The European Association of Internal Combustion Engine Manufacturers

EUROMOT

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Amendment of the Nonroad Mobile Machinery Directive 97/68/EC: A perspective on policy options for emissions regulations for CI engines

Executive Summary

1. The characteristics of the non-road engine and machine business are very different to those of the on-highway industry. It is a substantially smaller market with much wider variation in installed power, application and usage.

2. It is essential to take account of the global nature of non-road products. The non-road engine and equipment industry relies upon the harmonisation of emission regulations in order to spread the cost of developing new products over the largest possible geographical market, due to the high development costs and relatively low production volumes.

3. Whilst engine manufacturers support the objective of emission reductions, with associated air quality and health benefits, if further levels of ambition beyond alignment with US limits are being considered the technical impact and cost-effectiveness of further levels of ambition MUST be individually assessed for different power classes. It is ESSENTIAL that BEFORE any such limit values are finalised the European Commission engage with EPA to discuss how appropriate limits could be jointly determined, both in respect to stringency and timing. To do otherwise would jeopardise the opportunity to develop products for the combined EU and US market and would be in direct contradiction to the objective of the current EU-US transatlantic trade discussions.

4. There will be no contribution from a more ambitious stage of non-road emission regulation if the machines become unattractive for the end-user to purchase, either due to high first cost, high cost of ownership, or constrained functionality in comparison to maintaining existing machines.

5. During prior stakeholder discussions and in the European Commission non-road consultation document it was proposed that if a further level of ambition (stage V) were to be introduced for CI engines it should be restricted to variable speed non-road engines in the range of 56 to 560 kW. Euromot continues to support this position.

6. It is the opinion of engine manufacturers that the fastest action that could be taken by EU for CI engines in the power ranges < 56 kW and > 560 kW would be introduction of limit values aligned with the US Tier 4 final limits. This would provide cost-effective emission reductions whilst achieving a larger aligned market for manufacturers.

7. For non-road CI engines in the range 19 – 560 kW the technologies chosen by engine manufacturers to achieve US Tier 4 final vary. Whilst some manufacturers have already chosen to incorporate a diesel particulate filter (DPF) others have chosen an alternative technology path. In consequence, the impact of a particle number limit will vary considerably from one engine or machine manufacturer to another, and in some cases also between product families for a given manufacturer. In those cases where a DPF is already present for stage IV the impact of a particle number limit may be limited, whilst for other manufacturers the incorporation of a DPF may require a complete re-design of both engine and machine. The distribution of the impact is consequently likely to be highly bi-modal.

8. It is the opinion of engine manufacturers that addition of a particle number limit AND a reduction in NOx to 0.4 g/kWh for non-road CI engines in the range 19 – 56 kW would be totally disproportionate, particularly given the limited incremental real-world emission benefit that would result. This could result in diesel-fuelled CI engines no longer being a commercially viable choice for powering the corresponding size of NRMM, with the result that existing machines with prior stage diesel engines remain in service for longer and/or new machines enter service with a different power source. This would clearly have a major impact on the manufacturers of such CI engines, most of which are based in or have manufacturing sites in Europe. The quest for a viable, simple, compact CI engine solution for lower NOx would require a major engine re-design and long-term research activity that would necessitate a considerable delay in the implementation of a new stage.

9. The data previously collected by Arcadis indicated that aligning with US in the non-road CI engine power class > 560 kW gave the highest ratio of environmental gain to compliance cost (almost 12:1). This is the option supported by both the engine and machine industry. Generally, DPFs are not foreseen as the technology of choice for these very large engines. Machines with engines > 560 kW are not normally found working in towns and cities and the volume of machines with > 560 kW engines placed on the EU market is especially small. Consequently, even if the considerable technical challenges of more ambitious regulation could be overcome, this makes the recovery of investment in a unique engine/machine for the EU highly doubtful, with the prospect that it becomes more cost-effective to maintain machines with existing (unregulated) engines, compared to replacement with new products. In this case the adoption of overly ambitious limit values could be counter-productive and actually result in higher overall emissions to the atmosphere than would be achieved with less ambitious limits.

10. It is important to highlight that whilst some respondents to the European Commission consultation clearly understood the purpose and limitation of in-service conformity (ISC), it is clear that the majority of respondents did not understand certain fundamental aspects. Much of the apparent support for ISC came from respondents that mistakenly understood this activity to be a process to check that an engine (complete with its after-treatment system) is being maintained correctly and free of tampering in-service. This is

incorrect. ISC does not fulfil this function. Euromot would like to make clear that its support for the ISC program has so far been limited to variable speed non-road engines 56 – 560 kW. Euromot does not support expansion of ISC to other power classes without an assessment of the practical implications and development of an appropriate test methodology for each power class and application. Both larger and smaller machines present particular challenges.

11. From an engine manufacturers perspective it is most important to provide transition provisions that:

- Enable the placing on the market of engines without also promoting abnormal levels of engine inventory. This minimises peaks and troughs in engine production.
- Notwithstanding the need to avoid abnormal inventory, set a clear date for end of engine PRODUCTION, followed by sufficient time to place engines on market, regardless of location of engine or machine plants.
- Above all, provide provisions that are clear and can be uniformly enforced.

