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Diesel Exhaust Fluid Forum
SCR emissions control technology
for heavy duty road transport
Tuesday, 11 November

For more information on the Diesel Exhaust Fluid Forum please contact
rita.auta@integer-research.com

Mack Trucks + SCR = EPA 2010

*David McKenna
Director – Powertrain Sales & Marketing*

DIESEL EXHAUST FLUID FORUM

US DEF supply strategy to 2010



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EPA 2010

BREAKTHROUGH

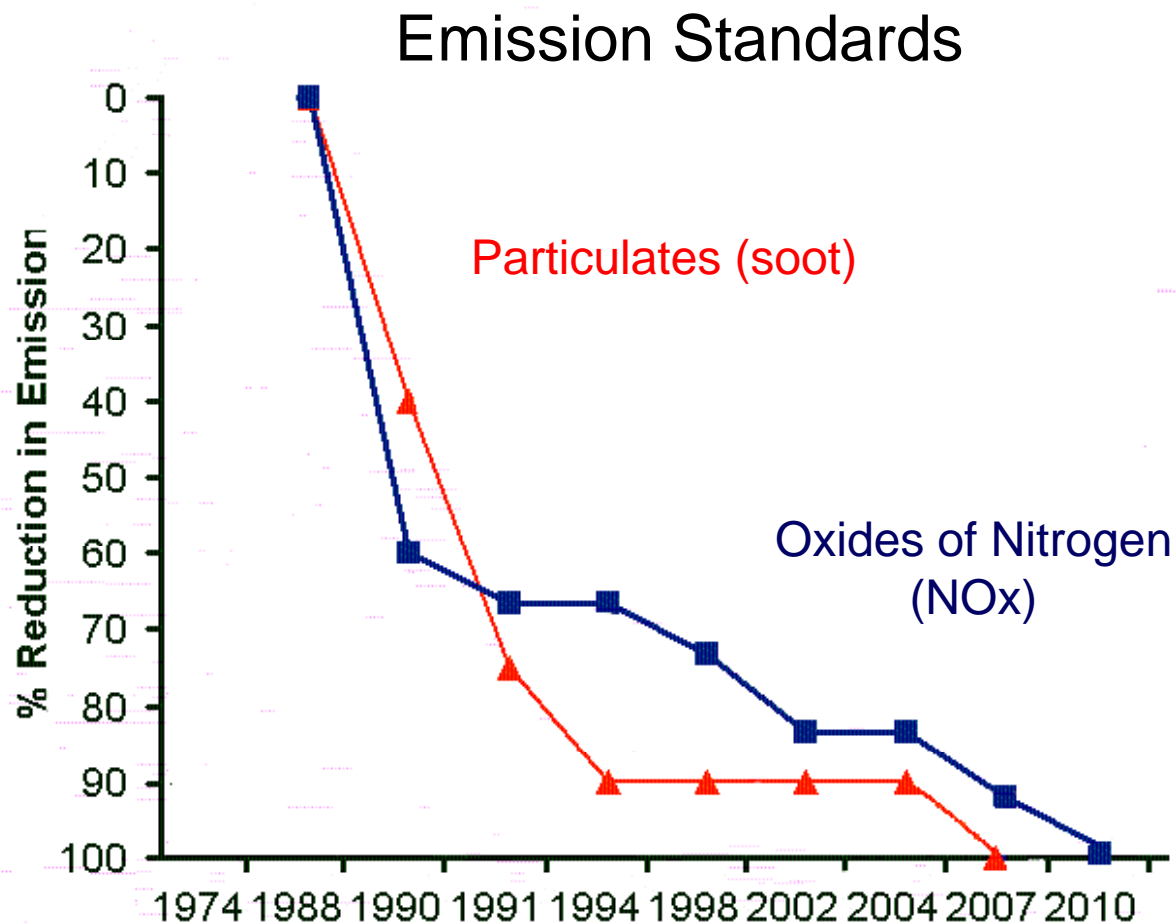


PERFORMANCE.

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What is Driving EPA'10?



By 2010, Mack diesel engines will have near-zero output of all regulated emissions

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Technology Paths for EPA'10

- 1. Massive EGR + Emission Credits.**
- 2. Diesel NOx Reduction.**
- 3. Diesel NOx Adsorber.**
- 4. Selective Catalytic Reduction.**



Known Competitive Positions for EPA'10

Selective Catalytic Reduction

- Mack Trucks
- Volvo Proprietary
- Detroit Diesel (M-B)
- Paccar MX (DAF)
- Cummins - Welcome

MASSIVE EGR

- International
MaxxForce (MAN)

• Under "Now we know" - *Case* *Similar*

Out!



