Heavy-Duty Vehicles Hit Goals Through Ongoing Innovation

Progress is being made in meeting the challenges posed by fuel economy and emission rules as well as customer needs.

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Nonroad, on-highway, construction, hauling, agriculture, environmental, marine. Engine specs. Phased regulations. Just as lions, tigers and grizzly bears are at the apex of their respective ecosystems, these are all at or near top of mind in the heavy-duty vehicle and equipment industry. And just as dealing with apex predators requires skill and effort, developing the technology for new applications and to meet various engine economy and emission standards for different types of trucks and equipment is tough work. There are more challenges after that. Once the development and design of the technology is complete ways must be found to manufacture it in an efficient, effective, timely and affordable manner.

It's All About Class

Gross vehicle weight (GVW) classes 1-8 are defined by the US Federal Highway Administration and used throughout the industry. GVW is the maximum operating weight a truck can carry, including the truck itself, cargo, fuel and passengers. Medium-duty includes Classes 3–6 [10,001–26,000 lb (4536–11,793 kg)], with examples (thanks to the Oak Ridge National Laboratory Center for Transportation Analysis, Knoxville, TN) being a heavy-duty pickup truck (Class 3), a box truck (Class 4), a utility company’s bucket truck (Class 5) and a school bus (Class 6).
In the heavy-duty category are Classes 7 and 8 (26,001 lb to >33,000 lb (11,793 kg to >14,969 kg)). Class 7 vehicles might be refuse trucks or city buses. Class 8 vehicles include concrete mixer trucks, tractor trailers (18-wheelers with five axles) and single-unit dump trucks with three or more axles. Beyond vehicles in these classes are other pieces of special purpose motorized heavy-duty equipment ranging to the enormous, such as locomotives, steam shovels, pile drivers and tunnel borers—things that make the neighborhood trash truck look like a toy.

Rules in Tiers and Phases

Engines powering nonroad vehicles have been subject to several phases of fuel efficiency and emissions regulations. These vehicles work in diverse applications and involve many different operating characteristics and engine technology, and standards have been introduced over several decades.

Administered by the US Environmental Protection Agency, the current rules—Tier 4—were phased in from 2008 to full effect on January 1, 2015, and cover emissions requirements for nonroad diesel engines. Tier 4 establishes emissions for particulate matter, oxides of nitrogen (NOx) and air toxins emitted by new, nonroad diesel engines. Since 2007 only diesel engines have been allowed in the heavy-duty segment, and ultra-low sulfur diesel fuel (15 ppm maximum) is required.

Another term—Phase 2—refers to standards for lower fuel consumption and greenhouse gas emissions for the medium and heavy-duty vehicle (MHDV) commercial (on-highway) class. Phase 1 rules, in effect since 2011, cover vehicles from model year 2014 through model year 2018. Phase 2, announced in June 2015 and expected to be finalized in 2016, would affect such vehicles after model year 2018. The standards will phase in over the next decade in three steps, provide leading time for technology development and adoption. This is the phase in which manufacturing solutions are being developed and will soon be implemented.
Engine Updates

Always facing continuous changes in regulations and standards, engine builders have to stay on top of product innovation for both the nonroad and on-highway MHDV market. Fuel consumption is a major factor. According to the recently released “Review of the 21st Century Truck Partnership: Third Report” published by the National Academies Press, in 2012 MHDVs “consumed about 25% of the petroleum used by on-road vehicles in the US transportation sector,” with consumption expected to increase “by about 40% between 2012 and 2040, from about 2.8 million bbl/day [barrels per day] to 3.91 million bbl/day. About 70% of the fuel used by MHDVs is used by Class 6 and Class 8 trucks,” where diesel engines dominate.

Since January 1, 2016, Tier 4 emissions rules also apply to high and medium-speed diesel engines (ratings equal to and greater than 1400 brake kilowatts) used in such marine vessels as ferries, small cargo boats, work boats and government vessels. These rules are the most significant reduction demanded in marine emission levels to date, specifically for NOx. Diesel engines tend to be most feasible, but cleaner fuels like natural gas are under consideration in this situation.

Engine producers such as Cummins Inc. (Columbus, IN) and GE Transportation (Chicago) cleared the 2015 Tier 4 regulatory bar early for MHDV and other applications. GE’s Evolution Series medium-speed, 12-cylinder diesel engine, updated for EPA Tier 4, was production tested in early 2015 prior to installation in a GE Evolution Series locomotive. The engine is also available for marine applications. It produces the same 4400 hp as its 16-cylinder predecessor using less fuel, creating fewer emissions and having extended overhaul intervals. Enhanced cooling and higher-strength materials improve reliability and allow for future increases in power and efficiency. The engine also is offered in a 16-cylinder configuration that delivers 6000 hp (4413 kW).

