Summary of EPA 2007 Emissions compliance strategies used by truck diesel engine manufacturers.

As the truck manufacturing industry prepares for the implementation of EPA 2007 emissions standards, significant changes have been adopted by diesel engine manufacturers. These changes are too widespread to address in detail in the context of this update. For instance, more than one engine OEM has made radical changes to diesel engine piston design with the introduction of skirtless, steel-alloy trunk pistons so you can expect significant revisions to textbooks dealing with diesel engine technology during the next couple of years. This type of innovation will be properly covered when a new edition of *Truck Engine, Fuel, and Computerized Management Systems* is released (2009): the current edition of the textbook (2004) is referenced (by page and chapter) in this summary.

The objective here is to prepare students entering the workplace for some of the fundamental changes that will be introduced with 2007 truck engines. We will be take a brief and generic look at those changes that directly impact on the new EPA standards which are NOT covered in the 2004 textbook. The approach is generic except where a single manufacturer has used a radically different technology: for instance, CGI is exclusively a Caterpillar technology. Every effort has been made to get the information presented here correct: however, at the time of writing, even the engine OEMs are still uncertain of some of the specifics so there could be some inaccuracies. The following areas are covered:

Some key words

Adsorb
Clean Gas Induction (CGI)
Diesel particulate filter (DPF)
Engine Manufacturer Diagnostics (EMD)
NOx adsorber catalyst (NAC)
Particulate trap
Selective catalytic reduction (SCR)
Ultra low sulfur (ULS)
Urea

THE NEW EPA (2007) STANDARDS

The Tier 3 or EPA 2007 standards have been changed slightly since their inception into legislated EPA tier schedules due to an accord between the EPA and diesel engine OEMs to enable a phase-in period detailed a little later. However, the overall targets (see figure 45.1 on page 725 of the engines textbook) for both particulate matter (PM) and oxides of nitrogen (NOx) set for 2010 have not been compromised. Here is a quick look at them and the specifics of phase-in period:

NOx

The EPA has authorized a NOx reduction phase-in from 2007 to 2009 during which 50% of the engines produced by an OEM must meet the NOx standard while the other 50% can continue to meet the current standard (2004) up until 2009. This can be achieved in different ways which are outlined a little later. Both NOx and PM output are measured in grams per horsepower hour expressed as: g/hp-hr.

The current standard for maximum NOx output is 2.5 g/hp-hr. The 2007 standard will be less than one tenth of this that is, 0.2 g/hp-hr. However, because of the 50% compliance concession (good until 2009), an engine manufacturer can meet 2007 emissions standards by producing 100% of its engines that output no more than 1.2 g/hp-hr … or 50% engines that meet the 2007 standard of 0.2 g/hp and the other 50% that meet the current standard of 2.5 g/hp-hr. This means that some engine OEMs will continue to manufacture and sell engines that do no more than meet the current standards up to 2009.

PM

There will be no phase-in for the particulate matter (PM) in diesel exhaust meaning that all diesel engine production must meet the standard at the beginning of 2007. Current maximum PM output is 0.10 g/hp-hr. Like maximum NOx output, this will be reduced to one tenth the current value that is, 0.01g/hg-hr. The EPA's refusal to allow any type of phase-in compromise on PM emissions means just about every medium and heavy-duty highway truck diesel engine manufactured after 2007 will be equipped with a diesel particulate filter (DPF).

The following table compares the EPA maximums for PM and HC from the current to 2010 standards.

Table 1 **EPA diesel emissions**

Exhaust emission	**Current (to 2007)**	**2007**	**2010**
NOx	2.5 g/hp-hr	0.2 g/hp-hr (50% av)	0.2 g/hp-hr (100%)
PM	0.10 g/hp-hr	0.01 g/hp-hr (100%)	0.01 g/hp-hr (100%)

ULS FUEL

Beginning 10.15.06, fuel refiners and retailers will make ultra low sulfur diesel fuel available in 80% of refueling outlets. The current (to 2007) diesel fuel standard is known as low sulfur (LS) and can contain up to 500 ppm (parts per million) sulfur. 500 ppm can also be written as 0.05%.

