MAXXFORCE®

# ADVANCED EGR

## 2010 Emission Compliant

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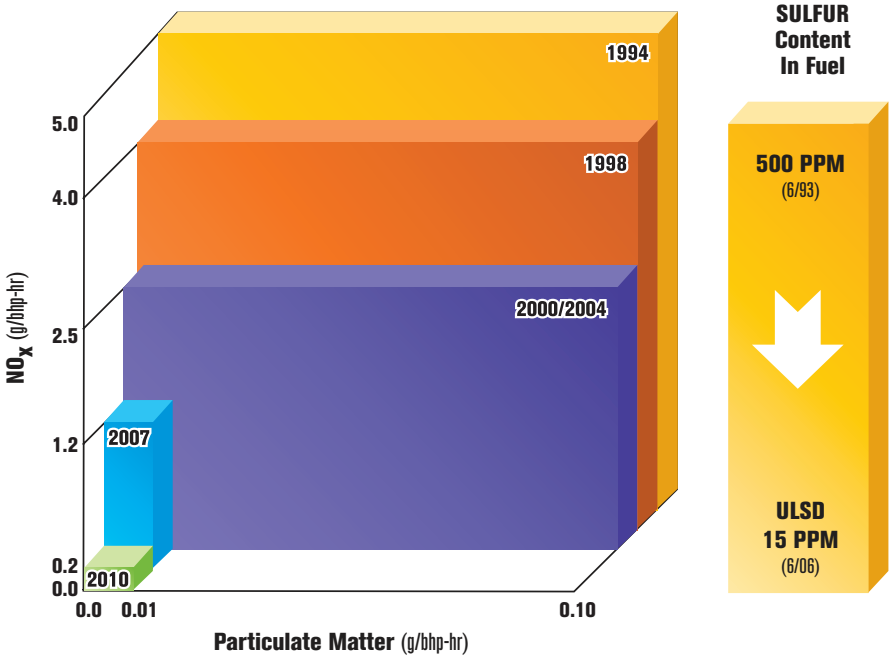
# OVERVIEW OF 2010 EMISSIONS REGULATIONS

## WHAT ARE THE NEW EPA REQUIREMENTS?

In 2007, diesel engine manufacturers were required to reduce particulate matter emissions (soot) by 90%, so manufacturers added DPFs (diesel particulate filters). At the same time, diesel fuel providers were required by the government to lower the sulfur content of fuel from 500 PPM to 15 PPM.

EPA 2010 regulations focus not on reducing particulate matter emissions, but instead NOx gasses. EPA is requiring new diesel powered RVs to achieve a new diesel exhaust emissions regulations limit, which is 0.20 NOx (g/bhp-hr) down from 1.2 in 2007. Permitted levels of NOx will be a 25 fold reduction from 1994 and a hundred fold reduction in particulate matter.




EPA 2010 NOx emissions must be reduced from 1.20 g/bhp-hr (grams per brake horsepower hour) to 0.20 g/bhp-hr.

## WHY WORRY ABOUT NOx?

78% of the air around us is Nitrogen. When that air goes into an engine, the high combustion temperatures oxidize the nitrogen, forming oxides of nitrogen, or NOx. Once in the atmosphere, NOx results in ground level ozone formation and smog. These EPA regulations are targeted directly at reducing ground-level ozone and smog.

*In 2010, an interim emissions limit of 0.50 g/bhp-hr was allowed with the use of credits from the 'Averaging, Banking, and Trading Program'. Without credits the limit was 0.20 g/bhp-hr.*

# OEM TECHNOLOGY CHOICES

## TWO SOLUTIONS

There has been great debate among diesel engine manufacturers with regards to meeting 2010 emissions regulations. Most diesel engine manufacturers have aligned behind a technology called liquid Selective Catalytic Reduction (SCR) to clean up the NOx emissions and meet the 2010 standards. An alternative solution– Advanced EGR –involves refining current engine technology to provide an in-cylinder solution without the need of Diesel Exhaust Fluid (DEF). Rather than continuing to create NOx and then having to clean it up, Advanced EGR systems are designed to prevent the NOx from being formed in the first place.

