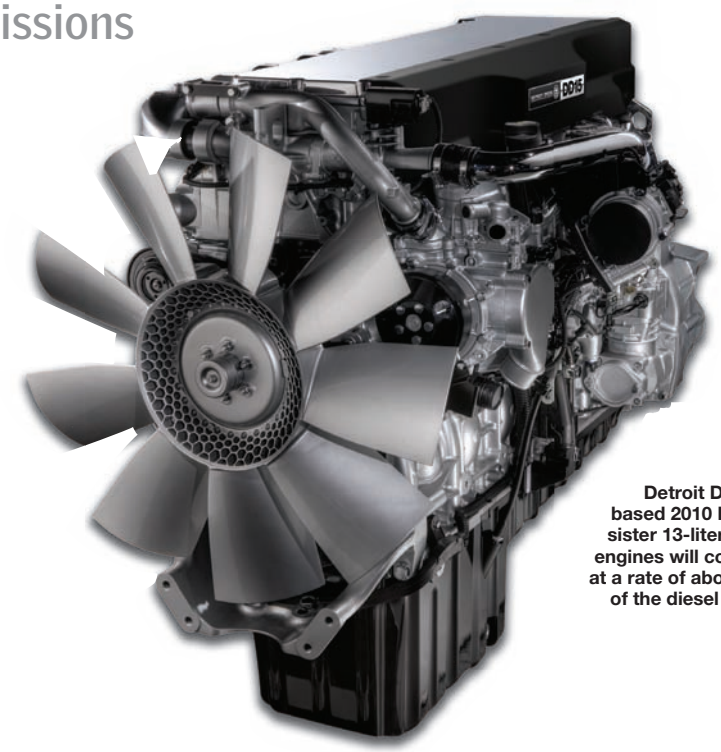
Clearing the air

As 2010 approaches, most diesel engine makers line up on side of SCR for cutting emissions



Detroit Diesel's SCR-based 2010 DD15 and its sister 13-liter and 16-liter engines will consume urea at a rate of about 2 percent of the diesel fuel burned.

Preparing for the next round of U.S. Environmental Protection Agency emissions standards has divided the U.S. heavy-duty diesel engine industry into two camps as far as the best way to meet the 2010 standard of only two-tenths of a gram of nitrogen oxides per horsepower hour. That's just a tenth of the NOx allowed in 2004, a percentage reduction comparable to the drop in soot enabled by the diesel particulate filter, which was introduced with the 2007 engine changes.

When Cummins – the single-largest on-highway heavy-duty engine supplier in North America – announced Aug. 13 that its engines would use selective catalytic reduction, the balance of engine makers relying primarily on SCR and those employing only exhaust gas recirculation changed substantially. Now at least five manufacturers – Cummins, Detroit Diesel, Mack, Paccar and Volvo – will use SCR, a form of aftertreatment, to reduce NOx outside the engine.

Cummins' original approach to 2010 had been to add a new XPI common-rail injection system so the engine would need to swallow less air, and then raise the amount of exhaust being recirculated. With this technology, only a small increase in EGR was needed, and the engine would not be overstressed.

However, the company had explored a new copper-zeolite SCR catalyst that reduced the amount of diesel exhaust fluid needed. With a steep rise in fuel prices in recent months, adding this form of SCR to the other modifications became the lowest cost move for engine users.

International, with its proprietary MaxxForce engine, stands alone in saying it will rely on high-pressure fuel injection systems to reduce NOx through enhanced cooled EGR without an aftertreatment in heavy-duty applica-

tions for its 2010 solution.

The other major change coming to the engine landscape involves Caterpillar. In June, the company announced it will not produce an engine for North American on-highway truck makers that will meet stricter 2010 emissions standards.

The technology choices in many ways mirror what these engine makers' European sister companies and strategic partners are doing to meet current and upcoming emissions reductions on that continent. Mercedes-Benz and Volvo AB – affiliates of Detroit Diesel and Volvo/Mack, respectively – already use SCR in Europe. The same goes for Paccar, which uses SCR in diesel engines built for its DAF trucks and likewise will use SCR for Paccar engines in Kenworth and Peterbilt heavy-duty trucks beginning in 2010.

What are the advantages of the two kinds of emissions control technology? It may come down to how you operate – and what happens to the price of fuel between now and 2010.

SCR feeds a small amount of ammonia-containing urea solution into a catalytic exhaust chamber, where the ammonia combines with NOx to form harmless byproducts. Urea occurs naturally in the urine of humans and other mammals. The urea used in trucks will be manufactured as an industrial chemical, rather than being derived from livestock, however. Many in the industry prefer to call it "diesel exhaust fluid" or DEF.

"Using SCR will be similar to turning the clock back to the days before EGR engines," says Ed Saxman, Volvo's drivetrain product manager. "Urea and NOx become nitrogen and water. That's how SCR aftertreatment works. Why are we going to use it to kill NOx? Because everything else the engine makes can be reduced by making combustion more efficient."

Not needing to reduce the NOx to 2010 levels inside the combustion chamber allows the engine to be "tuned" for higher efficiency, Saxman says. This likely means adjusting injection timing so injection begins earlier, closer to where the engine gives the highest fuel efficiency. But, even engines using SCR will still have to produce relatively little NOx in order to avoid requiring excessive doses of DEF.

Cummins said it changed its mind based on data establishing the superiority of new copper-zeolite SCR catalyst technology compared to the conventional iron-zeolite technology commonly used in SCR catalysts. Copper zeolite-based SCR will offer improved heat rejection, more efficient conversion of NOx, lighter weight and improved fuel economy over EGR-only engines and SCR catalyst systems based on iron zeolite, Cummins says.

