

NRMM Stage V

Tightening the legislative net around emissions
from non-road mobile machinery

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Gearing up for stricter emission standards for off-road machinery.

As air pollution continues to beleague many cities, environmental legislators turn their attention to non-road mobile machinery.

Car ban in Germany's "car city"

Germany's car hub Stuttgart is home to world-famous automotive brands Daimler (Mercedes) and Porsche. Each day, some 500,000 car journeys are made in Stuttgart. In January 2016 residents faced an unusual request. The city mayor urged citizens to use public transport, electric taxis or carpools – and leave their vehicles at home. This made Stuttgart the first city in Germany to issue an official alarm over levels of polluting particles in the air. Levels of harmful particulate matter (PM) had reached 89 micrograms per cubic meter – nearly double the safe maximum of 50 micrograms imposed by the European Union, according to the regional environmental agency. Stuttgart clearly illustrates the fact that air quality remains a key and topical concern – and not just in less-regulated parts of the world.

Emissions continue

So how can this happen given the increasingly tight legislation around automotive emissions in Europe and the US in particular? One reason is related to the geography of Stuttgart itself. The city sits in a cauldron-like basin, with warm air higher up trapping harmful particulate-rich colder air closer to the ground. In the absence of rainfall and wind, PM levels can rise rapidly.

Despite average emissions of the main pollutants in Europe declining over the past two decades, there are many highly densely populated areas in not dissimilar situations to Stuttgart. For this reason additional measures are needed across multiple industry sectors to significantly reduce emissions from static, transportation and even marine-based sources in order to achieve the long-term objective of air quality that does not lead to harm to human health and the environment.



Despite increasingly tight legislation around automotive emissions, air quality remains a key concern.

While cars account for the lion's share of air pollution from combustion engines in relative terms, especially of PM and nitrogen oxides (NOx), there are other classes of equipment and machinery that also play a significant role. More specifically, the non-road mobile machinery (NRMM) sector has become an increasingly important source of air pollution, responsible for around 15% of total NOx emissions and 5% of total PM emissions in the EU. While the PM share is expected to decrease, the NOx share is expected to increase to nearly 20% by 2020.

Reaching beyond automotive

In acknowledgement of this fact, European legislators are tightening the net around sources of emissions other than automotive. At the end of 2016, they released a new "Regulation of the European Parliament and of the Council on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery". The new measures aim to progressively reduce emissions from non-road mobile machinery and phase out polluting equipment.

This new regulation is set to replace the legal framework currently in place. At present, this spans five directives with 15 annexes. The initial directive has been updated eight times since it was first introduced in 1997. To complicate matters further, each Member State in Europe is free to put more stringent requirements in place than those required under European law. The upshot is a patchwork of 28 different legal regimes. So one of the main aims of the new legislation is to harmonise this disparate landscape and cut complexity.

In overcoming market fragmentation, harmonisation across EU countries will also create a more level playing field, reducing local market distortions and unfair competition. In addition, the new ruling will widen the scope of the existing framework to include NRMM engine types not currently covered. Last but not least, it will update emission limits and measurement / type-approval processes to align with state-of-the-art technologies and the latest developments in the on-road sector.

So what exactly is non-road mobile machinery?

Non-road mobile machinery (NRMM) is a mixed bag. It essentially refers to any tool, machine or item of equipment that is powered by a combustion petrol or diesel engine but is not driven on the road. So it ranges from small, handheld power tools such as chain saws, hedge trimmers, grass trimmers, brush cutters and blowers through heavy-duty construction machinery and generators to trains and inland waterway vessels. It even includes recreational vehicles such as snow mobiles and jet skis.

One might wonder why such a diverse pool of vehicles and equipment has been bundled together? Although each category within this cluster is not a particularly significant source of emissions when viewed in isolation, the impact overall is considerable. So it made sense to take a wide-angle view. Plus one body of legislation is preferable to navigating 200 or more individual sets of rules. However, because this group is so heterogeneous, the new regulation is complex and sophisticated – simply because it must cover such a broad range of emission sources. For manufacturers, this means that sample collection and measurement methods can vary considerably and they may need assistance in interpreting and applying the new legislation.