The new standard ULS will be phased in under what is known as a voluntary compliance option beginning in October 2006 and increasing to 100% by 2010. The new ULS fuel can contain a maximum of 15 ppm of sulfur (0.0015%). Refiners have stated that ULS will cost approximately 5 cents a gallon more to produce than the current standard LS fuel, a figure that is much less noticeable today given the current cost of fuel at the pumps. In terms of the way it performs in a diesel engine fuel system, ULS should have approximately the same lubricity as LS fuel but there will be a 1% reduction in Btu. This means that a small difference in fuel economy will be observable.

Importance of using the correct fuel

It should be noted that diesel engines using diesel particulate filters (DPFs) (some OEMs will call these particulate traps) to achieve 2007 emissions compliance REQUIRE the use of ULS. If LS fuel is used, the result will be heavy PM emission followed by total restriction (complete plug-up) of the DPF within a relatively short period of operation, maybe as little as 1 or 2 hours.

BIODIESEL

The use of biodiesel has increased incrementally over the past few years. Some portion of this increase is due to the introduction and adoption of B2 fuel. Biodiesel B2 fuel is petroleum base diesel fuel cut with just 2% biodiesel. While cynics might argue that this is more about optics than substance, a response might be that if every fleet changed to B2 fuel this would represent at least some reduction in the dependence on imported petroleum products … with the additional bonus of at least a small decrease in noxious emissions. Operators that use B2 fuel get to put a sticker on the truck advertising how environmentally conscientious they are …. and in some jurisdictions, get a tax break thrown in …. while avoiding some of the performance problems experienced by users of higher percentage biodiesel cuts.

What is biodiesel?

Any biodiesel that finds its way into a truck fuel system should conform to American Society of Testing and Materials (ASTM) standard D 6751. ASTM defines biodiesel as a domestic, renewable fuel for diesel engines derived from natural oils such as soybean and other vegetable oils. It is NOT raw vegetable oil: a biodiesel must be refined (processed) so that all natural glycerin is removed from the oil. The term biodiesel can refer to 100% vegetable base fuel oil known as B100 … or a range of blends (known as *cuts*) of biodiesel and petroleum fuel oil. For instance, B20 is petroleum base diesel fuel blended with 20% ASTM D6751 biodiesel. Despite some reports to the contrary, using spent frying oil from fast food outlets will not be a likely large scale source of biodiesel due to the variables (read ‘contamination’) of the base oil and the cost of refining this to a reliably performing highway fuel.

Biodiesel and engine warranty

Diesel engine manufacturers warranty engines and are required to meet emissions standards using commercially available ASTM D1 and D2 fuels. When problems result in an engine that can be sourced to the fuel, the responsibility passes to fuel supplier and away from the engine OEM. However, while not wholeheartedly embracing the use of biodiesel, most engine OEMs have stated that the use of biodiesel cuts of 20% or less (B20 down to B2) will not void warranty. It is expected that the entire industry will incorporate ASTM biodiesel standards into performance profiles in the near future.

Biodiesel and the future

World-watch Institute (WWI) reports that in 2005, biofuels accounted for just 1% of global fuel consumption: while small, this 1% represents a doubling since 2001. You can take a look at the report using this link: www.worldwatch.org/node/4075
The forecast is for a significant increase in the use of biofuels in the United States, possibly increasing to up to 35% by the year 2030. However, there are limitations. If the entire 2005 U.S. soybean crop were to be converted to biodiesel, it would represent just 6% of the diesel fuel requirements of the transportation industry. An undesirable consequence of increasing the use of agriculturally derived fuels (biodiesel and ethanol as a gasoline substitute) is said to be an overall increase in domestic food costs.