What about the cost of adding urea, a new chemical, to the mix? Urea will be consumed at a rate of roughly 3 percent of the diesel fuel burned, Saxman says. Urea is made using natural gas rather than crude oil, so urea costs only 75 percent as much as diesel fuel, he says. Moreover, "Diesel fuel [prices] will go up faster than urea," Saxman says.

Detroit Diesel's 2010 DD15 and its sister 13-liter and 16-liter engines will consume urea at a rate of about 2 percent of the diesel fuel burned, says David Siler, Detroit's marketing director. While SCR engines potentially have higher upfront costs, the long-term benefits more than make up for that, Siler says. "The financial implications of our choice were in the center of our discussion on which path to take in 2010."

Urea should be readily available because other sectors already demand it in large amounts: Agriculture uses it in fertilizer, and utilities use it to reduce NOx emissions at power plants. Truck stops and other fuel outlets are making plans for widespread distribution.

In the Paccar platform, as in other 2010 engines, SCR will be used in concert with EGR. Craig Brewster, Paccar assistant vice president, says the company's vehicles have operated SCR emissions systems in Europe successfully for years.

Paccar's $400 million engine production facility in Columbus, Miss., is expected to be completed by late 2009. The facility will produce the 12.9-liter and 9.2-liter MX and PR engines, respectively, for Kenworth and Peterbilt tractors, launching Paccar heavy-duty engines in the North American market.

International's new MaxxForce line of engines will address emissions requirements via EGR through an advanced fuel system, air management, combustion and controls.

International plans to meet the 2010 standards with its new MaxxForce engine line. A new plant in Huntsville, Ala., is producing the on-highway big-bore variants of the MaxxForce line of heavy- and medium-duty engines.

"I have publicly been an advocate of customer-friendly emissions control solutions that do not add additional costs to our truck and bus customers' operations," says Daniel Ustian, chairman and chief executive of International parent Navistar. "While SCR is a means to achieve the NOx reduction requirement for 2010, it comes with a steep cost to our customers. Our ability to achieve our goals without adding customer cost and inconvenience is a competitive advantage for International."

A different means of dealing with EGR is demonstrated in the SCR camp, in the new Detroit Diesel DD15: The fuel will be pumped in slowly at first, then much faster later, during each injection cycle. This means the engine needs less air while achieving the same smoke limit, says Edward Crawford, Detroit director of product engineering.

ENGINE SPECS. The engines included in the spec listings represent the products that are most popular with owner-operators. Consult a dealer for information on other models; contact information begins on Page 6. ■

Engines

C13 ON-HIGHWAY WITH ACERT TECHNOLOGY

Configuration: In-line 6-cylinder
Displacement: 763 cu. in. (12.5 liters)
Bore x stroke: 5.12 in. x 6.18 in. (130 mm x 157 mm)
Weight: 2,610 lb. (1,184 kg)
Biodiesel blend approval: B20, B5

CATERPILLAR®

C15 ON-HIGHWAY WITH ACERT TECHNOLOGY

Configuration: In-line 6-cylinder
Displacement: 928 cu. in. (15.2 liters)
Bore x stroke: 5.4 in. x 6.75 in. (137 mm x 171 mm)
Weight: 3,090 lb. (1,402 kg)
Biodiesel blend approval: B20, B5

*Two multitorque offerings are provided for each rating

(a) GFRSS option available for Eaton Fuller RTLOC 16909A-T2
(b) GFRSS option available for Eaton Fuller RTLOC 18909A or 18909A-T2

ADVERTISED HORSEPOWER	MAXIMUM HORSEPOWER	PEAK TORQUE (lb-ft)	GOVERNED SPEED (rpm)
305	320	1150	2100
335	350	1250	2100
350	365	1350	2100
350	365	1450	2100
350	420	1550	2100
370	385	1350	2100
370	385	1450	2100
380	395	1450	2100
410	425	1550	2100
410*	425	1450/1550	2100
430	445	1550	2100
430	445	1650	2100
430* (a)	445	1550/1750	2100
470	485	1550	2100
470	485	1650	2100
470*	485	1550/1750	2100
435	450	1550	2100
435	450	1650	2100
435*	450	1550/1650	2100
435* (a)	450	1550/1750	2100
475	490	1650	2100
475	490	1850	2100
475*	490	1650/1750	2100
475* (b)	490	1650/1850	2100
500	515	1850	2100
550	550	1850	2100
600	600	1850	2100
600	600	2050	2100
625	625	2050	2100

ISM

Configuration: In-line 6-cylinder
Displacement: 11 liters
Dry weight: 2,206 lb. (1,000 kg)
Governed speed: 2,100 rpm
Biodiesel blend approval: B20

Cummins®

MODEL	ADVERTISED HP	PEAK TORQUE (lb-ft @ rpm)
ISM 410	410	1550 @ 1200
ISM 370	370	1450 @ 1200
ISM 370	370	1350 @ 1200
ISM 350	350	1350 @ 1200
ISM 350	350	1250 @ 1200
ISM 330	330	1350 @ 1200
ISM 330	330	1250 @ 1200
ISM 310	310	1150 @ 1200
ISM 280	280	1150 @ 1200

SMARTTORQUE RATINGS

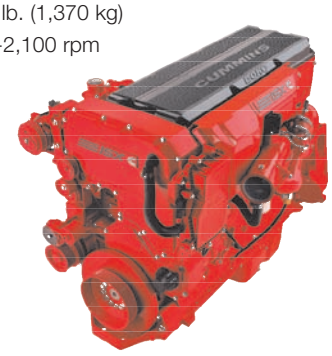
ISM 350 ST	350	1350/1450 @ 1200
ISM 330 ST	330	1250/1350 @ 1200

