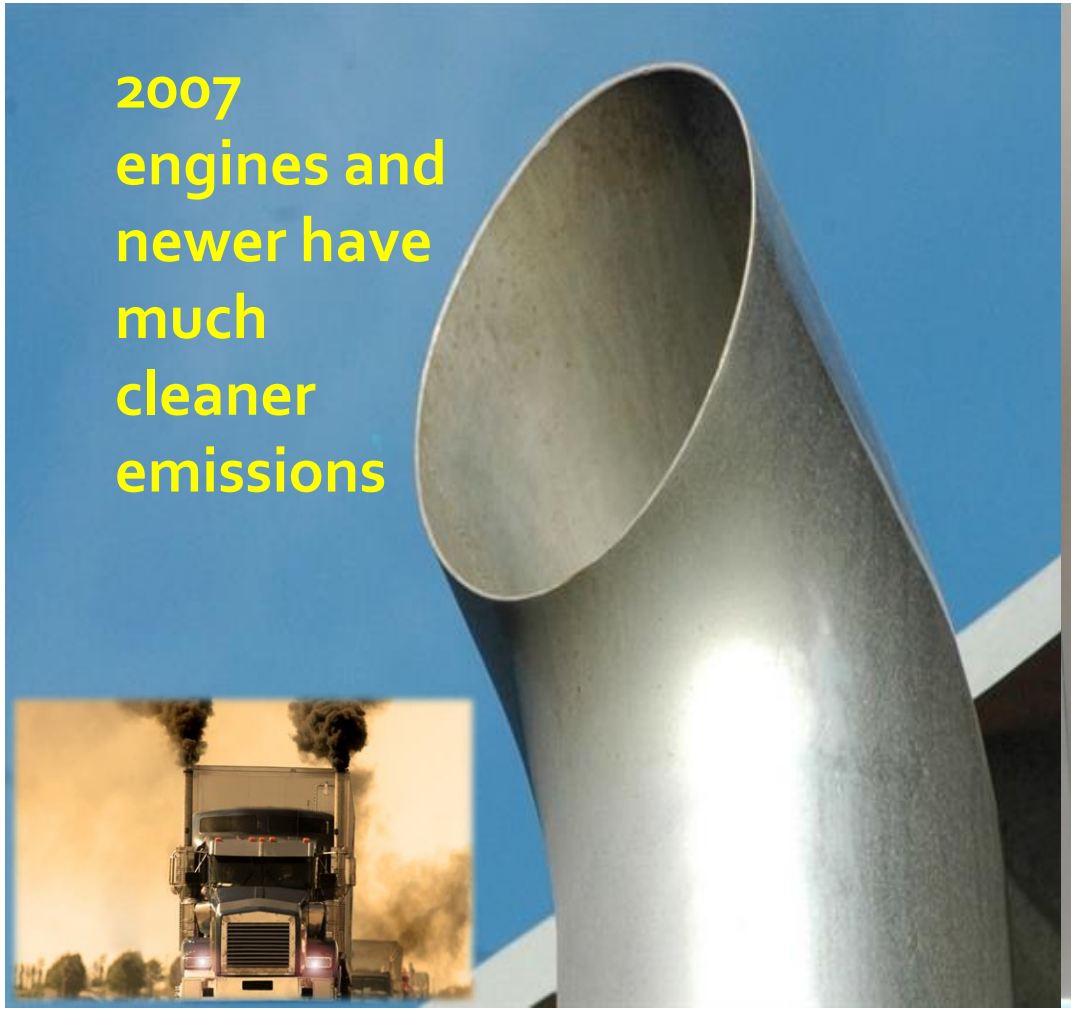
Our Discussion Today Includes

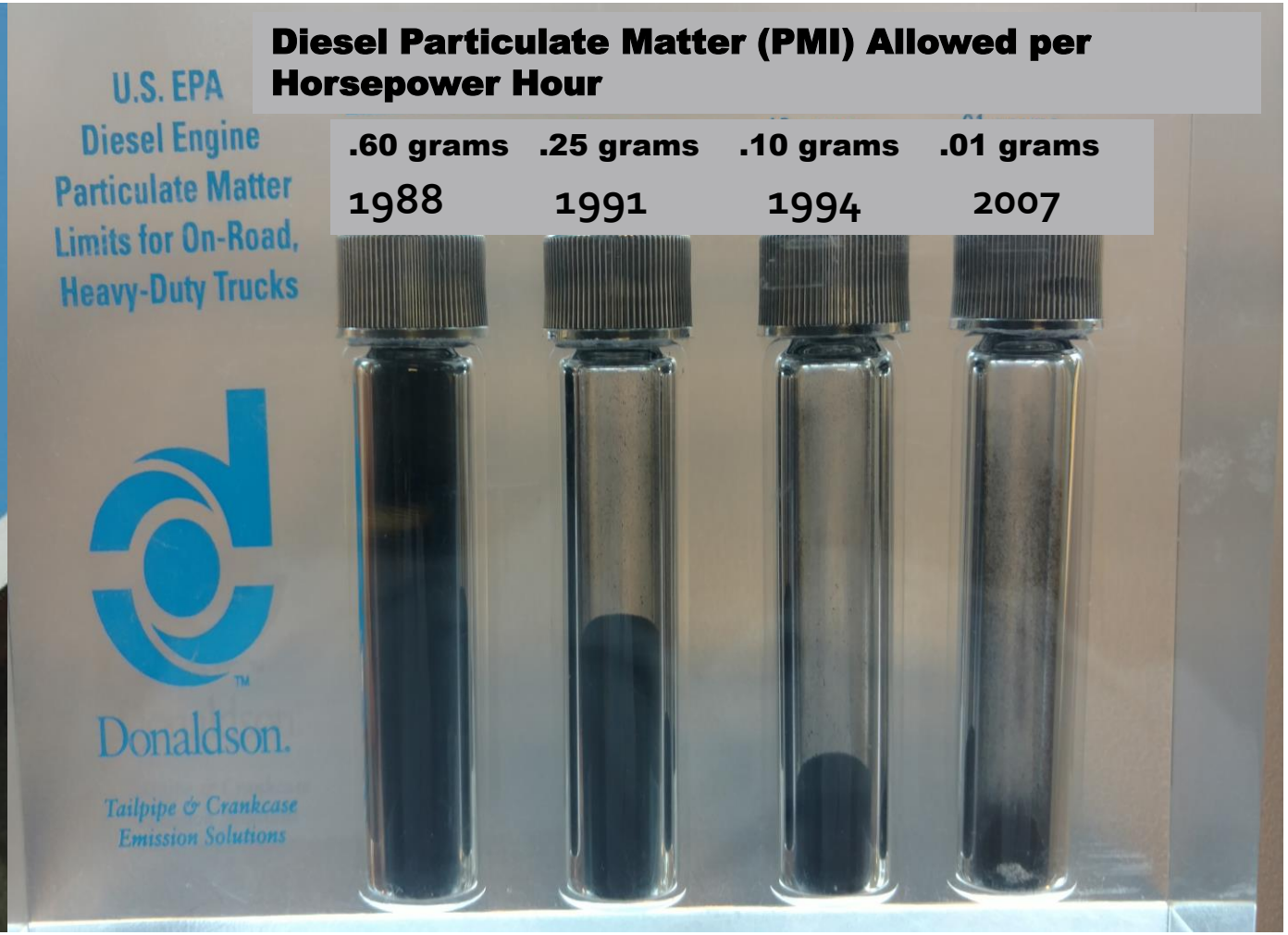
- Commercial Truck Engine Emissions, where we came from and where we are now
- EPA clean engine emissions mandates; Pre-2007, 2007 to 2010 engine emissions levels
- 2007 to 2010 engine technologies, what they are and how they work
  - Diesel Particulate Filter Technology Review
  - SCR and DEF Technology Review
- Clean Truck Engine Maintenance Best Practices
- DPF Cleaning and Maintenance
- Buying Issues, Credit, Available Inventory, Pricing Fluctuations

