



# Stage V Diesel Engine Guide

FOR PORTABLE PUMPS IN THE UK AND EUROPEAN MARKETS

# Introduction

## Understanding the Change

We all know change can be a challenging time but having someone to go to, who's been there and done it, to guide and advise you, can greatly ease the journey. We understand the rules around Stage V Engine compliance, and equally, we understand the anxieties, challenges and implications that brings; whether it is the costs; day-to-day pump operations, or selecting the right pump and engine optimal for your application. We know how to make it work for you, to keep your business running.

We know how to make it work for you, to keep your business running.



Our expertise of Stage V engines and emissions compliance has been built over many years. We have successfully delivered the previous Stage emission compliant engines (Stages I-IV) throughout Europe (and US EPA Final Tier 4); and are now delivering Stage V engines to our customers in Europe. As a recognised industry leader, Xylem has fully adopted a complete set of Stage V pump solutions that maximise performance, minimise maintenance and downtime, and meet the most stringent EU diesel engine regulations. Drawing on this experience, we are here to support and guide you as an assured partner through the next steps to deliver confidence in compliant solutions.

# Introduction

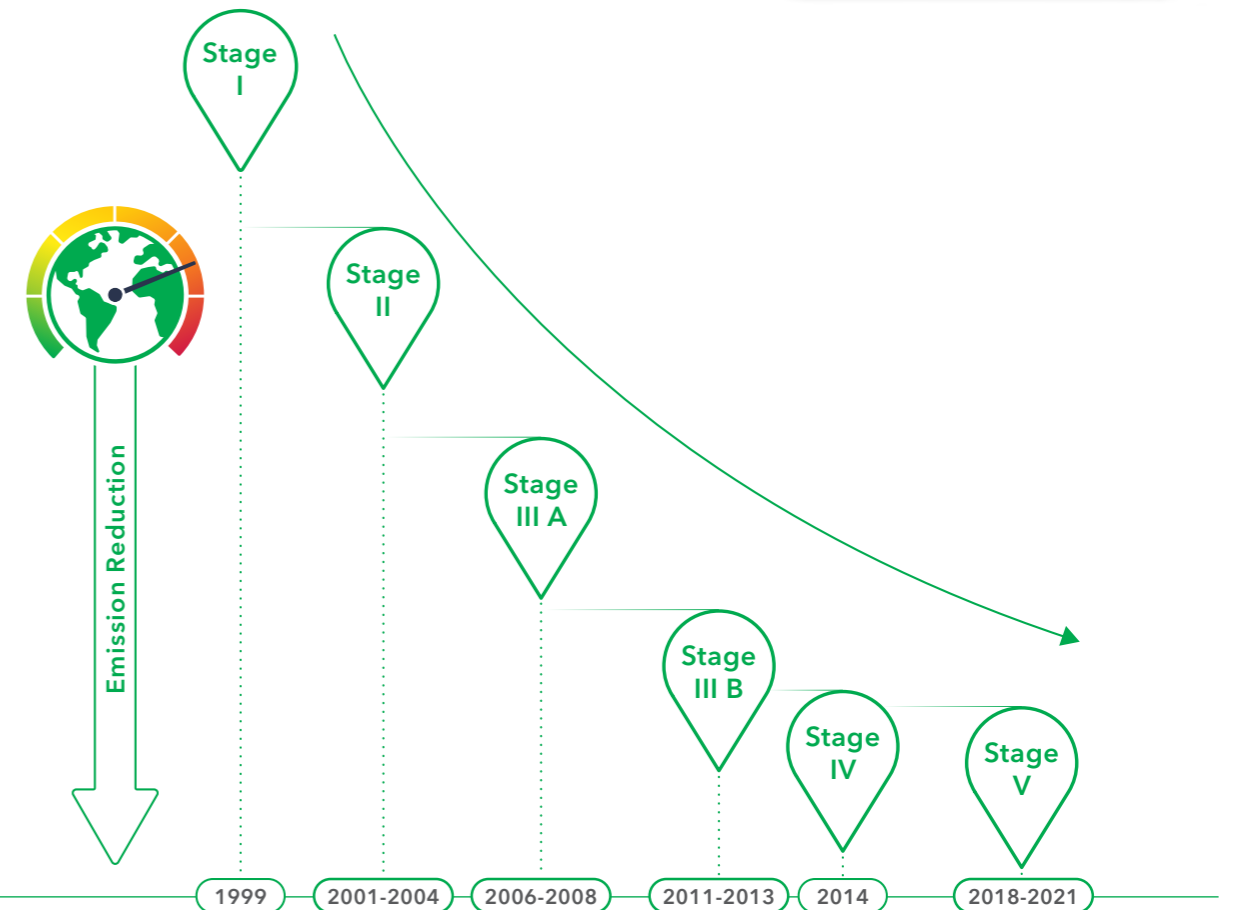
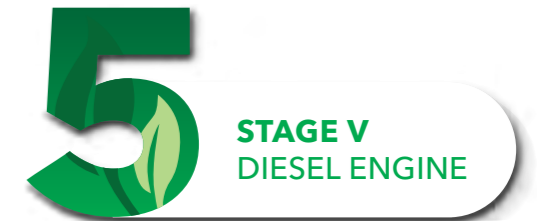
## Ready for Change

Being ready for the change, understanding it and being compliant is part and parcel of being leaders in our industry.

Through our extensive and advanced global research, development and validation activities, we have tested, selected and paired the best engines for your applications and our products. We understand there will be differences, for example, with engine regeneration processes; monitoring of Particulate Matter (PM); and additional maintenance operations and procedures.