Massive EGR
It's an
accepted
technical
term - Just
Google it....

massive egr - Google Search - Microsoft Internet Explorer

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[\[PDF\] Low Emissions Combustion – One Path Forward? Tom Ryan](#)
File Format: PDF/Adobe Acrobat - [View as HTML](#)
Premise. Lowest Possible Emissions and. Highest Efficiency in Diesel Engines. Achieved Using: Ultra High Injection Pressure and Small. Holes. **Massive EGR** ...
www.erc.wisc.edu/symposiums/2005_Symposium/June%208%20AM/Ryan_SVRI.pdf - [Similar pages](#)

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This represents a 17 percent improvement through the use of **massive EGR** combined with the use of a. high-energy ignition system. The high-energy ignition is ...
www.osti.gov/bridge/servlets/purl/829804-lvf6b3/native/829804.pdf - [Similar pages](#)

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Massive EGR. Independent Variables. Table 1. Independent Variables Examined in the Cycle Simulation Calculations. TestMode ...
www.eere.energy.gov/vehiclesandfuels/pdfs/deer_2003/session7/2003_deer_ryan.pdf - [Similar pages](#)

[Air induction, EGR, and fuel economy \(John De Armond; Bob Hale\)](#)
Assuming a fly-by-wire system, has there been any consideration to using **massive EGR** as a means of throttling the engine? It seems to me that with the fast ...
yarchive.net/car/air_induction.html - 11k - [Cached](#) - [Similar pages](#)

[SwRI: Clean Diesel V Consortium, 5 projects for developing an ...](#)
Massive EGR in Heavy-Duty Diesel Engines (continued from CD IV). Goal—achieve 2010 HD on-road emissions standards using minimum post-combustion NOx ...
www.swri.org/4org/d03/engres/cleandieselv/default.htm - 20k - [Cached](#) - [Similar pages](#)

[\[PDF\] CLEAN DIESEL V](#)
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Massive EGR in Heavy-Duty Diesel Engines. This project will be continued from CD IV. The goal is to achieve 2010 HD on-road ...
www.swresearch.com/3pubs/brochure/d03/CleanDV/CleanDieselV.pdf - [Similar pages](#)

[Compression-ignition internal combustion engine - US Patent 6688279](#)
Specifically, since lowering combustion temperature is effective in reducing NOx, this is done by comparatively **massive EGR**. There is the concern that smoke ...
www.patentstorm.us/patents/6688279-description.html - 63k - [Cached](#) - [Similar pages](#)

[Ulstd: Encouraging Sign For Diesel Nox/Pm Traps - ultra-low-sulfur ...](#)
The scheme requires multiple fuel injections including post-main injection, allowing "rich low-temperature exhaust with **massive EGR** ...
findarticles.com/p/articles/mi_m0CYH/s_11_5/ai_75532057 - 34k - [Cached](#) - [Similar pages](#)

[\[PDF\] Stoichiometric Compression Ignition \(SCI\) Engine Concept](#)
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Massive EGR – high percentages of EGR at. relatively rich A/F ratio to reduce NOx.

Done

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History of Exhaust Gas Recirculation

	EGR Flow	Oxygen
Light EGR EPA'04	10%-20%	16-17%
Heavy EGR EPA'07 & '10	20%-35%	14-16%
Massive EGR EPA'10	35%- <u>>50%+!</u>	12-14%
Medium EGR EPA '10 w/SCR	~28%	~16%



Comparing Massive EGR vs. SCR

	<i>MEGR + DPF</i>	<i>EGR+DPF+SCR</i>
<i>Power Density (HP per Liter)</i>	<i>Less (New Engine)</i>	<i>More (Same Engine)</i>
<i>Heat Rejection (Cooling Load)</i>	<i>MORE</i>	<i>LESS</i>
<i>Fuel Efficiency</i>	<i>LESS (It's a matter of Physics)</i>	<i>MORE (It's still a matter of Physics)</i>