EPA North American Diesel Emission Standards



Why the push for newer emission vehicles?



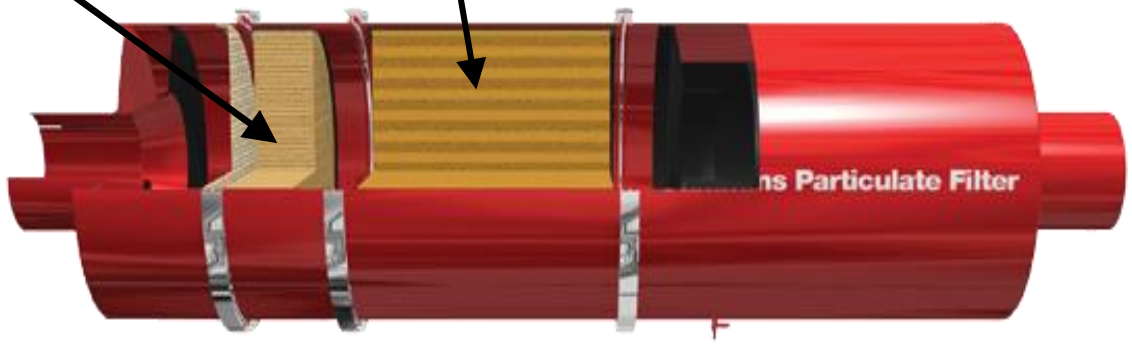


Cummins 07 Aftertreatment System

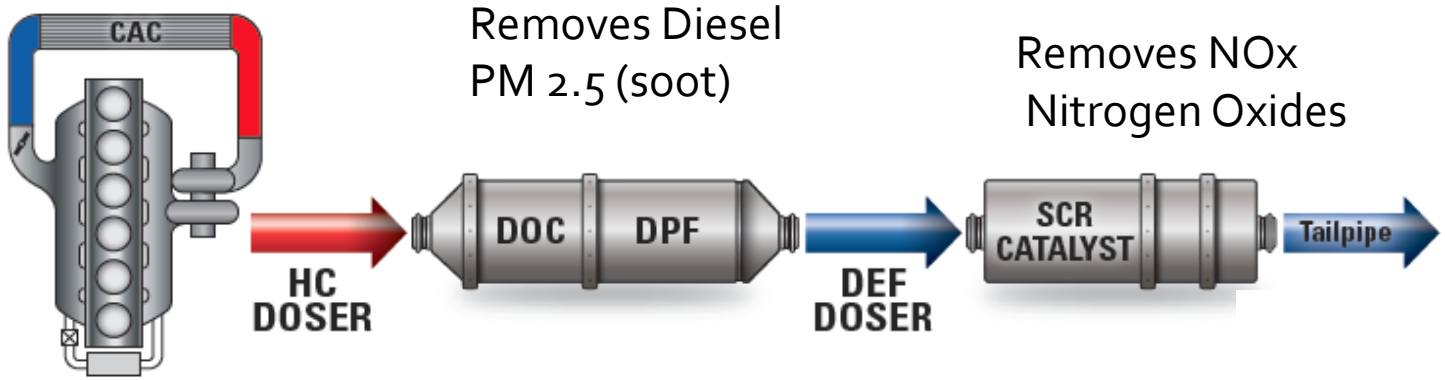
Diesel Oxidation Catalyst- A diesel oxidation catalyst (DOC) is an aftertreatment component that is designed to convert carbon monoxide (CO) and hydrocarbons into carbon dioxide (CO2) and water. ... It breaks down pollutants in the exhaust stream from a diesel engine, helping to reduce particulate matter (PM).

