

SIX of the

At the close of this year, we kiss goodbye to Euro 5 heavy-duty diesels and say hello to Euro 6. Brian Tinham looks at engines launched so far and their chosen technologies – and the implications, in terms of complexity, maintenance and cost

Euro 6 is big; very big. It's as big a deal as Euro 3 was and way more difficult to achieve than Euro 4 or Euro 5. That's not only because of the much more stringent absolute emissions limits, but also the dictates of the new World Harmonised Driving Cycle (WHDC), which aims more closely to mimic real truck cycles, and demands compliance throughout.

The bottom line is that, whereas, notionally, Euro 6 forces a 50% reduction in particulates (in terms of mass), compared to Euro 5, the real figure is more like 95%, due to the regulation's tight PN (particulate number) requirement throughout the cycle. NOx emissions are also down significantly (75%). And Euro 6 engines must achieve that performance between -7 and +35°C.

Hence the wholesale adoption of SCR (selective catalytic reduction) for all Euro 6 engine after-treatment systems. And it's expensive SCR, at that – actually comprising oxycat-DPF (oxidation catalyst and diesel particulate filter) technology, followed by the urea injection systems and SCR catalyst, and finally a urea slip catalyst to prevent excess ammonia pollution.

Advanced after-treatment

Hence also the emphasis on after-treatment packaging, with almost universally dual-flow standardised catalyst systems (internally), to minimise back pressure, physical size and cost, while maximising NOx conversion efficiency. And hence finally the much more advanced SCR control and sensor systems. Their task is not only to maintain emissions within legal limits – throughout as much of the exhaust temperature range as possible – but also to help mitigate the fuel consumption increase initially threatened by what many regard as unreasonable heavy-handedness by the European Commission.

But SCR is not the whole story. There's more than one way of skinning a cat, as the rather unpleasant metaphor goes. So it's interesting to look in a little

more detail at what's behind the truck manufacturers' Euro 6 engines we now know about – if for no other reason than to understand any potential pros and cons. What, for example, are the implications for complexity, cost, weight and reliability – and indeed maintenance?

The vast majority of manufacturers have gone with the widely anticipated cooled EGR (exhaust gas

Right: Mercedes-Benz new OM93x Euro 6 engines: four- and six-cylinder, 5.1 and 7.7 litre respectively, and all ground-up redesigns



recirculation), to minimise NOx-out, followed by SCR, to bring it within the new limits. That much follows a well established trend. As Andrew Nicol, technical specialist on engine performance and calibration with world-renowned Ricardo, says: "Manufacturers have for some time been working to maximise SCR conversion efficiency, in order to reduce the levels of EGR needed. Everyone aims for good fuel consumption, but, by reducing EGR rates, you reduce engine-out soot and turbocharging inefficiencies."

VERY BEST



And we might add that rising injection pressures – up to 3,000 bar in Delphi's case, but commonly 2,400 bar for Euro 6 engines unveiled to date – have also helped to massively clean the burn and improve control. Ditto the wholesale move to common rail (or equivalent, with Delphi's F2, for example, effectively converting some existing Euro 5 engine designs by fitting directly to the unit injector housings).

Boosting pros and cons

Whatever the choice, the truck manufacturers have chosen to nuance their particular engine boosting choices beyond the initially predicted ubiquitous VGT (variable geometry turbo). While VGTs are certainly widely used by, for instance, DAF, Iveco, Scania and Volvo, wastegate turbos have also been found adequate for many engine sizes and applications by most of the manufacturers.

Meanwhile: MAN has opted for conventional two-stage turbos with a bypass valve; Mercedes-Benz, asymmetric turbines (twin-entry, but throttled down for three-cylinder EGR only – must have been quite a turbo matching program); and Volvo, turbo-compounding. All have their pros and cons, but the bottom line in every case is maximising efficiency across the load range, while minimising fuel consumption and cost – and leaving much of the

NOx issue to the after-treatment.

Back on SCR, then – and Scania (with two of its 9-litre engines) and Iveco (throughout its new heavy-duty diesel range) have gone the whole hog, removing entirely the requirement for EGR. Little is known publicly about Scania's engine-out gas mix, but Iveco's is high on NOx, relying on what is widely accepted to be the most advanced of the SCR packages available for after-treatment. Nicol describes the choice as "a pretty aggressive strategy" and points out that AdBlue consumption will be high. That said, there are clear weight and mechanical complexity savings, if not cost.

At the other extreme is Volvo, with its unusual use of hot (uncooled) EGR as an option on the D13K 460 13-litre engine (see engine description). Nicol is impressed: "It's very clever and robust. It uses EGR to minimise NOx from start-up and at low load [not a problem, because there's plenty of excess air], when exhaust temperatures are low, so SCR is ineffective. On the one hand, that means clean low-temperature operation and, on the other, it speeds up the warming process to bring in the SCR. But it also means no expensive cooler for EGR heat rejection. And, once the engine is warm, EGR is switched off and Volvo achieves its NOx conversion through SCR."