Here are the Highway Numbers

Engine	Fuel Economy @ \$3.50/ga	Fuel Usage Gallons	Expense Total per mile	Expense @ 100,000 mi	Savings <Cost>
2007	6.5 MPG	15385	\$0.538	\$53,847	Baseline
2010 SCR	6.78 MPG @ 3% DEF	14754 443 @\$2.75g	\$0.516 \$0.012 \$0.528	\$51,639 <u>\$1,218</u> \$52,857	\$990
2010 MEGR vs. 2007	6.37 MPG - 2%	15699	\$0.741	\$54,946	<\$2089>
Net SCR vs. MEGR		<945>	<\$.031>	<\$2089>	<\$3079>
CO ₂ Reduction					26,460#



Here are the Vocational Numbers

Engine	Fuel Economy @ \$3.50/gal	DEF Economy @ \$2.75/gal	Total per hour	Expense @ 2,100 hr	Savings <Cost>
2006 AI*	3.5 GPH	\$0.	\$12.25	\$25,725	Baseline
2007 MP7*	3.17 GPH	\$0.	\$11.09	\$23,299	\$2426
2010 MP7	3.01 GPH +3%	\$0.248	\$10.78	\$22,643	\$656
2010 MEGR	3.32 GPH -2%	\$0	\$11.62	\$24,402	<\$1759>
CO ₂ Reduction					18,228#

*Reference chassis 2006 MR Auto Side Loaders & 2009 MRU Auto Side Loaders



EPA'10 So Far...



- *Job #1 EPA'10 Customer Field Test.*



EPA'10 So Far...



- *SCR System installed and functional.*



EPA'10 So Far...



- Urea Tank – clean compact installation



EPA'10 So Far...



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EPA'10 So Far...



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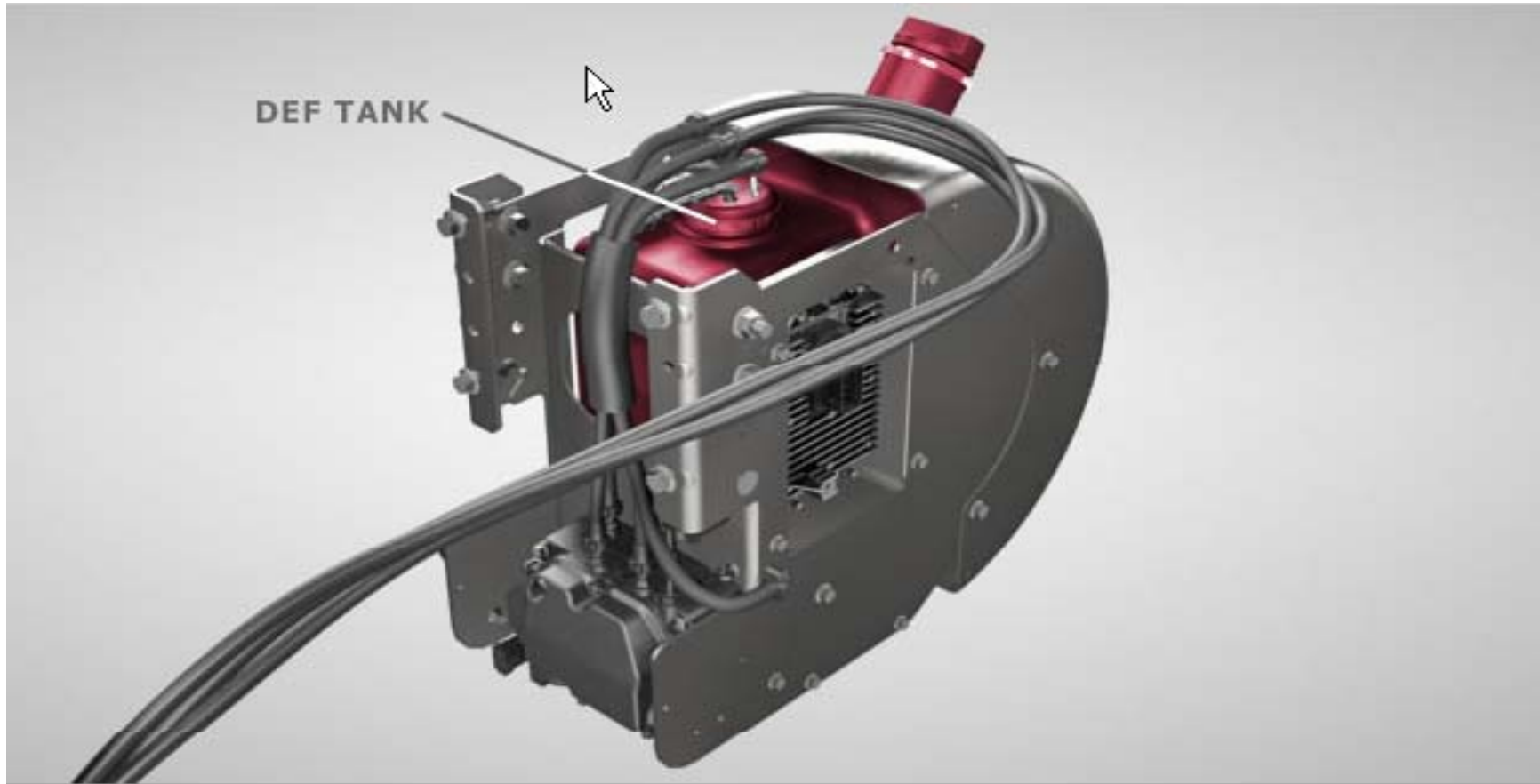
EPA'10 Solution In Action...