Our commitment is to "Keep you Running".

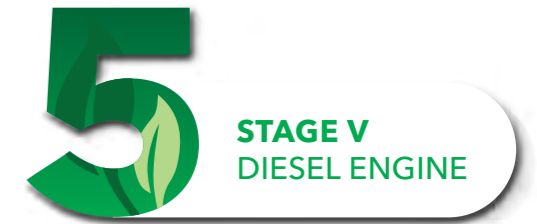
Our innovation and smart technology, such as Xylem Field Smart Technology (FST) can simplify Stage V engine and pump operation, allowing remote monitoring and alerting to sub-optimal conditions, to increase pump uptime, fleet utilisation, and reduce maintenance schedules.



We are with you to share our knowledge and experience; to educate and train you on Stage V engine and pump operation; to keep you up and running, with minimal disruption.

This guide discusses the engine technologies used to ensure compliance with EU standards for Stage V diesel engines, the implications for operating the pump, and how Xylem understands the changes to support you through the transition.

# Compliant Solutions



Implementation of the standards has occurred in stages, with the deadline for compliance under the final stage - Stage V - now imminent.

Diesel engines in every industry, in every application, from large-scale marine engines to small horticultural equipment engines, are subject to these regulations. Whilst deadlines are contingent on engine size, Stage V engines are required to be fully implemented for all non-road diesel engines by the end of 2021.

Whether you work in construction, mining, municipal wastewater or at an industrial plant, the emission reduction technologies on Stage V diesel engines for portable pumps are no doubt on your mind. Xylem is here to help.

98%  
in 20 years

**Engine gaseous pollutants have been reduced by 98% over the last 20 years.**

**As the deadline to meet EU Stage V emission standards for diesel powered portable pumps approaches, Xylem is with you every step of the way.**

The European Commission sets out emission limits for gaseous and particulate pollutants for diesel engines. The standards demand a reduction in 'gaseous pollutants', specifically, carbon monoxide (CO), total hydrocarbons (HC) and oxides of nitrogen (NOx); and, 'particulate matter' (PM) which includes particles such as soot from incomplete combustion. The regulation has also introduced a limit on the number of particles that can be emitted.

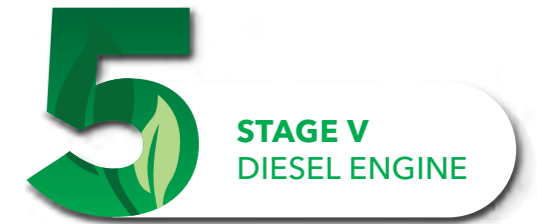
We understand that the transition to Stage V demands change, and we have been working hard to make this as seamless as possible for you. As an industry leader, we have fully adopted a complete set of Stage V solutions that deliver high performance while significantly reducing carbon, nitrogen oxides (NOx), and particulate emissions, and are delivering our Godwin dewatering pumps with Stage V engines to our customers throughout Europe.

Xylem is leading the dewatering industry in the European Commissions' required transition to Stage V. Our unrivalled experience is based on thousands of hours of hands-on application experience and testing to simplify maintenance requirements while ensuring even longer service intervals. When it comes to Stage V, you don't need to go it alone - we are ready to help and guide you through this process.

**We know Stage V and we're here to share our expertise and guide you through the change.**

# Challenge and Solutions

## Understanding the Change



The EU's primary pollution targets in engine exhaust emissions are particulate matter (PM), and ozone precursors of nitrogen oxides (NOx) and hydrocarbons (HC).

### PM

Particulate matter (PM) from exhaust emissions is the result of incomplete combustion of diesel fuel and is made up of soot, nitrates and sulphates, organic chemicals, metals and carbon debris, and is a major factor contributing to respiratory conditions such as lung cancer.

### NOx

Nitrogen oxides (NOx) is the generic name for a group of highly reactive gases made up of nitrogen and oxygen that form when fuel is burned at high temperatures, as in a combustion event found in a diesel engine. When NOx reacts with water in the atmosphere, nitric acid forms, causing acid rain.

### HC

The combustion of fuel, which mainly comprises hydrocarbons (HC) is known to affect the environment and human health. For example, increasing CO<sub>2</sub> which contributes to the greenhouse effect and climate change; producing toxic chemicals that inhibit photosynthesis in plants; and causing eye and lung irritations.

### O<sub>3</sub>

Nitrogen Oxides (NOx) and gaseous hydrocarbons (HC) from exhaust emissions, exposed to sunlight, are key ingredients in the formation of ozone and photochemical smog. Ozone at ground level is a harmful air pollutant, because of its effects on people, for example respiratory conditions, and it is also the main ingredient in "smog".

Reducing nitrogen oxides (NOx) and PM pollutants in diesel exhaust is complex. High temperatures and excess oxygen within a diesel engine's combustion chamber increases the amount of NOx formed. While it might be expected that lowering the in-cylinder temperature of the engine and limiting the amount of oxygen would reduce NOx levels, lower temperatures increase the production of PM because less of the fuel is converted into energy, leaving behind soot.

Most Stage V engines are programmed to go through lengthy regeneration cycles to remove PM and soot if levels get too high. These regeneration cycles are often unpredictable, and can cause pumps to shut down when you least expect it; out of hours; or during jobs with high environmental impact.

The typical time for a Stage V 75 kW diesel engine to release 6kg of Particulate Matter or soot is around 20 years, compared to about 2 months for an unregulated engine.