VOCATIONAL RATINGS

ISM 425V	425	1550 @ 1200
ISM 385V	385	1450 @ 1200
ISM 385V	385	1350 @ 1200
ISM 350V	350	1450 @ 1200
ISM 350V	350	1350 @ 1200
ISM 320V	320	1150 @ 1200

ISX

Configuration: In-line 6-cylinder
Displacement: 15 liters
Dry weight: 3,021 lb. (1,370 kg)
Governed speed: 2,000-2,100 rpm
Biodiesel blend approval: B20



VOCATIONAL RATINGS

MODEL	ADVERTISED HP	PEAK TORQUE (lb-ft @ rpm)
ISX 500V	500	1850 @ 1200
ISX 500V	500	1650 @ 1200
ISX 435V	435	1450 @ 1200

MODEL	ADVERTISED HP	PEAK TORQUE (lb-ft @ rpm)
ISX 600	600	2050 @ 1200
ISX 600	600	1850 @ 1200
ISX 550	550	1850 @ 1200
ISX 525	525	1850 @ 1200
ISX 500	500	1850 @ 1200
ISX 500	500	1650 @ 1200
ISX 485	485	1850 @ 1200
ISX 485	485	1650 @ 1200
ISX 450	450	1650 @ 1200
ISX 450	450	1550 @ 1200
ISX 425	425	1650 @ 1200
ISX 400	400	1450 @ 1200

SMARTTORQUE RATINGS

ISX 500 ST	500	1650/1850 @ 1200
ISX 485 ST	485	1650/1850 @ 1200
ISX 455 ST	455	1550/1750 @ 1200
ISX 450 ST	450	1550/1750 @ 1200
ISX 450 ST	450	1450/1650 @ 1200
ISX 425 ST	425	1550/1750 @ 1200
ISX 425 ST	425	1450/1650 @ 1200
ISX 400 ST	400	1550/1750 @ 1200
ISX 400 ST	400	1450/1650 @ 1200
ISX 385 ST	385	1450/1550 @ 1200

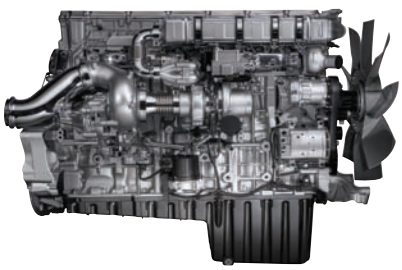
ISC

Configuration: In-line 6-cylinder
Displacement: 9 liters
Dry weight: 1,630 lb. (739 kg)
Governed speed: 2,200-2,400 rpm
Biodiesel blend approval: B20

MODEL	ADVERTISED HP	PEAK TORQUE (lb-ft @ rpm)
ISC 330	330 (246)	1000 (1356) @ 1400
ISC 315	315 (235)	1000 (1356) @ 1400
ISC 300	300 (224)	860 (1166) @ 1300
ISC 285	285 (213)	800 (1085) @ 1300
ISC 260	260 (194)	800 (1085) @ 1300
ISC 260	260 (194)	660 (895) @ 1300
ISC 240	240 (179)	660 (895) @ 1300

DD15 14.8-LITER

Configuration: In-line 6-cylinder with DDEC VI Control
Displacement: 906 cu. in. (14.8 liters)
Bore x stroke: 5.47 in. x 6.42 in. (139 mm x 163 mm)
Weight: 2,970 lbs.
Rated speed: 1,800 rpm
Compression ratio: 18.4:1
Biodiesel blend approval: B5



MAXIMUM HP (@1800 rpm)	TORQUE (lb-ft @ rpm)
455	1550 @ 1100
475	1550 @ 1100
455	1650 @ 1100
475	1650 @ 1100
505	1650 @ 1100
475	1750 @ 1100
515	1750 @ 1100
485	1850 @ 1100
500	1850 @ 1100
530	1850 @ 1100
560	1850 @ 1100

Engines

DD13 12.8-LITER

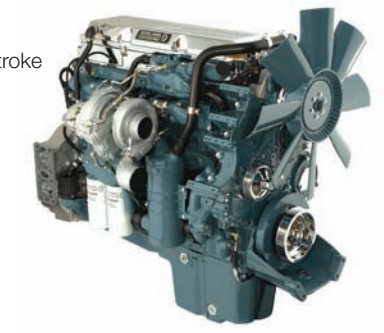
DETROIT DIESEL

Configuration: In-line 6-cylinder with DDEC VI Control
Displacement: 781.12 cu.-in. (12.8 liters)
Bore x stroke: 5.20 in. x 6.15 in. (132 mm x 156 mm)
Weight: 2,540 lbs.
Rated speed: 1,900 rpm
Compression ratio: 17.3:1
Biodiesel blend approval: B5

MAXIMUM HP (@1800 rpm)	TORQUE (lb-ft @ rpm)
350	1350 @ 1100
380	1350 @ 1100
410	1450 @ 1100
450	1560 @ 1100
450	1650 @ 1200

SERIES 60 14-LITER

Configuration: In-line 6-cylinder four-stroke with DDEC VI Control
Weight: 2,557 lb.
Bore x stroke: 5.17 in. x 6.61 in.
Rated speed: 1,800 rpm
Compression ratio: 17:1
Biodiesel blend approval: B5



MAXIMUM HP (@1800 rpm)	TORQUE (lb-ft @ rpm)
425	1450 @ 1100
445	1450 @ 1100
455	1550 @ 1100
470	1650 @ 1100
490	1550 @ 1100
515	1450 @ 1100
515	1550 @ 1100
515	1650 @ 1100

