NON-ROAD EMISSIONS CONTROL

This special feature gives an introduction to emissions control in non-road mobile machinery (NRMM), a promising growth area for pgm demand. Regulations governing engine emissions from NRMM have been in force in various regions of the world since the late 1990s but, with a few minor exceptions, have not been sufficiently tight to require pgm aftertreatment. With the general introduction of Stage IIIB legislation in Europe and Tier 4 Interim in the USA this year, followed by Interim Tier 4 in certain engine categories in Japan next year, all that is about to change.

LEGISLATION

NRMM can be defined as any transportable industrial equipment or vehicle in which an internal combustion engine is installed and which is not intended for the use of passenger or goods transport on the road. This definition encompasses a vast range of machinery including agricultural, construction and industrial equipment, locomotive engines, non-ocean-going marine vessels, mobile generators, and pumps, although aftertreatment-enforcing legislation is largely limited to engines above 19 kW (25 hp), which puts a substantial number of engines outside our consideration. Ocean-going ships are not covered by the NRMM legislation, and fall instead under the International Maritime Organization (IMO) regulations. As ocean-going vessels are only regulated for NOx and SOx, it is unlikely that pgm in aftertreatment systems will see much demand in the foreseeable future.

There have been significant efforts to harmonise worldwide non-road emissions standards. In the main markets of Europe, North America, and Japan, the diesel engine emissions limits under each regulation and power band, as well as the test procedures, are broadly similar and engines will be designed to meet all three standards.

Legislation is being phased in according to the engine power band, and in some cases depending on the end application (e.g. for inland marine and rail engines).

Emissions limits are defined and measured in grams per kilowatt hour (g/kWh). This is the same measure as that used in the heavy duty diesel on-road sector, and in general terms the emissions allowable under the non-road Stage IIIB and Tier 4 Interims are comparable with those of on-road Euro V legislation. Likewise, Stage IV and Tier 4 Final levels, which mainly phase in from 2014, are comparable with those of on-road Euro VI, with the significant exception that there is no particulate number limit.

AFTERTREATMENT STRATEGIES AND PGM

As the range of engine applications is so wide, it is not surprising that different approaches will be adopted to tackle emissions.

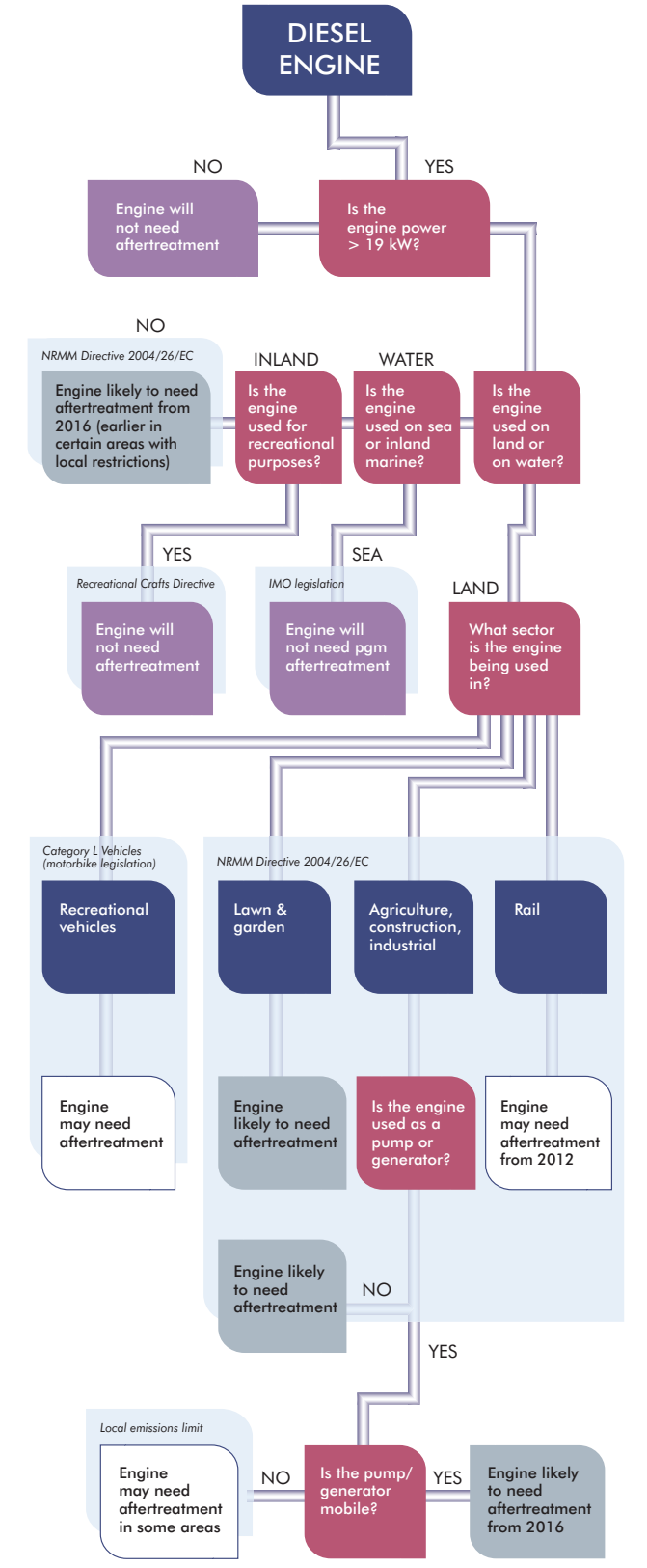
The step-change of the current legislations (i.e. Stage IIIB and Tier 4 Interim) is the reduction in allowable mass emissions of particulate matter

