



INTRODUCING THE NEW

D38 ENGINE



ENGINEERING ANATOMY

IN ASSOCIATION WITH TRANSPORT ENGINEER MAGAZINE

ENGINEERING INNOVATION

For 2017, MAN's D3876 engine range has been upgraded to Euro 6c. But there's much more to the new power plant than meets the eye. Brian Tincham explains

It is just over two years since MAN launched its Euro 6 straight-six 15.2-litre D38 engine to replace its trusty 16.2-litre V8 D28. Now for 2017, the company's new D3876 moves up to meet the latest Euro 6c emissions standard. Interesting enough, but the truck giant has also used the opportunity to launch significant enhancements that together deliver even greater fuel efficiency and reliability alongside lower total cost of ownership.

So what's new? Top of the list is improved power and torque performance for the earlier 520 and 560hp variants, which now move up to 540 and 580hp respectively, while also each adding 200Nm of torque – yielding a chunky 2,700 and 2,900Nm. Performance of the range-topping unit remains unchanged at 640hp and 3,000Nm torque. However, availability has now spread beyond 8x4/4 heavy-duty tractors to include many of the company's standard two-, three- and four-axle tractor units and chassis.

And MAN claims up to 1.9% fuel economy improvement, compared with the previous generation Euro 6 D38, excluding the 640hp variant (albeit not yet certified for UK models and weights).

Looking in more detail though, aside from these improvements, there are several other notable developments. These include: the engine cooling and lubrication

systems, which are now demand-based; and enhanced coolant pressure and temperature monitoring systems. Also in evidence are: revisions to MAN's two-stage turbocharging system; and a third generation common rail system, which takes injection pressures up to 2,500 bar, so enabling ultra-fine fuel atomisation and hence more efficient combustion.

EURO 6C EMISSIONS

Emission controls first, and key to MAN's new engine is a two-stage EGR (exhaust gas recirculation) system and a revised SCR (selective catalytic reduction) after-treatment package that, incidentally, also now extends service life to match vehicle lifespan.

The EGR system has essentially been re-optimised such that exhaust gases are now managed via two cooling circuits (one high- and one low-temperature). Combined with an improved flow design, the result is a more even distribution of cooled exhaust gases and charge air for all cylinders – together minimising NOx generation during combustion itself, without compromising power output.

Meanwhile, on the exhaust gas aftertreatment side MAN has moved to new, more highly reactive SCR substrates for its Euro 6c D38 (as well as the latest D20 and D26 diesel engine ranges). The company explains that its earlier Cordierite (magnesium-aluminium-silicate) material has been replaced by a full extrudate of newer technology catalytically-active oxides to achieve



the tighter Euro 6c emission limits.

Add this enhancement to reduced NOx from combustion itself, and MAN says operators can expect further savings in the form of a reduction in AdBlue consumption – while still complying with the new NOx limits. And, of course, MAN's D3876 control systems also now meet the Euro 6c OBD (on-board diagnostics) and urea quality monitoring requirements. These include earlier detection of NOx emission deviations beyond the permitted threshold, as well as improved monitoring of OBD functionality itself.

COOLING SYSTEMS

Moving on to heat rejection, MAN points first to the fact that, as well as providing for lubrication, the oil also has a role in engine cooling. So, among new design features of the D3876 is a re-optimised oil cooler (heat exchanger) aimed at preventing oil temperature spikes – including a new thermostat that provides for tighter regulation. Additionally, MAN's new oil module now combines the oil filter, cooler and separator into a single component group, which also reduces the weight of the assembly.

As for the engine coolant loop itself, fan speed modulation (via the

CANbus) ensures that cooling fans supply just enough air to dissipate heat via the radiator – no more, no less. Advantages of this development include: reduced parasitic losses and hence better fuel economy; potentially increased available power; and a reduction in fan noise.

MAN also states that engine operating temperatures are reached faster and then maintained within a tighter tolerance band – meaning longer service life for the fans and associated components, as well as reduced maintenance costs. Incidentally, enhanced coolant pressure and temperature monitoring systems have also been implemented to prevent engine damage.