NAVISTAR® ENGINE GROUP

MAXXFORCE 10

Configuration: In-line 6-cylinder
Displacement: 570 cu.-in. (9.3 liters)
Aspiration: Turbocharged
Dry weight: 1,560 lbs. (708 kg)
Combustion system: Direct Injection
Biodiesel blend approval: B5

MAXIMUM HP	PEAK TORQUE (lb-ft @ 1,200 rpm)
310	1050
330	1150
350	1150

MAXXFORCE 11

Configuration: In-line 6-cylinder
Displacement: 641 cu. in. (10.5 liters)
Aspiration: Twin-series turbochargers, air/liquid intercooled
Dry weight: 2,244 lbs. (1,018 kg)
Combustion system: Direct Injection
Biodiesel blend approval: B5

MAXIMUM HP	PEAK TORQUE (lb-ft @ 1,000 rpm)
330	1250
370	1350
390	1400

NAVISTAR® ENGINE GROUP

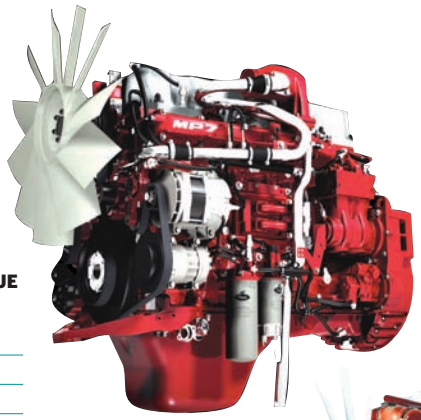
MAXIMUM HP	PEAK TORQUE (lb-ft @ 1,000 rpm)
410	1450
430	1550
475	1700

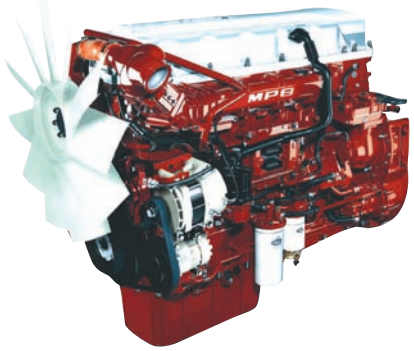
MAXXFORCE 13

Configuration: In-line 6-cylinder
Displacement: 757 cu. in. (12.4 liters)
Aspiration: Twin-series turbochargers, air/liquid intercooled
Weight: 2,244 lbs. (1,018 kg)
Biodiesel blend approval: B5

MP7

Configuration: In-line 6-cylinder
Displacement: 636 cu. in. (11 liters)
Weight: 2,270 lb. (1,030 kg)
Peak torque speed: 1,200 rpm
Biodiesel blend approval: B5, soy methyl ester





MODEL	MAXIMUM HORSEPOWER	PEAK TORQUE (LB-FT)
325E Econodyne	325 @ 1500-1800	1260
355E Econodyne	355 @ 1500-1800	1360
405E Econodyne	405 @ 1500-1800	1460
345C MaxiCruise	345 @ 1500-1700	1360
365C MaxiCruise	365 @ 1500-1700	1460
395C MaxiCruise	395 @ 1500-1700	1560
325M Maxidyne	325 @ 1500-1900	1200
365M Maxidyne	345 @ 1500-1900	1340
405M Maxidyne	405 @ 1500-1900	1480

MP8

Configuration: In-line 6-cylinder
Displacement: 751 cu. in. (13 liters)
Weight: 2,560 lb. (1,161 kg)
Peak torque speed: 1,200 rpm
Biodiesel blend approval: B5, soy methyl ester

Mack

MODEL	MAXIMUM HORSEPOWER	PEAK TORQUE (LB-FT)
425E Econodyne	425 @ 1500-1800	1560
455E Econodyne	455 @ 1500-1800	1660
485E Econodyne	485 @ 1500-1800	1660
415C MaxiCruise	415 @ 1500-1700	1660
445C MaxiCruise	445 @ 1500-1700	1660
485C MaxiCruise	485 @ 1500-1700	1660
425M Maxidyne	425 @ 1500-1900	1540
455M Maxidyne	455 @ 1500-1900	1650
485M Maxidyne	485 @ 1500-1900	1700

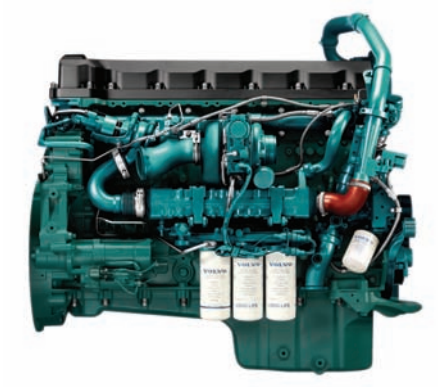
Engines

Volvo Trucks. Driving Success.®

D11

Configuration: In-line 6-cylinder
Displacement: 661 cu. in. (10.8 liters)
Bore x stroke: 4.84 in. x 5.98 in. (123 mm x 152 mm)
Weight: 2,246 lb. (1,019 kg)
Governed rpm: 2,100
Biodiesel blend approval: B5