But whatever the engine and NOx management approach, under Euro 6 constraints it's no longer possible to get away without a DPF to strip out any remaining soot. That, in turn, means a requirement to regenerate the DPF. "In heavy trucks, that's not a problem, because you're running at high loads and the engine-out NOx runs at a good ratio to maintain passive regeneration," comments Nicol. "But, in other cycles, there will be a periodic need for active regeneration, too." And hence, again, the complexity and cost of the new after-treatment systems.

So what are the issues for making engine and brand choices, in terms of duty, reliability, maintenance, weight and cost (capex and opex)? Nicol makes the point that all of these engines meet the Euro 6 criteria, so all are proven to perform throughout the WHDC. In that sense, whatever you choose, you're safe. He also agrees that, with modern zeolite-based SCR (as opposed to vanadium), there is a kind of conversion capacity

Left: Scania's 9-litre 320 and 360bhp Euro 6 engines feature SCR-only NOx management

build-up, which helps deal with mixed duty cycles that could otherwise be a problem for AdBlue injection – as long as the control systems perform.

“For most operators, the technology choice shouldn’t be an issue,” he suggests. “However, SCR could be a bit of a concern for heavy urban operation – say, buses or RCVs [refuse collection vehicles] – because there may be occasions where the SCR runs out of stored urea. So, for city centre vehicles, the EGR plus SCR solution might be more robust. However, EGR in urban operations is not totally free of issues, such as clogged systems.”

As for maintenance, all of the manufacturers advise no change in R&M schedules and costs, with the exception of DPF maintenance every 300,000–500,000km for accumulated ash (not soot) removal. There is, however, bound to be a requirement for more training. The main issue will be the sophistication of the SCR systems and their controls,

which will place greater demands on diagnostics systems. But there is room for some confidence: those, too, are part of Euro 6 certification, with the authorities looking for rapid fault-finding and resolution, whatever the problem.

What about weight? Some talk of a 150–200kg penalty; others (notably Mercedes-Benz) talk of full weight mitigation for certain tractor units where every kg counts – such as in tanker operations. Best advice is to ask.

And finally cost, which is just as variable. Most expect approximately 10% on the price of a tractor unit, so around £7,000–10,000 extra. However, some of those already running Euro 6 trucks talk of excellent deals. And while many of the OEMs suggest no change on average in opex (mostly fuel consumption), others claim fuel savings up to 5%, which has the potential to actually reduce the real-terms cost of ownership. Again, ask your dealer. **TE**

Euro 6: the new engine ranges

DAF Trucks

DAF’s new engines for Euro 6 comprise three distinct ranges, between them delivering power from 150–510bhp and torques up to 2,500Nm, broadly matching today’s Euro 5 ratings. First to be released (last year) was the top-end 12.9-litre Paccar MX-13 as a revamped, four-valves-per-cylinder unit, upgraded from unit injectors to common rail and providing 410, 460 and 510bhp variants, with peak torques of 2,000–2,500Nm.

In common with the vast majority of Euro 6 engines, this range has been equipped with cooled EGR (exhaust gas recirculation), in combination with SCR (selective catalytic reduction) and DOC/DPF (diesel oxidation catalyst/diesel particulate filter) technology. It also has an electronically-controlled VGT (variable geometry

turbocharger) to optimise power output and minimise fuel consumption across the delivery range.

At the lower end, brand new engines, launched last month in Germany, are all Cummins-based units (as per DAF’s Euro 5 choice), with similar four- and six-cylinder versions – Paccar FR (140–210bhp; 580–760Nm) and GR (220–310bhp; 850–1,100Nm) respectively – as well as a new 10.8 litre engine (MX-11, covering 290–440bhp) for its revitalised CF truck. Again, all use the EGR/SCR/DOC/DPF approach. See page 40 for the DAF MX-11 report.

Interestingly, DAF marketing director Tony Pain says that, although the torque curves throughout match closely those of the Euro 5 engines they replace, they will feel more responsive. He also states that, on average, operators can expect equal or slightly better fuel consumption, particularly on long haul.

Isuzu Truck

As we go to press, Isuzu has not yet gone public with its Euro 6 engine range: specifications are likely to be revealed in August. However, the truck manufacturer already produces EPA10-compliant engines for the US and Keith Child, marketing director, says he is not expecting major surprises.

