

For the Environmental Protection Agency's 2010 diesel emissions standard, truck purchasers will have to decide between two hotly debated technologies that broadly fit the descriptions of in-cylinder emissions compliance and exhaust aftertreatment compliance.

Compliance with what? The 2010 standard cuts the oxides of nitrogen, or NOx, down from the 2007 level of 1.2 g to the targeted level of 0.2 g per hp-hr. This target was EPA's original goal throughout the progression of the 2002/2004, 2007 and 2010 mandates.

The 2010 standard also calls for 0.01 g of particulate matter emitted per hp-hr. This is the same level introduced in 2007, so it presents no significant obstacles. In fact, there are some opportunities to deal with particulate matter that will come from technologies to reduce NOx.

The latest emissions mandate – possibly the last for a few years – kicks in on Jan. 1, 2010, barring any legal challenges that may delay implementation of the standard while courts decide (see story on page 37). But there is wiggle room available for the engine manufacturers through the use of emissions credits. These have been gained through the sale of engines over the last few years that were certified to emit less NOx than the prevailing standard required. These credits can be applied post-2010, but there is

Truck buyers will have to choose which technology they want to meet 2010 emissions standards.

The **2010** technology debate

still a maximum NOx out of the tailpipe of 0.5 g per hp-hr.

That sets the stage for the discussion of the different technologies – a discussion that has become highly acrimonious, with claims and counter claims over which is safer, cleaner, more convenient and even more likely to be an enduring technology.

The technical paths chosen are advanced cooled exhaust gas recirculation (A-EGR) and selective catalyt-

ic NOx reduction (SCR). Navistar is the sole proponent of A-EGR for its entire range of MaxxForce diesels, from the smallest V-8 up through the 15-liter due to make an appearance somewhere in the 2011-2012 timeframe. All other diesels sold in the United States and Canada –

including medium-duty and some light-duty and diesel passenger cars – will be SCR. A notable exception is the Cummins ISB-powered Dodge Ram, which uses a different aftertreatment based on NOx adsorption plus EGR, a technology solution that is not really scalable up to heavier engines.

