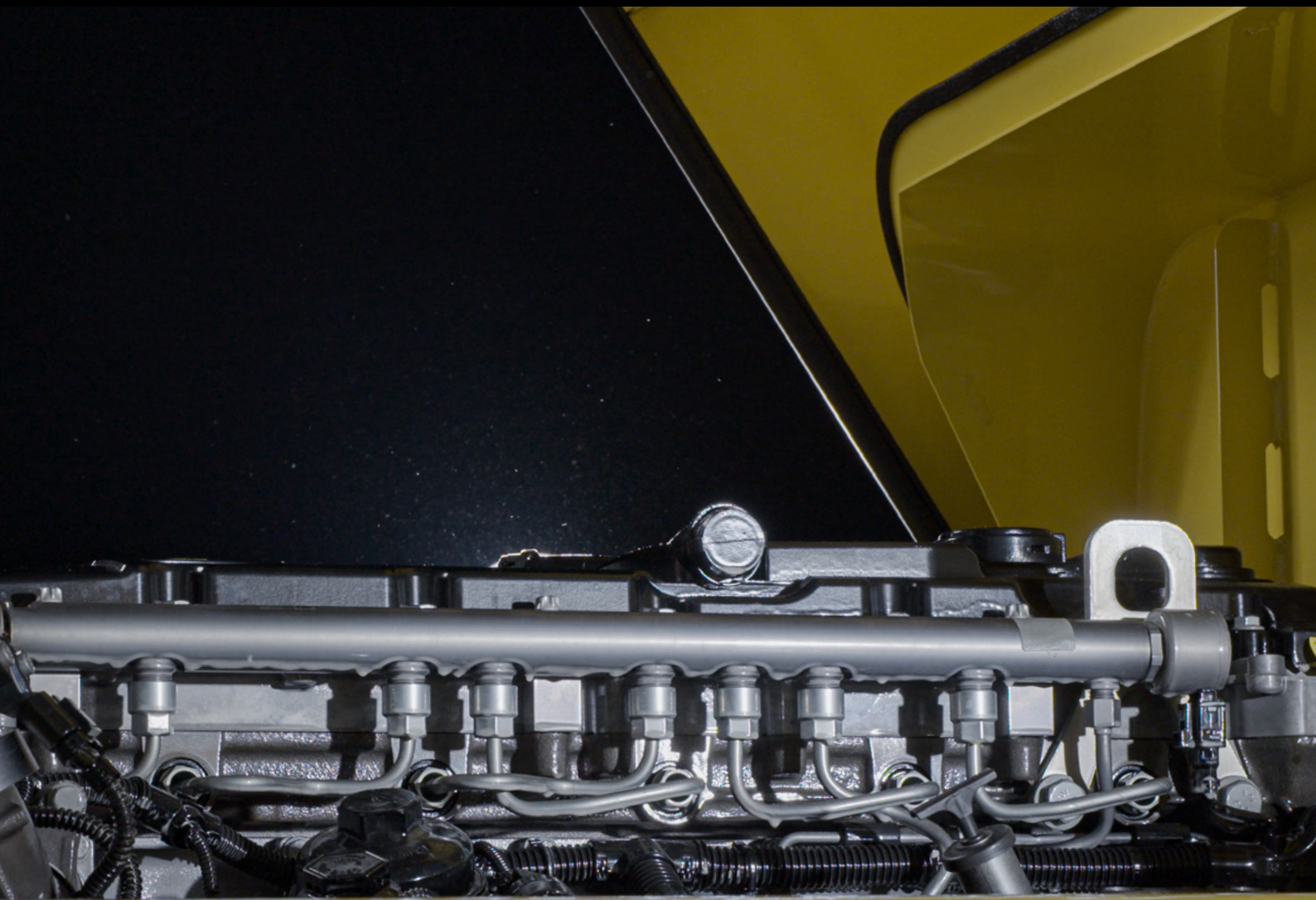




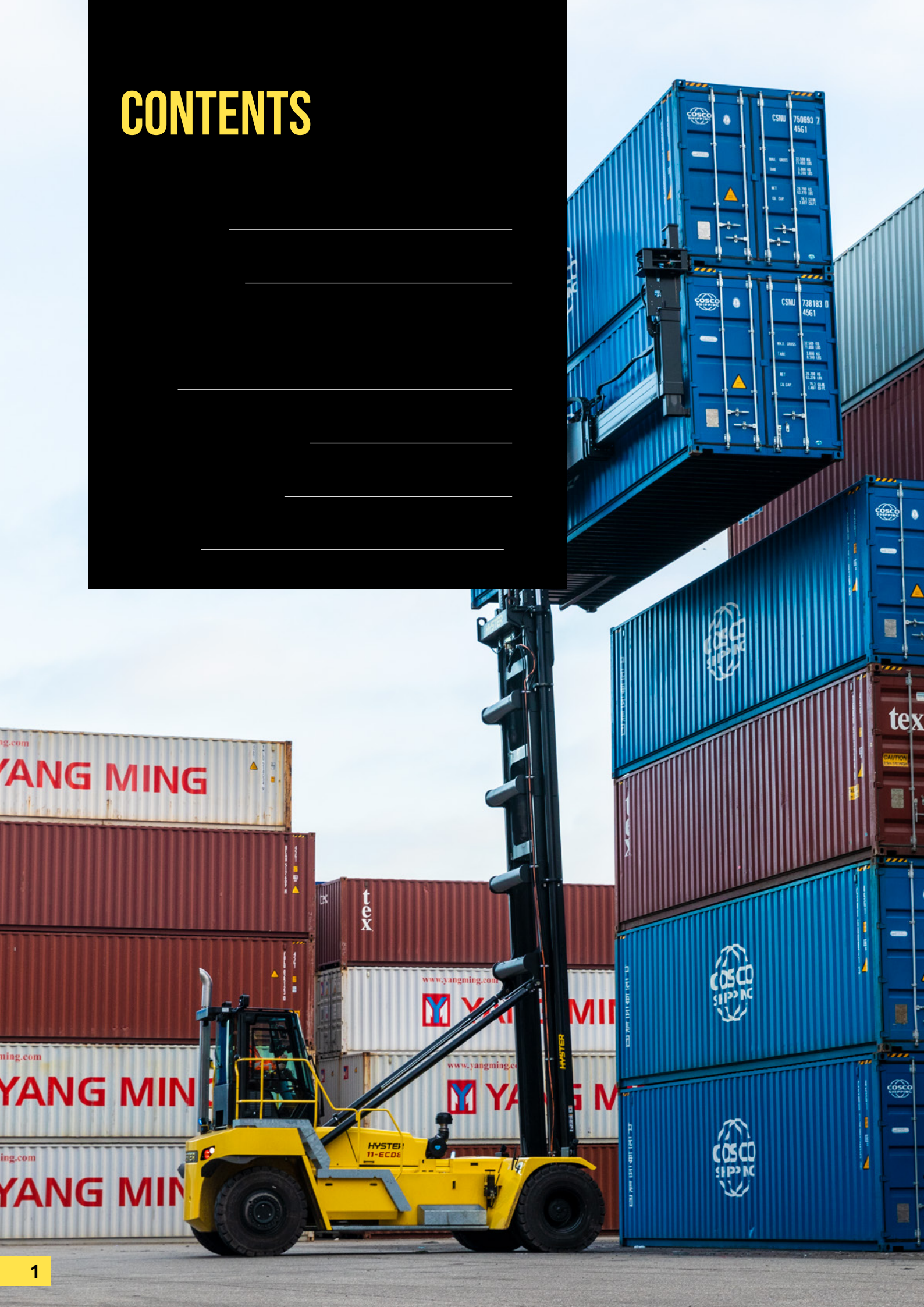
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EU STAGE V EMISSIONS REGULATIONS & HYSTER[®] BIG TRUCKS

