2007 Diesel Regulation Technologies EVOLVE

Over the next four years, increasingly stringent diesel fuel regulations will fall into place. The government has targeted December 2010 for 100-percent availability of 15-ppm ultra-low sulfur diesel fuel.

By John Dolce

U.S. fleets are starting to use 15-parts-per-million (ppm) ultra-low sulfur diesel (ULSD) fuel. This past summer, ULSD was in the pipeline; in September, it was available for delivery; on October 15, the diesel fuel was available for retail sales. Some 80 percent of diesel fuel available by Oct 15, 2007 will be ULSD, and 20 percent will be 500-ppm low sulfur diesel (LSD) with a target date of December 2010 for 100-percent ULSD availability. Off-road equipment will still use 5,000 ppm where available.

A fleet management concern is the cleaning characteristics of ULSD in removing deposits in fuel-tank infrastructure, the supplier delivery trucks, storage tanks, and fleet vehicle fuel tanks. These concerns are being met with increased-efficiency fuel filters on the infrastructure fuel pumps and on fleet vehicles.

Another concern is fuel filter change-out frequency cycles during the initial surge of early filter contamination and the subsequent relaxed change-out cycle as contamination is eliminated.

Still another concern is the new fuel's reduced lubricity and current vehicle fuel system-ULSD compatibility. For decades, the transit industry has used #1 diesel, jet fuel, and kerosene with two- and four-stroke diesel engines to limit smoke emissions in urban environments and has not noticed premature injector and diesel fuel pump deterioration and/or failures. Differences are not expected, but aftermarket suppliers will address this challenge in the rebuilding process.

Fuel Temperatures Present Concerns

Diesel fuel sold at temperatures above 60 degrees presents additional concern, since at that temperature, fuel economy statistics are impacted. Sixty degrees is the national standard for dispensing diesel fuel. When fuel at higher temperatures is introduced into a vehicle fuel tank, the physical quantity of the diesel fuel shrinks, affecting that vehicle's mpg.

Most diesel fuel systems return fuel pumped through a vehicle with an ambient engine temperature of about 180 degrees to the vehicle fuel tank, again impacting fuel expansion, which is averaged with ambient fuel tank size and quantity, further influencing the expansion and conversion of the fuel quantity, affecting mpg readings.

At a Glance

Technologies and processes developed to meet new diesel fuel regulations include:

- Diesel particulate filters.
- Diesel oxidation catalyst.
- Selective catalyst reduction.
- Exhaust gas recirculation.

Fuel pumped into the vehicle from aboveground tanks at temperatures higher than the vehicle fuel tank inventory temperature results in fuel quantity contraction and an increased cost per gallon. That cost increase, multiplied by 5,000 gallons per vehicle per year, is a minor expense compared to 20,000 gallons per vehicle per year. Volume exacerbates the loss in mpg value.

2007 Inaugurates Engine System Changes to Meet Regulations

2007 will introduce diesel particulate filters (DPF), which will require cleaning by compressed air and/or fluids to wash out captured particles. Cleaning tools will cost $500-$5,000. DPFs will have a calculated location in the exhaust system to maintain and adequate +/- 900



degrees F. When mounted equipment is installed on the chassis, the DPF location cannot be altered since it would impact the DPF residual temperature and thus impair its performance, requiring replacement due to clogged conditions.

Enter the diesel oxidation catalyst (DOC), located between the engine exhaust manifold and the DPF, for post-2007 system use called a selective catalytic reduction (SCR) process.

The DOC component is designed to have a catalyst, either diesel fuel or an ammonia product (urea), in a water-based liquid solution sprayed into it to raise the exhaust temperature to 1,200 degrees F to burn and/or clean out the DPF. This process, known as after-treatment or regeneration, lasts 20 minutes and requires continuously running the engine to clean the system. A dashboard light indicates the process is in operation.

To avoid burning the nearby ground, roadway, grass, and/or groundcover during the after-treatment cycle, a horizontal diffuser is installed at the end of the exhaust system to diffuse the exhaust stream.

The exhaust gas recirculation (EGR) process is designed to cool combustion chamber temperatures to reduce nitrogen-oxide emissions (NOx). This system has existed since 2002, but has been ramped up to reduce the NOx level to meet the more-stringent 2007 standards.

To keep increased exhaust gases in the cylinder, the exhaust valve is open longer and/or the single or multiple turbocharger pushes more of the exhaust through the air-to-air coolers into the intake process. While some manufacturers take the exhaust gases before the DPF, others take it after the DPF because the exhaust gas is cleaner and cooler. Manufacturers choose single, double, or variable vane turbochargers to do this efficiently.

New technologies will cause different wear patterns. Reaction to failures will create longer lifecycles. A reaction approach is not cost-effective or competitive.

Fuel pressure has increased with each system design upgrade to efficiently increase fuel in the combustion process with a more-diffused injection spray into the cylinders.

These system changes increase engine compartment temperatures, so a larger and more efficient cooling system has been designed and installed to keep temperatures under control for on-road vehicles.

Tier System Regulates Off-Road Vehicles

Off-road vehicles — yellow iron — have a similar program called a tier system. Tier I, Tier II, and Tier III systems are for equipment with various horsepower engines. Lower horsepower units started in the mid 1990s with Tier I. The system has evolved to Tier III at the present time with the manufacture of higher horsepower engines.

Chart 1 indicates Environmental Protection Agency (EPA) expectations with Tier I to Tier III requirements. Tier IV standards for 2010 will be published in the near future.