Advanced EGR, or exhaust gas recirculation, is an emissions reduction technique that works by re-circulating a portion of an engine's exhaust back to the engine cylinders and burning off excess pollutants. The result is an engine that treats NOx in-cylinder, and therefore requires no extra effort from our customers. Navistar's MaxxForce® engines have been using EGR technology since 2004.

### WHAT IS ADVANCED EGR?

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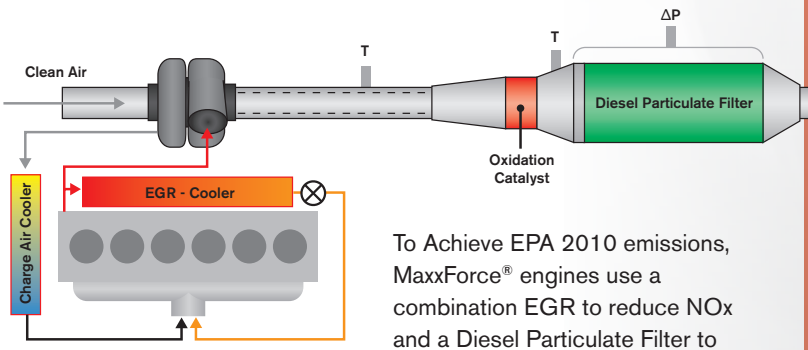
### WHAT IS LIQUID DEF SCR?

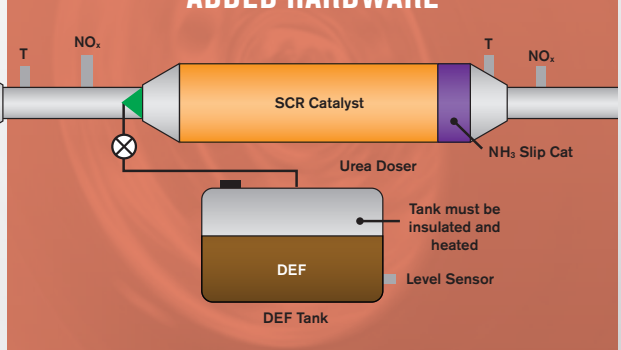
The system works like this. The engine creates exhaust which includes particulate matter and NOx. This exhaust passes through the oxidation catalyst and on to the diesel particulate filter, which cleans the soot. From there, the exhaust passes to the SCR catalyst. A DEF tank and pump–located near the exhaust system–supplies DEF to the SCR injection system. The injector sends the DEF into the SCR catalyst, where it mixes with the exhaust gases and turns into ammonia and carbon dioxide, then reacts with NOx to produce nitrogen and water vapor.

### BASE EGR SYSTEM




To Achieve EPA 2010 emissions, MaxxForce® engines use a combination EGR to reduce NOx and a Diesel Particulate Filter to reduce particulate matter.

### LIQUID DEF SCR SYSTEM ADDED HARDWARE




Liquid DEF SCR Systems also use EGR and Diesel Particulate Filters, but add the additional components featured above.