Latest findings on adverse health effects of diesel emissions

You may also be wondering why the EU has decided to introduce this NRMM regulation now? The answer is that this is a very timely piece of legislation, fully in line with a broader trend – particularly evident in Europe and the US – towards wider and stricter environmental controls. With this general trend, confirmed by the implementation of the EU's air quality policy, we are seeing a systematic reduction in the tolerated levels of harmful substances such as nitrogen oxides. At the same time, the legislative net is tightening to include more and more emission sources. And thirdly, policy-makers are looking to include new chemicals and chemical species within the scope of new and amended regulations. NRMM reflects all three dimensions.

The need for tighter legislation around diesel-powered engines was accentuated by a 2012 announcement by the International Agency for Research on Cancer (IARC), part of the World Health Organisation (WHO), reclassifying diesel engine exhaust from its group of probable carcinogens to its group of substances that are 'carcinogenic to humans'. In its announcement, the WHO emphasised the fact that people are exposed not only to motor vehicle exhausts, but also to exhausts from other diesel engines, including diesel trains and ships. Echoing growing concern about the cancer-causing potential of diesel exhaust, this announcement gave governments and decision-makers added momentum to work towards stricter environmental standards for diesel emissions. The new NRMM regulation is an attempt to address these concerns.

Timeline and policy options

The new regulatory framework, called Stage V, will be implemented in a four-step approach with key milestones in January 2018 (for new engines type-approval), January 2019, January 2020 and January 2021 (for new engines placed on the market).

To finalise its proposal, the EC considered a number of different policy options on the basis of cost-benefit analysis. They included for example the alignment with US standards and with the EU road sector i.e. the Euro VI emission standards for heavy-duty vehicles and the introduction of in-service monitoring systems. Due to the considerable diversity of engines and applications in the NRMM sector, the preferred path is a combination of elements cutting across all the studied policy options.



With new, stricter limits for NOx and PM, manufacturers will need to improve emission performance and measure emissions with greater precision.

Main impacts at a glance

The new legislation focuses on four main types of gaseous and particulate emissions: hydrocarbons (HC), particulate matter (PM), carbon monoxide (CO) and nitrogen oxides (NOx), the latter mainly comprising NO and NO₂. New to this legislation is the introduction of particulate matter number limits (PN), which currently do not exist in NRMM regulations. This is an important step, reflecting findings indicating that the size of the particles is a crucial factor behind the observed health effects, and that these effects can only be addressed by limit values based on a particle number count.

The proposed legislation will also set new, stricter limits for NOx and PM. This means that manufacturers will need to improve emission performance and measure emissions with greater precision.

Another change under the new regulation is scope. Many vehicles and items of equipment that are not covered under existing legislation would now come under scope. One good example is recreational vehicles such as snow mobiles and jet skis. The other important addition would be high-powered engines. At present, only engines below 560 kW are regulated; the new legislation extends the scope to 560 kW-plus

engines. Also to come under scope would be small hand-held equipment with compression ignited (diesel) engines. As a result, for many engines previously not in scope, manufacturers may now need to include engine after-treatment equipment in their vehicles with a view to controlling emissions of these pollutants.

In-service monitoring is a further key area of potential impact under the new legislation. At present, emission limits for NRMM are tested under laboratory conditions – when the engine is type-approved. For heavy-duty road vehicles, for instance, measures are in place to measure the emission performance of engines during service. The new NRMM regulation is looking at similar provisions for the non-road sector. The use of Portable Emission Measurement System (PEMS) becomes mandatory.

Last but not least, while the testing methods are largely established – including the Non-Road Steady test Cycles (NRSC) and the Non-Road Transient test Cycle (NRTC). The aim is to get worldwide harmonisation of these methods similar to what transpired in the on-road sector.



For many manufacturers, the new legislation will require significant changes to testing policies and methods.