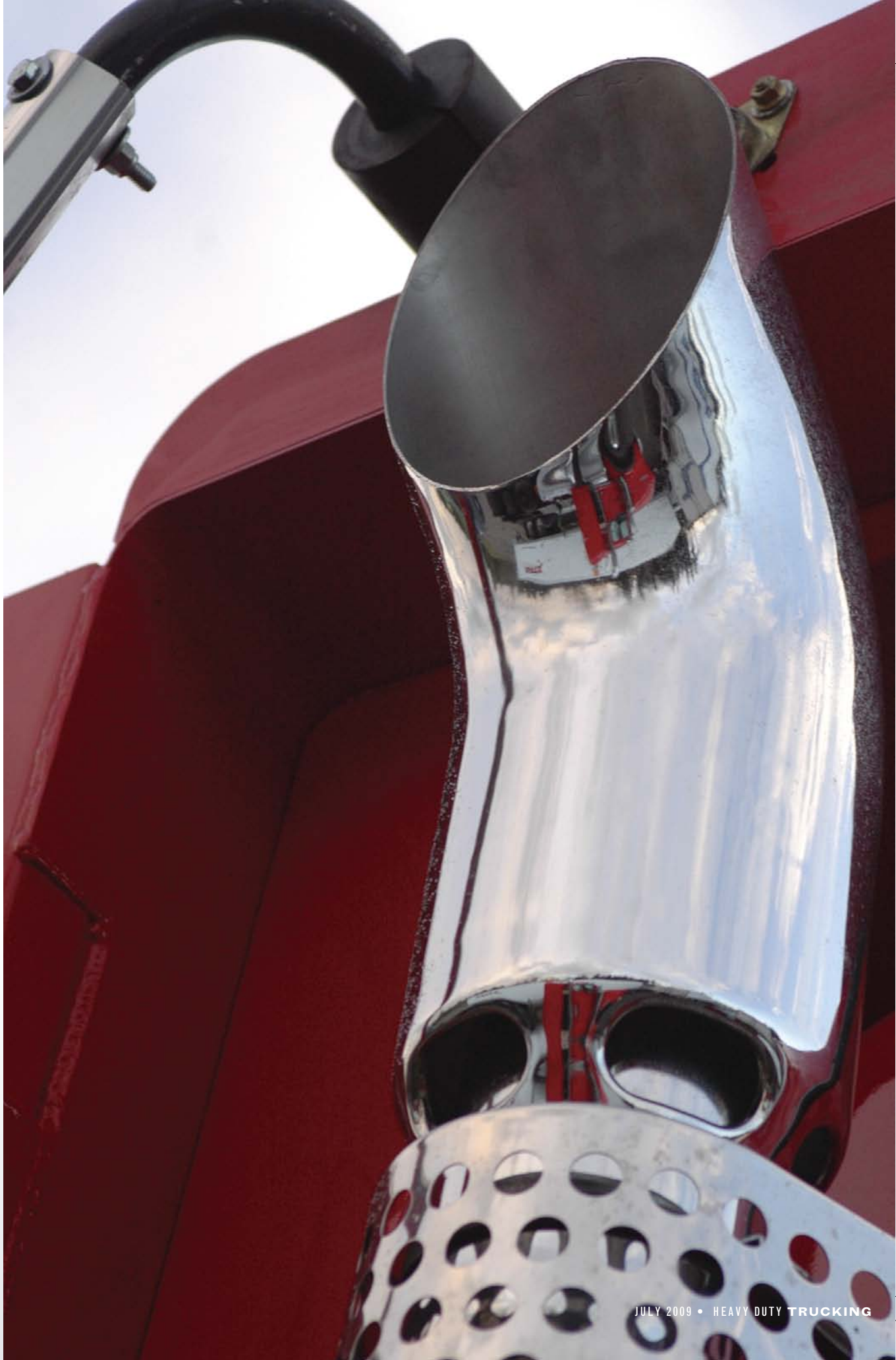
Advanced EGR

Basically, advanced exhaust gas recirculation, or A-EGR, is more of the same that was used to meet EPA's 2004 standards (which were actually implemented in October 2002). EGR is a well-understood technology, having been used on gasoline engines for many years. In the

diesel, it re-introduces metered quantities of cooled exhaust gas back into the cylinder as it fills with air, displacing some of the air volume and hence some of the oxygen. Replacing a proportion of this oxygen reduces the flame temperature in the combustion chamber; it is this hot flame that forms the NOx during combustion.

To meet the 2004 standard, EGR flow rates were of the order of 25 percent of the incoming charge, requiring an EGR valve to control the

Steve Sturgess • Executive Editor



amount according to the demands on the engine. Since the charge needed to be as cool as possible, an EGR cooler was introduced to reduce the temperature of the recirculated exhaust. But because heat was released from the exhaust into the engine coolant in the heat exchanger, more of the engine's waste heat was carried away through the radiator instead of up the exhaust stack, requiring larger cooling systems.

Higher flow rates

In 2007, to meet the reduced PM standard as well as the NOx limit, more EGR flowed – up to 35-40 percent – and a diesel particulate filter was introduced for every diesel engine to meet the PM target.

For 2010 and A-EGR, the DPF remains, but the flow rates for EGR jump up again, this time to as much as 55 percent, with still more heat being diverted from the exhaust

stream to the engine coolant. Since reducing NOx usually brings an increase in particulate matter, the DPF will definitely be a feature of A-EGR. Also, the lower NOx out of the engine makes it more difficult to regenerate the DPF passively while the truck is going down the road. It is possible, though it has not been stated, that to keep the DPF from plugging there will have to be an increase in active regenerations.

Because of the increased heat rejection into the coolant, cooling systems, radiators and grille openings will have to be sized to exchange this additional heat with the atmosphere. This entails additional cost. An indica-

tion of how much was a notice recently that Navistar school buses with A-EGR will see a \$6,000 increase to the price.

An alternative is to maintain the same cooling capacity, but reduce the available higher power engine ratings.