REVISED TURBOCHARGING

Turning to the turbocharging system, this sees improvements to the compressors themselves and to MAN's well established two-stage arrangement. Looking at the turbos, the high-pressure stage has seen both efficiency and transient behaviour uprated, resulting in enhanced response (due primarily to reduced inertia), while the low-pressure stage has been re-optimised for efficiency.

The result, says the company, is faster turbo response and hence also

engine agility and torque profiles. Those translate to better driving dynamics – particularly at low revs, but also at cruising speeds – while also contributing to enhanced fuel savings.

As for the turbocharging system, the principle is unchanged, involving high- and low-pressure turbos connected in series via a charge air intermediate cooler. The smaller, high-pressure charger handles low engine speed boosting, progressively augmented by the larger, low-pressure charger as engine speeds and loads increase. When engine demand is high, the low-pressure charger handles most charge air pressurisation, so optimising the torque band over a wide range of engine speeds.

In fact, maximum torque is now available from 930–1,350 rpm. Lower engine speeds mean fuel-efficient driving in high drive ratios at motorway cruising speeds, including during sustained hill climbing. Additionally, the wide torque range works well across all axle ratios, from short axles, designed primarily for traction, to higher-g geared axle typically specified for long-haul tractors.

MAN says its design also results in longer service life since pressurisation is split between the two turbos, so reducing the load on each. And, in this context, the company points to another benefit of its two-stage charge air cooling, which results in reduced heat load on the high-pressure turbocharger. Again, one of the results is increased reliability and service life for the components.

COMMON RAIL SYSTEM

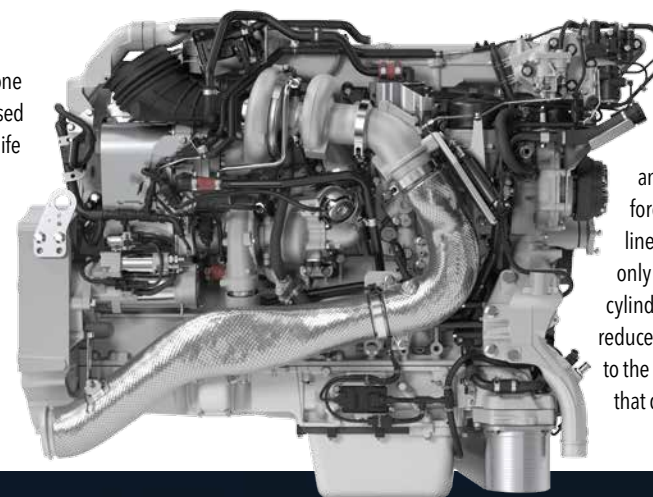
Moving on to the common rail system, MAN's D3876 features a

third-generation design that increases the diesel fuel injection pressure to 2,500 bar. That results in even finer atomisation of the diesel fuel as it enters the cylinders. However, with the electronic control unit also configured to enable precise pre-, main and post-injections at every stroke, the result is a new level of combustion – and hence also fuel – efficiency. Combined with the two-stage EGR cooling loop, the result is not only low NOx emissions at source, but also particularly low particulate levels.

OTHER INNOVATIONS

Too many to mention in detail, but among other engineering highlights of the D3876 for 2017 are: 160kg weight saving; top-down cylinder head cooling and domed valves (both 'firsts' for heavy-duty diesels); forged steel pistons and eight cylinder-head screws per cylinder; fire rings to prevent oil carbon; an encapsulated cable harness; and an on-demand air pressure management system.

Quickly looking at the lightweighting aspect, MAN has used high-strength GJV450 (cast iron with vermicular graphite) for the engine block and cylinder head, an aluminium flywheel housing, and plastic valve rocker cover and sump, with MAN patented spider's web structure on the underside – which



also reduces running noise.

Meanwhile, top-down cooling does what it says on the tin – pumps coolant from top to bottom, thus prioritising the injectors and exhaust valve seats, which are subject to the highest thermal stresses. The concept also increases effective cooling capacity, enabling a lower power pump – so reduced parasitic losses.

Moving on to that other 'first', the domed inlet and outlet valves, the objective is to increase their strength in order to better resist deformation around the valve seating ring – so increasing service life of both valve and seating ring. It's a similar story with the high-strength pistons, which enable lower compression travel and hence longer con-rods and near vertical force vectors. Furthermore, the compact piston construction reduces the surface contact between piston and cylinder wall, so reducing friction and fuel consumption, while improving service life for both pistons and cylinder liner.