FREQUENTLY ASKED QUESTIONS



CONTENTS



INTRODUCTION

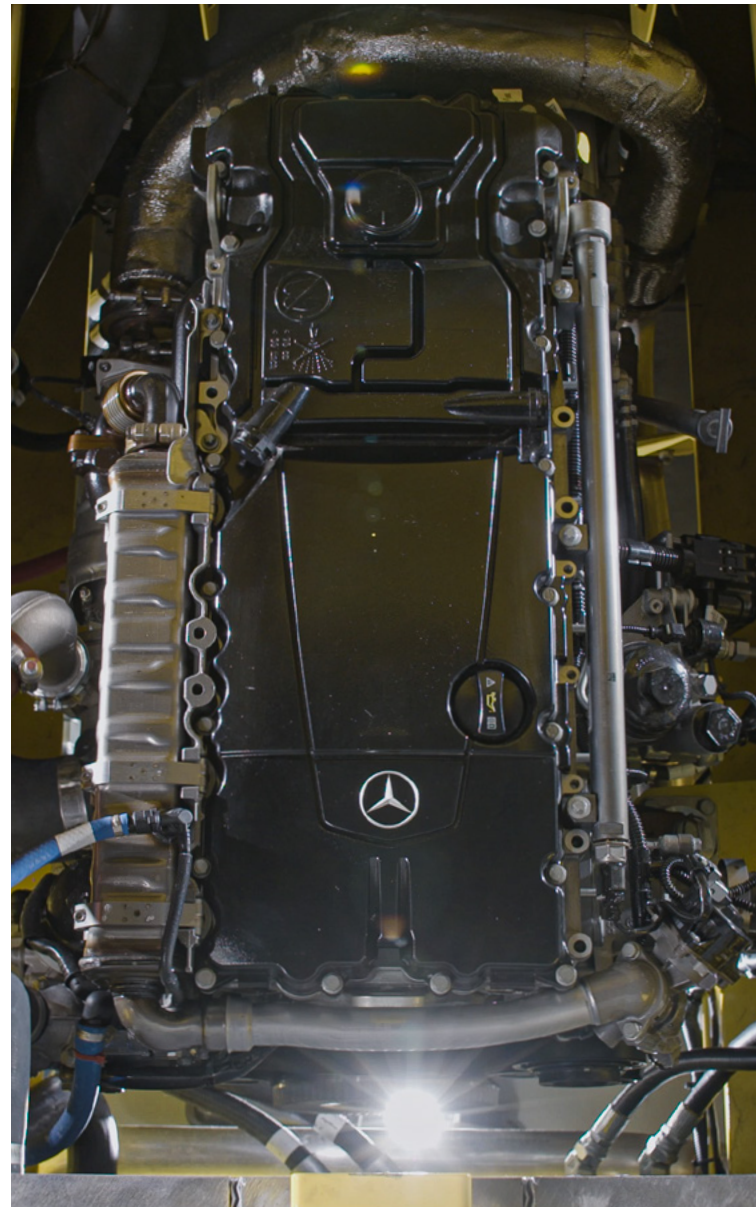
THE JOURNEY TO STAGE V EMISSIONS REGULATIONS

Over the past two decades, the EU has adopted a series of directives to address emissions from non-road engines. Since 1997 there were various annexes.

Stage I and Stage II emission standards were established in the late 90s for diesel-fuelled engines with a horsepower rating between 37 and 560 kW. Then in 2004, 2014/26/EC incorporated Stage IIIA, IIIB, and IV emission standards and extended the scope of regulated diesel engines.

The latest Stage V emissions standards replaced the previous multi-layered legal framework with one regulation for the whole of the EU, with emissions level targets now extremely “severe”. Stage V was phased in from January 2018 to January 2020 and is now law across the region.

Until Stage V, the EU and North America were following similar paths for emissions control with a Tier system being used in North America. Today in the US, it is still possible to use new machines with Tier 4 Final certification (the equivalent of Stage IV in Europe).



THE HYSTER JOURNEY

Hyster has always been at the forefront of environmental and fuel saving technologies, particularly during the launch of Stage IV engines for the Hyster® Big Truck range.

“We brought huge fuel savings to the market with our Stage III and Stage IV products, but we did not compromise on productivity. Now with our Stage V range, the fuel savings are significant, and the productivity is exceptional, making this the best balance for operations who want to make real financial savings while improving their environmental performance.”

Rob Maris, Product Strategy Manager EMEA Big Trucks for Hyster Europe.

Stage V equipment is available today, already supporting customers with greener operations. However, our development work never ends while we strive to optimise the environmental performance of our machines, considering more than just engines. This is one reason Hyster has been developing electric Big Truck options, including ReachStackers with electric drivetrain and Hydrogen fuel cells, and Container Handlers with lithium-ion batteries.

Find out more at www.hyster.com about this exciting new chapter for Hyster® Big Trucks.

ABOUT STAGE V

WHAT IS THE STAGE V ENGINE EMISSIONS STANDARD?

Stage V is the European Union (EU) emissions regulations for off highway diesel engines.

For engines 130 kW to 560 kW (174 – 751 hp)

The regulations commenced on 1 January 2019 across the 174 to 751 hp (130-560 kW) power category. This is typically large 18-52 tonne lift capacity lift trucks or ReachStackers. Diesel engines should reduce Particulate Matter (PM) from the exhaust emissions by 90% and Oxides of Nitrogen (NOx) exhaust emissions by 45% compared to the current Tier 4F and Stage IV emissions standards. The emissions standards for this power category are 0.4g/kW-hr for NOx and 0.015 g/kW-hr for PM.