Lube oil

The new generation of 2007 compliant diesel engines will also require a new oil standard that is currently known as PC-10. Once a formulation is agreed upon, this will be assigned an API code, almost certainly to be CJ-4. This change is likely to be official before the end of 2006. The primary feature of the new oil will be ultra low ash content with the objective of minimizing ash residuals discharged to the DPF assembly.

Engine Manufacturer Diagnostics (EMD)

Although truck chassis manufacturers have tended to be less proprietary than automobile OEMs when it comes to data bus access (ie, J1939/ CAN 2.0), the EPA is planning on adopting more structured regulations similar to the automotive OBDII. Mandatory universal access to any emissions related performance problem will be covered by Engine Manufacturer Diagnostics (EMD) which will govern common display codes.

NEW DIESEL EMISSION CONTROL HARDWARE

Tier 3 emissions have required all the diesel engine manufacturers to reengineer their product, sometimes significantly. Exhaust gas recirculation (EGR) systems were adopted by most engine OEMs to meet 2004 emissions standards: EGR systems of one type or another will become almost universal on highway diesels but essentially these have not changed since 2004. In this update report, we will take a look at mostly NEW technology so we will not reexamine EGR systems – though it does make sense to take a brief look at the newly introduced EGR system used on Caterpillar ACERT engines because it is distinct. With this in mind, in this section we will take a generic look at:

- Diesel particulate filters (DPFs) also known as particulate traps
- Selective catalytic reduction (SCR) systems
- NOx adsorber catalysts (NAC)
- Caterpillar's Clean Gas Induction (CGI) variation on EGR.
- Changes in fuel systems

NOTE: because the EPA have permitted diesel engine OEMs to stagger the meeting of NOx emissions standards (see previous table titled **EPA diesel emissions**), not all engines will be required to meet the 2007 standards until 2009. Bear in mind, the introduction of the foregoing technologies may not be immediate.

DIESEL PARTICULATE FILTERS (DPFs) These are also known as **particulate traps** and they have been around in the industry for a number of years usually in special applications such as a garbage packer required to operate inside for long periods of time. A DPF is an aftertreatment solution meaning that it addresses a regulated emission that has already been produced by the combustion process. Most engine manufacturers are attempting to minimize any cost increase to their 2007 engine families but this excludes DPFs which will now become common. Typically, a DPF will represent something around a $4,000 to $8,000 additional cost: though usually supplied by the engine manufacturer, DPFs will be considered an OEM chassis additional cost.

The typical DPF that will be used by most engine OEMs is a particulate trap integrated into a muffler/catalytic converter. The DPF/converter/muffler assembly combines an oxidation catalytic converter using platinum and palladium active media, with the DPF using cordierite or silicon carbide active media. As we said before, the DPF device is usually supplied to the chassis OEM by the engine manufacturer.

DPF operating principles

Operating temperatures of the combined oxidation converter and DPF can exceed 600 degrees Celsius so most of these devices incorporate heat shielding. Depending on the engine and its power rating, both single and dual canister versions are going to be used. Typically, single and dual canisters would be specified by horsepower rating as follows:

- Single canister: up to 500 BHP
- Dual canister: over 500 BHP

The idea behind a DPF is that engine-emitted soot first collects on the walls of the device. Engine manufacturers have designed DPFs to function primarily in self-regeneration mode. This means that when soot collection reaches a threshold level, it is burned off in what is known as a ***regeneration cycle***. In most cases, the regeneration cycle will occur when exhaust temperatures are sufficiently high during normal operation. When this regeneration takes place unassisted by additional fuel or air injection to the exhaust gas it is known as ***self-regeneration***. Self-regeneration can also be known as ***passive regeneration***: the terminology varies by engine OEM.

When the operating environment is not conducive to a self-regeneration cycle, regeneration can also occur assisted by injection of some fuel (diesel) ignited by spark plug. This mode of regeneration is known as ***active regeneration***. Fuel for an active regeneration cycle is usually sourced from the fuel subsystem and delivered at the specified charging pressure. For instance, on a Caterpillar ACERT C15, this would be at 250 psi delivered by an electromechanical injector.