That being the case, the industry should expect engines similar to the: 4JJ1TC 3.0-litre, 147bhp engine; the 4HK1TC 5.2-litre, 188bhp unit; and the 4HK1TCS, also 5.2 litres, but rated at 202bhp. Child believes that Isuzu’s Euro 6 power plants will have “virtually the same swept volumes, similar power ratings and torque curves, and similar fuel consumption”.

Below: DAF’s new Paccar MX-11, with a 290–440bhp spread. Ideal for the popular CF85 (see page 40)



Iveco

Iveco's Stralis Cursor engine replacements for Euro 6 are the new Cursor 9 (310–400bhp), Cursor 11 (420–480bhp) and revised Cursor 13 (505–560bhp; 2,300–2,500Nm), all of which have moved up from the former unit injectors to full common rail technology. The higher power engines above 400bhp also feature a VGT to optimise efficiency, while the lower output units get a wastegate. Martin Flach, Iveco's product director, states that, on shorter-range duties, the additional cost of a VGT would be unlikely to show a return from the potential marginal improvement in fuel consumption.

Meanwhile, for Eurocargo, Iveco's Tector four- and six-cylinder engines all see a displacement increase, with Tector 4 and 6 sliding up to 4.5 and 6.7 litres respectively. That means slightly higher power outputs – up to 206bhp and 320bhp (580–750 and 800–1,100Nm torque respectively). However, the engine fundamentals remain largely unchanged, with common rail fuel injection and fixed geometry or wastegate turbos.

Most noticeable, though, is that, with the exception of Scania, Iveco is out on its own among the big league in plumping for SCR and DOC/DPF



Iveco's new Cursor and Tector engines are alone in relying on SCR and DOC/DPF technology only: there is no EGR

without EGR. It is certainly unique in adopting that approach throughout its Euro 6 engine range. Flach argues that SCR-only is the simpler choice, although he concedes that Fiat Powertrain's Hi-eSCR (high efficiency) after-treatment system is more sophisticated than the rest.

He also claims some weight saving, compared to the EGR/SCR combination, and reckons that DPF maintenance intervals will be even longer than the others, due to the particulates benefits of eliminating EGR. That said, Flach concedes that AdBlue consumption will be higher – potentially around 7%, compared to the EGR/SCR boys, at 2–3%.

MAN Truck & Bus

MAN marches on with its existing D20 10.5 litre (320, 360 and 400bhp) and D26 12.4 litre, six-cylinder (which now provides for 440bhp and 480bhp; 2,300–2,500Nm) power plants. The engines are essentially unchanged against the Euro 5 versions, according to Les Bishop, MAN's product marketing manager, with both ranges continuing to utilise twin turbos and common rail fuel injection.

They also now all come with EGR, SCR and a DOC/DPF system as standard. Gone are the days of MAN's famous EGR-only 'No AdBlue' campaign. And, to achieve Euro 6 emissions compliance, as with the other manufacturers, the after-treatment package is more sophisticated than the SCR system (where used) on its previous engines – and managed via an additional control module. That looks after AdBlue injection and the gas flows, temperatures and automatic regeneration cycles, in line with the system's multi-sensor data.

Meanwhile, at the smaller engine end, MAN offers its mainly twin-turbo D08 four- and six-cylinder engines, again moving up to combined EGR, SCR and DOC/DPF, and providing for 150 (single-turbo), 180 and 220bhp (570–850Nm torque) in the four-cylinder versions, and then 250, 290 and 330bhp (1,000–1,250Nm) on the six – primarily aimed at TGM rigids and urban artics.

Mercedes-Benz

Daimler has taken the opportunity Euro 6 presents to usher in a suite of five brand new engines, running from 156 to 630bhp. OM934 is a four-cylinder, 5.1 litre unit, with a range of power variants. All the other ranges are six-cylinder inline units: OM936, at 7.7 litres; OM470, 10.6 litres (down from its 12 litre OM457 predecessor); OM471, at 12.8 litres; and OM473, 15.6 litres. All use the virtually industry standard approach of EGR combined with an SCR/DOC/DPF after-treatment package.

These are ground-up redesigns, in terms of everything from combustion chamber materials to piston profiles, the variable cam shaft timing and their new common rail system – the latter being Bosch's X-Pulse. Injection pressures can run up to 2,400 bar, but most operate around 2,100 bar, according to Nick Blake, Mercedes-Benz UK's sales engineering manager. The German firm has also gone for asymmetric turbos across the range (front three cylinders only, with wastegate charge limiting), with the exception of the largest OM 473, which has a turbo compound arrangement.