For engines from 56 to 130 kW (75 – 173hp)

For engines within the 75 hp to 173 hp (56 – 129 kW) power category, the Stage V regulations commenced on 1 January 2020. These are usually lift trucks with capacity of 6T to 18T and the emissions levels are the same as above.

For engines from up to 56 (75hp)

For engines up to 75 hp (56 kW) power category, the Stage V regulations commenced on 1 January 2019. These are usually lift trucks with capacity of 1T to 9T and the emissions level requirements differ slightly to the above.



WHAT ARE OXIDES OF NITROGEN (NO_x) AND PARTICULATE MATTER (PM)?

Oxides of Nitrogen are air polluting chemical compounds and are a regulated diesel engine emission. It is a collective term for gaseous emissions composed of nitrogen and oxygen. Particulate Matter is a regulated diesel emission composed primarily of carbon soot and other combustion by-products.

IS CO₂ ALSO A PART OF THE STAGE V STANDARD?

No, CO₂ is not regulated in the Stage V regulations although Governments and national bodies can force end users to use products with lower CO₂ emissions. CO₂ emissions can only be reduced by lowering the fuel consumption.

WILL ALL EQUIPMENT SUPPLIED INTO THE AFFECTED MARKET AREAS BE EQUIPPED WITH STAGE V ENGINES?

No, both EU and EPA permit a certain degree of flexibility in its enforcement. For Non-EU Countries (former EU stage IIIA territory) for example, engines with R96 standard can be used which covers most of the Stage V requirements, up to Tier III non-regulated engines for EMEA (depending on fuel quality) can be used or Tier 4F equivalent. Acceptance depends upon the local environmental regulations.

CAN I EXPORT STAGE V TRUCKS BETWEEN THE EU AND US/CANADA?

No. There are a number of factors that play into this including differences in emissions requirements. EU and EPA engines typically have a different certification, but some have dual certification. Hyster® Stage V trucks, for example, are dual certified, so they also have EPA/CARB certification for Tier 4F as well.

WHAT TECHNOLOGIES ARE USED TO ACHIEVE STAGE V?

There are two main approaches for meeting the Stage V emissions standard.

Advanced Exhaust Gas Recirculation (EGR)

To effectively control NO_x emissions, EGR is used in combination with high-pressure common-rail fuel injection and electronically controlled air- and fuel management. Cooled EGR works by re-circulating a varying proportion of the exhaust gas back to the cylinder. This reduces the oxygen content to a lower combustion temperature resulting in a reduction of NO_x formation. The engine is optimized on low NO_x emission.

Selective Catalytic Reduction (SCR)

To neutralize nitrogen oxides (NO_x) in the exhaust stream, a urea solution known as diesel exhaust fluid (DEF*) is introduced. This is known as SCR. The exhaust gasses are mixed in a catalytic converter which reduces the NO_x to Nitrogen and Oxygen elements. The engine is optimized on low PM emission.

The remaining particulates are collected in a Diesel Particulate Filter which are then oxidized by passive and/or active regeneration. Particulate Matter (PM) count forms part of Stage V certification.

* DEF is commercially known as "AdBlue" in Europe / DEF outside Europe and is a solution of 32.5% urea and purified water.

HYSTER® BIG TRUCK TECHNOLOGIES AND PERFORMANCE

HOW IS HYSTER MEETING STAGE V REQUIREMENTS?

Hyster has met Stage V standards with Rolls-Royce Solutions engines which feature:

- ▶ A cooled exhaust gas recirculation (EGR) system incorporated into the engine
- ▶ An integrated Mercedes-Benz Particulate Filter exhaust after treatment system

This is in combination with SCR and a Diesel Oxidation Catalyst (DOC) which is an aftertreatment component that converts carbon monoxide (CO) and hydrocarbons into carbon dioxide (CO₂) and water.

WHY DID HYSTER CHOOSE THESE ENGINES FOR STAGE V?

We believe the chosen Rolls-Royce Solutions Stage V engines offer significant advantages. Meeting the legislation demands new levels of system integration. It requires not only for the engine to be replaced, but the engine needs to work together with several other systems. All will result in a reduction of fuel consumption and therefore very low emissions, while improving performance.