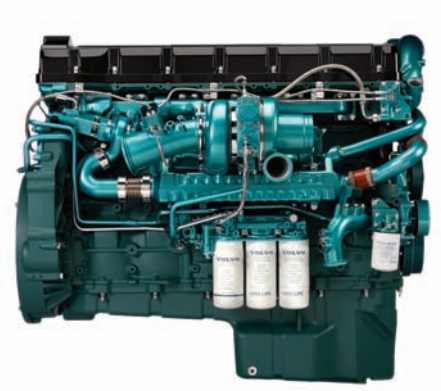
ADVERTISED HORSEPOWER	MAXIMUM HORSEPOWER	PEAK TORQUE (lb-ft @ rpm)
325	325 @ 1350	1250 @ 1100
355	355 @ 1500	1250 @ 1100
365	365 @ 1450	1350 @ 1100
385	385 @ 1400	1450 @ 1100
405	405 @ 1450	1450 @ 1100



D13

Configuration: In-line 6-cylinder
Displacement: 780 cu. in. (12.8 liters)
Bore x stroke: 5.16 in. x 6.22 in. (131 mm x 158 mm)
Weight: 2,519 lb. (1,143 kg)
Governed rpm: 2,100
Biodiesel blend approval: B5

ADVERTISED HORSEPOWER	MAXIMUM HORSEPOWER	PEAK TORQUE (lb-ft @ rpm)
335	340 @ 1300	1350 @ 1100
375	380 @ 1400	1450 @ 1100
405	410 @ 1450	1450 @ 1100
425	435 @ 1500	1550 @ 1100
435	445 @ 1400	1650 @ 1100
485	485 @ 1550	1650 @ 1100



D16

Configuration: In-line 6-cylinder
Displacement: 984 cu. in. (16.1 liters)
Bore x stroke: 5.67 in. x 6.50 in. (144 mm x 165 mm)
Weight: 3,047 lb. (1,382 kg)
Governed rpm: 2,000
Biodiesel blend approval: B5

ADVERTISED HORSEPOWER	MAXIMUM HORSEPOWER	PEAK TORQUE (lb-ft @ rpm)
450	465 @ 1500	1650 @ 1100
450*	465 @ 1400	1750 @ 1100
500	515 @ 1650	1650 @ 1100
500*	515 @ 1550	1750 @ 1100
500*	515 @ 1450	1850 @ 1100
535*	545 @ 1550	1850 @ 1100
550*	565 @ 1600	1850 @ 1100
600*	600 @ 1550	2050 @ 1200

*I-Torque version

The big picture

More and more, engines and transmissions are a package deal

Many powertrains on modern trucks have variable or multi-torque arrangements that provide more torque for unprecedented hill climbing and acceleration in top gear at cruise speeds without requiring heavier drivetrain components, thereby enhancing fuel economy.

Manufacturers say these features make trucks smarter for owner-operators.

The common electronic architecture used by Detroit Diesel and Daimler Trucks North America provides easy access to new electronic features and innovations, says Miguel Soetaert, Detroit Diesel group leader of component optimization.

"Common electronics open the door to optimized torque differentiation," Soetaert says. For Detroit Diesel's DD15 and trucks from Freightliner, Sterling and Western Star, an engine that allows more torque in top gears to keep the truck in top gear longer improves fuel economy.

It also limits the "torque where needed to protect the drivetrain, not only when using the engine to power but also to brake the truck," Soetaert says.

Volvo Trucks North America also has carried drivetrain integration further, says Ed Saxman, drivetrain product manager. Volvo still offers the same standard components as most American trucks. But one of its offerings is an I-Shift transmission coupled to a Volvo D13. The high degree of integration protects trucks from driver error, says Saxman. An I-Shift transmission can make engine-related decisions to protect itself and its integral clutch if necessary, he says.

"Consider what happens if the driver forgets the transmission is in gear and shuts off the engine," he says. "The transmission will keep the engine running, slip itself into neutral and then shut down the engine."

Building transmissions for specific engines is a global trend that is challenging but also makes opportunities for owner-operators.

John Beering, director of global marketing for Eaton Corp.'s truck components group, says that Eaton understands many truck manufacturers' desire to provide their own components.

"It's all right for the customer to be making some things in-house," he says. "But there may be many situations where an Eaton solution can enhance what is offered." Roadranger service is one of the ways the company's economies of scale and long experience can enhance the total package offered to the customer, Beering says.

Steve Slesinski, director of global product planning at Dana Holding Co., says his company works closely with Eaton to match drivetrain components. "This is particularly important where there has been a trend to having the engine develop more and more power and torque," Slesinski says. The drivetrain needs to handle the increased stress, yet it's impractical to keep escalating cost and weight.

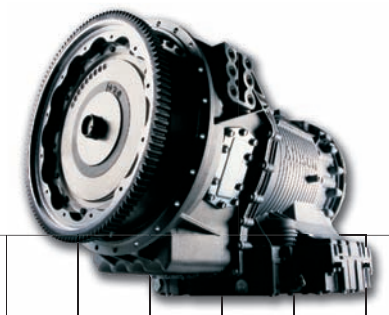
Slesinski emphasizes that integrating the engine and transmission helps vary torque output with gear position. "This is a nice feature, because providing that torque only in the top two gears helps prevent some abuse that can occur at low speeds and high torque conditions," he says. "High engine torque output is nowhere near as damaging at higher speeds." Components optimized for 1,550 or 1,650 lb.-ft. can be used with a 1,650 or 1,750 lb.-ft. engine that gives full torque only in the top two gears without causing drivetrain trouble, Slesinki says.

Specifying a properly integrated drivetrain that will be durable in an actual application is complex. For example, the torque that the driveshaft and axle pinions must handle depends not only on engine output torque, but also on the top gear ratio. Direct drive means much higher torque. Direct drive transmissions get more fuel efficiency, as much as 3 percent better than overdrive, says Charles Allen, ArvinMeritor's director of national service. "Yet, direct drive is limited by a lower input torque limit," he says.