In October 2015, Cummins shipped the first production 95-liter, 16-cylinder QSK95 engine built to a rail specification. The engine, rated at 4400 hp (3281 kW), was delivered to the Siemens manufacturing facility in Sacramento, CA, where it will be installed in a Charger diesel-electric passenger locomotive. The engine is capable of supporting a top locomotive speed of 125 mph (201 kph) and reportedly achieves the highest output of any 16-cylinder high-speed diesel. A modular fuel system, quad-turbocharging and exhaust aftertreatment help the QSK95 reach the ultra-low emissions required by EPA Tier 4 standards.

“We’re combining innovation with building on proven technologies. On our 2017 X15 engine, for example, we’ve optimized the compression ratio, air handling system and cam profile to gain better efficiency and performance,” said Jackie Yeager, director—emissions and fuel efficiency policy, at Cummins.

“Building on existing EGR/DPF/SCR [exhaust gas recirculation/diesel particulate filter/ selective catalytic reduction] engine architecture, there is significant opportunity for further engine efficiency improvement, including on the base engine system we have today, through improving combustion, air handling efficiency, friction and aftertreatment efficiency,” she added. “There is also continued work on increased powertrain efficiencies like the SmartAdvantage product as well as telematics and other technologies.” Cummins’ latest generations of midrange and heavy-duty engines are ready for 2017 greenhouse gas and fuel efficiency standards. Field-test drivers have reported a superior driving experience that has
surpassed expectations in both pulling and braking power, fuel efficiency and uptime.

MTU America Inc. (Novi, MI), part of MTU Friedrichshafen, a core business of Rolls-Royce Power Systems, a division of Rolls-Royce plc (London), develops and manufactures large, high-speed, high-performance engines and propulsion systems for ships and heavy land, rail and defense vehicles. Drive systems for the oil & gas industry and in power generation are also available. The diesel engines and gas engines have power outputs from 75 kW (Series 900) to 3000 kW (Series 4000). Fuel consumption reduction is accomplished by a second-generation common rail injection system and intelligent engine management. Optimized, efficient combustion and cooled exhaust gas recirculation (EGR) meet Tier 4 emissions specifications. Above 750 kW, exhaust aftertreatment is not needed; in the Series 2000/4000 engines, Tier 4 is met with EGR alone.

Fuel Reduction Strategies

Hybrid, bi-fuel, natural gas and propane alternatives have been explored to meet both fuel consumption reduction standards and emissions requirements for heavier-class vehicles. In April, Cummins, partnering with PACCAR (Bellevue, WA) and with participation from Ohio State University (Columbus, OH), the National Renewable Energy Laboratory (Golden, CO) and Argonne National Laboratory (Lemont, IL), was awarded a $4.5 million grant from the US Department of Energy (DOE) for development of a Class 6 commercial plug-in hybrid-electric vehicle that can reduce fuel consumption by at least 50% over conventional Class 6 vehicles [19,000–26,000 lb (8618–11,793 kg)]. An optimized powertrain matched with an engine with the best architecture will act as an electric vehicle range extender, with the engine managing the charge level of the battery pack.

Fuel is a significant portion of operating costs for diesel-powered fracking engines on a typical onshore well.
stimulation spread. Interest has increased in lower-priced, well-site available and environmentally friendly natural gas, aftermarket-installed in a bi-fuel system. MTU’s integrated diesel-natural gas bi-fuel engine has met the demands for a field-installable kit that keeps all internal diesel engine components and ensures safe and reliable operation at original engine specs. The control architecture is designed specifically for the company’s frack engines. Efficient bi-fuel operation is achieved by engine-mounted sensors and electronic fuel metering for an exact air-fuel ratio for a given load, speed and gas quality.

Compressed natural gas (CNG), liquefied natural gas (LNG) or biomethane can efficiently and cleanly fuel MHDVs. Cummins Westport Inc. (Vancouver, BC) ISL G and ISX12 G engines are EPA and California Air Resource Board emissions compliant. They also meet EPA and US Department of Transportation fuel-economy guidelines. The engines can be operated on up to 100% biomethane from landfills or anaerobic digestion, an important consideration as the use of biomethane to fuel refuse-collection and hauling vehicles increases. The natural gas engines, built at plants in Rocky Mount, NC, and Jamestown, NY, are delivered to numerous truck and bus OEMs for installation into school buses, motorcoaches, refuse trucks, truck tractors, sweepers and other vehicles.