Rolls-Royce Solutions designs and manufactures the particulate filter as an integrated system with the engine. They also have access to all key enabling technologies within their design and manufacturing resources: from after treatment, electronic control to turbo charging. Furthermore, Mercedes Benz offers a single box design for after treatment. This is advantageous as it is a compact, simplified system, and built with less connections.

ON HYSTER® BIG TRUCKS, WILL STAGE V ENGINE PERFORMANCE BE THE SAME AS STAGE IV?

Stage V Hyster® trucks have improved engine performance in certain areas compared to Stage IV trucks. Several aspects add up to this improved performance:

- ▶ Torque has been raised in the lower engine RPMs to meet the latest customer requirements and to enable a smoother operation.
- ▶ The engine response is faster in the Stage V engine to further increase productivity.
- ▶ Operators will furthermore notice that Hyster® Stage V trucks work cleaner and are quieter than previous series.
- ▶ Current EPA or EU regulations do not take into account the CO₂ emissions, these levels will be reduced in the Stage V trucks, nevertheless.
- ▶ Performance is further enhanced by introducing new cooling system fan technology to the Hyster® trucks, which is known as cooling on-demand.

WHAT IS COOLING ON-DEMAND?

Cooling on-demand is a system that monitors the different temperatures in the engine, hydraulic system, and transmission. The cooling fan speed is adjusted based on the measurements monitored, to assure all systems will remain in the most efficient temperature range. It has been implemented in the Hyster® trucks to reduce the power consumption of the cooling system. The cooling capacity of the cooling system is larger in the Stage V trucks, but cooling on-demand, improves fuel savings and reduces cooling fan noise.

HOW ARE THE STAGE V ENGINES PERFORMING IN OPERATION?

The Stage V engines in the Hyster® trucks have been used in field tests to prove their performance in operation.

Firstly, the engines have been tested in Rolls-Royce Solutions Stage V field tests, which started as early as June 2018 for Hyster trucks. Since then, Stage V represents the most extensive development, concept installation and field test program that Rolls Royce Solutions has ever undertaken with off-highway engine.

Secondly, Hyster tested the implemented Stage V engines in its big trucks extensively in the field. Prior to launch, the trucks will be used in operation to prove their reliability and to demonstrate low fuel consumption in daily applications. The Hyster® trucks that are currently used in customer operations prove their reliability day in, day out, confirming that they are tough, dependable machines for the most demanding applications.

HOW DOES THE DIESEL PARTICULATE FILTER REMOVE PM?

Diesel Particulate Filters consist of four sections: an inlet, a Diesel Oxidation Catalyst (DOC), a Diesel Particulate Filter (DPF) and an outlet. Exhaust flows out of the engine and into the inlet of the Particulate Filter unit. It passes through the Catalyst and then into the actual particle filter. Here, the particle material in the form of carbon is collected on the walls of the filter. The collected carbon is then oxidized to remove it from the filter's walls. This is known as regeneration.

When the engine load is high enough, operating conditions will enable the temperature in the exhaust to be sufficiently high. In these conditions, the DPF is self-regenerating. This is known as passive regeneration and results in a cleaner DPF.

Mercedes-Benz engines are designed to maximise the use of passive self-regeneration. The operator will not be aware of the passive self-regeneration process, and it does not affect the machine's operation or performance. Our field test results have shown that most forklift applications operate at a high enough engine load factor for the MB Diesel Particulate Filter to self-regenerate almost every time in passive mode. On very infrequent occasions, an active self-regeneration may be required to remove a build-up of PM in the DPF, due to insufficient exhaust temperatures. The Mercedes-Benz Stage V system is designed to minimise the need to do this.

COSTS

HOW WILL STAGE V IMPACT THE INITIAL COST OF EQUIPMENT?

The initial costs of acquisition of the Stage V powered equipment will be more than Stage IV equipment. Achieving very low levels of emissions for Stage V requires a major investment in engine technology and involves the addition of new systems such as Particulate Filter after treatment.

The cost of the equipment will therefore reflect the incorporation of a Stage V technology system and more advanced transmission and cooling packages.

However, while Stage V powered equipment will be more expensive than Stage IV equipment initially, the cost of achieving compliance will be offset by the lower overall operating cost.

HOW WILL EQUIPMENT OPERATING COSTS BE IMPACTED BY STAGE V?

Overall operating costs for Hyster® Big Trucks will be lower for Stage V compared to Stage III. With improved engine response, operators can expect improved equipment productivity together with the benefit of cleaner, quieter operation and reduced fuel costs.