**ADVANCED EGR : 2010 Emission Compliant**

# DRIVER IMPACT

## ADVANCED EGR, LIQUID DEF SCR SYSTEMS & THE DRIVER

**So how specifically does 2010 emissions impact an RV Owner? Let's take a look.**

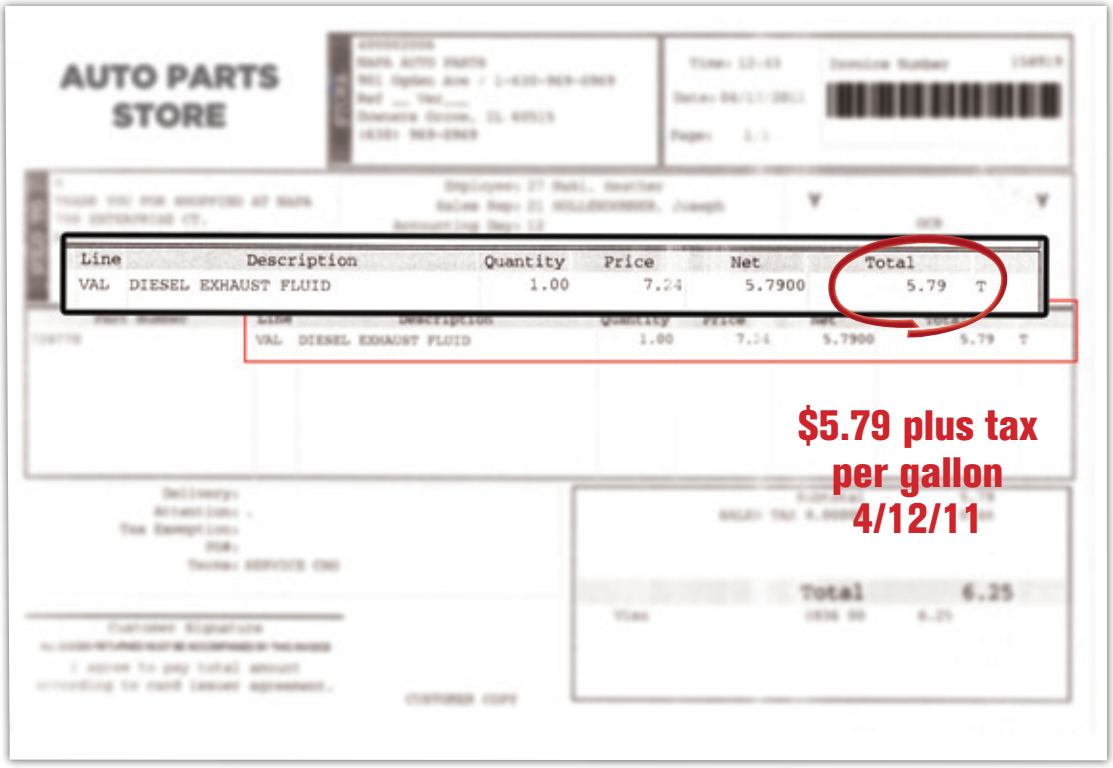
### ADVANCED EGR

- Achieves emissions standards in-cylinder
- Less additional weight with this solution
- No need to deal with DEF

***Now let's compare this to Liquid DEF SCR:***

### LIQUID DEF SCR

- Significant add-on aftertreatment equipment (as much as 500 lbs.)
- Requires drivers to fill DEF tank
  - Without DEF, the RV is not compliant
- Additional maintenance and service required



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# LIQUID DEF SCR SYSTEM & ADDITIONAL HARDWARE

**One of the major drawbacks of Liquid DEF SCR, in particular, is that the technology results in 300-500 lbs. of additional equipment to be added onto the RV. Specifically these items include:**