McNeilus Truck & Manufacturing Inc. (Dodge Center, MN), an Oshkosh Corp. (Oshkosh, WI) company, and Agility Fuel Systems (Santa Ana, CA) are working together on a comprehensive natural gas solution for North American heavy-duty fleets. Through its Next Generation Initiatives (NGEN) program, McNeilus designs, installs and services CNG systems for all types of heavy-duty fleets. Agility’s strategic partnership with Cummins is expected to benefit an optimally integrated engine and fuel system with performance enhancements, diagnostics improvements and telematics services.

LP propane engines [Power Solutions International (PSI) 8.8-liter] from IC Bus LLC (Lisle, IL), a subsidiary of Navistar, are installed in 149 CE Series buses delivered to the Waterbury Public Schools (CT). The engine provides diesel-like performance with higher torque at lower engine speeds, which greatly benefits stop-and-start and minimizes constant engine revving, reducing wear and maintenance.

Need Heavier?

As if heavy-duty didn’t connote big and tough strongly enough, International Truck Inc. (Lisle, IL), also a Navistar subsidiary, describes several of its lines as “severe duty.” HX, PayStar and WorkStar Series trucks, rated from 74,000 to 150,000 kg GVWR with engine options from Cummins (ISX15, ISB 6.7, ISL9) and Navistar (N9, N10, N13), have outputs up to 475 and 600 maximum hp (354 and 447 kW) and 1700 and 2050 lb-ft (2305 and 2779 N•m) torque.

Manufacturing of mining industry equipment has declined hand in hand since 2013 with the bumpy fall in mined commodities. There are fewer manufacturers in the industry, one continuing to be Caterpillar Inc. (Peoria, IL), although strategic review of some product offerings is under way while still supporting customers. Cat’s manufacturing footprint will change with the repurposing of its Winston-Salem, NC, facility from a mining to a rail facility operating under the Progress Rail sub-

A lightweight heavy hauler with an all-aluminum cab, the 9900i from International Truck is designed to maximize fuel efficiency.
Mining solutions firm Joy Global Inc. (Milwaukee) in July agreed to be acquired by Komatsu America Corp., a subsidiary of Komatsu Ltd. (Tokyo). The combined organization will continue to focus on developing technologies that provide safety, productivity and life cycle cost improvement for customers. Joy Global’s P&H, Joy and Montabert branded equipment serve a variety of markets in energy, hard rock and industrial minerals. Komatsu has a global footprint in construction and mining equipment and other industrial machinery and vehicles.

Digging in the Trash

The behemoths roar through the subdivision, collecting trash and recycling and driving their haul away to a transfer facility. Route efficiency and meeting community needs are among the top areas of focus for environmental services vendors. A rising trend in the refuse industry is pickup of organic waste. McNeilus Truck & Manufacturing offers an “organics package” for all of its rear-loader truck models, incorporating design features for better collection and containment of wet, heavy food waste and other organic material. The package can also be retrofit to existing trucks.

Key to keeping in liquid discharge is a full-height tailgate-to-body seal. By increasing the overall height to 96” (2440 mm), the extended seal protects along the full tailgate height. Traditional tailgate seals are 39” (990 mm). Sweep panel edges and brush skirting help contain organic material and liquids during compaction. A standard 40-gal (151-L) leachate tank, with options for 50, 60 and 90 gal (189, 227 and 341 L) diverts liquid from the body and holds it for easier disposal later. With contamination a major cause of hydraulic failure and downtime for refuse fleets, hardened tool steel shavers on McNeilus’ Excalibre cylinders keep corrosive organic material and plastic bags off the cylinder rods, preventing them from passing through the seal into the hydraulic system.

A pioneer starting with building refuse truck bodies (using the then-new process of electric welding) for Milwaukee, WI, in the early 1900s, Heil Environmental (Chattanooga, TN) combines its DuraPack body with the Rapid Rail arm for a vehicle with lifting capacity up to 1600 lb (726 kg) and the ability to do efficient residential, commercial and multifamily collection. Environmental services providers can eliminate the need for a chase truck, using one unit due to the greater payload volume and making fewer trips to the landfill.

Ultimately, “stuff” ends up at a landfill. Big machines work there, too, rumbling and rolling on mounds of refuse. Caterpillar’s new 816K landfill compactor has a robotically welded main structure and a full box-section rear frame that resists torsional shock and twisting forces, heavy-duty steering cylinder mounts and an axle-mounting design optimized for increased structural integrity.

The compactor is equipped with a Cat C7.1 ACERT engine and uses the Cat Next Generation high-pressure/common-rail fuel system to deliver fuel in precise microbursts during each cycle for efficient combustion. Control systems lower the engine’s average working speed for reduced heat loads and added fuel efficiency. An engine-idle-shutdown system saves fuel by eliminating excess idling.

Sidiart. Manufacturing of some components used in large mining trucks will move from Winston-Salem to an existing facility in Decatur, IL.