Diesel Exhaust Fluid / SCR – Frequently Asked Questions

EPA’s 2010 diesel engine emission standards will require engine manufacturers to further reduce the amount of nitrogen oxides (NOx) emitted. To reach these NOx emissions levels, several engine manufacturers will employ selective catalytic reduction (SCR) as an aftertreatment technology that when combined with exhaust gas recirculation (EGR), will reduce NOx emissions to the level prescribed by EPA’s 2010 standards. SCR is a proven technology that is currently being used in mobile applications in Europe & stationary applications here in the US. The combined SCR/EGR NOx reduction system needed to meet EPA’s 2010 standard is new.

Cummins, Daimler Trucks North America, Paccar and Volvo/Mack have indicated that they will utilize SCR technology to comply with EPA’s 2010 emissions standards. Navistar/International will utilize “Enhanced EGR” technology to comply with the standards.

How does SCR work? To reduce NOx, a small amount of urea-based solution called diesel exhaust fluid (DEF) is injected directly into the exhaust upstream of a catalyst. The DEF vaporizes and decomposes to form ammonia (NH₃), which in conjunction with the SCR catalyst, reacts with NOx to convert the pollutant into nitrogen (N₂) and water (H₂O). This means that trucks will have to carry a sufficient quantity of DEF on-board. Depending upon the capacity of the DEF tank, the SCR system is expected to add 300-400 pounds to the weight of a Class 8 truck.

What are the advantages of SCR? Certain engine manufacturers have indicated that the use of SCR will result in a fuel economy improvement, as engines can be run more efficiently with NOx emissions being reduced in the aftertreatment system. Estimates of fuel economy improvements range from 3% to 5% compared to today’s 2007-compliant trucks; however, trucks equipped with SCR systems meeting the EPA 2010 standards have not undergone sufficient fleet testing to validate these claims.

What is urea? Urea is a common agricultural fertilizer that is usually manufactured from natural gas. The amount of urea that will be used in motor vehicle applications is a small fraction of the urea used for agricultural purposes. Urea is a solid at room temperature.

What is Diesel Exhaust Fluid? Diesel Exhaust Fluid (DEF) is a urea-based solution that will be used by SCR systems. DEF is produced to an international standard (ISO 22241).
It consists of 32.5% automotive-grade urea and 67.5% de-ionized water. The difference between agricultural-grade urea and DEF centers upon purity and concentration. Purity is essential to performance and working life of the SCR aftertreatment system. Proper concentration is essential to the efficacy of the NOx reduction process. Trucks equipped with SCR systems will contain NOx sensors. If an SCR-equipped truck is emitting high concentrations of NOx, the SCR system will increase the dosing of DEF. If the high NOx emissions are not remedied, the truck likely will have a controlled loss of power for a period of time and will eventually reach a point where it will be electronically prohibited from operating. For this reason, DEF quality and concentration will be essential to the truck’s continued operation.

**Is DEF a potentially harmful chemical?** DEF is a non-toxic solution, corrosive to some metal. DEF is biodegradable and is not classified as a hazardous material under DOT or EPA regulations. DEF is less toxic than other automotive fluids, including diesel fuel, brake fluid, coolant and axle lube. Links to DEF Material Safety Data Sheets are provided below:


**Are there specific storage issues for DEF?** Yes. DEF is corrosive to aluminum and carbon steel. Storage tanks must be made of stainless steel or composite plastic material (e.g., polyethylene or PVC) and should not contain carbon steel, iron, zinc, nickel or copper. Depending upon the quantity being stored, DEF should be incorporated into a facility’s stormwater plans due to excessive nitrate levels.

**Are there specific temperatures at which DEF must be stored?** Yes. When stored between 10 and 90 degrees Fahrenheit, DEF should last at least one year. DEF freezes below 12 degrees Fahrenheit. The efficacy of DEF is not altered as a result of freezing and subsequent thawing. DEF is also sensitive to heat and should be stored below 86 degrees Fahrenheit. Exposing DEF to heat for an extended period of time will reduce its shelf life - if stored continuously at 90 degrees Fahrenheit, DEF shelf life is reduced to 6 months.

**How will DEF quality be monitored?** Ensuring the purity and concentration of DEF is important to the proper functioning of the SCR system. DEF must comply with the ISO 22241 standard. The American Petroleum Institute (API) has developed a certification program for DEF that is designed to ensure that North American supplies of DEF will meet applicable standards throughout the supply chain. API will take random samples at
storage facilities; however, API does not have the resources to inspect each batch of DEF throughout all points in the supply chain.

**How will DEF be distributed?** DEF is comprised of 67.5% de-ionized water – it is not efficient to ship DEF around the country, so blending facilities will receive automotive-grade urea and manufacture DEF for shipment. DEF will be available for sale in different size containers (e.g., bulk, IBCs, or in palletized drums and jugs). DEF weighs 9.1 lbs/gal. – a full bulk load will be approximately 5,500 gallons. Due to the low number of vehicles requiring DEF, many fuel stops will meet DEF demand by offering prepackaged containers; however, several truck stops have announced plans to offer DEF in a fuel island dispenser at some of their locations.