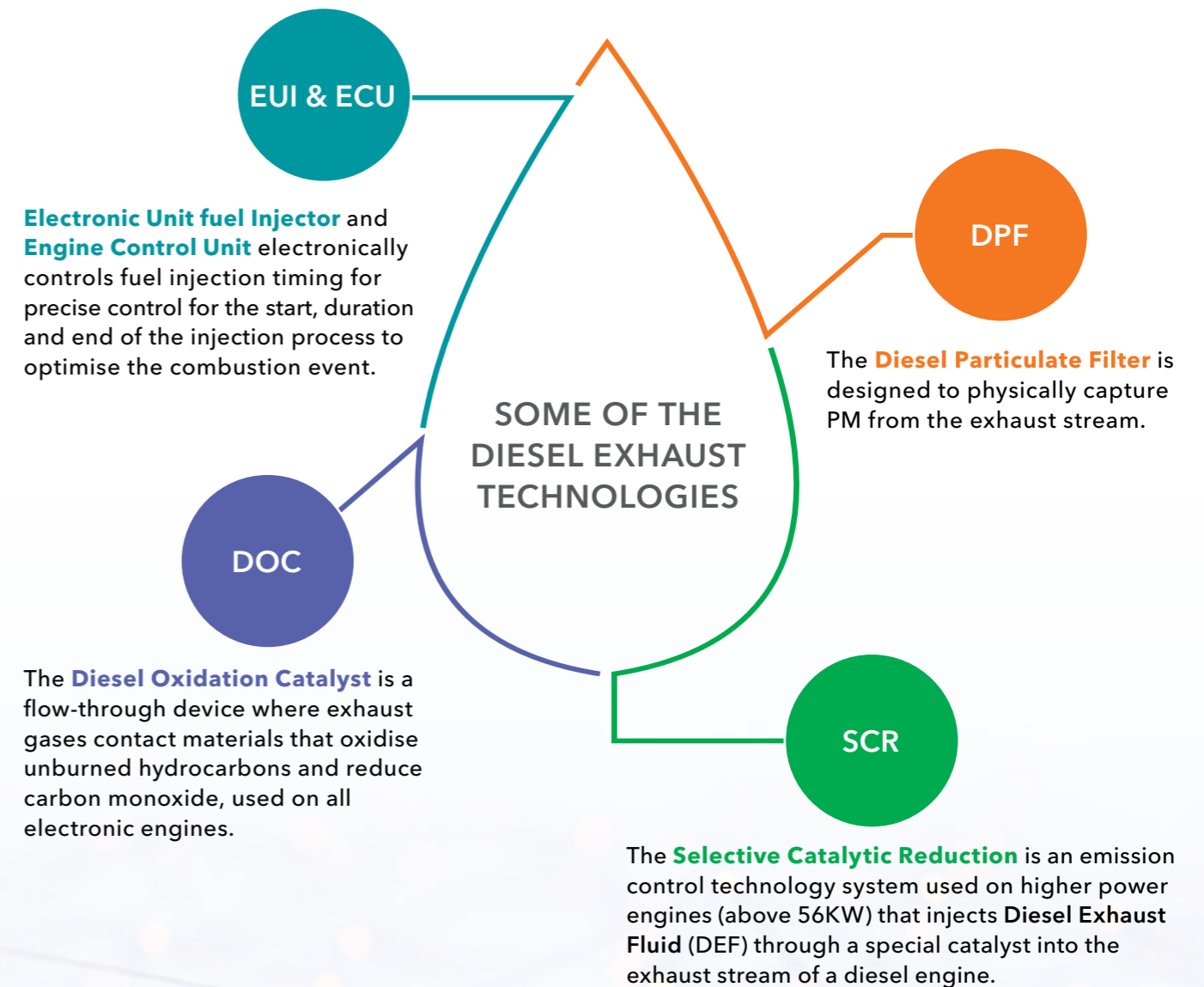
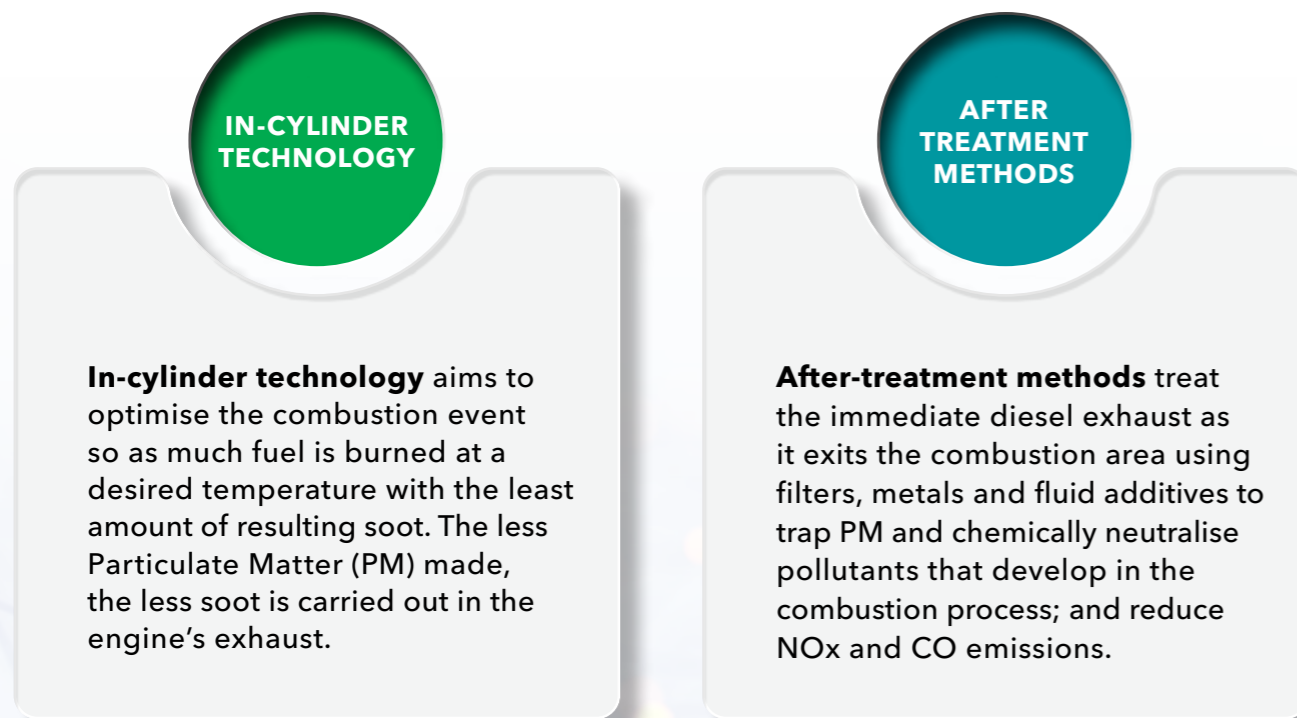