Regeneration cycles are designed to occur at set intervals. These set intervals may be as often as once every hour, or as infrequent as once every 8 hours of operation depending on the engine and its power ratings. Truck drivers should be informed about the expected intervals of the regeneration cycles of the equipment they operate. During both passive and active regeneration, there will be an increase in exhaust gas temperatures.

The following outlines one engine manufacturer’s DPF cycles but is generally consistent with what will be used industry-wide:

1. Passive: occurs when exhaust temperatures are high enough for regeneration to occur without the assist of a flame burn-off cycle. This is intended to be the primary means of DPF regeneration that should usually occur when the vehicle is running down the highway with the engine under load. For instance, the normal passive cycle is designed to occur every 8 hours or so, on Caterpillar EUI-fueled highway diesels. During the normal passive cycle, DPF temperatures can exceed 600 degrees Celsius.

2. Passive plus: this is designed to occur after a prolonged period of idling as soot build-up reaches 125% and the DPF is becoming restricted. This mode of passive regeneration occurs at a much lower temperature than the normal passive regeneration cycle. A small quantity of fuel (much less than during active transient mode) and spark ignition is used. The objective is to burn off a little soot every 2 hours or so to maintain the status quo. During passive plus regeneration, DPF outlet temperatures do not exceed 400 degrees Celsius.

3. Active transient: set to occur when soot levels are at 100% and the DPF is becoming restricted. The vehicle must be traveling at a speed exceeding 20 mph for an active transient burn cycle to take place.

4. Active steady state: commanded by ET using a dash button. Vehicle must be at 0 mph and in park. Fuel is injected and a spark ignites the fuel.

Transient regeneration events will NOT occur when:

1. ambient temperatures are less than 20 degrees C
2. turbo-out temperature exceeds 550 degrees C (because passive regeneration is possible)
3. coolant temperature is (below) 65 degrees

Regeneration system (RS) alerts (broadcast on data bus by engine ECM)
When soot level exceeds 100% ……… RS light illuminates
When soot level exceeds 125% ……… RS light blinks
When soot level exceeds 150% ……… engine derates by 25%
When soot level exceeds 175% ……… engine derates by 75%
When soot level exceeds 200% ……… engine shuts down

Regeneration system hardware

The regeneration system (RS) hardware consists of a RS head incorporating:

- a fuel injector
- swirler plate
- spark plug
- cooling system ports

The fuel injector nozzle can be compared to the low pressure injectors used in gasoline fuel injection: the fuel injector is supplied by the diesel fuel subsystem at its specified charging pressure. A defective fuel injector is not serviceable and usually the whole RS head must be replaced.

The spark plug consists of an electrode only (does not self ground). It is designed to ground to a swirler plate located directly below it. Spark plug cycles are driven by the ECM. The gasket should be replaced any time the head is removed because it functions as an insulator.

Regeneration leaves some ash residues. These ashes are primarily sourced from the additive package in the engine lube that is burned in the cylinder during normal combustion. Ash residues have to be removed manually – Federal law requires that this occur no more frequently than once a year or 150,000 miles (whichever comes first) – some manufacturers are aiming to have RS service intervals that exceed 300,000 highway miles.

Because the RS spark plugs are fired routinely (that is, outside RS cycles) to limit RS carbon build-up CRS can be deactivated using ET to prevent activation on the shop floor. The DPFs used by most engine OEMs should usually regenerate under ANY conditions: some manufacturers are using DPFs with extended in-operation cycles but the disadvantage that they must pull off the road to regenerate.

Temperature monitoring is by dual and single thermocouples (pyrometers). The operating principles of pyrometers are discussed in Chapter 12 and it is important to note that these thermocouple devices must be replaced as a complete unit when diagnosed as failed.