As for the move to eight cylinder-head screws per cylinder, once again, it's all about improving resilience – in this case by ensuring an even distribution of forces across the cylinder liners. The outcome is not only a longer life for the cylinder head gasket but also reduced oil consumption, due to the improved seal. And that design intent is also

seen in MAN's adoption of protective fire rings at the upper end of each cylinder liner. These prevent the ingress of combustion gases between piston and liner, so minimising oil carbon deposits and hence also erosive wear on the cylinder liners.

What about those cable harnesses? For the D3876, MAN has routed all cables in foam-filled harnesses, so reducing long-term vibration-induced material fatigue, while also improving environmental protection. And that attention to detail continues with the firm's introduction of a disconnectable, two-cylinder air compressor and air pressure management system that responds to demand – saving up to 90% of auxiliary power requirement and clearly cutting fuel consumption.

Taken together, MAN's upgraded D3876 for 2017 – and its latest D26 and D20 engine range, which also see the majority of these enhancements – represents a triumph of engineering. Fleet managers and fleet engineers alike cannot fail to be impressed by the scale of innovation and the resulting fuel efficiencies, driving improvements and the clear reduction in total cost of ownership. And note: workshop technicians will also be impressed with the company's attention to service- and repair-friendly design. Even the valve train is accessible without removing the air filter. And there is also the expected commonality of components with MAN's D26 and D20 engine ranges – meaning opportunities for savings in terms of stocking but also technician training



SPECIFICATIONS

D38 ENGINE SPECIFICATION



MAN D3876: six cylinder in-line 15.2 ltr displacement

540hp; 2,700Nm torque

580hp; 2,900Nm torque

640hp; 3,000Nm torque

PERFORMANCE AND ECONOMY

THIRD GENERATION COMMON RAIL INJECTION SYSTEM: injection pressures up to 2,500 bar. Provides for extremely fine fuel atomisation, ensuring combustion is even more efficient.

SECOND GENERATION CHARGE-AIR SYSTEM: High efficiency charge air cooling system with separate low temperature cooling

Two-stage turbocharging concept reduces demands and load on individual turbos

EMISSION CONTROLS

TWO-STAGE EGR (EXHAUST GAS RECIRCULATION): Exhaust gas is cooled via two coolers (one high-temperature and one low-temperature cooling circuit).

EGR system is efficient in reducing NO_x during combustion.



RELIABILITY FEATURES

EIGHT CYLINDER-HEAD SCREWS PER CYLINDER, meaning low liner distortion as well as even compression of the cylinder head gasket - resulting in longer service life and higher reliability.

PROTECTIVE ANTI-POLISHING RING at the top of the cylinder liner prevents combustion gases escaping between the piston and liner, so minimising oil carbon deposits. Reduced ash ingress also helps to protect the DPF (diesel particulate filter), which boasts 500,000km service interval.

ADVANCED ENGINE FEATURES

FORGED STEEL PISTONS: enabling high ignition pressures up to 250 bar, which optimises combustion and reduces fuel consumption. Pistons are also shorter, allowing longer connecting rods and hence optimal perpendicular con rod movement, while also minimising friction losses against cylinder walls.

TOP-DOWN COOLING: a first for a diesel truck engine, designed to deliver optimised and even cooling across all cylinders - so avoiding localised thermal stresses, while enabling high cooling output with lower coolant volumes.