# Challenge and Solutions

## Innovation Applied

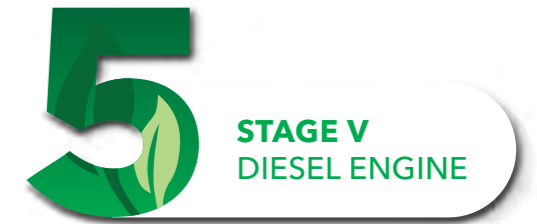
Some of the advances in Stage V engines for Godwin portable pumps include enhanced engine control technology, Xylem Field Smart Technology (FST), and advanced control systems to fully comply with the European Commissions' reduced emissions requirements.

The emission control methods and configurations used by manufacturers depend on variables such as power range and equipment type. Emission reduction technologies fall into two general categories:



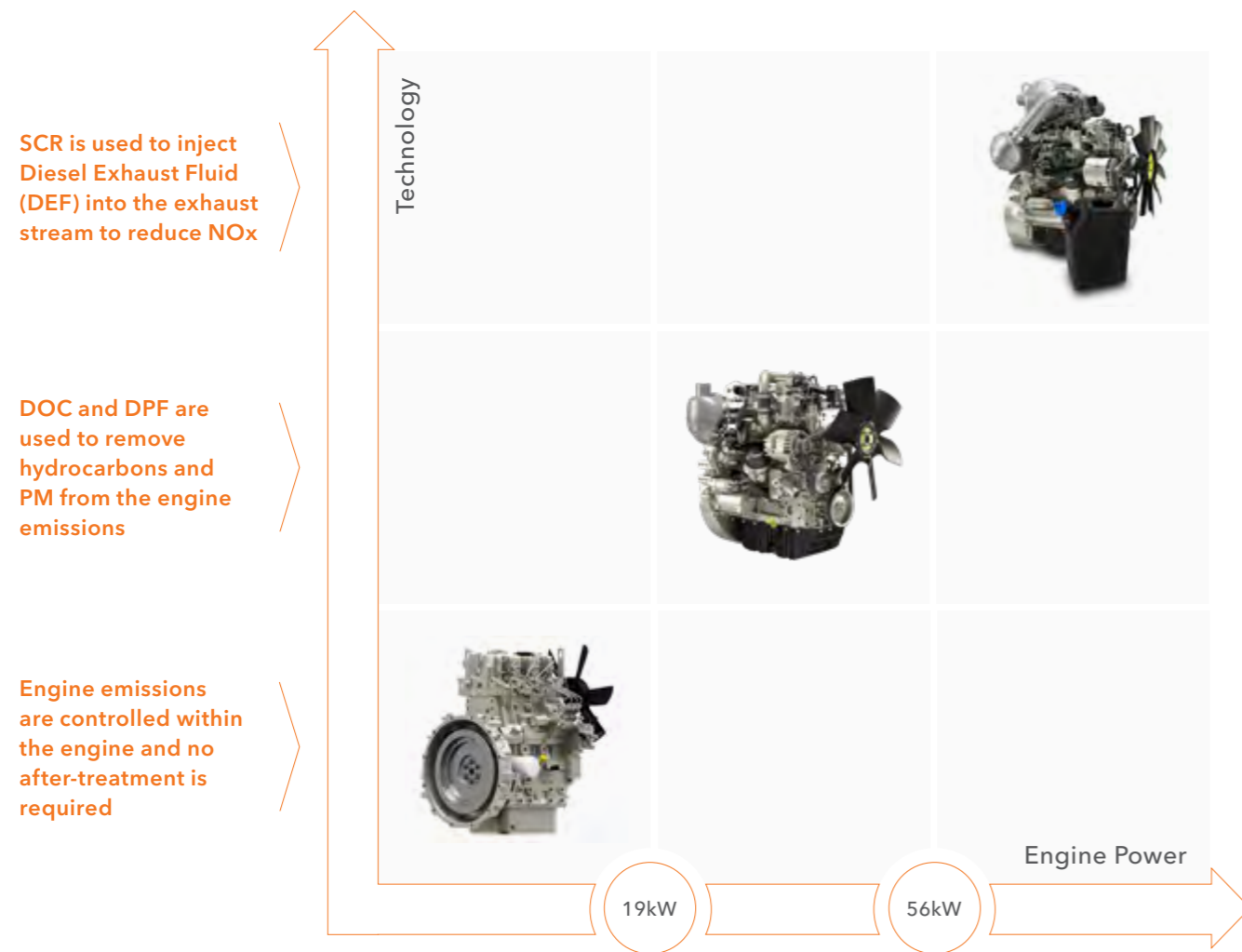
# Challenge and Solutions

## Stage V Exhaust Emission Control Strategy



With the introduction of Stage V emission regulations