So what does this mean for industry?

Many manufacturers of construction equipment, recreational vehicles, power tools and engines will face a number of challenges under the new legislation. For many players, it will entail significant changes to current testing policies and methods. Many others may suddenly find themselves within scope and need to quickly put suitable testing and certification processes in place. The specific impacts are outlined in the following.

Firstly, as emission thresholds drop, the measurement point will also drop. This means the calibration point is also falling (as testers need to calibrate near to the measurement point). So although some manufacturers may be measuring the same chemical species, their calibration gas or mixture specification may change. In other words, lower concentrations of the species will be required in the calibration gas or mixture.

Secondly, a widening of the net is pulling many new engine categories within scope. So their manufacturers will need to put either measurement equipment and processes in place or to review their current processes in order to comply with the new requirements. They will also need gas supply solutions for that equipment.

Thirdly, manufacturers will be required to measure more chemicals and chemical species. So they will need more instrumentation, more calibration gases and additional calibration mixtures to align that equipment. From this perspective the introduction of in-service monitoring via PEMS will represent a big challenge for the OEMs.

The other point to bear in mind is that the new regulation is complex and sophisticated – reflecting the heterogeneous nature of the NRMM sector. This means that sampling and measurement methods may vary considerably from one item of equipment or machinery to another. Newcomers to the field in particular may require assistance in interpreting and applying the new regulation.

Reducing complexity

Linde can help guide customers through these challenges. As Roberto Parola, Global Product Manager Specialty Gases and Specialty Equipment, at Linde explains: “We anticipate a real and rising need across industry for professional, qualified support from a gas expert. Emission thresholds are dropping, the number of species is growing and the number of companies that need to test is rising. This all translates into greater need for calibration gases, more accurate calibration gas mixtures and proper speciality gas supply systems.”

On the one hand, Linde can support customers by offering the calibration gases and mixtures they need in the purity and accuracies levels mandated by the new legislation. The company is ideally placed to help companies meet higher purity and accuracy standards as it provides gases and tailored mixtures specified down to part per billion and sometimes also down to part per trillion. In addition, these gases and mixtures are certified and fully traceable to help customers ensure process compliance.

Complementing these gases and mixtures, Linde also supports customers in supplying the requested gases in the most appropriate packages and in designing suitable gas supply concepts and its portfolios of installation equipment and regulators, for instance, are engineered specifically for the most demanding analysis and instrumentation tasks.



Linde can provide expert support and assistance to help manufacturers interpret and apply the legislation.

Even more importantly, Linde can guide customers through the entire process from initial consultation and trials through to installation and ongoing service. Faced with countless questions and options, newcomers may welcome the prospect of a partner who can advise on and deliver the gases, mixtures and distribution system best suited to individual needs. “We have a lot of experience in helping customers manage compliance with changing environmental legislation. The key lies in turning a complex situation into a more simple one. And that is exactly what we do,” says Roberto Parola.

US angle

One of the bigger challenges that manufacturers may face – and one that will not be so easy to resolve – results from discrepancies between US and EU legislation. Regulatory fragmentation complicates life for global players in particular, who are keen to harmonise production processes and testing standards worldwide.

Today’s US EPA (Environmental Protection Agency) standards are generally stricter than current EU standards. The new EU Stage V would have the effect of aligning both frameworks to an extent, but would also establish some key differences between the two geographies. The most important of these would be the addition of the particulate number to EU regulations. Currently not within scope in the US, this provision would require manufacturers to fit a particulate filter to vehicles or equipment. This would mean that global producers would have to put different processes in place in order to distribute their products worldwide.

Looking beyond growing pressure for a globally harmonised standard, it is likely that US legislation will also be stepping up its efforts in the NRMM sector. Medium-term changes to be expected include a focus on volatile organic compound (VOC) emissions from idle equipment, lower PM thresholds (down to the 2.5 ppm range) and periodic re-certification of heavier equipment and vehicles in the field.

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – Ideas become solutions.

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