SELECTIVE CATALYTIC REDUCTION (SCR) - To meet the strict EPA 2010 emission requirements, MACK trucks are equipped with an SCR system that reduces emissions of nitrogen oxides (NOx) to a near zero level. The system consists of: a small tank for the Diesel Exhaust Fluid (DEF) **1**, a DEF supply pump **2**, an injector **3**, a muffler with built-in catalytic substrates **4**, and an Aftertreatment Control Module (ACM) **5**.



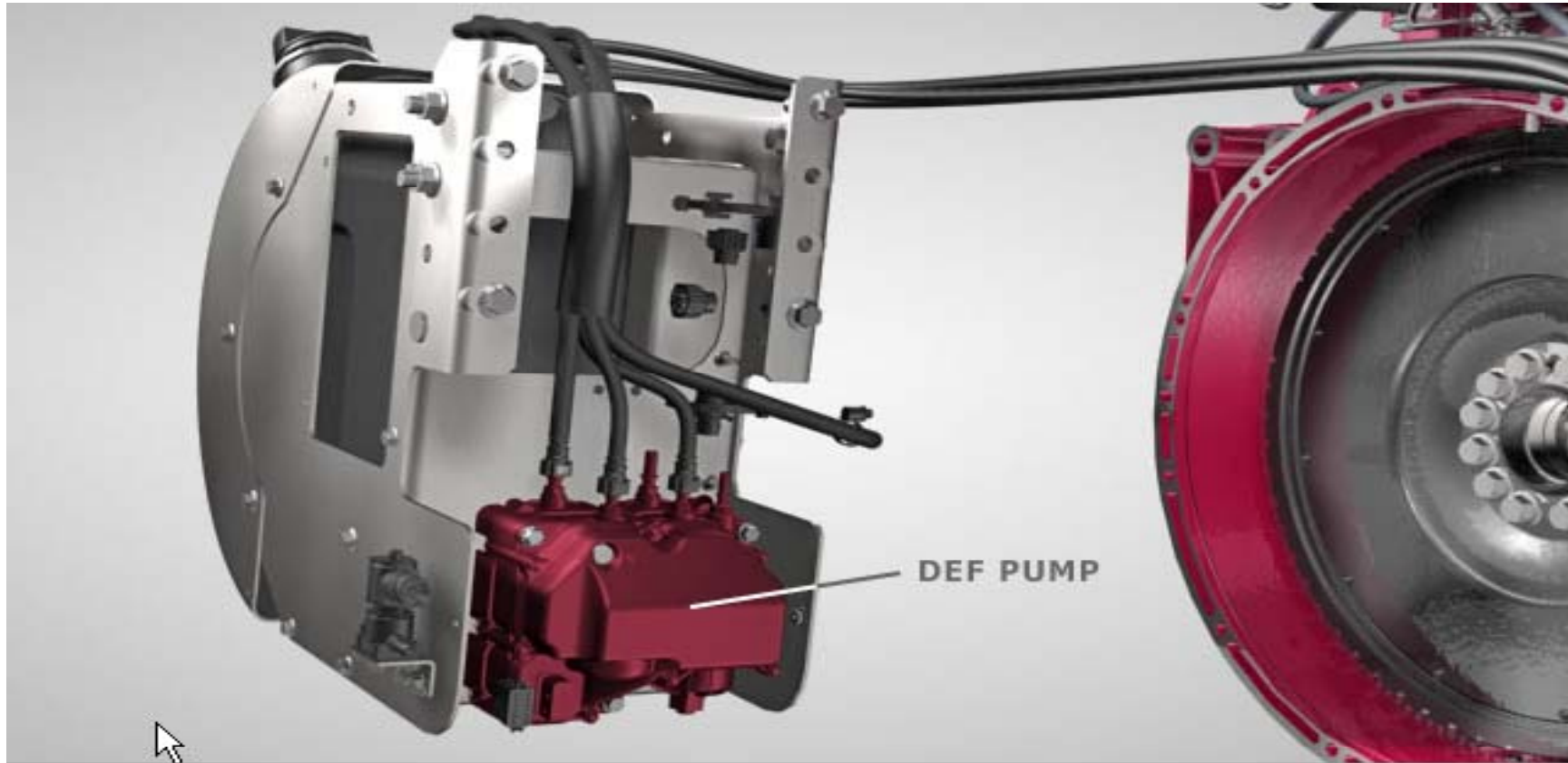
EPA'10 Solution In Action...