The Mercedes-Benz Stage V engine offers lower fuel consumption, and, depending on duty cycle and application, Hyster® Stage V trucks can achieve fuel consumption reductions of up to 20% for ReachStackers and our 40-52T lift trucks.

In addition to the Rolls-Royce Solutions technologies applied to reduce fuel consumption, Hyster has introduced cooling on-demand technology and improved coolant balancing resulting in lower noise, lower fan speed, and lower fuel consumption. The optimisation of the powertrain by including a new transmission and torque converter is also part of the total fuel consumption reduction.

The improved fuel consumption will more than offset the marginal cost increase associated with using ULSD fuel, low ash lube oil and particulate filter – see the next sections for details.

Fuel savings are only part of the story, as better productivity may have a greater impact on the cost per container moved.

WILL THIS REDUCE THE COST PER CONTAINER OR TONNE MOVED?

Hyster has done extensive analysis using data from telematics which offers insight into ways to reduce the cost per tonne moved. The overall conclusion is that productivity has a greater impact on Total Cost of Operation (TCO) compared to minimising fuel consumption. Real-life testing shows that the Hyster® ReachStacker can be up to 12% more productive than a comparable product. That is 12% more containers that can be moved in a day, which quickly adds up and significantly reduces the cost per tonne moved. Excellent power response and productivity is often much better for operations with seasonal peaks and tight timescales when trucks are pushed harder.

DOES STAGE V AFFECT THE DRIVER?

The way Hyster has approached Stage V means that while our fuel savings are significant, the productivity of Hyster® Stage V machines is exceptional. This provides the best balance for operations, and for drivers.

The fast, responsive Hyster® machines help keep drivers productive, designed to deliver up to 12% greater productivity.

In comparison, truck manufacturers that have only focused on emissions control and fuel savings can have much slower machines. This could lead to complaints, poor driver morale, and an inefficient operation, despite marginal savings at the fuel pump.

SERVICE REQUIREMENTS

HOW IS THE DIESEL PARTICULATE FILTER SERVICED?

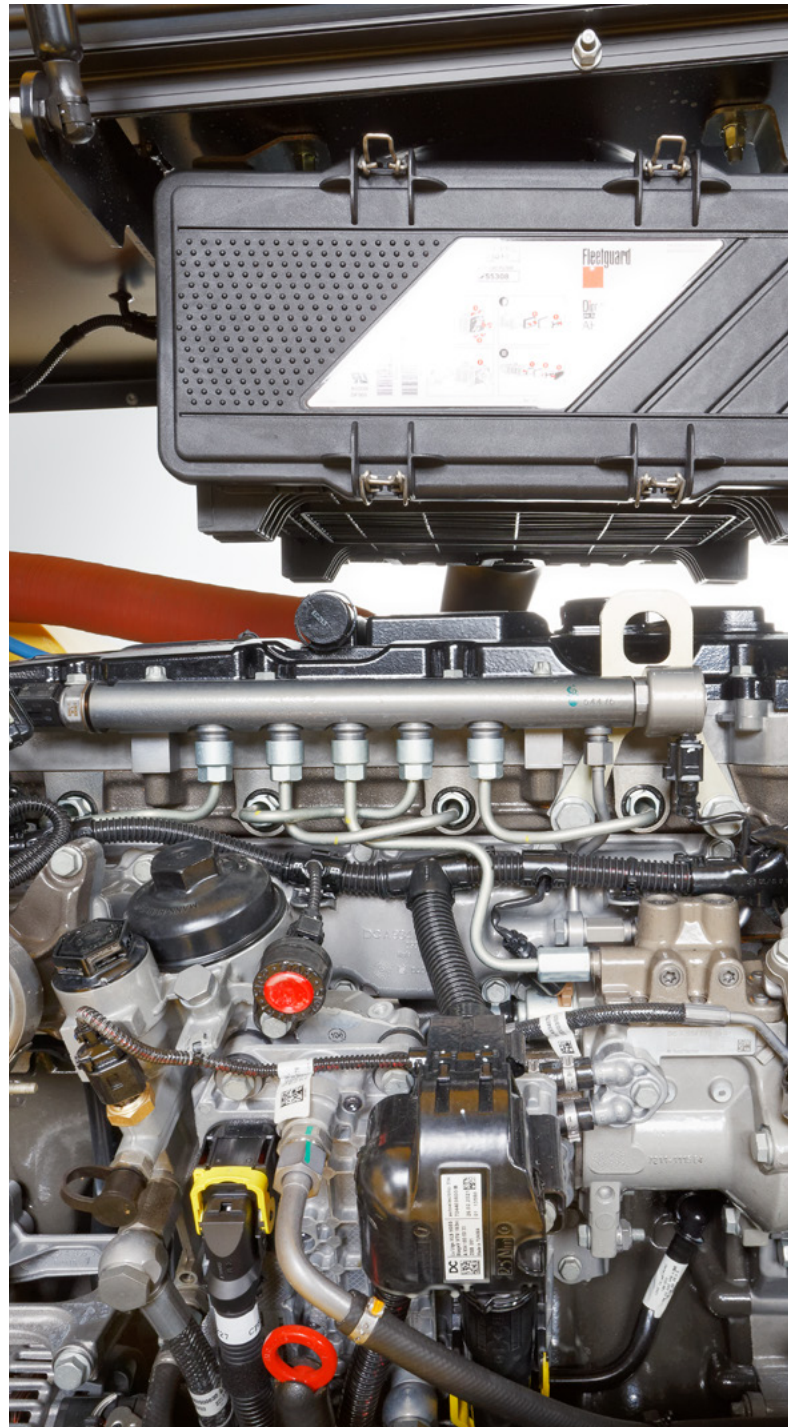
The Diesel Particulate Filter must be removed and cleaned by an authorised technician, typically after 4,500 hours. The ash cleaning process usually takes around 30 minutes, plus the time to remove the Particulate Filter from the equipment. The Diesel Particulate Filter is designed to last the life of the engine.