- **Tier I.** 1996 through 2000: reduce NOx by 54 percent through delayed engine timing and increased injector pressure.
- **Tier II.** 2001 through 2004: Reduce NOx by an additional 35 percent, reduce hydrocarbons by increased turbocharger boost and addition of air-to-air after-coolers, and incorporate electronic system control and waste-gate turbochargers (excess air from the EGR turbocharging component creates an air-leak hissing sound).
- **Tier III.** 2006 through 2008: Reduce NOx by an additional 40 percent through new combustion chamber design, which incorporates "best known principles;" higher EGR system injection pressures; DOC; catalytic converters; DPF; low-sulfur fuel with ppm decreased from 5,000 to 500 by June 7, 2008, and to 15 ppm by June 2010; variable geometry turbocharger rear-engine drivetrain; and a larger engine block to dissipate increased combustion heat. Reduce noise pollution and implement full-authority electronic controls.
- **Tier IV.** 2008 through 2014: Reduce NOx an additional 90 percent and reduce hydrocarbons (particulate matter) to less than 22-percent

smoke opacity by closed crankcase ventilation, routing crankcase vapors into the engine intake system and burning it in combustion.

Major engine manufacturers are expected to continue using their present Tier III technology and not tip their hand on future technology until they must comply with Tier IV requirements (2010 for 174-751 hp and 2011 for 49-173 hp). When the deadline arrives, will they meet Tier IV requirements with Tier III technology? If they cannot, add EGR as well as after-treatment (regeneration).

Maintenance Focus Shifts from Repair to Diagnosis

New technologies will cause different wear patterns. Reaction to failures will create longer lifecycles. A reaction approach is not cost-effective or competitive. Proactive efforts are more cost-effective. They compensate for problems before they occur because past practice, historical trends, and data can provide clues to anticipated events. This information and data are provided to engineers who develop components to meet new demands. We measure, watch, and pay attention to what is meaningful throughout diagnosis.

Today, more than ever, the focus is on diagnosis. During the 1940s and 1950s, 95 percent of maintenance time was spent on repair and 5 percent on diagnosis. In the '60s and '70s, those numbers evolved to 80 and 20 percent; in the '70s and '80s, they were at 75 and 25 percent. Currently, the numbers are closer to 50/50, which means we must train and be trained to diagnose a problem, fix it right the first time, and ensure it stays fixed.

Other factors in symptom diagnosis include:

- Intermittent problems — limp-in-mode, for example — are more prevalent today.
- Engine computers do much more to control engine operations to meet regulations. We must use computers to read computers to pinpoint and treat the symptoms and repair the root cause.

New technologies require diagnostics. Changes evidence circumstances that require corrective actions that bring consequences. Before initiating any actions, we must be aware of the consequences and their cost and effect on longevity and reliability. Measure, watch, and pay attention: measure what's meaningful, pay attention to what's meaningful, and watch everything. AF

About the Author

John Dolce is a fleet manager consultant and trainer. He can be reached at (973) 226-9061 or by fax (973) 226-7982.

Chart 1 **EPA Tier 1-3 Non-Road Diesel Engine NOx & PM Emission Standards**

Engine Power	Tier	Year	NOx[1]	NMHC[2] + NOx	PM[3]
kW < B	Tier 1	2000	-	10.6 (7.8)	1.0 (0.75)
(hp < 11)	Tier 2	2005	-	7.5 (5.6)	0.80 (0.60)
8 ≤ kW ≤ 19	Tier 1	2000	-	9.5 (7.1)	0.80 (0.60)
(11 ≤ hp ≤ 25)	Tier 2	2005	-	7.5 (5.6)	0.80 (0.60)
18 ≤ kW ≤ 37	Tier 1	1999	-	9.5 (7.1)	0.80 (0.60)
(25 ≤ hp ≤ 50)	Tier 2	2004	-	7.5 (5.6)	0.60 (0.45)
37 ≤ kW ≤ 75	Tier 1	1998	9.2 (6.9)	-	-
(50 ≤ hp ≤ 100)	Tier 2	2004	-	7.5 (5.6)	0.40 (0.30)
	Tier 3	2008	-	4.7 (3.5)	-
75 ≤ kW ≤ 130	Tier 1	1997	9.2 (6.9)	-	-
(100 ≤ hp ≤ 175)	Tier 2	2003	-	6.6 (4.9)	0.30 (0.22)
	Tier 3	2007	-	4.0 (3.0)	-
130 ≤ kW ≤ 225	Tier 1	1996	9.2 (6.9)	-	-
(175 ≤ hp ≤ 300)	Tier 2	2003	-	6.6 (4.9)	0.20 (0.18)
	Tier 3	2006	-	4.0 (3.0)	-
225 ≤ kw ≤ 450	Tier 1	1996	9.2 (6.9)	-	0.54 (0.40)
(300 ≤ hp ≤ 600	Tier 2	2001	-	6.4 (4.8)	0.20 (0.15)
	Tier 3	2006	-	4.0 (3.0)	-
450 ≤ kW ≤ 580	Tier 1	1996	9.2 (6.9)	-	0.54 (0.40)
(600 ≤ hp ≤ 750)	Tier 2	2002	-	6.4 (4.8)	0.20 (0.15)
	Tier 3	2006	-	4.0 (3.0)	-
kW ≥ 560	Tier 1	2000	9.2 (6.9)	-	0.54 (0.40)
(hp ≥ 750)	Tier 2	2006	-	6.4 (4.8)	0.20 (0.15)

Source: Dieselnet.com

The off-road equipment tier system is related to engine power size. All on-road diesel vehicles fall under EPA regulations in 2007.

[1] Nitrogen oxide. [2] Non-methane hydrocarbons. [3] Particulate matter.