Above: MAN's D26 for Euro 6, which now provides for 440bhp and 480bhp and 2,300 to 2,500Nm torque

Mercedes-Benz expects both its OM934 (156–231bhp, 900Nm torque) and the OM936 (238–299bhp, 1,000–1,250Nm) to be used on the new Atego rigids from 7–16 tonnes. Then from 18 tonnes upwards, the OEM will offer its Antos, Arocs and Actros trucks with four engines: OM936 (283–353bhp; 1,000–1,400Nm); OM470 (326–428bhp; 1,700–2,100Nm); OM471 (421–510bhp; 2,100–2,500Nm); and the OM473 (625bhp, 3,000Nm torque) bruiser, according to application.

Renault Trucks

As we go to press, Renault has not provided official information on its Euro 6 engine range. The manufacturer says that specifications will be released on 11 June. Transport Engineer expects significant commonality with Volvo’s power plants.

Scania

Scania revealed some of its Euro 6 engine line-up at last year’s IAA in Hannover, with one big surprise. The higher output pair of its new five-cylinder DC09 9-litre engines (320 and 360bhp; 1,600Nm and 1,700Nm) are the only units beyond Iveco/FPT to run on SCR only. The other two DC09s so far released (250 and 280bhp; 1,250Nm and 1,400Nm) harness conventional EGR/SCR.

Jonas Hofstedt, Scania’s head of powertrain development, says SCR-only engines are aimed at heavier distribution and lighter, long-haul or regional distribution, including middle weight tractor units.

Looking at the rest of the Scania range, it’s the familiar six-cylinder inline modularised DC13 13-litre and (as yet not released at Euro 6) the DC16 V8 16-litre engine platform. The former are currently available as 440 and 480bhp output variants (2,300 and 2,500Nm), with more to follow down the range (370 and 410bhp). Then Scania’s v8 engines are likely to mirror its existing Euro 5 EEV range, offering 520, 580 and the massive 730bhp beast.

All again use EGR/SCR and DOC/DPF technology, and Hofstedt says that the oxicat, DPF, twin SCR catalyst and twin urea slip catalyst package is common throughout Scania’s inline engine range. He also states that it is just as compact as the silencers on its Euro 5 engines –

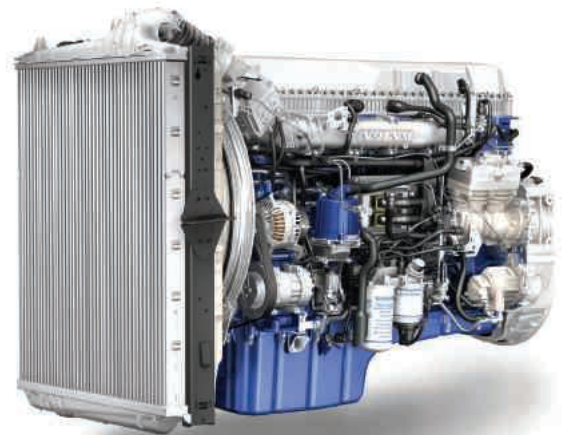
leaving plenty of space for equipment and tanks, even on UK 6x2 tractors with special equipment.

As for the rest, all also harness common rail technology with Scania’s XPI digital fuel injection system. And all except the SCR-only five-cylinder engines – which are adequately managed by wastegate turbos, in the absence of EGR boosting requirements – use VGTs.

Volvo Trucks

Volvo’s first Euro 6 engine release was its D13 K460 six-cylinder inline 13-litre unit, delivering 460bhp and 2,100Nm torque. As with almost all of its forthcoming range, emissions management is via cooled EGR with SCR and DOC/DPF technology, with a seventh injector for the catalyst on duty cycles where regeneration is required. This engine has also been equipped with a VGT to optimise power

Right: Volvo’s D13 K460 six-cylinder inline 13-litre unit at Euro 6, delivering 460bhp and 2,100Nm torque



delivery and fuel efficiency throughout the rev/demand range – and, again, that will be the story for the rest of the range, when it is released.

However, there is one exception: a hot (uncooled) EGR (see main feature), high-torque (2,800Nm) version of the D13K 460. This uses the company’s new I-Torque – a dual-clutch version of its automated I-Shift transmission – to optimise power delivery across the narrower, low revving torque band. As John Cromer, Volvo UK trucks product manager, explains: “I-Torque is designed to get 4% additional fuel economy out of a 44 tonne tractor by keeping the engine in the power band between 900 and 1200rpm, while maintaining driveability.”

As for the other engines – due for release as we go to press, with the launch of Volvo’s new FM – these will include 420, 500 and 540bhp versions of the D13, which will also be offered on the new FH.

No other Euro 6 engines have yet been released, although Volvo says there will also be 380 and 460bhp variants of its D13 for the FM. And, when the lower-weight (140kg less) D11K 11-litre six-cylinder series is launched, we can expect 330, 370, 410 and 450bhp variants. **TE**

Below: Scania’s 13-litre Euro 6 engine cutaway, with its integrated silencer and exhaust after-treatment