ENGINE INNOVATIONS

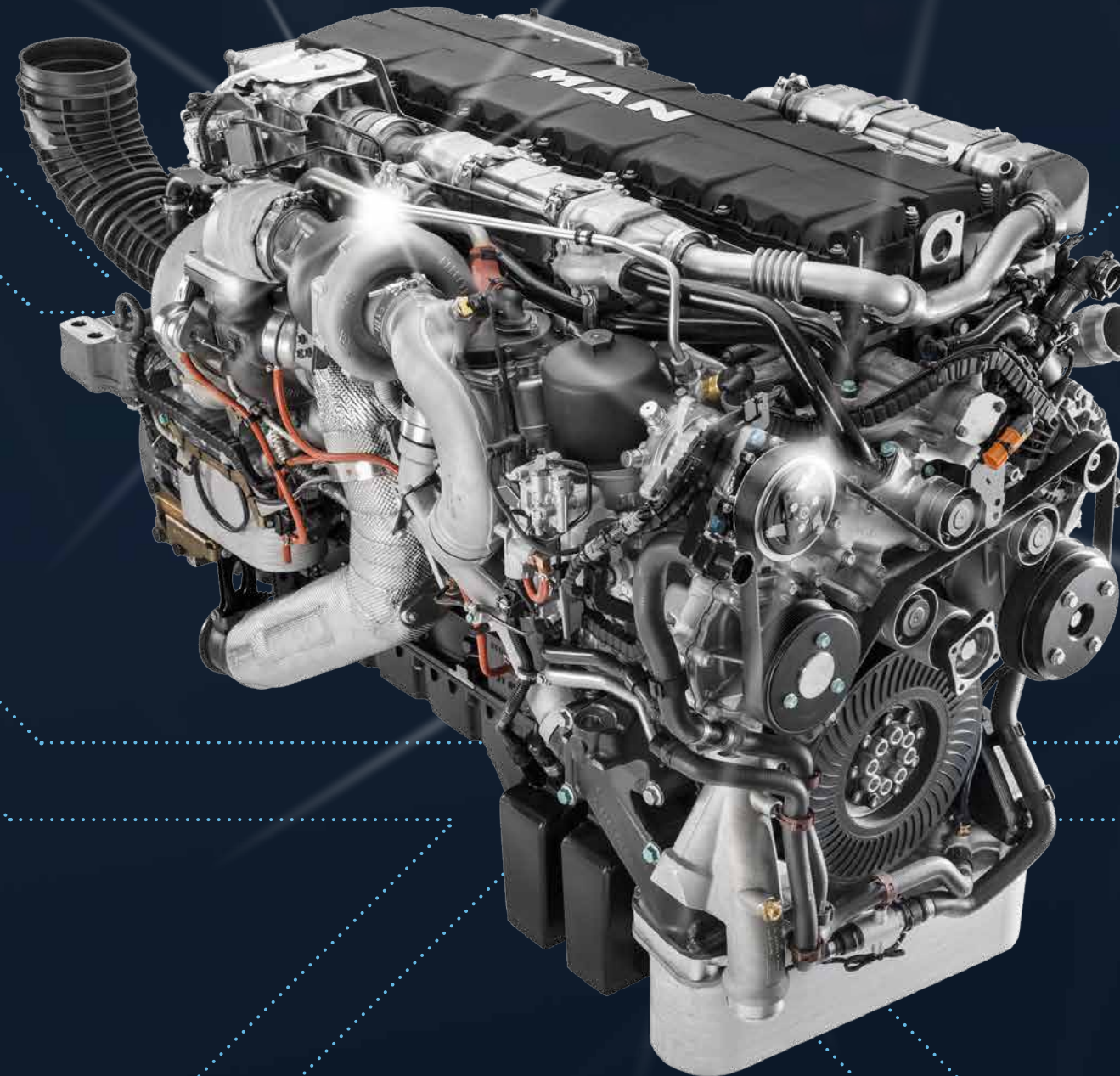
DOMED VALVES: another first in truck diesel engines, designed to minimise wear on the valve seat.

LIGHTWEIGHT CONSTRUCTION, thanks to compact design and innovative choice of materials.

IMPROVED ACOUSTICS: cobweb-like ribbing on the oil sump prevents sound transmissions

FOAM-PACKED CABLE HARNESSES reduce internal wear and prevent breaks and short circuits.

Approval for HVO (hydro-treated vegetable oil) fuels, allowing renewable diesel fuel EN 15940.



AUTOMATICALLY BETTER

With the arrival of its latest Euro 6c engines, MAN has taken the opportunity to enhance the performance and driver appeal of the popular Tipmatic automated gearbox used in its TG tractors and rigids.

Brian Weatherley explains

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very good engine deserves an equally good gearbox behind it, working together in perfect harmony. That's certainly the case with MAN's latest Euro-6c TG

chassis, which now benefits from the adoption of the new generation of Tipmatic two-pedal AMT (automated manual transmission).