The reason direct drive is more efficient is that, in top gear, the power flows directly through the transmission mainshaft without passing through any gears. The gears in a direct drive gearbox also rotate more slowly, reducing churning of the lube.

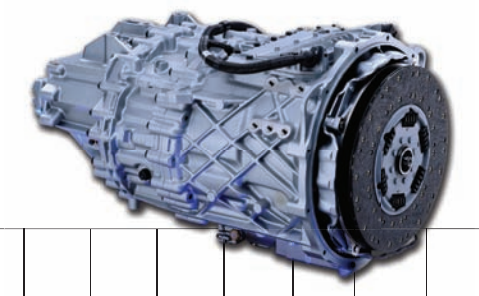
TRANSMISSION SPECS. The transmissions included in the spec listings represent the products that are most popular with owner-operators. Consult a dealer for information on other models. Contact information begins on Page 6. ■

Transmissions



ALLISON

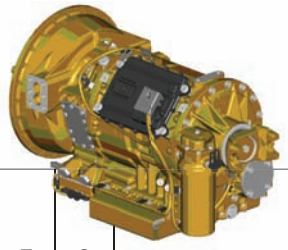
SPEEDS	TORQUE	OVERALL RATIO	FORWARD RATIOS 1	2	3	4	5	6	7	8	9	10	WEIGHT (LB)	LUBE (PT)
4000 RDS: ON/OFF HIGHWAY														
4, 5 or 6	1770	5.48	3.51	1.91	1.43	1.00	0.74	0.64					831	51
4000 RDS: SPECIALTY PTO, HET														
4, 5 or 6	1850	5.48	3.51	1.91	1.43	1.00	0.74	0.64					893	51
4500 RDS: ON/OFF HIGHWAY														
4, 5 or 6	1650	7.01	4.7	2.21	1.53	1.00	0.76	0.67					831	51
4500 RDS: SPECIALTY PTO, HET														
4, 5 or 6	1650	7.01	4.7	2.21	1.53	1.00	0.76	0.67					893	51
4700 RDS: ON/OFF HIGHWAY														
7	1770	11.92	7.63	3.51	1.91	1.43	1.00	0.74	0.64				1,087	54
4700 RDS: SPECIALTY PTO, HET														
7	1850	11.92	7.63	3.51	1.91	1.43	1.00	0.74	0.64				1,149	54
4000 HS														
4, 5 or 6	1770	5.48	3.51	1.91	1.43	1.00	0.74	0.64					831	48
4500 HS														
4, 5 or 6	1650	7.01	4.7	2.21	1.53	1.00	0.76	0.67					831	48



ARVINMERITOR

	SPEEDS	TORQUE	OVERALL RATIO	1	2	3	4	5	6	7	8	9	10	11	12	WEIGHT (LB)	LUBE (PT)
ZF FREEDOMLINE AUTOMATED																	
M-13Z12A-A13	12	1350	15.86	15.86	12.33	9.57	7.44	5.87	4.57	3.47	2.70	2.10	1.63	1.29	1.00	565	23.25
M-14Z12A-A14	12	1450	15.86	15.86	12.33	9.57	7.44	5.87	4.57	3.47	2.70	2.10	1.63	1.29	1.00	565	23.25
MO-13Z12A-A13	12	1350	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25
MO-14Z12A-A14	12	1450	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25
MO-13Z16A-A13	12	1350	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25
MO-14Z16A-A14	12	1450	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25
MO-15Z12A-A15	12	1550	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25
MO-16Z12A-A16	12	1650	15.81	12.33	9.59	7.44	5.78	4.57	3.55	2.70	2.10	1.63	1.27	1.00	0.78	565	23.25

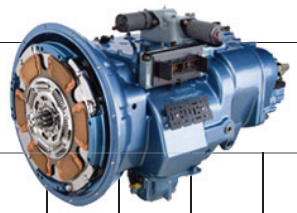
CATERPILLAR



CX31*	SPEEDS	TORQUE	MAXIMUM HORSEPOWER	OVERALL RATIO	FORWARD RATIOS 1	2	3	4	5	6	7	8	WEIGHT (LB)
On/off Highway use	6 forward, 1 reverse	1770	550 hp @ 2100 rpm	7.21	4.40	2.33	1.53	1.00	0.72	0.61			906; with retarder, 1,088
Refuse use	6 forward, 1 reverse	1650	500 hp @ 2100 rpm	7.21	4.40	2.33	1.53	1.00	0.72	0.61			906; with retarder, 1,088
HET use	6 forward, 1 reverse	1850	600 hp @ 2100 rpm	7.21	4.40	2.33	1.53	1.00	0.72	0.61			900, with retarder, 1,088
CX35*													
Automatic transmission	8 forward, 1 reverse	2150	625 hp @ 2100 rpm	9.10	5.73	3.57	2.72	1.95	1.43	1.00	0.74	0.63	1,326; with retarder, 1,476

*Specs subject to change.