1 DIESEL EXHAUST FLUID (DEF) - The tank is filled with liquid urea (DEF), which is a clear, non-hazardous fluid. As DEF freezes at approximately 12°F, the DEF temperature is continuously monitored and, when needed, heated to 60°F by a heater coil located in the tank.



EPA'10 Solution In Action...



2 DEF PUMP - This low-pressure pump supplies the DEF to the SCR injection system. When the engine is turned off, the pump drains the DEF in the system back to tank.



EPA'10 Solution In Action...



3 DEF INJECTOR - The amount of NO_x in the engine-out exhaust gas is closely monitored. When needed, a measured amount of DEF is injected directly into the exhaust gas stream. The finely atomized DEF droplets mix with the hot exhaust gases and turns into ammonia (NH₃) and carbon dioxide (CO₂).



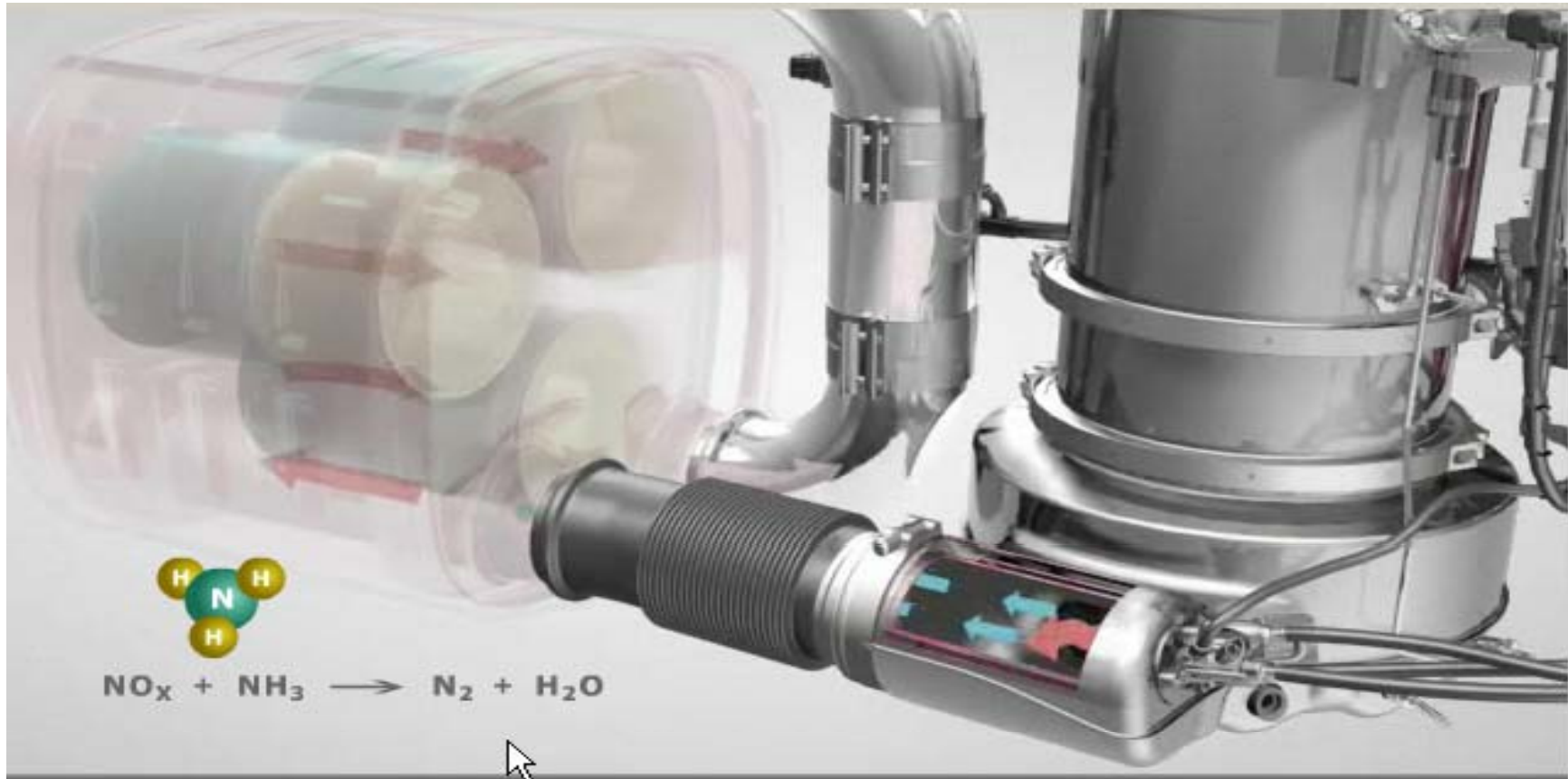
EPA'10 Solution In Action...