Cummins was a proponent of A-EGR in its initial development for 2010, and acknowledged that another consequence of introducing higher EGR flow is a reduction in the available horsepower from the engine. Thus as part of its development, Cummins had planned to introduce a 16-liter version of the ISX for higher horsepower ratings. Cummins'

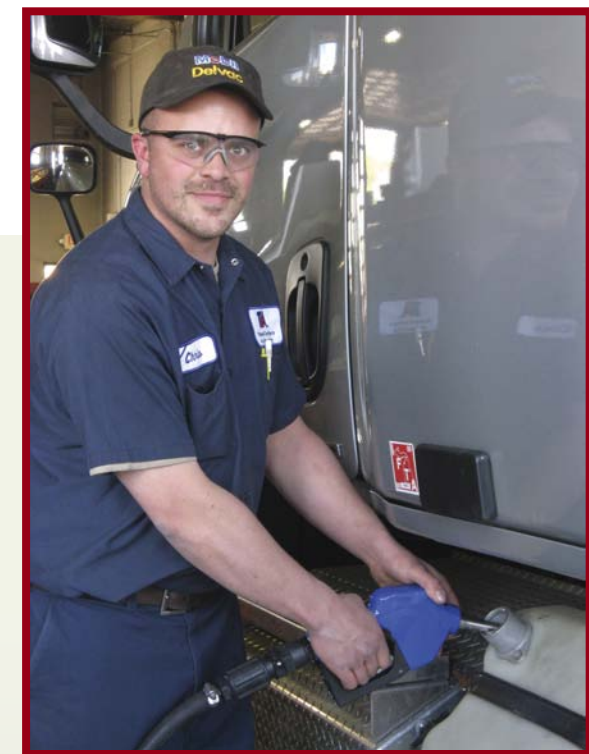
Roll-out of diesel exhaust fluid well under way

Based on news so far this year, the infrastructure for the distribution of diesel exhaust fluid will be solidly in place ready for the first 2010 trucks.

Cummins, for instance, will support its customers and others through its Cummins Filtration distribution channels. "DEF will be widely available through all our Cummins distributor locations by Oct. 1, 2009," said Pamela Carter, president of Cummins Distribution. Customers will be able to easily access product through all 20 Cummins distributors at more than 187 locations throughout the U.S., Canada and Mexico. And it's not just at distributor locations. DEF will also be available throughout the network, which includes over 20,000 locations in North America.

DEF is not a new product for Cummins Filtration, which has been providing it since 2003, formerly under the StableGuard Urea name. Fleetguard DEF product is currently available in several packaging options, from bulk and 330-gallon plastic totes all the way down to 1-gallon containers.

TravelCenters of America announced that all 234 of its TravelCenters of America and Petro Stopping Centers locations are now stocked with 2.5-gallon containers of diesel exhaust fluid for retail sale. As a truck can travel around 300 miles on a gallon of DEF, these jugs will give 700 miles



TravelCenters of America already has a bulk diesel exhaust fluid dispensing operation at a Michigan facility.

plus, which should be more than adequate for emergency supplies.

The truckstop announcement also pointed out that DEF is already available to every one of the 400 RoadSquad emergency roadside assistance vehicles at TA and Petro locations for trucks that run out of DEF while on the highway.

TravelCenters also announced the launch of the nation's first retail DEF bulk dispensing operation at its facility in Ann Arbor, Mich. The bulk DEF dispensing unit is housed in TA's heavy truck repair

Continued on page 32 >>>

shift to SCR has seen that proposal shelved. But this aspect of A-EGR accounts for International's decision to introduce a 15-liter, based on the mechanicals of Caterpillar's C15, to complement the recently introduced 11- and 13-liter big-bore MaxxForce International engines.

Because A-EGR achieves emissions limits within the combustion chamber, it needs no aftertreatment of the exhaust other than the DPF. What comes out of the cylinder head – initially at 0.5 g per hp-hr but by around 2012 at the 0.2 level – is the same level of NOx as appears at the end of the tailpipe. Navistar says this is a big plus for the technology, since users will see no difference in the day-to-day operation of post-2010 engines. All the emissions reductions are being done within the engine, so maintenance and driver responsibilities do not change with 2010.