The familiar 12-speed Tipmatic – based on ZF's tried and tested AS-Tronic box but with MAN's own shift-strategy software and controls – has long been a favourite with drivers and hauliers. That's not least due to its user-friendliness and low operating costs. Now the latest version carries on that tradition by being not only quicker but also more intuitive than ever before.

To improve driveability even further, Tipmatic now gains MAN's latest SpeedShifting function, which

permits rapid gear changes whatever the driving conditions and terrain. In particular, new Tipmatic works in conjunction with MAN's electronically-controlled exhaust valve brake (EVBec – standard on all D20, D26 and D38 Euro 6c engines) to deliver ultra-fast upshifts, especially when a truck is driving uphill. MAN's up-shift assistance (HSU) enables the Tipmatic box to change up even on tough gradients that would previously have thwarted the system as the break in engine torque and power would have meant losing too much road speed.

So how does it work? In simple terms, when you're climbing a hill with a new TG Euro 6 chassis (tractor or rigid) equipped with the Tipmatic and HSU, when the auto box judges it's capable of making an up-shift then EVBec operates for a split second. This creates engine back pressure, which in turn

drops the engine revs – so allowing the Tipmatic auto to achieve much faster gear synchronisation.

The upshot of a shorter interruption to tractive force is that a TG driver can now tackle steep inclines employing a higher gear than before. This results in lower engine speeds (thereby saving fuel) and simultaneously higher road speeds. That means higher productivity across an entire journey.

Just as important, not only does the new Tipmatic auto shift more quickly, but it's smoother too, because MAN has focused on driver comfort with its new shift strategy software.

CRAWLER GEARS

Meanwhile, as well as improving the performance of its popular 12-speed auto, MAN has also introduced an additional version called Tipmatic 12+2 with two extra crawler gears, which is now standard on all 4x2 TGS and TGX tractors powered by the

D26 engine. Just like the regular 12-speed auto, it comes with the latest MAN control software and features.

That said, no matter what version they have, drivers using the new Tipmatic boxes will find everything familiar in their control layout. The drive mode selector knob is still handily placed to the left hand side of the driver's seat. It also retains the previous 'D' position for drive, plus 'DM' and 'RM' for forward and reverse low-speed manoeuvring. In the two latter positions the accelerator pedal has greater travel for the same input, allowing for extremely precise control.

However, even in normal drive the 'feel' of the new transmission is superb, with its control software allowing up-shifts by gentle use of the throttle pedal when pulling away from rest. And, whatever the circumstances, Tipmatic always knows what shift pattern to choose for optimum fuel economy and driveability.

The control stalk, on the right hand side of the steering column, then allows further fine tuning of Tipmatic's gear shifts should a driver require

it. There are three options. First, full auto, where the driver controls all shifts via his right foot. Second, semi-auto, which allows the driver to make manual shifts via the control stalk, before the box returns to full automatic mode after a 10 second delay. And third, full manual, where the driver dictates all changes, again by pushing the steering column stalk either up or down.

The earlier load sensing function on Tipmatic is also retained, but with the addition of a new inclinometer. So, with the latest version, it not only automatically chooses the optimum shift pattern based on the truck's gross weight, but also knows whether it's starting off on a level road or a hill.

In combination with the Tipmatic load sensor, the EVBec also delivers precisely the right amount of downhill engine retardation, again automatically taking into account whether the truck is laden or unladen. Moreover, if additional braking power is anticipated – for example, to handle hilly terrain or arduous conditions – operators can specify an optional ZF Intarder,