Troubleshooting and servicing DPFs

DPFs can be evaluated by measuring total exhaust system backpressure. Each engine OEM produces its own backpressure specifications but there is not too much variance between them. During a full load dyno test, typical specified back-pressures (measured at DPF outlet) are in the region of 15 to 20 in/ H_20. Most engine OEMs will provide a maximum back pressure specification and if this is exceeded, the DPF requires shop cleaning. DPF shop cleaning requires the use of special apparatus provided by the OEM. Attempting to clean DPFs without using the specified tooling and method can result in damage.

DPF-related codes

DPF performance is monitored by the engine ECM and typically there are 3 types of failure that can trigger codes:

- high restriction
- failure to ignite
- failure to combust

DPF cleaning cart

Most of the engine OEMs state that their DPFs will require routine in-shop cleaning using special equipment: at the moment of writing, DPF shop cleaning equipment is supplied exclusively by the engine OEM. This is expected to change. The shop-based DPF cleaning cart is connected to the DPF in chassis in a procedure that essentially back-pressurizes the system for a period of around 20 minutes. The total time of the DPF cleaning procedure is expected to take less than 2 hours. Skill levels required to perform the cleaning are not expected to be that high.

SELECTIVE CATALYTIC REDUCTION (SCR). Like DPFs, selective catalytic reduction or SCR is also an aftertreatment process. While the DPF addresses particulate HC, a SCR system attempts to ‘reduce’ oxides of nitrogen (NOx) back to nitrogen and oxygen. Some OEMs are planning to use SCR on some of their engines though maybe not at the beginning of the 2007 production year: remember the staggered phase-in of NOx standards. The operating principles of SCR systems are described on page 209 of the engines book and it helps if you understand a little chemistry to see how these devices function. Very briefly, we will take a look at the simple chemistry behind SCRs here.

Oxides of nitrogen or NOx are formed when conditions in the combustion chamber have caused the normally inert nitrogen (N_2) component of air to oxidize to compounds of oxygen and nitrogen. SCRs attempt to ‘reduce’ these compounds back to harmless elemental oxygen (O_2) and nitrogen (N_2) that are constituents of air. Gasoline fueled auto engines have used NOx reduction catalytic converters (rhodium is the catalyst) for over 30 years, but these have the disadvantage of only being able to function when the AFR is at stoichiometric or richer. They do no function at all in a lean-burn diesel engine.

SCRs use consumable **urea** to achieve what the rhodium catalyst does in the gasoline fueled engine. Urea is composed of crystallized nitrogen compounds sourced from natural gas. The urea is in liquid form and is injected into the exhaust gas stream by a computer controlled injection system. After injection, the urea reduces to ammonia which itself reacts with NOx compounds, reducing them back to oxygen and nitrogen.

SCR is managed by the engine ECM. The urea is contained in aqueous/ water form (32%) in a replenishable vessel. It is injected upstream from the converter/DPF/muffler assembly assisted by on-chassis compressed air. The urea injection has to be precisely metered by the ECM. Too much urea can result in ammonia discharge through the exhaust system. Too little results in NOx emission.

Urea is carried onboard the truck in tanks with a capacities of 20 to 50 gallons. An aqueous urea solution freezes at 12-degrees Fahrenheit (minus 8-degrees C) so it must be freeze-protected in winter operation. The urea is consumed at a rate that varies between approximately 1.5% to 10% of the fuel used, the variability depending on how the engine is being operated that is, how much NOx has to be reduced.

In the U.S., urea costs about as much as the 2006 diesel fuel pump price. This means that there is some negative cost of operation impact. When urea injection is used as a NOx reducer it is consumable meaning that it must be routinely replenished: this concept has not been accepted by the EPA in the past. However, at least two diesel engine OEMs are planning on using urea injection to meet the phase-in NOx standard. Urea injection has been used in Europe for a number of years.