Selective Catalytic Reduction

The alternative technology, selective catalytic reduction, is an aftertreatment in the exhaust system.

A chemical reaction, with the help of a catalyst, combines ammonia with the NOx coming out of the engine to reduce the oxides of nitrogen to plain old nitrogen and water (naturally occurring components of the air that surrounds us daily). It does not directly address particulate matter, so SCR also needs the diesel particulate filter in the exhaust.

SCR also needs a way to introduce the ammonia into the exhaust stream at the catalyst. The most satisfactory way of doing this is to use a refined aqueous solution of urea, which in North America will be referred to as diesel exhaust fluid, or DEF.

SCR is also not a new technology. It has been around for decades as a way of reducing NOx from stationary power plants, and it was the technology of choice by most European truck and engine manufacturers to meet Euro 4 emissions standards in 2005 and continues as Euro 5 hits in September this year. This European limit is fairly close to

the EPA 2007 emissions levels.

Since the Europeans have considerable experience with SCR, the application of the technology here for 2010 by companies with connections “across the pond” is to be expected. After all, experience with SCR since 2005 has shown that it is a technology with some other deliverables in addition to clean exhaust, which we'll get into later.

The European connection

Obviously, manufacturers Daimler, with Mercedes-Benz and Fuso brands in Europe and Japan, and Volvo with Volvo and Renault brands at home and abroad, are heavily invested in SCR. Daimler's Detroit Diesel engines will be introduced with the technology, and Cummins engines that will be alternatives in Freightliner and Western Star trucks also will have SCR aftertreatment. Volvo's North American brands are Volvo and Mack and both will feature similar SCR technology. Peterbilt and Kenworth parent Paccar also owns

Roll-out of diesel exhaust fluid *Continued from page 30*

facility at Ann Arbor. More accessible outdoor dispensers will later be installed near diesel pumps, and TA said it is researching available products.

A retail price for DEF at the Ann Arbor bulk dispenser has not been set because the unit is still in test, a TA spokesman said. At the time of the announcement in May, a 2.5-gallon jug of DEF was selling for \$9.99, or about \$4 per gallon.

Other truckstop chains, including Pilot and Love's, have indicated they will be offering DEF in some form. Pilot will roll out 25 bulk dispensing units per quarter, starting in the third quarter of this year and continuing through the second quarter of 2010. Ultimately, approximately 100 of Pilot's locations will have bulk dispensing capabilities at the fuel island where it will be most convenient. All 328 truckstops will have the packaged quantities available. Love's Travel Stops and Country Stores said it will begin installing bulk containers for DEF at 50 of its truckstops beginning in the fourth quarter.

All the truck OEMs that intend to use SCR technology are committed to having DEF supplies at their service locations. Many of the car dealerships for brands that will have

diesel engines are also planning to support the DEF infrastructure.

DEF suppliers are also gearing up. In addition to TA/Petro supplier Colonial Chemical Company, Old World Industries has developed a brand of fluid it calls BlueDEF that it plans to distribute through its supply chain.

The infrastructure at the truck plants is also developing. Terra Environmental Technologies is to supply diesel exhaust fluid to Volvo and Mack, Freightliner and Western Star for DEF first fills. Its brand is TerraCair and it will also be available in portable 1- and 2.5-gallon containers. Terra says it has plans to expand distribution of DEF and grow its relationships further within the trucking industry.

Larger sized containers will also be available with suitable dispensing equipment for fleets.

For instance, Cummins is already making available air or electrical powered pumps suitable for totes and drums. And EZ Fuel and Tank in Atlanta has teamed up with Blue1 of Belgium to form Blue1USA, a strategic partnership to offer DEF storage and dispensing solutions for North American fleets.



Cummins combined diesel particulate filter and selective catalytic reduction chamber. Both have sensors and controls to make it a complex assembly, which may have its share of maintenance issues.