for non-road mobile machinery the EU has required engine manufacturers to add emission reduction technology based on engine power. The higher the maximum engine power the greater the potential to release pollutants into the atmosphere, and this has led the EU to require more emissions technology to be incorporated on larger engines.

This graph illustrates the emission control technology and strategy used for each engine power range.

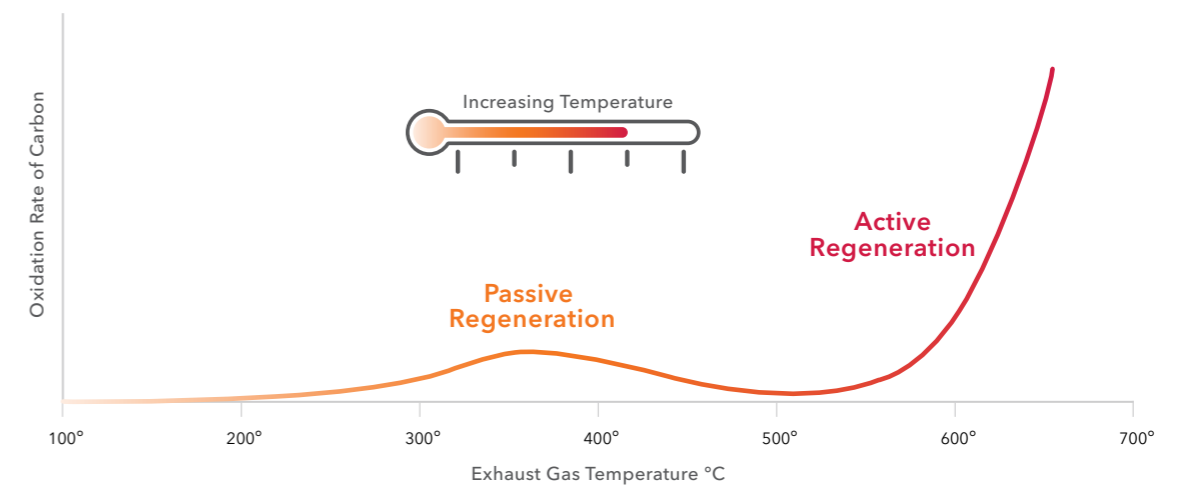
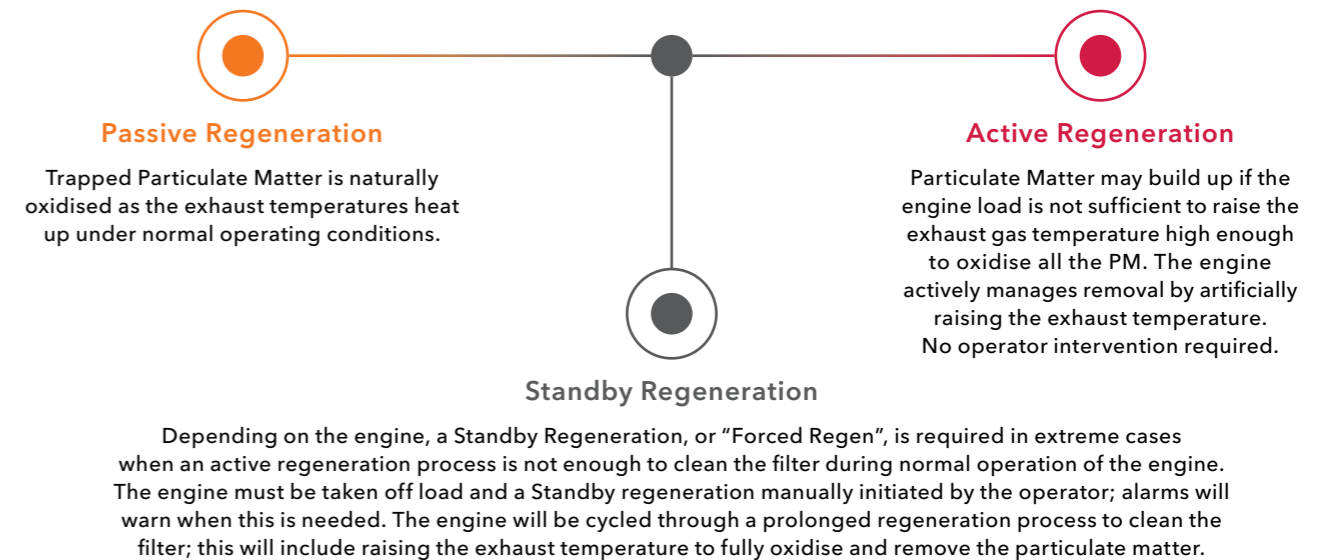


Engine graphics by permission of the manufacturer.

### DPF Regeneration - Keeping the Exhaust Filter Clean

Keeping the filter clean is key to keeping a Stage V engine operating efficiently.