US Emissions Limits
g/kWh

kW	(hp)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
19-36	25-48	NOx + HC = 7.5, CO = 5.5, PM = 0.3					NOx + HC = 4.7, CO = 5.5, PM = 0.03				
37-55	49-74	NOx + HC = 4.7, CO = 5.0, PM = 0.3					NOx + HC = 4.7, CO = 5.0, PM = 0.03				
56-74	75-99	NOx + HC = 4.7, CO = 5.0, PM = 0.4				phased in:			NOx = 0.4, HC = 0.19, CO = 5.0, PM = 0.02		
75-129	100-173	NOx + HC = 4.7, CO = 5.0, PM = 0.3				NOx = 2.0, HC = 0.19, CO = 3.5, PM = 0.02					
130-560	174-751	NOx + HC = 4.7, CO = 3.5, PM = 0.2			NOx = 2.0, HC = 0.19, CO = 3.5, PM = 0.02			NOx = 0.40, HC = 0.19, CO = 3.5, PM = 0.02			
>560	>751	NOx + HC = 6.4, CO = 3.5, PM = 0.2			NOx = 3.5, HC = 0.40, CO = 3.5, PM = 0.10			NOx = 3.5, HC = 0.19, CO = 3.5, PM = 0.04			

CO – Carbon Monoxide
NOx – Oxides of nitrogen
HC – Non-methane hydrocarbons
PM – Particulate matter

TIER 2 | TIER 3 | TIER 4 INTERIM | TIER 4 FINAL



As a guide through the complexities of the NRMM legislation, the above diagram gives a snapshot of which engines will, will not, or might require aftertreatment under the European legislation.

(PM). In selecting aftertreatment strategies, there is always a 'trade-off' between engine-out emissions of PM and those of NOx: action to decrease the one increases the other and vice versa. PM can be controlled by engine calibration, generating an increase in NOx emissions which can be handled by selective catalytic reduction (SCR). Alternatively, exhaust gas recirculation (EGR) can be used to reduce NOx to a certain extent, with a corresponding increase in PM, which can, but does not always, lead to the requirement for a diesel particulate filter (DPF). DPFs use pgm, SCR uses very little.

This choice is in essence the same as that which faced the heavy duty diesel on-road sector. Just as North American heavy duty truck manufacturers largely chose to meet EPA 2007 limits using the DPF route, plus diesel oxidation catalyst (DOC), so the North American non-road engine manufacturers are adopting a similar strategy for Tier 4 Interim. Conversely, European heavy duty on-road vehicle producers have typically opted for the SCR route, and many European non-road engine makers have chosen SCR to meet Stage IIIB. However, in non-road applications the choice is further complicated by subtle differences in allowable NOx emissions between different engine power bands. These alter the relative merit of the various aftertreatment options. In addition, the broad range of applications and power bands, and the different ways in which the engines are required to perform, make the choice of aftertreatment much more individual than in the on-road sector.

Imagine a farmer, working his fields with his own tractor. His primary concern will be fuel consumption, and this will typically favour the use of SCR. Then consider a construction equipment hire company. Its equipment is run periodically at high load and periodically at idle, making engine calibration to control PM highly challenging. Its equipment may be used in an industrial area where local regulations on PM may apply. It will typically be less concerned with running costs, because fuel is normally the responsibility of the party which leases the equipment. The likely choice here will be DPF.

Aftertreatment choice is complex, but the main point is that the non-road sector is highly diverse, and to estimate pgm demand we cannot simply look at the size of the non-road market in terms of engine numbers or displacement and compare that directly with the on-road sector. We need to evaluate the individual market segments, of which there are many, and we need to understand the thinking of the engine producers, who in many cases are completely new to the world of pgm-based aftertreatment.

Whatever the individual strategies adopted, the overall impacts of the evolving legislation are good, both for the environment and for pgm demand. We estimate that pgm demand from all non-road sectors in 2011 will amount to 130,000 oz. This includes demand from all non-road engine sectors including, where applicable, small gasoline engines and stationary engines for which the legislation is not discussed here.

As non-road emissions legislation is increasingly implemented in Europe, Japan and North America, and becomes more stringent, demand for pgm in NRMM can be expected to grow over the next few years.