DAF Trucks in Europe and will be building DAF's 12.9-liter MX engine in its Greenfield, Miss., plant starting late next year. That of course will use SCR, as will any Cummins engines spec'ed in Paccar's North American nameplates.

injection rate is only around 2 percent, the DEF tanks will be relatively small. However, they are sized so that they need to be filled only half as often as the truck's diesel tanks, and this makes them relatively easy to accommodate on the chassis. It also

makes the driver's task less onerous, having to find the fluid out on the highway and top off the tank less often. Centrally fueled truck fleets will have DEF facilities alongside their diesel pumps, perhaps removing the driver from the loop altogether.

DEF has yet to make an appearance at the fuel island, but in bulk it is anticipated to be at or below the price of diesel fuel. It weighs around 9 pounds per gallon and the system is anticipated to add around 450 pounds to the weight of the chassis.


Some questions have been presented by Navistar and some concerns expressed by fleets that SCR will bring with it additional maintenance and repair. And there may be some pushback from drivers. However,

The DEF debate

As far as the additional chassis components are concerned, SCR requires a tank for the DEF urea solution, a pump, injector and a catalytic chamber. It will also require additional sensors to check for the presence of NOx or ammonia in the downstream exhaust and a controller to adjust flow rates accordingly. DEF does get slushy at 12 degrees, so there are heaters for the tanks. The pumps are configured to draw back any DEF in the lines when the truck is keyed off.


Because the packaging requirements for North American truck frames and the extremely compact European cabover are so different, North American systems being perfected right now are not simple carry-overs. However, the basic technology and the reagent (called AdBlue in Europe and DEF here) are the same.

The need to keep the urea solution on the trucks is also common. Drivers will be presented with an additional "fuel" gauge that will give the level in the DEF tank. Since the

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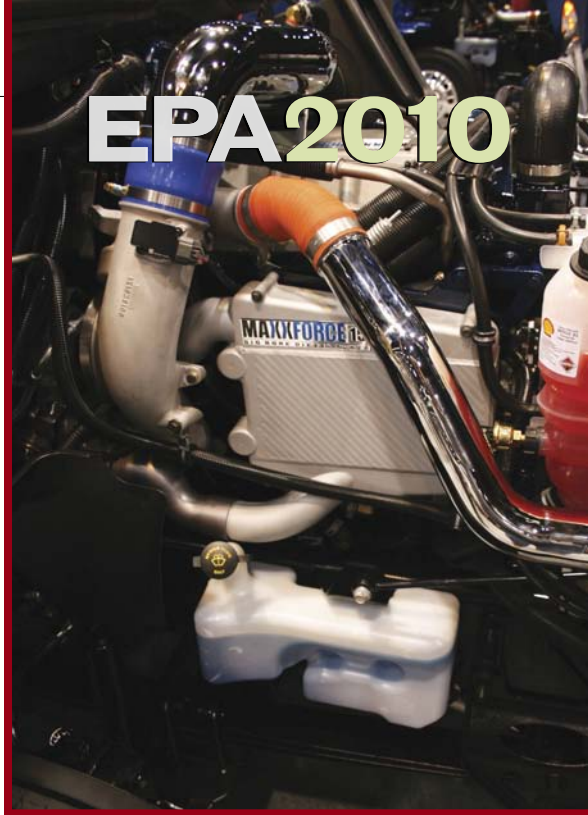
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SCR proponents point out that DEF is less hazardous than windshield washer fluid (judging from the labeling), and drivers handle the chore of topping up washer fluid without grumble.

EPA has laid down a number of safeguards that prevent the operation of the truck without DEF in the tank. Low-level warnings are built in to the monitoring of the tank. Satisfying EPA's early concerns, sensors monitoring NOx in the downstream exhaust can indicate whether the driver has ignored alarms and run the vehicle out of the fluid or substituted water, for instance, for the DEF. In such a case, the truck will be derated to a limp-in mode if a driver refuses to respond to warnings of low or non-existent DEF.