Wall-Flow Diesel Particulate FilterFilter

A diesel particulate filter (DPF) is a device designed to remove 98% or greater of the (PM) or soot from the exhaust gas of a diesel engine



Cummins Particulate Filter



Removes Diesel
PM 2.5 (soot)

Removes NOx
Nitrogen Oxides

Pre – 2007

EGR

EPA 2007

EGR +

Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF)

EPA 2010

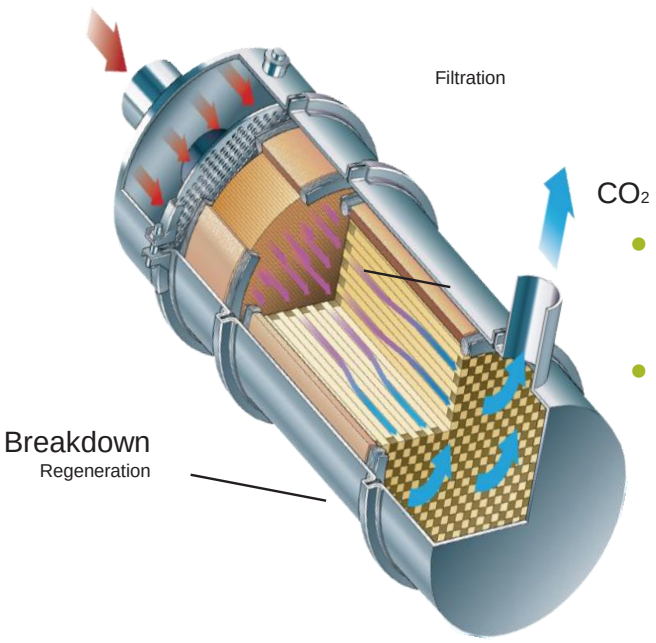
Reduced EGR +

DOC & DPF +

SCR Catalyst- Hydrolysis-the chemical breakdown of a compound due to reaction with water.

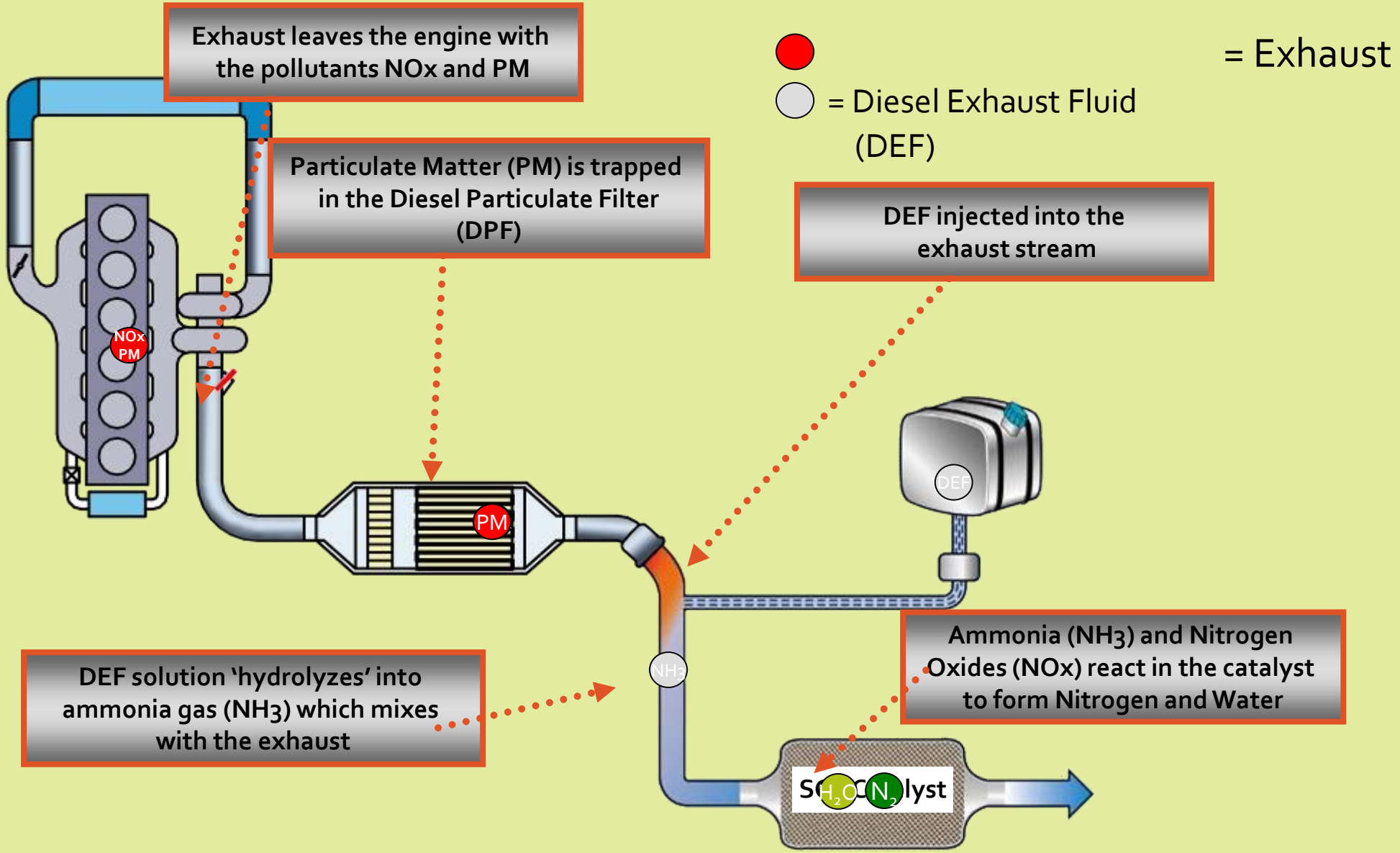
EGR, DOC, DPF and SCR to meet all of the 2010 emissions standards at the tailpipe.