Diesel Particulate Filter (DPF) Regeneration is the process by which the engine removes Particulate Matter it has captured in the DPF to keep it clean. Stage V engines with DPF use Passive, Active and Standby Regeneration (Forced Regeneration).



Some engine manufactures have developed automatic DPF regeneration processes that do not require operator intervention, meaning duty cycles and workload are unaffected.

# Sizing an Application

## LESSONS LEARNED

“ Xylem experts IAN WELLS, Director of Engineering, and SIMON MATHIAS, Godwin Regional Product Manager, answer some frequently asked questions (FAQs) about purchasing or renting pumps equipped with Stage V engines. Godwin pumps using engines in the range 19 to 130 kW represent the vast majority of equipment sold or rented, so our experts focus on this equipment range. ”

### What differences will I see in the Stage V engines in the 19 to 130 kW range?

**Ian Wells (IW):** The Stage V engine emissions standard does not alter required NOx reductions, but does require a major reduction in Particulate Matter.

**Simon Mathias (SM):** Due to the new Stage V legislation that limits the number of emission particles (PN), the addition of a DPF to the engine in this power range would be necessary. Xylem has focused on high performance engines that maximise passive and active regeneration during normal operation over engines that can potentially undergo lengthy and unpredictable regeneration cycles.

### Where are the additional emissions components located, and will they take up more of the pump's footprint?

**IW:** This varies for engine size and manufacturer with most changes and additions located on or around the engine and convenient for customer application. An increase in footprint may be necessary in some cases.

### Will there be a difference in initial purchase costs of the new 19 to 130 kW Stage V compliant pumps?

**SM:** Generally, yes. This is due to the added emissions components and electronic controls required to operate the fully compliant Stage V engines. However, Xylem is working to minimise the power and footprint of diesel engine drivers as much as possible, and is focused on choosing diesel engine solutions that optimise the power available, minimise the engine cost and maintenance required, and improve fuel economy.

### Can my older pump be retrofitted with a Stage V compliant engine? Some applications are subject to more stringent local emissions regulations

**IW:** Yes. According to the European Commission, older Stage engines can be replaced with Stage V engines.

### How will operation procedures change for pumps with Stage V engines?

**IW:** Excellent question! It will be very important to size the power of your engine to your pump and application. A high power rated engine running at less than maximum efficiency will create more soot or PM, which will affect performance and require more frequent cleaning or regeneration cycles. It is better to match an appropriately sized engine running at peak levels to optimise pump operation.

### Is regeneration going to interrupt my pumps' operation?

**IW:** Some Stage V engines use active regeneration that is triggered automatically and is a seamless part of the pump's operation. For applications where there is any doubt as to pumping capacity during a regen process, we recommend putting in place two smaller pumps, rather than one, that will compensate for each other during regeneration periods.

### In the past, I've been able to make adjustments to the pump engine in the field. Can I do that with Stage V engines?

**SM:** Yes, you should still be able to make adjustments (eg to engine RPM) although some things will be new and different to previous engines. We're here to support you, and can provide full training to get you up to speed with the changes.

# Fuel Handling and Storage

## LESSONS LEARNED

The quality, storage and cleanliness of Low Sulphur fuel and Diesel Emission Fluid (DEF) are key factors to ensure correct and reliable operation of Stage V engines.

### ULTRA-LOW SULPHUR DIESEL

EN 590

Ultra-Low Sulphur Diesel (ULSD) is the only fuel used in Stage V engines. ULSD is highly refined and formulated to contain less than 10 mg/kg ppm of sulphur. Interestingly, this low sulphur recipe is the main reason why it is imperative that fuel storage containers are clean and free of condensation. Water in diesel fuel is the perfect incubating medium for fungus and assorted bacteria that form a slime that floats on top of the fuel. The slime reacts with metal to produce corrosive hydrogen sulphide that corrodes metals in fuel tanks, fuel injectors, connectors, etc.

LESS THAN  
10 mg/kg  
SULPHUR

ULSD  
FUEL

### DIESEL EXHAUST FLUID (DEF)

Diesel Exhaust Fluid (DEF) - Engine manufacturers that use Selective Catalyst Reduction (SCR) systems require DEF, a precise mix of 67.5 percent de-ionised water and 32.5 percent highly pure synthetic urea.

DEF bonds to and converts NOx into simple nitrogen and water. DEF purity is vital. Even small concentrations of trace elements can contaminate an entire tank containing DEF.

If the required chemical interactions do not occur or the catalyst's baffles are compromised, the SCR system will malfunction and cause the engine to shut down. While DEF is non-toxic and not hazardous, it is corrosive.

Corrosion leads to particles - the ISO standard recommends DEF does not come in contact with: copper, copper alloys, zinc, lead, chromium, nickel, aluminum, aluminum alloys, metal-coated plastics or solder containing lead, silver, zinc or copper.



# Smart Decisions

The new generation of Xylem Field Smart Technology (FST) is an advanced telemetry and cloud based service that allows you to remotely monitor and control your pump from anywhere in the world. In the middle of the night. In the middle of a storm. At your most remote site.

Very importantly, Xylem FST will play a major role in the control and operation of Stage V engines, to support compliance and the required shift to meet the new Stage V pump operating conditions, and comes as standard on our Godwin S-series pumps.

## Xylem Field Smart Technology (FST), enables you to:

- › Monitor engine load and soot build-up from the engine to manage regeneration cycles
- › Warn the operator if a regeneration cycle is needed
- › Ensure optimal pump running and uptime

Stage V diesel, electronically controlled engines integrate with the Godwin Advanced Controller - a fully programmable engine control system. Engine operating conditions are monitored continuously.