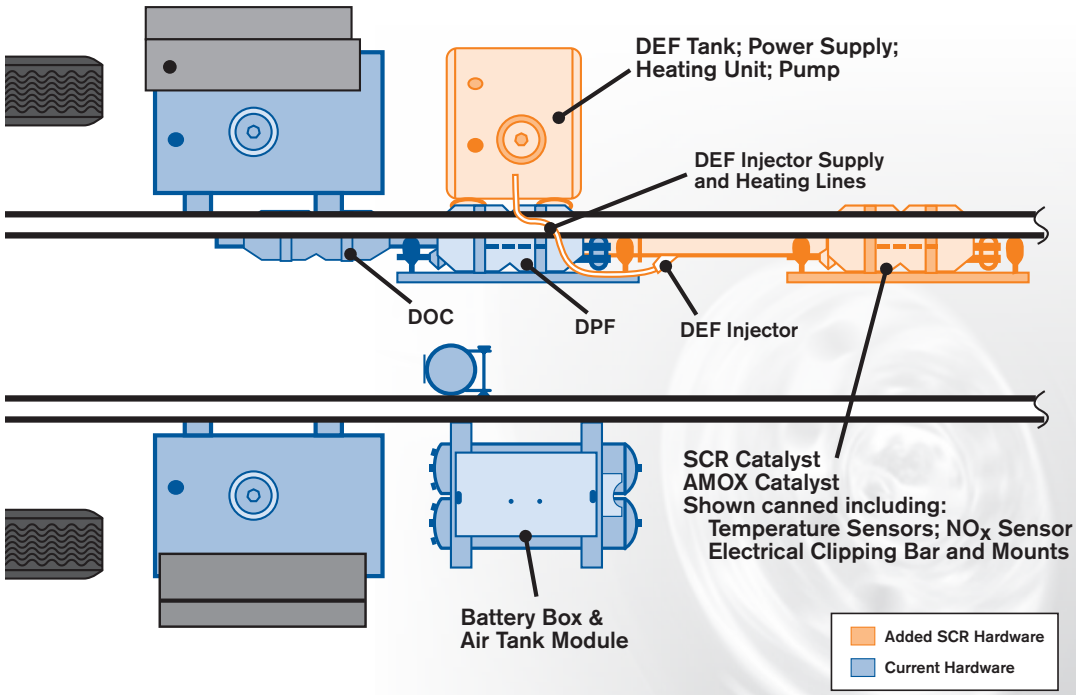
### DEF TANK:
This 7-15 gallon tank (depending on make and model of RV) includes a heat exchanger to attempt to control the temperature of the DEF inside the tank.

### DEF PUMP:
This pump is designed to pump DEF to the main aftertreatment system.

### DEF INJECTOR:
Similar to a fuel injector, this device "injects" vaporized DEF into the exhaust gas and neutralizes NOx gasses.

### SCR CATALYST:
This large component is where catalytic reduction occurs.

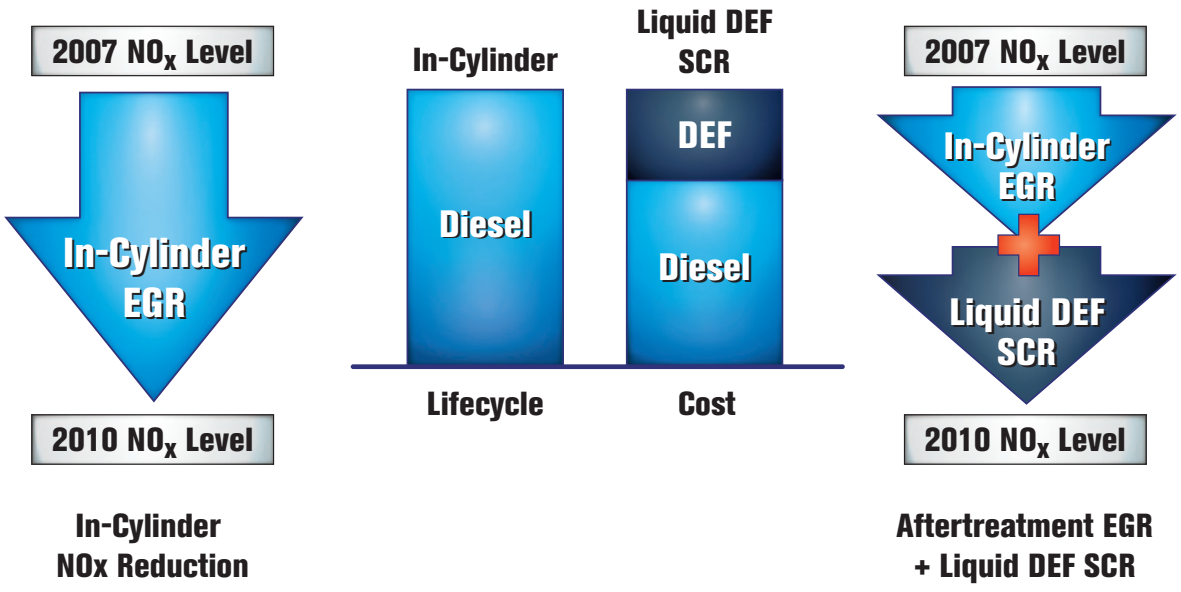
### AFTER-TREATMENT CONTROL MODULE:
This device, the main control system of the SCR technology, monitors flow and dosing rate of DEF to ensure 0.2 grams of NOx per brake horsepower hour.