Understanding Your DPF's Regeneration System

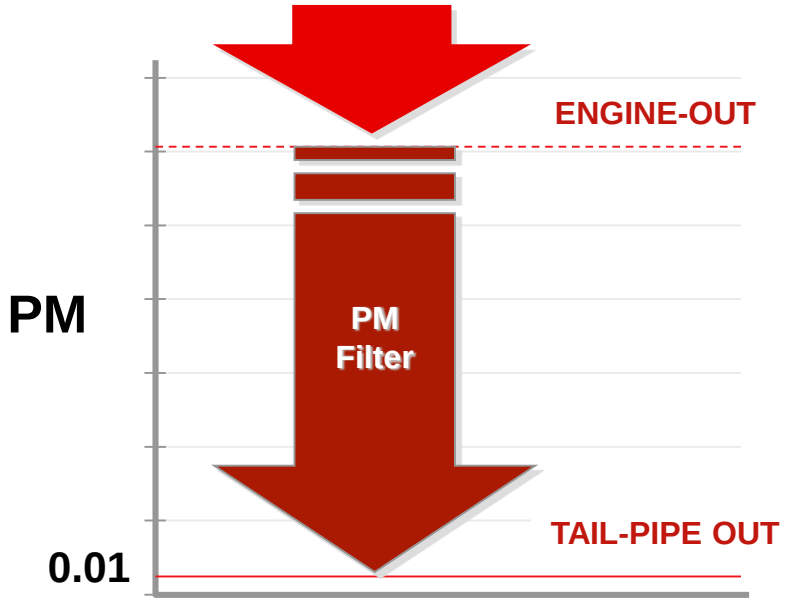


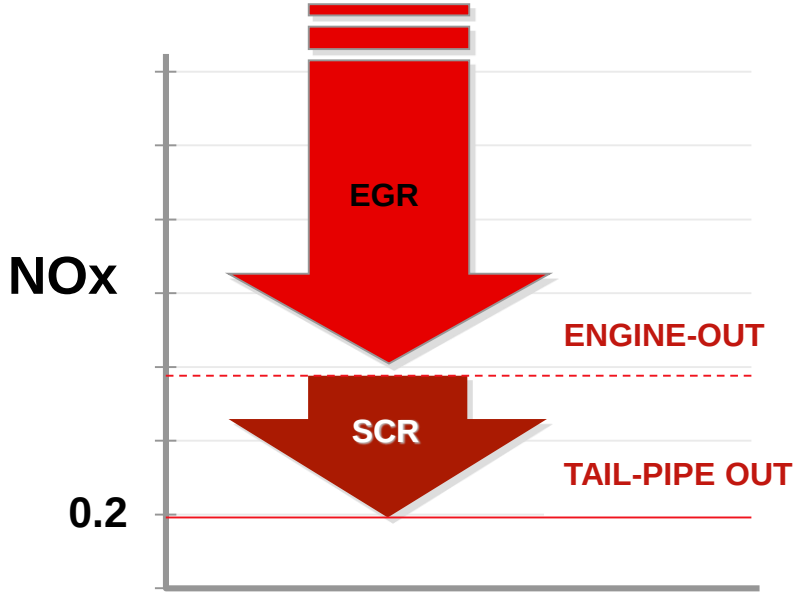
- The DPF collects soot from the engine exhaust. This must eventually be removed to keep the filter from clogging. The process of burning the soot in the filter is called **REGENERATION**.
  - High temperatures for an extended amount of time are required for the DPF to be regenerated properly.
- ***Passive Regeneration*** – In this system operation, the engine exhaust temperature gets hot enough to trigger regeneration during vehicle use.
- ***Active Regeneration-*** This process may or may not require action by the driver.
  - 1- Most DPFs, for example, automatically dose and ignite diesel fuel in the filter for regeneration.
  - ***2- Driver Initiated (STATIONARY/PARKED) Regeneration***:
    - The DPF regeneration light is blinking so the driver must pull over and proceed with a parked regen. This can take up to 45 minutes to complete. Make sure that the driver gives DPF the required regeneration time, so the soot can be completely removed from the filter before the vehicle is driven again.
    - Actively regenerated DPFs should not be parked near flammable materials when the regeneration takes place. The DPF gets very hot and could cause combustibles to catch on fire.

How 2010 level SCR systems work



Cummins Aftertreatment System

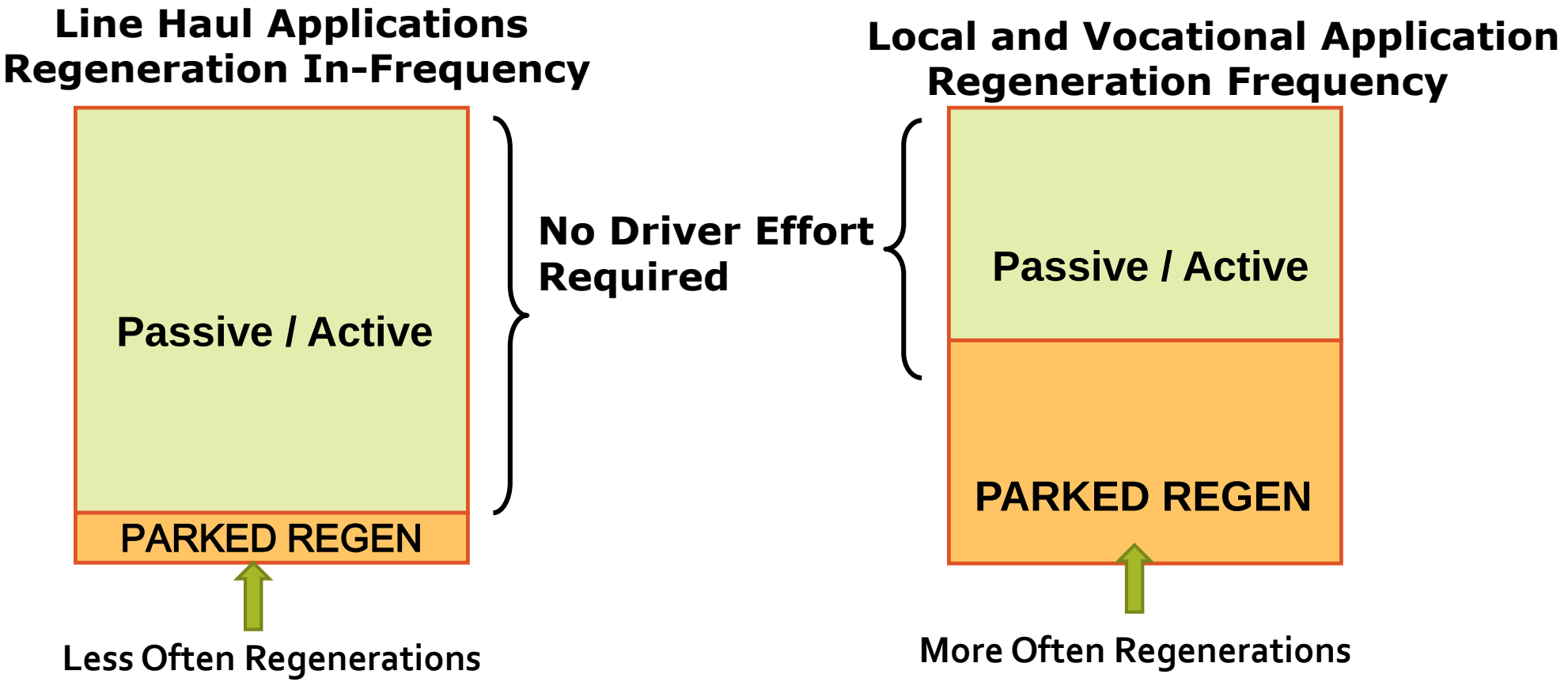




Parked regenerations occur more frequently in local and vocational applications due to the stop and go driving and lightly loaded conditions.