The Advanced Controller is capable of varying the engine RPM in response to changing pressure/level transducer signals and can be programmed to exercise the diesel engine on a routine basis.

With custom timings, both engine warm up and engine cool down cycles can be programmed to meet engine and application requirements.

# Intelligent Solutions

## Increase service offerings, asset utilisation and customer value

Pumps with Xylem Field Smart Technology (FST) can be monitored and controlled from any smartphone, tablet or desktop computer, anywhere in the world.

Built with onboard cellular and satellite connectivity, and GPS, you can track, monitor and communicate with your pump in real-time, no matter if it's in transit, being stored at a local depot, or out on site serving your customers.

Keep track of multiple pumps, on multiple sites, in multiple languages from one screen; and with alarms and notifications, you always know what's going on.

Feel assured that with our proprietary **Field Smart Technology (FST)**, we are able to offer a dedicated service, to meet your changing telemetry needs, enabling you to:

- › Maintain uptime of your pump and fleet, and increase asset utilisation
- › Optimise maintenance schedules and reduce operational costs
- › Alert to sub-optimal operating conditions
- › Manage risk and improve safety

And with our 24/7 FST support helpdesk, we're here to help keep you up and running.



### REMOTE ENGINE MONITORING AND CONTROL

Speed | Temperature | Battery Voltage | Oil Pressure | % Load | % DPF Soot | Fuel Rate | Fuel/DEF Levels\* | Engine Hours

Start | Stop | Accelerate | Decelerate  
Engine Diagnostic Codes

### REMOTE PUMP MONITORING

Suction/Discharge Pressure\* | Vibration RMS\*

### REMOTE SYSTEM MONITORING

Flowrate\* | Turbidity\* | pH Level\* | Fluid Temperature\*  
Pressure\* | Total Suspended Solids\* | Sump Level\*

### ALARMS AND NOTIFICATIONS

Text | Email | Automated Telephone Alarming

### MULTI-LANGUAGE

English | French | German | Italian | Spanish

\*Additional equipment required

# Xylem's Stage V Commitments

Xylem is committed to providing the most reliable, durable, and efficient EU compliant pumps in the industry, while helping our customers meet Stage V engine standard requirements.



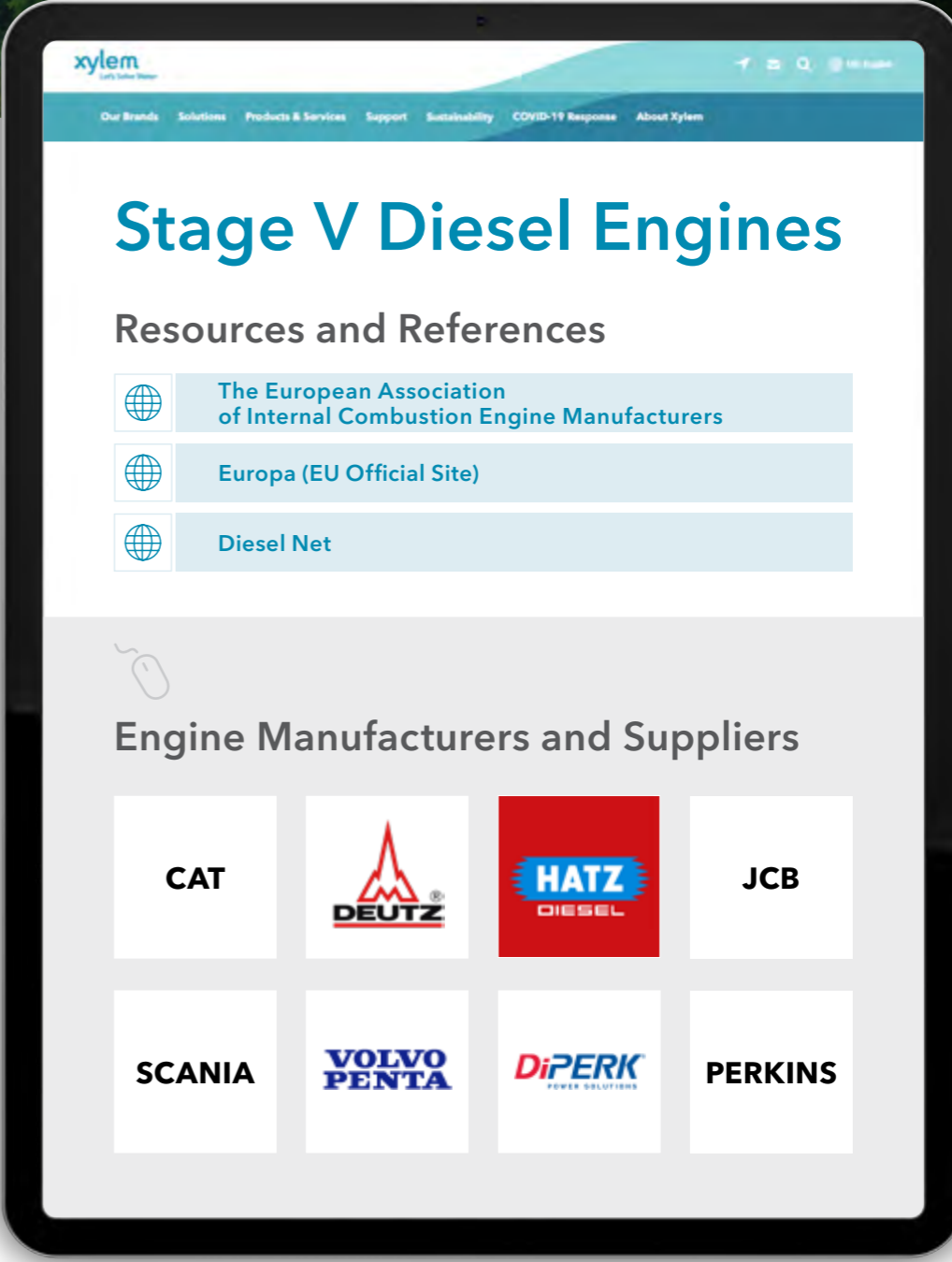
- Maximum Performance**
- Minimum Maintenance and Downtime**
- Compliant with the most Stringent EU Diesel Engine Regulations**