EATON FULLER



MANUAL TRANSMISSIONS	SPEEDS	TORQUE	OVERALL RATIO	FORWARD RATIOS L	1	2	3	4	5	6	7	8	9	10	WEIGHT (LB)	LUBE (PT)
FR-9210B	10	950	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FR-11210B	10	1150	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FR-12210B	10	1250	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FR-13210B	10	1350	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FR-14210B	10	1450	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FR-15210B	10	1550	14.8		14.8	10.95	8.09	5.97	4.46	3.32	2.45	1.81	1.35	1.00	592	24
FRO-11210B	10	1150	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-12210B	10	1250	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-13210B	10	1350	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-14210B	10	1450	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-15210B	10	1550	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-16210B	10	1650	14.8		11.06	8.19	6.05	4.46	3.34	2.48	1.83	1.36	1.00	0.75	592	24
FRO-11210C	10	1150	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-12210C	10	1250	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-13210C	10	1350	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-14210C	10	1450	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-15210C	10	1550	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-16210C	10	1650	17.17		12.69	9.29	6.75	4.90	3.62	2.59	1.90	1.38	1.00	0.74	592	24
FRO-17210C	10	1750	17.51		12.94	9.29	6.75	4.90	3.62	2.64	1.90	1.38	1.00	0.74	592	24
FRO-18210C	10	1850	17.51		12.94	9.29	6.75	4.90	3.62	2.64	1.90	1.38	1.00	0.74	592	24
RTLO-12913A	13	1250	16.86	12.31	8.64	6.11	4.43	3.23	1.95 2.29	1.38 1.62	1.00 1.17	0.73 0.86			714	28
RTLO-14913A	13	1450	16.86	12.31	8.64	6.11	4.43	3.23	1.95 2.29	1.38 1.62	1.00 1.17	0.73 0.86			714	28

Transmissions

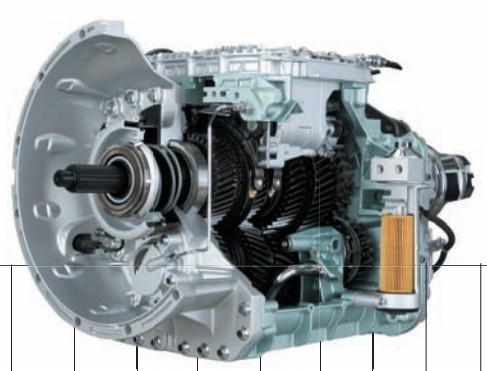
EATON FULLER CONTINUED

	SPEEDS	TORQUE	OVERALL RATIO	FORWARD RATIOS L	1	2	3	4	5	6	7	8	9	10	WEIGHT (LB)	LUBE (PT)
MANUAL TRANSMISSIONS																
RTLO-16913A	13	1650	16.86	12.31	8.64	6.11	4.43	3.23	1.95	1.38	1.00	0.73			714	28
									2.29	1.62	1.17	0.86				
RTLO-18913A	13	1850	16.86	12.31	8.64	6.11	4.43	3.23	1.95	1.38	1.00	0.73			716	28
									2.29	1.62	1.17	0.86				
RTLO-20913A	13	2050	16.86	12.31	8.64	6.11	4.43	3.23	1.95	1.38	1.00	0.73			716	28
									2.29	1.62	1.17	0.86				
RTO-14915	15	1450	16.94		9.96	7.63	5.90	4.54	3.57	2.79	2.14	1.65	1.27	1.00	696	28
					16.94	12.98	10.03	7.73	6.07							
RTO-16915	15	1650	16.94		7.83	6.00	4.63	3.57	2.81	2.19	1.68	1.30	1.00	0.79	696	28
					13.31	10.20	7.88	6.07	4.77							
RTLO-14918B	18	1450	19.72	12.29	7.30	5.16	3.74	2.73	1.95	1.38	1.00	0.73			716	28
				14.40	8.56	6.05	4.38	3.20	2.29	1.62	1.17	0.86				
RTLO-16918B	18	1650	19.72	12.29	7.30	5.16	3.74	2.73	1.95	1.38	1.00	0.73			716	28
				14.40	8.56	6.05	4.38	3.20	2.29	1.62	1.17	0.86				
RTLO-18918B	18	1850	19.72	12.29	7.30	5.16	3.74	2.73	1.95	1.38	1.00	0.73			716	28
				14.40	8.56	6.05	4.38	3.20	2.29	1.62	1.17	0.86				
RTLO-20918B	18	2050	19.72	12.29	7.30	5.16	3.74	2.73	1.95	1.38	1.00	0.73			716	28
				14.40	8.56	6.05	4.38	3.20	2.29	1.62	1.17	0.86				
RTLO-22918B	18	2250	19.72	12.29	7.30	5.16	3.74	2.73	1.95	1.38	1.00	0.73			716	28
				14.40	8.56	6.05	4.38	3.20	2.29	1.62	1.17	0.86				
ULTRASHIFT AND AUTOSHIFT TRANSMISSIONS																
RTO-10910B-DM3	10	1050	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	671	26
RTO-12910B-DM3	10	1250	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	671	26
RTO-14910B-DM3	10	1450	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	681	26
RTO-16910B-DM3	10	1650	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	681	26
RTO-10910B-AS3	10	1050	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	646	26
RTO-12910B-AS3	10	1250	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	646	26
RTO-14910B-AS3	10	1450	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	656	26
RTO-16910B-AS3	10	1650	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	656	26
RTO-18910B-AS3	10	1850	14.81		10.96	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	0.74	656	26
RTO-14910C-AS3	10	1450	17.53		12.80	9.25	6.76	4.90	3.58	2.61	1.89	1.38	1.00	0.73	656	26
RTO-16910C-AS3	10	1650	17.53		12.80	9.25	6.76	4.90	3.58	2.61	1.89	1.38	1.00	0.73	656	26
RTLO-14918A-AS3	18	1450	16.7	10.40	7.26	5.16	3.74	2.73	1.94	1.38	1.00	0.73			738	28
					8.51	6.05	4.38	3.20	2.28	1.62	1.17	0.86				
RTLO-16918A-AS3	18	1650	16.7	10.40	7.26	5.16	3.74	2.73	1.94	1.38	1.00	0.73			738	28
					8.51	6.05	4.38	3.20	2.28	1.62	1.17	0.86				
RTLO-18918A-AS3	18	1850	16.7	10.40	7.26	5.16	3.74	2.73	1.94	1.38	1.00	0.73			738	28
					8.51	6.05	4.38	3.20	2.28	1.62	1.17	0.86				
RTLO-20918A-AS3	18	2050	16.7	10.40	7.26	5.16	3.74	2.73	1.94	1.38	1.00	0.73			738	28
					8.51	6.05	4.38	3.20	2.28	1.62	1.17	0.86				
RTLO-22918A-AS3	18	2250	16.7	10.40	7.26	5.16	3.74	2.73	1.94	1.38	1.00	0.73			738	28
					8.51	6.05	4.38	3.20	2.28	1.62	1.17	0.86				

TRANSMISSION TECHNOLOGY CORP.