SCR benefits

The SCR technology is a very effective way to remove NOx from the exhaust. So much so, that it



To offset any problems with lower power density from increased exhaust gas flows, International plans to introduce a 15-liter diesel based on the Caterpillar C15 with new air handling.

allows the engine manufacturers to actually reduce EGR flow (SCR does not eliminate the need for some EGR) back to 2004 levels. In so doing, some of the fuel economy penalty that has been accumulating

passive regeneration of the particulate filter, there will be fewer occasions when the active regeneration using diesel fuel kicks in. This in part accounts for the fuel savings, but it also means drivers will be confronted

with each emissions change can be rolled back. The SCR proponents talk in terms of 5 percent fuel savings, but there's a 2 percent offset for the DEF that has to be used. The net gain is thus 3 percent.

However, the cost of the SCR system will be added to the price of a truck starting in 2010. The only company to address this cost so far is Volvo, which has said it will be an additional \$9,600. The payback from fuel savings will vary with the cost of diesel, but it will likely offset this upcharge during the first life of the truck.

Along with better fuel consumption from easing of EGR comes the additional NOx in the exhaust stream. Since NOx is what enables

Other SCR technologies in the works

Alternatives to the use of urea in SCR systems have been proposed. One, from Argonne Labs and licensed to Integrated Fuel Technologies, involves the use of a newly developed catalyst to generate ammonia directly on the vehicle by reforming the diesel fuel. IFT is a small company and is held to be a minor player by engineers from the truck and engine OEMs.

Another is from Eaton, where a series system uses a lean-NOx trap to directly produce nitrogen and ammonia in the exhaust. This then performs the catalytic NOx reduction downstream. Eaton recently announced it has entered into a licensing agreement with Clean Diesel Technologies that

could move the technology forward.

Any developments here, say A-EGR proponents, could result in urea-based SCR becoming a "marooned" technology.

While engine manufacturers are watching these developments closely, the urea-based SCR has progressed alongside, with everything in place for a 2010 launch. Certainly the alternatives are not ready for 2010 — Eaton's target is supposedly 2011 — and difficulties in developing a robust and inexpensive lean NOx adsorber, notwithstanding its use on the lighter Dodge Rams, would indicate a difficult road ahead for the technology. Also, according to a report in a recent Automotive World article, the system brings a fuel penalty in contrast to urea SCR's fuel savings.

A further development is a joint agreement between Tenneco and GE Transportation to develop a proprietary SCR aftertreatment technology designed to reduce and control diesel engine emissions for various transportation and other applications. The target appears to be locomotive projects, but Tenneco is positioned to become a long-term strategic supplier of diesel aftertreatment solutions to GE Transportation.

Tenneco will also have the opportunity to develop GE's HC-SCR technology for expanded markets. Tenneco currently offers its own innovative ELIM-NOx urea-based SCR aftertreatment solutions for commercial on and off-road vehicle customers.

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less with dashboard lights indicating an active event. Volvo goes as far as to say that no over-the-highway truck will see an active regen event and even vocational trucks may never see one. This means drivers will have less to worry about and not have to intervene in those occasions when active regens are inconvenient or even dangerous.

Time will tell

Faced with these two alternatives, truck purchasers are going to have to make choices. These will be based on the preferences for the deliverables of the A-EGR or the SCR solution. And also the downsides.

Another imponderable will be the new choices in engines such as the Navistar International MaxxForce 11- and 13- liters and the upcoming 15-liter based on the rugged Cat C15.

There's also the still-to-be-launched Paccar 12.9-liter MX.

Further complication comes from the withdrawal of Caterpillar from the on-highway engine business. This leaves the way clear for

Cummins to step in at Freightliner, Kenworth and Peterbilt – but not at Navistar.

And overlying all is, what happens

truck/engine solution will deliver superior fuel economy.