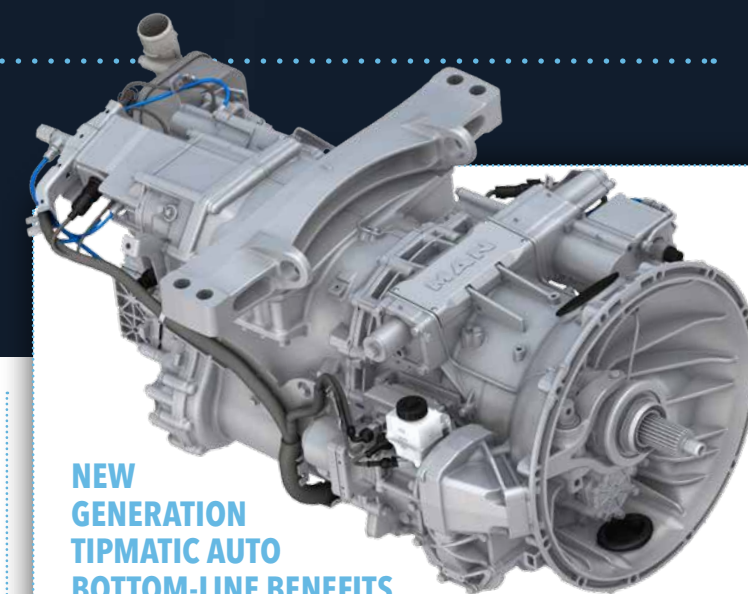
delivering up to 4,100Nm of braking torque on the latest Tipmatic box.

OFF-ROAD EXTRAS

Meanwhile, for those drivers working off-road in a TG model with either the D26 or D20 engine, there's a new Rock-Free mode option. Operated by a dashboard switch it allows for rapid shifts between drive and reverse without harming the gearbox or clutch. This 'rocks' the truck back and forth, enabling easy extraction if the vehicle gets stuck in snow or on muddy ground.

Whatever the mission, the bottom line for MAN drivers is that the latest Tipmatic is even more intuitive in use and fully in-tune with their driving style. Meanwhile, for operators it offers the prospect of improved fuel economy and vehicle productivity. Additionally, it delivers the peace of mind that comes from knowing that, through optimal gear selection, Tipmatic always protects the clutch and drivetrain when starting off – thereby reducing maintenance costs and eliminating any risk of accidental drivetrain abuse.

Equally significant, the standard



NEW GENERATION TIPMATIC AUTO BOTTOM-LINE BENEFITS

- + Latest SpeedShifting function incorporating EVBec electronically-controlled exhaust brake delivers even quicker changes with maximum driver comfort
- + Shorter interruption of tractive force, particularly on gradients, allows higher gears to be selected when hill-climbing – saving fuel and maintaining good road speeds
- + Optimal gear selection every time protects clutch and drivetrain, minimising maintenance costs
- + Latest software developments and load/inclinometer detection delivers best gear-changing, regardless of vehicle weight or topography
- + Rock-free mode makes it easier to keep moving when operating off-road in snow and mud (D20 and D26-engined models)
- + While the latest 12-speed Tipmatic is fitted to the majority of TG models, TGX and TGS 4x2 tractors with the D26 engine have the new 12+2 Tipmatic with two extra crawler gears
- + Continuity preserved, with previous driver controls retained on new models – allowing full auto, semi-auto or full manual control
- + Option of ZF Intarder for additional braking capacity

Tipmatic direct-drive auto, combined with the latest 2.53:1 rear-axle ratio on TG chassis, takes full advantage of the 'low-revs/high torque' characteristics of MAN's Euro-6c engine line-up. On the D20, D26 and D38 engines, peak torque is typically delivered between 900-1,400rpm – ensuring the very best fuel economy. Should the mission require it, however, an overdrive top ratio is optionally available.

While Tipmatic auto is the standard transmission on the latest Euro 6c MAN TGX and TGS chassis (with Tipmatic 12 +2 in the case of 4x2 tractors with the D26 diesel), for those operators preferring a full manual box there's still the option of a 16-speed ZF Ecosplit. Moreover, the latest Ecosplit

4 also features several improvements, including a newly-designed alloy housing that saves 15kg and also contributes towards a noise reduction of -2 dB(A). For drivers, the clutch pedal effort has also been further reduced. Like Tipmatic, the latest Ecosplit synchro box can also be spec'd with an Intarder.

Although manual boxes remain a popular choice for heavy haulage STGO operators – the Ecosplit 4 is capable of being used in MAN chassis plated up to 120 tonnes gcw – Tipmatic with an overdrive top ratio is more than capable of being spec'd for STGO chassis operating up to 80 tonnes gcw, assuming the appropriate software changes and rear-axle ratios.



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