For Line-Haul, parked regenerations are much more limited in frequency

Regeneration Frequency- As a result of the trucks application



Exhaust Temperatures, beware

Area	Normal Operation	Regeneration
Pipe surface ahead of particulate trap	600-800 °F	600-1000 °F
Surface of the particulate trap	350°F	500°F
Pipe surface after particulate trap	600°F	900°F
Exhaust temp at exit of tailpipe	750°F	1150°F

The chart above depicts the exhaust temperatures at various locations on the average aftertreatment device.

Diesel exhaust fluid (**DEF**) is an aqueous **urea** solution made with 32.5% **urea** and 67.5% deionized water. … **DEF** is used as a consumable in selective catalytic reduction (SCR) in order to lower NO_x concentration in the diesel exhaust emissions from diesel engines. (Wikipedia)

- **How much DEF will my engines emission system consume while I am driving?**
- **The system will consume approximately 2% DEF consumption to fuel consumption.**

Every 50 gallons of fuel = 1 gallon of DEF

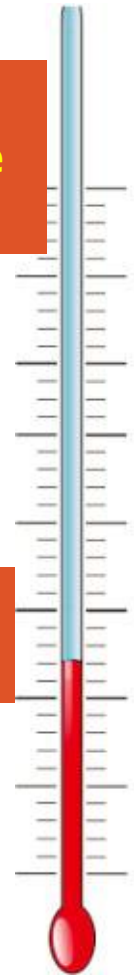
Truths about DEF

Material Safety Data Sheet (MSDS)

- **Hazards Identification:**
- "Urea Solution is not flammable"
- **First Aid Measures:**
- "Wash area thoroughly with soap and water"
- **Fire Fighting Measures:**
- "Urea solution is not flammable"
- **Transportation Information:** "Urea solution is not listed by any US or Canadian transportation authority as a hazardous material…"
- You can pour it on your lawn, "would make a great fertilizer"

At 86°F DEF has a shelf life of 1 YEAR!

DEF will start to freeze at 12 degrees F



2010 aftertreatment dash lamps that drivers now have to pay attention to.

- **HEST Lamp**
  - High Exhaust Temperature

- **DPF Lamp**
  - Diesel Particulate Filter

- **Diesel Exhaust Fluid Lamp**
  - Low level warning

- **Malfunction Indicator Lamp**
  - OBD (On-board Diagnostics)
  - Emissions non-compliance indication

Emissions System Related Dash Notification Lights- Detroit

NOTIFICATION AND DESCRIPTION	DRIVER ACTION
 **Check Engine Lamp or Amber Warning Light (CEL or AWL)** • Engine controls, aftertreatment control system and/or component issues exist.	Vehicle can be driven to end of shift. Call for service.
 **High Exhaust System Temperature Lamp (HEST)** • **Solid**: Exhaust is at **high** temperature and vehicle is at low speed or parked. • **Flashing**: Parked regeneration in process. 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) /Check Engine Lamp** • There is a potential problem with the emission control system or component. • May illuminate at the same time as the Check Engine Lamp. • Driving for a prolonged period with the MIL on can cause damage to the engine and/or aftertreatment system as well as degrade mileage and drivability.	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**: Parked regeneration may be needed. • **Flashing** 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  **DPF Regeneration Lamp / Check Engine Lamp** **ENGINE DERATED** • 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  **Stop Engine Lamp** **ENGINE SHUTDOWN** • 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.
 **Fuel Filter Restriction Sensor Lamp (FFRS)** • Fuel Filter is restricted.	Driver has one to three days to seek service or the engine may derate.
 **Water In Fuel Lamp (WIF)** • Water level is too high and must be drained from the fuel system.	Engine water separator must be drained or an engine derate will occur.

(Some notifications may be reported by Virtual Technician™.)

DETROIT™
DEMAND PERFORMANCE™

Regen Procedure EPA2010 Detroit

DETROIT
DEMAND PERFORMANCE™

PARKED REGENERATION PROCEDURE

1. Keep engine at slow idle (cannot be in PTO mode).
2. Cycle transmission out of neutral and back into neutral.*
3. Cycle the park brake from OFF to ON.*
4. Press and release clutch pedal.*
5. Hold DPF Switch to the ON position for five (5) seconds, then release. Engine speed will increase and DPF Lamp will go out.

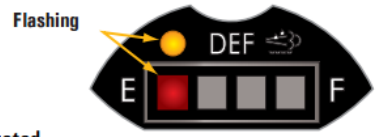
- The parked regeneration may take up to 40 minutes.
- The parked regeneration is complete when the engine returns to idle and the DPF lamp remains off. The HEST light may remain on, but the vehicle can be driven.
- A parked regeneration will stop if the key is turned to the OFF position, clutch is depressed,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

*These steps are not required on GHG14 engines or later.