**How much DEF is required (dosing)?** While final figures are not yet available, engine manufacturers have stated that their SCR systems will require a 2%-3% DEF dosing rate compared to the amount of diesel consumed. This works out to one gallon of DEF required for every 300 miles traveled (assuming fuel economy of 6 mpg). At this rate, a heavy duty truck traveling 120,000 miles annually would require approximately 400 gallons of DEF per year. Note, trucks manufactured for sale in Europe do not use EGR with their SCR systems, so their DEF dose rates are higher.

Trucks are expected to have on-board urea tanks that range in size from 15-30 gallons. With this capacity, it will not be necessary to add DEF each time the truck refuels.

**How much will DEF cost?** DEF costs are driven by the price of urea and the quantity of DEF purchased. Urea prices in turn are driven by global supply and demand. Last year the price of urea varied from $1.73/gallon to $2.73/gallon. The retail price of DEF is expected to vary from $2 to $6 per gallon depending upon the quantity purchased (note small containers of DEF sold at automobile dealerships will likely be priced higher).

**Can I make DEF?** Yes. End users are capable of purchasing automotive grade urea in granular form and mixing it with de-ionized water; however, the purity and concentration of DEF is important to the proper functioning and longevity of the SCR system. Strict manufacturing and blending processes are necessary to ensure high quality DEF. For this reason, although end-users may save money by blending their own DEF, it is recommended that end-users purchase certified DEF and avoid blending it themselves.

**Are there dispensers for DEF?** Yes. A typical bulk dispenser for use at a truck stop or large central refueling facility will cost between $15,000 and $50,000 dollars.
Underwriters Laboratories (UL) has not yet certified DEF dispensers and there may be an issue with the local fire marshal concerning the use of a heated dispenser in close proximity to where flammable liquids are being stored and dispensed.

Is Misfueling a Concern? Yes. The inlet for DEF will be smaller than the nozzles used to dispense diesel fuel. So it is unlikely that diesel fuel will be dispensed into the urea tank. This will prevent damage to the SCR system. It will, however, be possible to dispense DEF into the diesel tank, as the DEF dispenser nozzle or canister will be smaller than the diesel fuel tank inlet. This type of misfueling is unlikely due to the size differential between the diesel and urea nozzles. If misfueling does occur, the fuel/water separator would capture up to a quart or two of DEF to prevent engine damage. There is a magnetic nozzle interlock solution mandated in some countries, but not in the United States, making the potential for misfueling a significant concern for end-users.

What happens if the DEF is not Replenished? The failure to refuel the DEF tank will cause the truck to exceed allowable NOx emissions. For this reason, EPA is requiring OEMs to ensure that there is a visual or audible warning that alerts the driver when the DEF tank is running low (i.e., less than 2.5% of the DEF tank capacity). Once the tank is empty a derating of engine power will occur and eventually the truck will be restricted to travel at a maximum speed of 5 mph. The following symbol has been specified for low DEF levels:

What happens if poor quality DEF is used? If the SCR system detects poor quality DEF that inhibits the system from reducing NOx to the levels mandated by EPA, a warning lamp or message will illuminate. If the driver fails to remedy the problem within 500 miles or 10 hours, the maximum available engine torque will be reduced by 25%. If the driver fails to remedy the problem within 1000 miles or 20 hours, the vehicle speed will be restricted to no more than 5 mph. Similar driver inducements will be triggered by tampering activities (e.g., disconnected DEF sensor or dosing valve, SCR wiring harness, NOx sensor or DEF quality sensor).

For suggested updates to this FAQ, please forward comments to Richard Moskowitz at rmoskowitz@trucking.org
Blue1USA http://www.blue1usa.com
Brenntag http://www.brenntagdef.com
Colonial Chemical http://www.urea-scr.com
Micro Matic http://www.industrial.micromatic.com
Terra Environmental Technologies http://www.tet.terraindustries.com/
Yara NA (Air1) http://www.air1.info/us/index.html

Detroit Diesel http://www.detroitdiesel.com/emissions/epa2010/
Paccar http://www.paccar.com/company/environmental/

SCR Facts http://truthaboutscr.com
DEF http://afdcdev.nrel.gov/afdc/locator/index.php?apptype=def&mode=basic
Locator
Dept. of Energy http://www.afdc.energy.gov/afdc
EPA Clean Diesel http://www.epa.gov/otaq/eparecovery/index.htm
Campaign Funding
Diesel Technology Forum http://www.dieselforum.org
SCR & DEF Information http://www.factsaboutscr.com
SCR Information http://truckscr.com