“You pays your money and takes your choice” is often attributed to Mark Twain’s Huckleberry Finn of 1884. It appears even earlier in the British satirical magazine *Punch* in



SCR tanks are sized to make filling only half as frequent as the fuel tanks. The filler neck is smaller than a diesel nozzle and coded blue to avoid mixing the fluids when filling.

to the price of fuel? Any increase argues strongly for an SCR-based solution with its fuel savings. Navistar argues, though, that by the time 2010 rolls around, its overall

1845. But a suitable modification here would be: “You makes your choice and pays your money.”

Light and medium diesels will follow heavies

What's true for emissions-reduction equipment in heavy-duty 2010 diesels also applies to light- and medium-duty diesels, and with the same technology split: Navistar International will use “advanced” exhaust-gas recirculation (A-EGR) for all its engines, while everyone else will go with selective catalytic reduction (SCR) using urea fluid.

The advantages and disadvantages of each will also apply to midrange and light-truck diesels, though the numbers for weight and cost will be less. The new EPA

exhaust limits go into effect Jan. 1 and affect engines, not trucks, so backlogs of pre-2010 diesels will be installed in new trucks for a time after that date.

The “everyone else” SCR crowd among midrange builders includes Freightliner’s M2 series with Mercedes-Benz and Cummins midrange diesels; Ford, whose F-650 and F-750 will use the Cummins ISB; and Kenworth and Peterbilt, whose T and 330 series, respectively, will use Paccar PX-brand diesels made by Cummins. Isuzu, Mitsubishi Fuso, Hino and Nissan UD have all said they will use SCR for engines and

trucks sold in the U.S. and Canada. SCR has been successful in Japan, where it has been used for about two years, and will also work well here, those builders say.

General Motors will stay in the light-truck business even though it's dropping its medium-duty models. Chevrolet Silverado and GMC Sierra 2500 and 3500 pickups and cab-chassis trucks will use Vortec gasoline and optional DuraMax diesel V-8s, with the diesels switching to SCR to handle 2010 emissions limits. The fate of the diesel-powered W-series low-cab-forward trucks supplied by Isuzu is

Navistar challenges EPA on emissions control authority

Navistar has raised the ante in the competition among engine manufacturers by challenging the Environmental Protection Agency's plan to allow use of selective catalytic reduction to achieve 2010 emission standards.

Navistar, which is alone among engine builders with its preference for advanced exhaust gas recirculation over SCR as an emissions reduction technology, asked a federal court to review EPA's decision-making. The engine company alleges that EPA violated federal procedures, circumventing the normal rulemaking process, when it changed its mind about allowing SCR.

Back in 2001, when EPA issued the final rule outlining the 2007 and 2010 emission regulations, the agency was looking at NOx adsorbers to



Navistar International's MaxxForce engines could get the market to themselves in the latest stalling tactic.

comply with the NOx emission standard. Urea SCR technology was not considered feasible by the EPA, for reasons including the establishment of a urea distribution infrastructure and concerns about engines running without the solution in the urea tank.

Since then, the agency has decided that SCR can be a solution. In March 2007, the agency issued a guidance document on emission certification of engines equipped with urea-SCR technology. Again modified in February 2009, the docu-

ments introduced requirements for driver warning and "inducements" to make sure that the vehicle cannot be operated with an empty urea tank.

Navistar is arguing that these documents were not a part of the 2001 regulation and that they represent an amendment of the 2001 emission regulation. As such, they can only be adopted through a proper rule-making procedure. That could delay the certification and introduction of urea-based SCR solutions beyond the 2010 deadline.

The other engine manufacturers – Cummins, Detroit Diesel, Daimler, Volvo and Mack – have asked to join the case, arguing that they have an important interest in ensuring that EPA's 2009 SCR guidance is not delayed.

Timing is critical. The engine manufacturers have been racing to get their chosen technologies vetted in field tests and ready for EPA certi-

unclear, and Isuzu is trying to determine if still-bankrupt GM wants to continue them and the heavier W trucks GM has assembled for its dealers and for Isuzu. In April, GM built the last of the gasoline-powered Class 3 and 4 W trucks, which Isuzu sells as its NPR Gas, and these, too, may or may not continue.