DIESEL EXHAUST FLUID (DEF) INDICATOR LAMPS

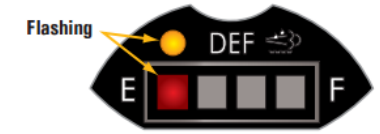
DEF level is very low

DEF level is **EMPTY**

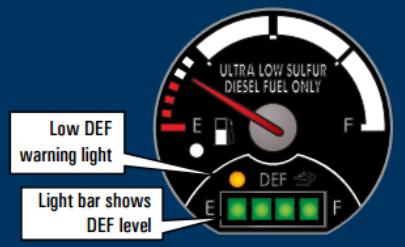


Vehicle speed limited to 55 mph / engine derated

DEF level is **EMPTY** and **IGNORED**

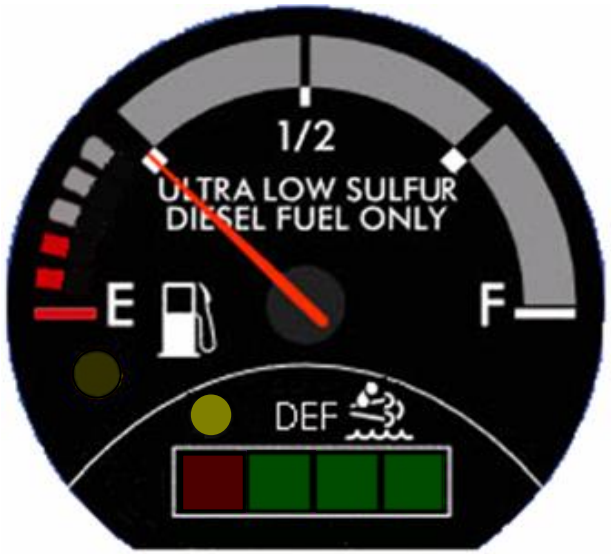


Vehicle speed limited to 5 mph / engine derated



- The use of improper fluid will trigger a decrease in engine performance.
- In the empty and ignored state, vehicle speed will be limited to 5 mph until DEF is detected in the tank.
- The light bar indicates the level of fluid in the DEF tank.
- Low DEF levels will trigger a decrease in engine performance.

What happens when a driver ignores the DEF Level



FULL

DEF Level	Gauge Lamps	DEF Lamp
75% to 100%	4 green lights	off
50% to 75%	3 green lights	off
25% to 50%	2 green lights	off
10% to 25%	1 green light	off
5% to 10%	1 yellow light	on solid
0% to 5%	1 red light flashing	on flashing

EMPTY

Check Engine Lamp

- 25% Engine Derate
- 55 MPH Vehicle Speed Limit

Malfunction Indicator Lamp (MIL)
and 5 MPH speed limit

What happens when the driver puts Improper Fluid in the DEF tank

If the driver accidently puts an improper fluid into the DEF tank, the SCR system will detect the error and the malfunction light will illuminate

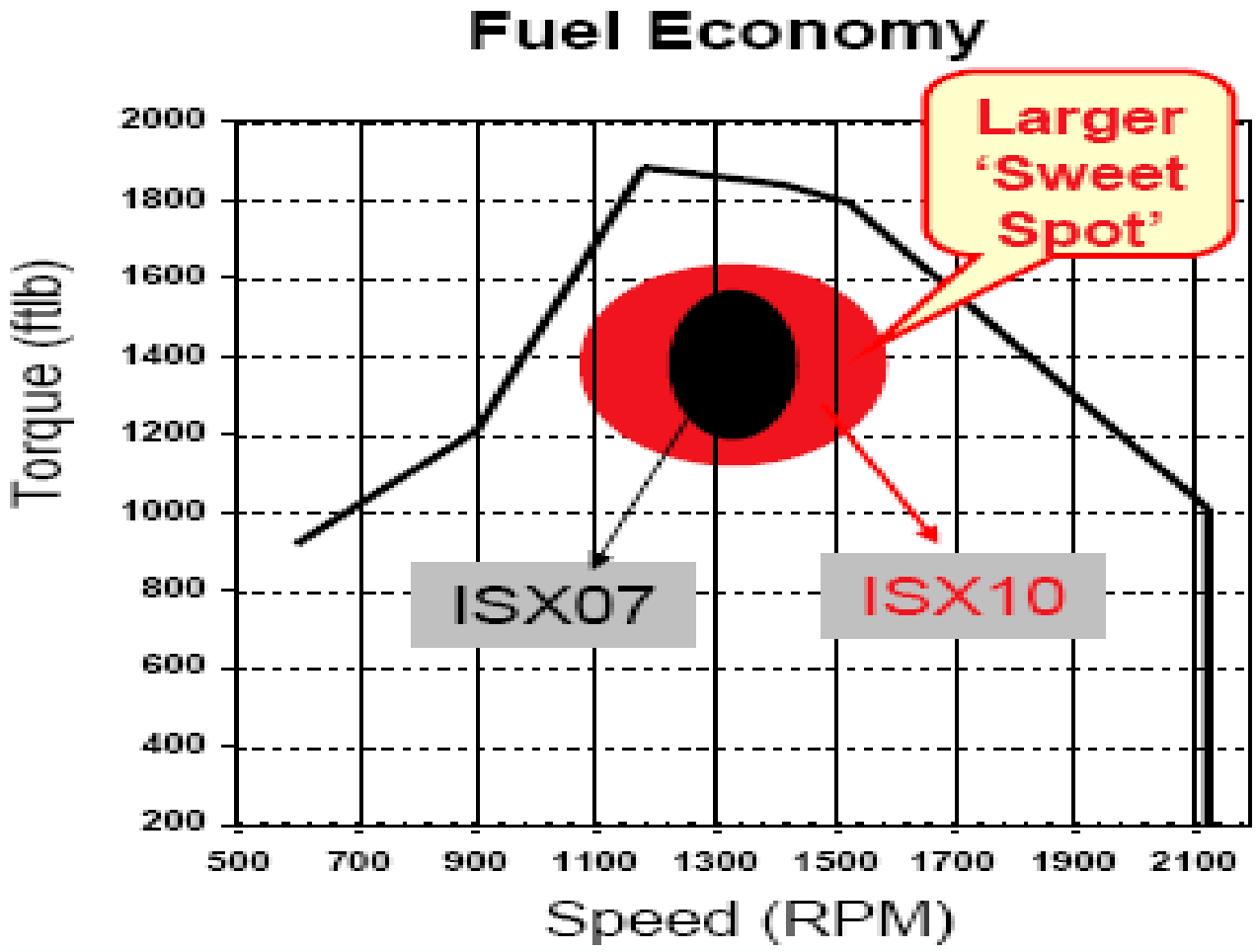
- The following action will be employed once this condition is detected:
  - 25 % engine derate
  - 55 mph speed limit imposed

Malfunction Indicator Lamp

- After 1,000 miles or 20 hours of operation without remedy a more significant action will be initiated. Vehicle speed will be limited to 5 mph provided the vehicle is in a safe situation.