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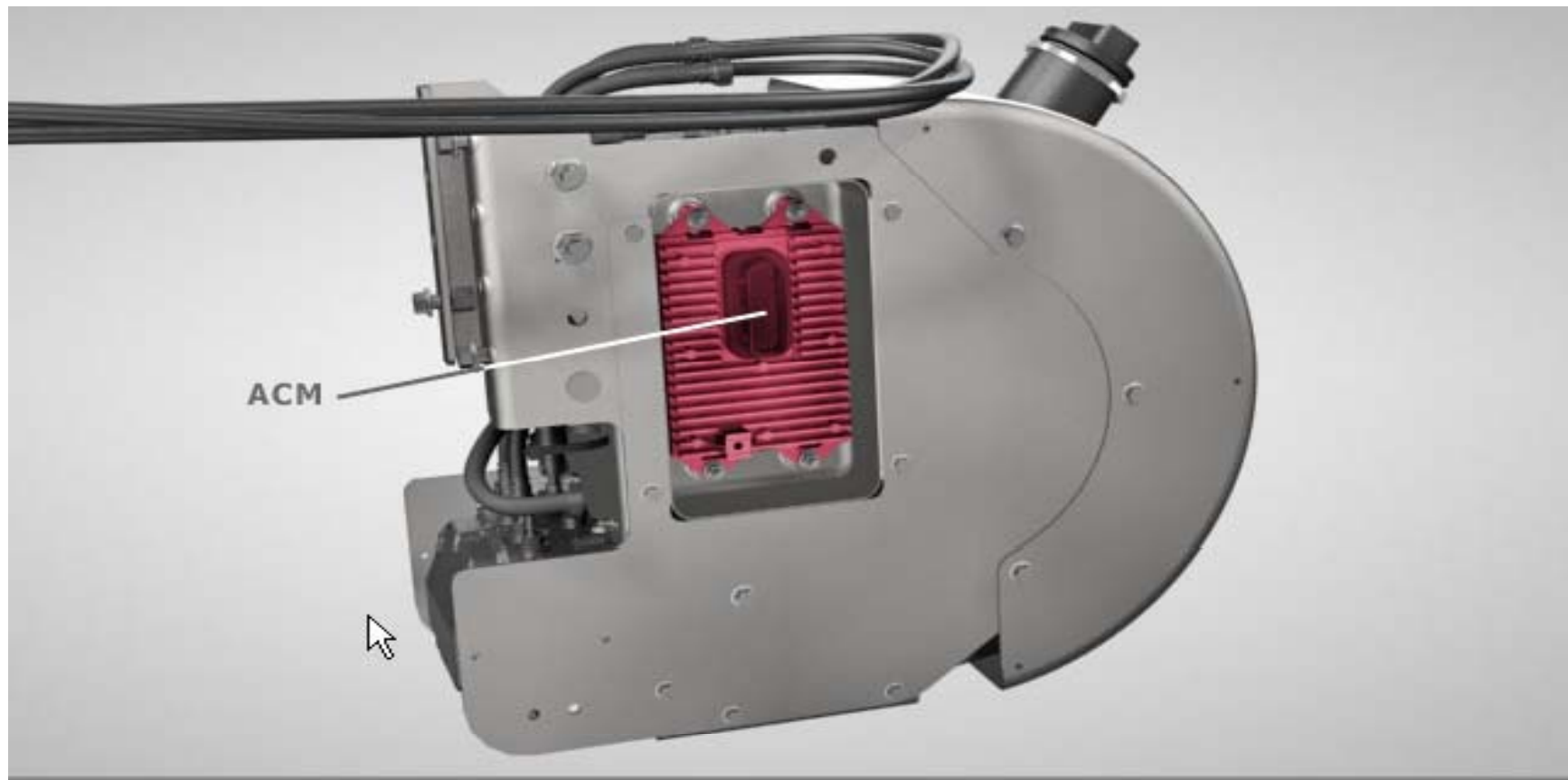
EPA'10 Solution In Action...