For its light trucks, Ford will drop the 6- and 6.4-liter Navistar-built Power Stroke V-8 diesels in December and switch to its own diesel, reportedly also a V-8 of similar displacement, and it's likely to use SCR. Like the current engine, the new diesel will be used in F-250, F-350 and F-450 SuperDuty pickups, cab-chassis models and E-series vans;

as now, those trucks will be standard with Triton gasoline V-8s and V-10s. Ford has scheduled an announcement on the new diesel for September.

Dodge will continue to offer the Cummins Turbo Diesel in its Ram heavy pickups; this version of the engine uses a NOx adsorber and is already 2010-legal without SCR. The Turbo Diesel for 3500, 4500 and 5500 cab-chassis models, however, will switch to SCR aftertreatment, needed to handle higher loads and hotter exhaust that these trucks see. All this hinges on Chrysler, which is now in bankruptcy, negotiating a new supply agreement with Cummins.

Coincident with the 2010 emissions

limits is Navistar's dropping of its MaxxForce 5 V-6 diesel, now used in some Workhorse walk-in van chassis and in the low-cab-forward Class 3 and 4 truck also sold by Ford. The replacement is likely to be a similar-size inline-4 diesel made in Brazil, and presumably it will use A-EGR. Will Ford's low-cab-forward use this engine? Will that slow-selling truck even continue? Ford isn't saying.

Upcharges for 2010 light- and medium-duty diesels have not been announced as of this writing, but should range from about \$3,500 to \$6,500.

—Tom Berg, Senior Editor

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NEXT MONTH: *Real-world testing of 2010 engines*

fication this summer in time to tool up for production ahead of the Jan. 1 deadline.

But under the normal schedule for this type of proceeding, the court might not reach a decision until next year, according to a spokesman for the U.S. Court of Appeals for the District of Columbia Circuit.

Julie Domike, counsel for Volvo Group North America, said she expects Navistar will ask the court to hear the matter well before the end of the year. Roy Wiley, spokesman for Navistar, said he could not comment on whether or not the company might ask the court to expedite the proceeding.

“The basic question is, did EPA in

their apparent blessing of SCR technology ... circumvent the normal rulemaking process and in effect legislate a new emissions standard that in the eyes of Navistar possibly endangers public health,” said Allen Schaeffer, executive director of the Diesel Technology Forum. The forum is an industry group dedicated to raising public awareness about diesel power. Navistar and the other manufacturers are members.

Kent Hanson, the attorney with the U.S. Department of Justice who is handling the matter for EPA, said he was not able to comment.

— *Oliver B. Patton,*
Washington Editor, and
Steve Sturgess, Executive Editor

Survey: Fleets lean toward SCR

With just six months to go before the new EPA 2010 emissions standards for heavy-duty diesel engines go into effect, fleets so far seem to be leaning toward selective catalytic reduction – but enhanced EGR is not being ruled out.

In a national research study conducted in May, more than half (51.2 percent) of all respondents said they are likely or very likely to consider SCR for their EPA 2010 engine purchase, compared to 31.2 percent that are likely or very likely to consider increased EGR. Overall purchase consideration for the two emissions choices have remained statistically unchanged since the last survey was conducted in November 2008.

The online study by Quixote Group Research was conducted among owners and operators of Class 8 trucks on behalf of the North American SCR Stakeholders Group and FactsAboutSCR.com. The final sample of 1,603 responses has a margin of error of ± 2.4 percent.

Three-quarters (75.4 percent) of respondents rated fuel efficiency as very important to the decision to purchase an EPA 2010 compliant engine, and nearly half (48.8 percent) correctly related fuel savings with SCR, which is up from 38.7 percent in November 2008.

Proven technology was rated as very important to the purchase decision by 70.1 percent of respondents. Engine optimization and scheduled maintenance required by the 2010 technology were rated very important by 59.6 percent and 59 percent of all respondents, respectively. The weight added by the 2010 emissions technology was cited by 44.2 percent.

Knowledge of what is included in the EPA 2010 regulations has also increased, with 62.5 percent of respondents correctly identifying NOx as being specifically included in the standards, up from 59.6 percent in November.

— *Deborah Lockridge, Editor*

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