- Under no circumstances will the engine be shutdown due to running the vehicle out of DEF or putting the improper fluid in the DEF tank

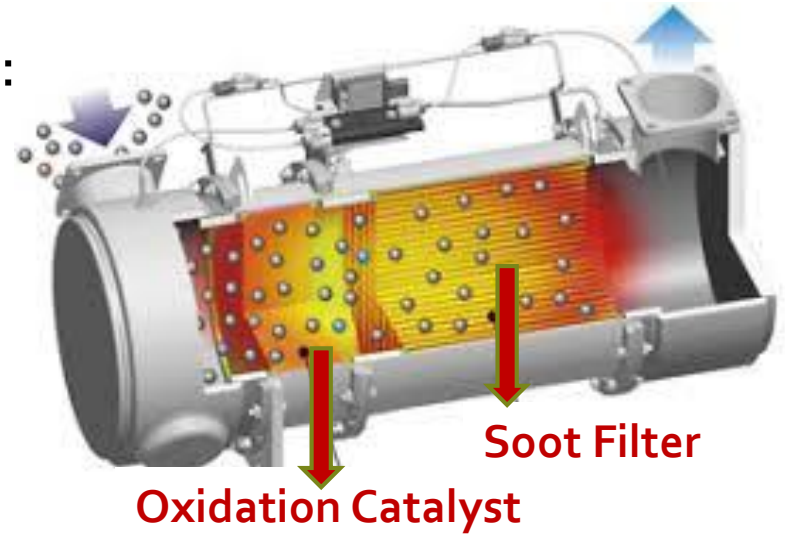
ISX15 RPM operation sweet spot, 2007 vs 2010



Regular preventative maintenance is critical to keeping your truck and your business, healthy and profitable

Don't Let Your Filter Get Out of Kilter!

- Keep in mind that a DPF is not a "have and forget" device. Protect your investment by understanding the needs of your emissions system.
- Improper care of your engine and DPF can lead to:
  - Very expensive repairs and expensive replacement parts
  - Voided warranties, if applicable
  - Major engine malfunction and/or breakdown
  - Extended downtime, loss of daily revenue/income
- Maintain engine in its original configuration.
- Do not exchange filter parts unless allowed by the DPF manufacturer.



Vehicle Maintenance is Critical

- **Preventative/proactive vehicle engine maintenance is required to minimize issues with your emissions system.**
- **Loss of lube oil control** can damage or destroy your DPF leading to expensive repairs. A DPF captures soot from the engine and can mask engine problems that were formerly detectable by observing exhaust smoke characteristics. Reducing soot from your engine reduces filter plugging and increases cleaning intervals.
- **Fuel injectors**: Repair and replace at any signs of injector mis-operation or failure. Worn fuel injectors can lead to excessive fueling and more soot generation and accumulation in the filter. In severe situations fuel in the DPF can cause a run away fire.
- **Air filters**: Replace at intervals required by the engine manufacturer. Dirty air filters reduce air flow to the engine leading to more soot generation.
- **Turbocharger**: Check turbocharger for proper operation and excessive wear. Turbochargers that do not produce sufficient air or have leaking seals lead to more soot or the presence of lube oil in the exhaust.
- **Fuel filter**: Replace at prescribed intervals. Look for the presence of lube oil in the fuel filter during regularly scheduled maintenance. A blackening of the filter may indicate that oil from the crank case is mixing with the fuel due to a leaky injector.
- **Coolant**: Monitor coolant consumption. Keep a log of the coolant added to the engine. Coolant leakage can poison the DPF catalyst and/or cause filter plugging.
- **Lube oil**: Change the lube oil at mileage intervals indicated by the engine manufacturer. Track your oil consumption and usage.
- **Be Proactive!**

Frequent Causes of DPF Failures

- Some aftertreatment systems have issues of their own. We find that much of the trouble fleets have with their emissions system are caused by upstream failures.
- The delicacy of the aftertreatment system can be disrupted by many things. Any upstream failures, many of which you may not even be aware of, can have disastrous consequences for your truck and your pocket book. You can't let those things go anymore.
- This list reflects a list of common upstream failures, but isn't limited to:
- Leaky injectors contaminate the DPF, can cause a catastrophic fire in the emissions system as well
- Excessive idling creates excessive soot buildup
- Leaky exhaust pipes, manifold gaskets
- Coolant leaks
- EGR (exhaust gas recirculation) cooler leaks
- The so-called 7th injector (doser valve)
- Turbo failures
- Sensors and wiring harness failures

Monitor Lube Oil Consumption Closely

- Some of the components in lube oil can collect in the DPF and cause plugging or make the catalyst malfunction. Therefore, it is important to ensure that the engine is not consuming lube oil at a rate higher than recommended by the engine manufacturer.
- If the lube oil consumption exceeds specifications the engine must be repaired.
- Increased lube oil consumption leads to increased ash load and filter plugging. The ash cannot be removed by regeneration. The result is an increase in DPF cleaning frequency which is costly and involves downtime.
- Track lube oil usage by keeping a log of how much oil is added to the engine between oil changes.
- Low ash (CJ-4 "low ash") lube oil is recommended.
- Never put clean or used lube oil, additives, or alternative diesel fuels that are not authorized by the engine manufacturer in the fuel tank.
- Be Proactive!

Why you need to use CJ-4 oils in the newer trucks

- **Newer emission heavy-duty engines meeting the EPA 2007 and EPA 2010 emissions guidelines are equipped with advanced emission control technologies, including diesel particulate filters (DPF) and in 2010 trucks selective catalytic reduction systems (SCR).**
- **The API CJ-4 performance category was developed to address both the unique needs of these new engines and the emission control systems as required for regulatory compliance.**