Xylem is committed to providing the most reliable, durable, and efficient EU compliant pumps in the industry, while helping our customers meet Stage V engine standard requirements.

As an industry leader, Xylem has fully committed to and has adopted a complete set of Stage V pump solutions that maximise performance, minimise maintenance and downtime, and meet the most stringent EU and UK diesel engine regulations.

All Godwin portable pumps sold to the EU and UK markets are now available with Stage V diesel engines. The seamless configuration of electronic control and emission technology within Godwin pumps ensures unrivalled reliability. Stage V diesel powered portable pumps reflects our continued focus on advancing efficient, sustainable solutions for the toughest dewatering challenges.

We are committed to ensuring compliance across all markets in line with future engine legislative changes.





# for Effective Maintenance



## CLEAN FUEL TIPS



Use only low sulphur fuels that conform to the EU standard EN 590.



Mount portable fill tanks at an angle with a drain at the low end to eliminate water.



Maintain portable tanks and nozzles to keep out surrounding dust, water and debris.



Biofuels have a short shelf life of only two to three months, with some engine manufacturers advising against the use of Bio Fuels in their Stage V engines. Xylem recommends the use of petroleum-based diesel fuel



Store bulk fuel inside and out of sunlight to avoid temperature extremes that cause condensation.



Consider treating large stores of ULSD with an EU approved biocide to treat microbe waste.

## TIPS FOR STAGE V ENGINES USING DEF



Never attempt to make your own DEF recipe.



Do not use containers used for other materials, even if they have been cleaned. Detergents and contaminants in tap water will foul DEF.



Air can cause DEF to form crystals, so keep small containers tightly closed.



Use a coupler designed to limit air exposure during fills.



Keep DEF storage areas at a constant temperature. Fluctuations affect DEF stability.



Use corrosion resistant containers and accessories.



Do not use tap water to top-off or stretch DEF. Contaminants can alter the DEF properties.



# Glossary

Here are some of the Diesel Exhaust Technologies you will find.

## DEF Diesel Exhaust Fluid

Diesel Exhaust Fluid (DEF), is synthetic urea used in the Selective Catalytic Reduction (SCR) process. DEF reacts with NOx in the exhaust and converts pollutants into nitrogen, water and tiny amounts of carbon dioxide.

Several brands of DEF exist. AdBlue® is well recognised - it is a trade name registered by the German car manufacturers association. Other brands include, BlueHDI, BlueTec and FLENDs (Final Low Emission New Diesel System)

## DOC Diesel Oxidation Catalyst

The Diesel Oxidation Catalyst (DOC) is a flow-through device where exhaust gases contact materials that oxidise unburned hydrocarbons and reduce carbon monoxide.

## DPF Diesel Particulate Filter

The Diesel Particulate Filter (DPF) is designed to physically capture PM from the exhaust stream. The trapped PM eventually oxidises within the DPF during passive regeneration, a cleaning process that automatically activates and uses exhaust heat created under normal operating conditions.

## DPF Regeneration

Diesel Particulate Filter (DPF) Regeneration is the process by which the engine removes the particulate matter it has captured in the DPF to keep it clean.

## EGR Exhaust Gas Recirculation

Exhaust Gas Recirculation (EGR) happens when some exhaust gas is directed back into the intake manifold to mix with incoming fresh air. The process reduces oxygen levels in the cylinder so temperatures during combustion are lower, hence less emissions and particulates.

## EUI & ECU Electronic Unit fuel Injector and Engine Control Unit

The Electronic Unit fuel Injector (EUI) and the Engine Control Unit (ECU) electronically controls fuel injection timing for precise control for the start, duration and end of the injection process to optimise the combustion event.

## SCR Selective Catalytic Reduction

The Selective Catalytic Reduction (SCR) is an emission control technology system that injects DEF through a special catalyst into the exhaust stream of a diesel engine. The DEF combines with nitrogen oxides to produce environmentally friendly nitrogen, water and tiny amounts of carbon dioxide.

## VGT Variable Geometry Turbocharger

Variable Geometry Turbocharger (VGT) varies the exhaust pressure based on load and speed to ensure proper EGR flow.

## VVA Variable Valve Actuation

Variable Valve Actuation (VVA) controls the intake valve closure timing. When the valve closes later, it reduces the effective compression ratio, which results in lower temperatures and lower NOx.



# Xylem |'zīləm|

- 1) The tissue in plants that brings water upward from the roots;
- 2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities.

In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

**For more information on how Xylem can help you, go to [www.xylem.com](http://www.xylem.com)**



Xylem Water Services Ltd,  
Quenington, Cirencester,  
Gloucestershire, GL7 5BX,  
United Kingdom  
+44 (0)1285 750271  
[www.xylem.com](http://www.xylem.com)