4 CATALYTIC CONVERSION - The ammonia (NH₃) reacts with nitrogen oxides (NO_x) as the exhaust gases pass the catalytic substrates. The catalytic substrates quickly enable the NH₃ and NO_x to chemically react to produce harmless nitrogen (N₂) and water (H₂O) vapor.



EPA'10 Solution In Action...



5 AFTERTREATMENT CONTROL MODULE (ACM) - The entire SCR system is controlled by the Engine Electronic Control Unit (EECU) by way of an ACM which controls the in-jection flow rate of the DEF. Combined; these systems constantly monitor NOx levels and various engine operating parameters. The system guarantees industry-leading fuel economy and reduction of emissions which meet the strict EPA 2010 requirements.



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Talking SCR



Dave McKenna, Mack powertrain products marketing manager, answers your questions about SCR

[Click here to responses.](#)

CLICK

There is a lot of talk these days about the different technologies truck and engine manufacturers have chosen to meet the 2010 EPA emissions regulations. As you've probably heard, Mack has chosen Selective Catalytic Reduction, or simply SCR. Some folks have speculated that we made this decision only because we're part of a large global organization that uses this technology in Europe. That's hogwash. And that's a kind way to describe some of the claims that have been made about the technology itself, many contrary to basic science! The simple truth is that SCR is "*clearly*" the best choice for our customers- and, for that matter, anyone who owns or operates a heavy-duty truck. Why? Answering this and others questions about SCR is the purpose of this site. But I will give you one hint. Seen the price of diesel lately?

Submit your question(s) below:

* Required

* Name:

* E-Mail Address:

Question (s):

Submit

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The Mack SCR Blog

Dave's SCR Responses



[next page >>](#)

Q: *From John:* I find your choice of the name Diesel Exhaust Fluid (DEF) interesting. Are you fully committed to using a liquid urea solution and are just trying to make the name sound more interesting, or are you leaving yourselves wiggle room to use a different 'fluid' in the event that something like direct ammonia injection becomes feasible? I know of at least one solid state ammonia absorption and release system being suggested for SCR applications.

[Ask Dave a question here.](#)

CLICK

A: John...

I'd really like to take credit for the Diesel Exhaust Fluid, or simply DEF, moniker. But I must confess it was not me. But the name simply refers to what the product actually is -- and more importantly - - does. This is a continuance or offshoot of known accepted automotive fluids such as windshield washer fluid and automatic transmission fluid. In Europe, the term AdBlue has been used by Daimler.

As far as making the name more interesting, I could do better than DEF. But this is exactly what the product is. As for wiggle room, we are committed to Selective Catalytic Reduction using DEF -- period.

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To summarize...

- Mack will use the same engine as today.
- Add on is EATS only.
- Significantly improved FE.
- Significantly reduced CO₂ foot print.
- Known reliability of an integrated system.
- Certified and Compliant to EPA 2010.
- Driver and shop acceptance of Mack EPA '10 demos is very good.
- Visit www.macktrucks.com for SCR system animation.



Thank you

Q & A