NOx ADSORBER CATALYSTS

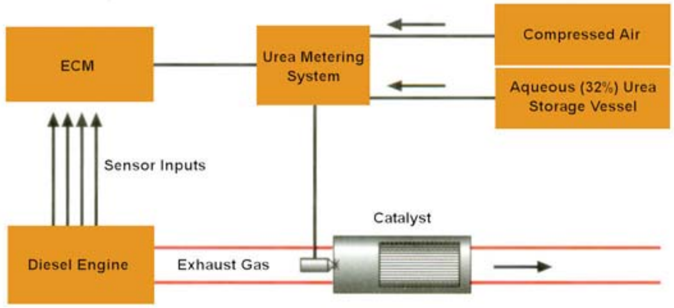
For well over thirty years, reduction catalysts have been used on gasoline fueled automobile engines: these have used a rhodium catalyst to 'reduce' NOx compounds back to elemental nitrogen and oxygen. When using rhodium as a reduction catalyst it is limited by the fact that it only functions as such when the air-fuel ratio is at stoichiometric or richer. Basically, this limitation meant that a rhodium based reduction catalyst could not be effective on a lean burn diesel engine that continuously dumps excess (unreacted) oxygen into the exhaust. With the introduction of the NOx adsorber catalyst, diesel engine designers found a way around this problem.

Adsorption is a chemical term that is best defined as *adhesion*: when a substance is adsorbed it does not undergo any significant chemical change so don't get this confused with the term *absorb*. NOx adsorber catalysts (NACs) use base metal oxides to initially 'store' NOx compounds, then use a rhodium reduction catalyst to reduce them back to N_2 and O_2 during an ECM-managed reduction phase. In the storage phase, NOx is adsorbed onto a metal (barium) oxide substrate: when the available NOx storage sites within the device are occupied, the engine ECM temporarily simulates a 'rich' (reduced oxygen) running condition or injects fuel directly into the exhaust system. Operation in this simulated 'rich' mode releases the NOx from its base metal storage locations and allows a rhodium catalyst to convert it to nitrogen gas (N_2), oxygen (O_2), and water vapor (H_2O). In other words a NAC functions in two stages:

- NOx storage: NOx is adsorbed to the base metal oxide substrate during the normal lean burn operation of the diesel engine.
- NOx reduction: the engine ECM temporarily operates the engine operation in a rich AFR mode or injects fuel into the exhaust system to simulate a rich AFR allowing a rhodium catalyst to reduce the NOx to elemental nitrogen (N_2), elemental oxygen (O_2), and water vapor (H_2O).

The key to enabling a NAC to function in its regeneration cycle, is to temporarily eliminate excess oxygen from the exhaust. NACs require the use of the new ULS fuel. Sulfur at any levels can be damaging to NACs and some systems will require occasional de-sulfation regenerative modes even when only the appropriate ULS fuel has been used. A de-sulfation regenerative cycle requires temporarily raising the exhaust temperatures using fuel injected directly into the exhaust system. NACs will be used initially on light duty diesel engines. The foregoing figure shows the basic operating principle of a NAC.

Selective Catalytic Reduction - SCR



Basic Principal - Injecting Urea into exhaust gas to "reduce" oxides of nitrogen back to elemental nitrogen and oxygen

CLEAN GAS INDUCTION (CGI).

Caterpillar was able to meet the EPA 2004 highway diesel engine emissions standards without resorting to using exhaust gas recirculation (EGR). However, Caterpillar will use a form of EGR to meet the 2007 standards. In chapter 45 we defined the objective of an EGR system as diluting the intake charge with 'dead' gas. Dead gas is unreactive gas: it enters the engine cylinder and does nothing but take up volumetric space. It is sort of like reducing the engine displacement during certain modes of operation. The objective is to reduce engine temperatures and therefore NOx output. The fact of the matter is that there is no better source of dead gas than the engine exhaust system because it is produced any time the engine is running.