Handle the Filter with Care

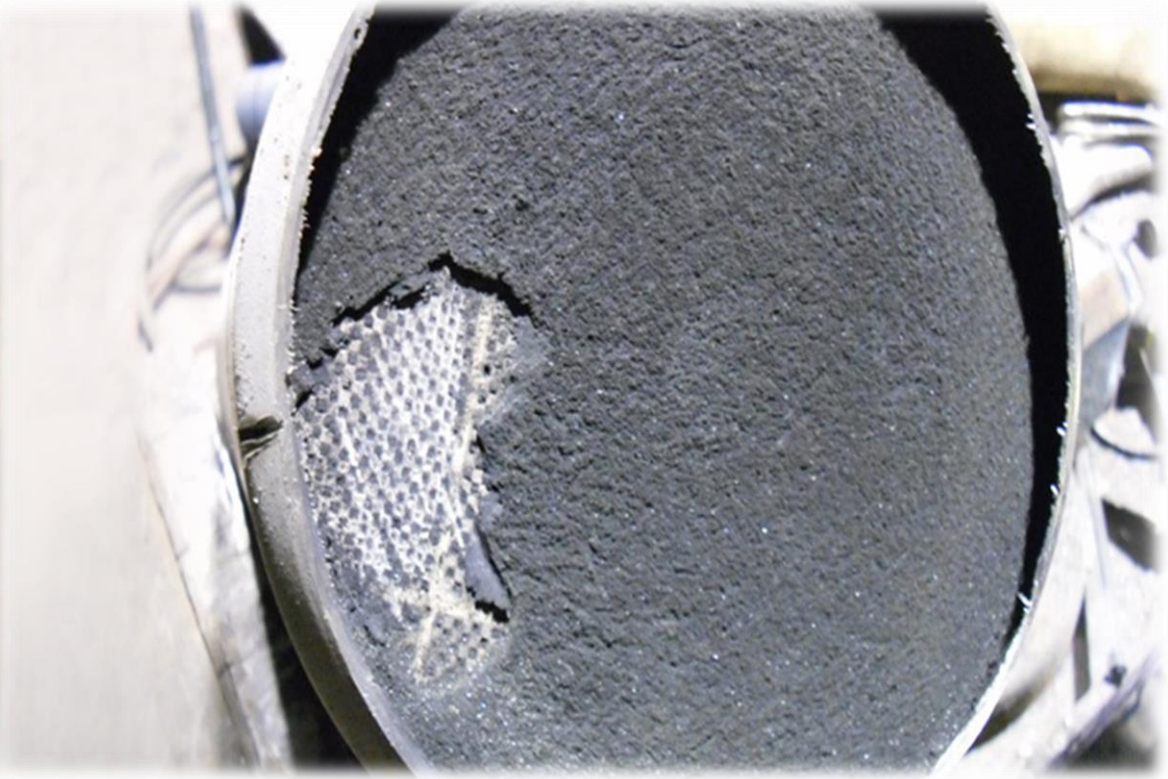
- The DPF appears rugged but is commonly made with very delicate and expensive materials including ceramics.
- Make sure the DPF is handled properly during Removal & Installation.
- Never bang or tap on the filter because this could crack the filter element.
- Replacing the DPF filter element is costly. Cracking the filter element may void the warranty (where applicable) and requires replacement.
- When working on your vehicle, do not weld any other components on the retrofit system, cut, or disconnect any control lines.

Freightliner **1** Box System, DPF and DEF System all in one box

DPF Cleaning Basics

- The DPF is a regular maintenance item. It must be removed and cleaned periodically to remove accumulated noncombustible ash from the filter.
- Ash removal is different and separate from regeneration. In general, DPF cleaning requires heating the filter, using compressed air combined with a vacuum system to blow the ash, and capturing it in a sealed container.
- Only use filter cleaning procedures approved by the DPF manufacturer.
- Using an improper cleaning method may and probably will ruin the DPF. It can also expose personnel to hazardous waste.
- Never use shop compressor in open area to clean filter.
- Never steam clean the DPF.
- Do not rap on the filter element to remove ash.
- Unless it has been tested and verified as safe, DPF ash must be handled and disposed as a hazardous waste.
- Make sure that filter elements are installed correctly after they are cleaned. Do not reverse the filter elements.
- Never operate the engine without the filter elements.

Repairing your truck's emission system is no simple task, and these kind of repairs can be very expensive



- **Disclaimer: It is the responsibility of every truck owner to know the proper maintenance procedure's regarding their particular diesel particulate filter. Contact the manufacturer of the system for all specific maintenance guidelines and procedure's related to your specific truck's emissions system.**

Truck Replacement issues

- **Credit Issues**: **a**- your credit history **b**- FICO level **c**- have like credit **d**- lending company **e**- finance term available based on the year of the replacement truck
- **Down payment**: **a-** amount **b**- is there a trade
- **Replacement truck**: **a**- year model **b**- mileage **c**- specification **d**- condition **f-** price of the replacement truck **e**- how long will the process take to get a replacement truck
- **Available Inventory**: **a**- type of dealership that you deal with **b**- Trade Cycles..2015/16 **c**- overall available inventory
- **Competition for the same trucks:** Over 1900 Drayage carriers need to upgrade their trucks by January 1 2019. The non-drayage carriers are upgrading their trucks at the same time. This higher than normal demand will cause artificial inflation of prices and a scarcity of the right trucks for your niche and application.
- **Do Not Wait, start looking at your options asap!**

You should consider getting a warranty on your replacement truck

- **Potential Repair Costs on Today's Used Truck.**
- **Turbocharger** $1,600 - $2,500, **Turbo Actuator** $900, **Axial Power Turbine (APT)** $1,500
- **EGR Valve** $1,500, **EGR Cooler** $1,800
- **Fuel Injector** (1) $1,500, **Fuel Injector** 6 Pack $5,500
- **Fuel Pump** $3,000, **Fuel Pump with Metal Contaminated System** $9,000
- **After-Treatment System (ATS) Temperature Sensors** $700-$1,000,
- **Pressure Sensors** $700-$1,000, **NOX Sensors** $700-$1,000, **Doser Injector** $575 - $675 **Diesel Exhaust Fluid Injector** $240 - $375, **Diesel Oxidation Catalyst (DOC/SCR)** $2,500 - $4,000, **Diesel Particulate Filter(s) (DPF)** $650 - $6,500, **Header Assembly** $800 - $1,000 **DEF Pump** $520 - $720, **Metering Unit** $1,150 - $1,425, **DEF Tank** $1,500 - 1,850 **Detroit One Box** $8,000 - $12,000

Replacement trucks that may be suspect

- **2014 and older International Maxxforce powered units, due to questionable technology**
- **Trucks over 800,000 miles**
- **Trucks without dyno reports**
- **Trucks without current DOT inspections**

Frequently Asked Questions

1) ?
2) ?
3) ?
4) ?

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