	SPEEDS	TORQUE	OVERALL RATIO	REVERSE RATIOS 1	FORWARD RATIOS 1	2	3	4	5	6	7	8	9	10	WEIGHT (LB)	LUBE (PT)
PS100-10D	10	1000	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	626	18
PS125-10D	10	1250	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	636	18
PS135-10D	10	1350	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	636	18
PS145-10D	10	1450	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	636	18
PSO100-10S	10	1000	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	631	18
PSO125-10S	10	1250	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	641	18
PSO140-10S	10	1400	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	641	18
PSO150-10S	10	1500	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	641	18
PSO165-10S	10	1650	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	641	18
PSO10-VPD	10	1650	16.74	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	641	18
LPS125-10D	10	1250	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	580	18
LPS135-10D	10	1350	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	580	18
LPS145-10D	10	1450	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	580	18
LPSO125-10S	10	1250	16.72	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	585	18
LPSO140-10S	10	1400	16.72	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	585	18
LPSO150-10S	10	1500	16.72	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	585	18
LPSO165-10S	10	1650	16.72	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	585	18
LPSO10-VPD	10	1650	16.72	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.39	1.0	0.75	585	18
LLPS125-10D	10	1250	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	514	18
LLPS135-10D	10	1350	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	514	18
LLPS145-10D	10	1450	14.95	16.71	14.95	11.01	7.96	5.98	4.5	3.32	2.45	1.77	1.33	1.0	514	18
LLPSO125-10S	10	1250	16.7	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.9	1.0	0.75	519	18
LLPSO140-10S	10	1400	16.7	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.9	1.0	0.75	519	18
LLPSO150-10S	10	1500	16.7	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.9	1.0	0.75	519	18
LLPSO165-10S	10	1650	16.7	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.9	1.0	0.75	519	18
LLPSO10-VPD	10	1650	16.7	14.02	12.54	9.24	6.68	4.8	3.6	2.61	1.92	1.9	1.0	0.75	519	18
PS86-10V	10	860	19.02	21.27	19.02	14.02	10.13	7.28	5.2	3.66	2.7	1.95	1.4	1.0	633	18
PSO115-10V	10	1150	19.02	15.19	13.59	10.01	7.24	5.2	3.71	2.61	1.92	1.39	1.0	0.71	643	18
PSO125-10V	10	1250	19.02	15.19	13.59	10.01	7.24	5.2	3.71	2.61	1.92	1.39	1.0	0.71	643	18
PSO145-10V	10	1450	19.02	15.19	13.59	10.01	7.24	5.2	3.71	2.61	1.92	1.39	1.0	0.71	643	18
PSDO165-18	18	1650	21.27	15.64	14.89	12.41	10.4	8.66	7.32	6.09	5.05	4.21	3.54	2.94	794	29.5
					2.47	2.06	1.74	1.45	1.2	1.0	0.84	0.7				
PSDO185-18	18	1850	21.27	15.64	14.89	12.41	10.4	8.66	7.32	6.09	5.05	4.21	3.54	2.94	794	29.5
					2.47	2.06	1.74	1.45	1.2	1.0	0.84	0.7				
PSDO205-18	18	2050	21.27	15.64	14.89	12.41	10.4	8.66	7.32	6.09	5.05	4.21	3.54	2.94	794	29.5
					2.47	2.06	1.74	1.45	1.2	1.0	0.84	0.7				
AMO1750-4C	4	17500	2.93		2.37	1.24	1.0	0.81							540	14
AMO1750-4D	4	17500	1.96		1.59	1.24	1.0	0.81							540	14
APO1750-4C	4	17500	2.93		2.37	1.24	1.0	0.81							540	14
APO1750-4D	4	17500	1.96		1.59	1.24	1.0	0.81							540	14
ATO1750-4C	4	17500	2.93		2.37	1.24	1.0	0.81							540	14
ATO1750-4D	4	17500	1.96		1.59	1.24	1.0	0.81							540	14

Transmissions



VOLVO TRUCKS NORTH AMERICA

	SPEEDS	TORQUE	OVERALL RATIO	FORWARD RATIOS 1	2	3	4	5	6	7	8	9	10	11	12	WEIGHT (LB)	LUBE (PT)
DIRECT DRIVE FOR D11, D13																	
AT2512C	12	1850	14.94	14.94	11.73	9.04	7.09	5.54	4.35	3.44	2.70	2.08	1.63	1.27	1.00	597	30
OVERDRIVE FOR D11, D13																	
ATO2512C	12	1850		11.73	9.21	7.09	5.57	4.35	3.41	2.70	2.12	1.63	1.28	1.00	0.78	597	30
OVERDRIVE FOR D16																	
ATO3112C	12	2300	15.04	11.73	9.21	7.09	5.57	4.35	3.41	2.70	2.12	1.63	1.28	1.00	0.78	597	30