# FUEL ECONOMY VS. OPERATING COST

Many liquid DEF SCR engine manufacturers are advertising a slight improvement in fuel mileage over previous models. However, RV owners should not use fuel economy alone to determine operating cost to run their RV. Since liquid DEF SCR systems require the addition of DEF, one must take into consideration the cost of this additional fluid, not to mention the additional downtime needed to service the Liquid DEF SCR system each year.

When taking into consideration all these things, the operating cost advantage goes to Advanced EGR.




**In-Cylinder NOx Reduction**

**Aftertreatment EGR + Liquid DEF SCR**

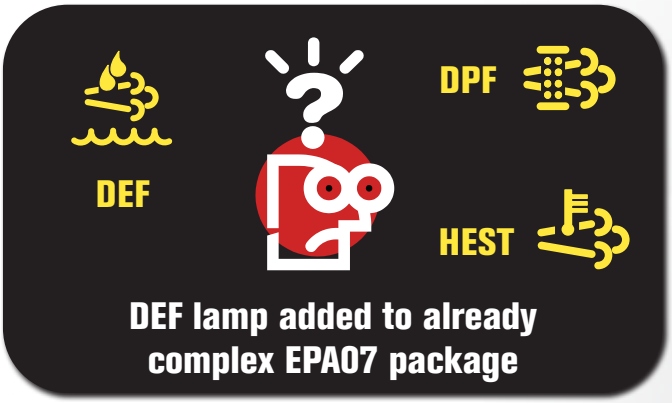
# LIQUID DEF SCR & "DERATING" MODE

In December of 2009, the EPA issued a letter containing guidelines for the design and operation of Liquid DEF SCR systems to be used on RVs. Among these guidelines was a requirement that the Liquid DEF SCR system be tamper-resistant to prevent operation of the vehicle without fully functioning emissions controls in place, or with a fluid other than DEF in the tank.

EPA Vehicle Compliance requirements indicate RVs to be equipped with sophisticated sensors to detect NOx in exhaust. If the sensors detect that there is a bad DEF solution or no DEF is available, there will be four progressive stages of warning and vehicle response.

1. With a low DEF level, a warning light will appear along with an audible warning.
2. The engine will de-rate and the driver will feel a power loss.
3. Vehicle speed would be limited well below typical operating levels.
4. Finally, when the vehicle is shut down, it will not restart unless the DEF tank is refilled.

Customers should think of DEF much like diesel fuel: without it, the vehicle cannot run. The vehicle will eventually lose power and, if DEF is not available, will become inoperable.




**DEF lamp added to already complex EPA07 package**

# ENVIRONMENTAL IMPACT

Both Advanced EGR and Liquid DEF SCR comply with emissions standards...

## CARBON FOOTPRINT

The carbon footprint of each technology should be considered. Think about all the necessary energy required for the production, distribution, infrastructure, and the manufacturing for a solution that requires a new second fuel versus Advanced EGR, which requires no fueling changes whatsoever.

## LIQUID DEF SCR NOx CONTROL GAPS

In addition, the most recent EPA guidance on 2010 emissions allows for significant gaps in NOx control:

- Frozen urea test standard allows for 70 min. of operation without Liquid DEF SCR function.
- Certification testing does not require manufacturers account for impact of Liquid DEF SCR not functioning.

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