IS “LOW ASH LUBE OIL” REQUIRED FOR STAGE V?

Yes. To maintain regulated ash cleaning intervals, it is strongly recommend to use oils according to MB 228.51.

WHAT IS THE SERVICE INTERVAL OF THE OIL?

The service interval of the engine oil has been extended from 500 to 1000 hours on Hyster® Big Trucks. The engine oil level is shown on the truck’s in-cabin display, so there is no need to even use a dipstick.



FUEL REQUIREMENTS

IS ULSD FUEL LEGALLY REQUIRED FOR STAGE V ENGINES?

Yes. In the EU, Ultra Low Sulphur Diesel (ULSD) is legally required for Stage V engines. The ULSD must legally be 10ppm at the point of manufacture and is expected to be 15ppm at the point of use.

ULSD is widely available today in North America and Europe. Any other fuel (i.e. with a higher sulphur content) will damage the engine and after treatment system.

WILL ULSD BE AVAILABLE OUTSIDE OF NORTH AMERICA AND THE EUROPEAN UNION?

Availability of ULSD is very limited outside of North America and the European Union.

WHAT HAPPENS IF HIGHER SULPHUR FUEL IS INADVERTENTLY USED?

Continued improper fuel use of sulphur levels greater than 15ppm with Mercedes-Benz engines can cause permanent damage to the engine and after treatment systems within a short period of time. This could possibly cause the engine to be inoperable and cause unplanned downtime and unnecessary expense.

IS THE ENGINE WARRANTY AFFECTED IF ULSD IS NOT USED?

Yes. Improper use of fuel with sulphur levels greater than 15ppm with the Mercedes-Benz Stage V engines can result in denial of warranty coverage.

CAN ULSD BE USED IN TIER 4 FINAL / STAGE IV OR OTHER ENGINES?

Yes. Hyster® equipment with Tier 4 Final / Stage IV engines will work correctly when using ULSD.

CAN BIODIESEL FUEL BE USED WITH MERCEDES-BENZ STAGE V ENGINES?

Mercedes-Benz Stage V engines are compatible with biodiesel blends up to 7%.

WARRANTY

DOES STAGE V TECHNOLOGY CHANGE THE CURRENT WARRANTY COVERAGE ON ENGINES?

Current engine warranty will become a broader engine and system warranty for Stage V by incorporating the Diesel Particulate Filter after treatment and Direct Flow air cleaner housing. However, warranty hours and terms and conditions remain unchanged for Stage V.

WHAT HAPPENS IF STAGE V ENGINES ARE OPERATED OUTSIDE OF THEIR INTENDED EMISSIONS REGION?

Stage V engines (and after treatment) which are exported and operated outside of their intended emissions region will not carry a warranty. The very low emissions levels for Stage V require specific technology that is not appropriate for regions with less rigorous standards.