Clean gas induction (CGI) is a variation on EGR used exclusively on Caterpillar's 2007 ACERT family of engines. It differs from EGR in that it sources its 'dead' exhaust gas downstream from diesel particulate filter (DPF) – meaning that it is 'clean EGR". CGI is monitored by mass airflow sensor (MAF) and just like its competitors EGR, the system's objective is to keep combustion temperatures lower to reduce NOx under certain running conditions. It is easy to identify a Cat CGI engine because the CGI pipe can be seen to exit the muffler/converter/ DPF assembly.

In terms of managing CGI cycles, the CGI gate is spring-loaded to default to no-recirculation. Gas from clean side of the DPF is admitted up to a15% mixture concenticity (with EGR systems this can be up to 30%). CGI is ECM-managed so it does not occur during DPF regeneration cycles.

CGI Sensors: A CGI uses three sensors. Two of these are pressure sensors, an absolute and pressure differential measurement sensors, while the third is a temperature sensor. Gas exiting the CGI venturi passes into a bundle type, coolant-cooled heat exchanger. In common with EGR engines, there is an advantage to cooling recycled exhaust gas. And Cat's heavy-duty family of engines will also use a pre-cooler. The CGI pressure sensor is a delta (3-terminal), variable capacitance type sensor.

The CGI gate is controlled by a pulse-width modulated (PWM) actuator, in other words, a linear proportioning solenoid, energized by V-Bat voltages.

FUEL SYSTEMS AND TUNE-UP

While the 2007 families of engines are going to be cluttered with plenty of emission control apparatus, the good news is that diesel fuel systems are beginning to become a lot more simple. Common rail (CR) fueling first became commonplace on small bore highway diesels back in 2001 but now it is being introduced on medium and large bore highway diesels. Navistar will be using a CR fuel system on their new family of medium bore diesel engines based on a MAN (Germany) platform. Caterpillar have opted to abandon the HEUI system on their ACERT C7 and C9 engines, they will be going with a newly engineered Cat CR system capable of peak injection pressures of up to 27,000 psi. Because CR fuel systems use electro-hydraulic injectors (see Chapter 20, pages 311-12), an NOP 'event' becomes entirely soft, having no pressure limitations below peak system pressure. An example of how this provides an advantage is during a cold start. By stepping up the pressure to the injectors during cranking, a CR injection system can greatly reduce the fuel droplet size minimizing ignition lag (pages 265-66) and enabling complete combustion even in subzero temperatures.

Electronic unit injectors (EUIs) will still be around but some OEMs have changed the way in which the nozzle assembly functions. The new style EUI adopts a 4-terminal, 2-solenoid control cartridge assembly. One solenoid is used to manage the effective stroke of the EUI plunger, while the other switches the integral nozzle. EUI effective stroke (see chapters 38, 39, and 40) is managed in the same way, but the (hard-limit) hydraulic injector nozzle is replaced with an ECM-controlled electro-hydraulic nozzle (see chapter 20) that can in theory be opened or closed at any pressure within the system's limitations.

Most engine OEMs have also simplified fuel injector/EUI installation and set-up procedures, especially where EUIs are concerned. EUI timing/height setting procedures have been generally replaced by a simple torque-to-spec operation. Programming of EUI fuel flow codes now becomes an operation enabled by the technician rather than one in which new codes have to be keystroke-programmed to the ECM. The new method reduces the possibility of human error by requiring a connection to the OEM data hub and downloading driver software for a replacement injector.

SUMMARY

You might well ask how the technician keeps up with the pace of change when working with modern truck technology. The answer is simple really, what has happened in recent years has changed the type of technician required by the trucking industry. Having the ability to remember sets of specifications and step-by-step details of an overhaul procedure may have been desirable assets for past generations of technicians but these skills do not count for much today because by the time you have remembered a procedure, it has become obsolete. Modern technicians work with, and are not afraid to reference, *service literature*. And don't expect to find service literature in a book. Service literature is for the large part on-line, usually only accessible by means of OEM-managed, electronically-secure (well, at least as much as anything is these days!) data hubs. As truck technician pay scales have increased, so have the standards expected of them. Maintaining these standards requires accepting professional development (continual learning) as simply part of your job.