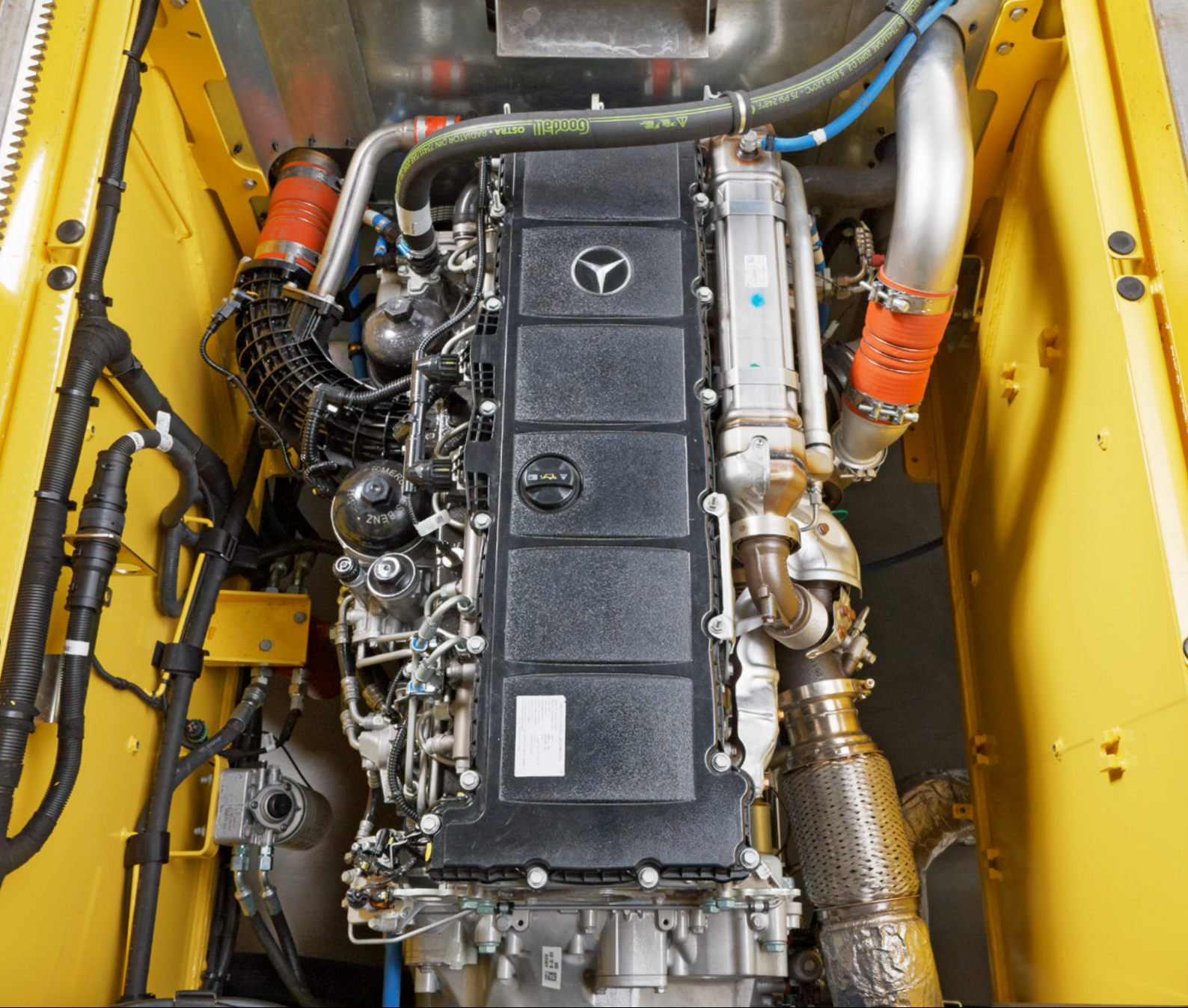
Since emissions standards vary across the world, Hyster designs its products to meet the standards of an individual country and/or emissions region. Dealers and customers should carefully select the correct engine to meet the emissions requirements of their respective country.



WHEREVER YOU ARE IN THE WORLD

benefit from a low Total Cost of Ownership and meet local emissions regulations with Stage V, IV and IIIa options for all Hyster® Big Trucks.


For more information on the changes being made to the Hyster® range of Big Trucks, as a result of the emissions legislation, please visit www.hyster.com or speak to your local Hyster® dealer.





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