Note: In the following text, references to 'option 2' mean the European Commission regulatory option to align with US limits, whilst reference to 'option 3' mean the European Commission regulatory option of 'road ambition'. All references to a particle number limit are based upon the value of 1×10^{12} as proposed by European Commission as the non-road equivalent to the on-highway Euro VI particle number limit ('road ambition'), based upon the experience from the Swiss micro-market, as measured on the appropriate non-road regulatory cycle(s) using the particle measurement method described in the UN ECE regulation R49.

1. Characteristics of the EU non-road mobile machine (NRMM) engine and machine business

The EU NRMM engine and machine market is a substantially smaller market than the heavy-duty on-road engine market with much wider variation in installed power, application and usage. There are thousands of applications for which industrial engines are used, many in niche markets of less than one hundred sales units per year. Whilst some engine manufacturers active in this business also manufacture engines for the on-highway market, there are others that only specialise in developing and manufacturing industrial engines. Furthermore, whilst some manufacturers produce both engines and non-road machines, some manufacturers only produce engines and a large number of manufacturers only produce machines and purchase their engines from the market.

The needs of the engine and machine business can be summarized as follows:

- Long-term certainty in future requirements in order to enable investment for growth.
- Global alignment of emission leading areas to maximise market size and gain economies of scale (EU, USA, Japan), enabling maximum emissions reduction at minimum cost to society.
- Sufficient lead-time prior to introducing new stages to enable cost-effective product development/technology transfer and sufficiently long duration of stages to recover investment.
- Harmonised EU regulation to eliminate or at least minimise inefficient local regulation, either within or between Member States.
- Appropriate transitional provisions that provide sufficient time to enable machine manufacturers to integrate new engine and after-treatment systems into machines, whilst, for engine manufacturers, avoiding large peaks and troughs in engine production.

2. NRMM engine exhaust emission regulation

This document specifically covers the non-road (land-based) power classes. Unlike on-highway emission regulation where there is a distinction made between the regulation of the smallest and largest vehicles, with separate legislation for motor cycles, light duty and heavy duty vehicles, the NRMM emissions directive includes in scope engines for a huge range of applications, with the expectation that in future it will cover the entire range of engine power from zero to infinity. Additionally, the NRMM emissions directive is used to provide the emission limits for agricultural tractors. It is necessary to recognise that there is no single technical solution that is optimum or even suitable for this entire range. Historically, as a consequence, the emission limit values, associated test cycles and other technical requirements have been developed to be appropriate for individual power classes.

During current discussions on the potential adaptation of on-highway heavy-duty Euro VI requirements to the non-road sector it should not be assumed that all features of the Euro VI regulations are technically or commercially feasible for amendments to the NRMM legal act. The availability of certain key technologies (such as particulate filters and NOx after-treatment) must not be the only consideration. Substantial development work and resources are required for adaptation of on-road technology to NRMM engines and machines and this adaptation may not be practical or cost effective across all applications and power classes.

Considerations during the adaptation process include:

- Design changes to withstand the non-road operating conditions, including long-term exposure to more aggressive environments, high shock loading and vibration compared with on-highway applications.
- Physical shape and size reconfiguration in order to fit within dimensional envelope of the variety of non-road machines and minimise overall size of after-treatment system.
- Wide variety of work/load cycles over which after-treatment systems must work effectively, including rapid transient loading.
- Ensuring appropriate thermal and chemical balances in the exhaust system for effective after-treatment system operation including regeneration of particle filter systems under a wide range of conditions.
- Re-optimisation of entire engine and after-treatment system to ensure acceptable transient response and minimise fuel and reagent consumption.

Consequently, whilst engine and machine manufacturers support the objective of emission reductions, with associated air quality and health benefits, **if further levels of ambition are being considered the technical impact and cost-effectiveness of further levels of ambition MUST be individually assessed for different power classes. It is unacceptable to consider the entire range of power classes en bloc.**

3. Global markets and regulatory diversity for non-road CI engines

It is essential to take account of the global nature of non-road products. The non-road engine and equipment industry relies upon the harmonisation of emission regulations in order to spread the cost of developing new products over the largest possible geographical market, due to the high development costs and relatively low production volumes.

Prior to the introduction of stage IIIB it was possible to create non-road compression ignition (CI) engines and machines that could be sold worldwide. These machines predominantly used mechanical fuel injection systems, without complex electronics, and were relatively tolerant to high fuel sulphur levels. In order to achieve emission levels from stage IIIB onwards the majority of non-road engines and machines use electronically controlled engines and require ultra-low sulphur diesel fuel for operation, due to their use of sulphur-sensitive after-treatment systems. Such fuel is generally only available in relatively few markets, principally Europe, USA and Japan. Furthermore, the supporting maintenance infrastructure in much of Africa, Asia and the Far East (other than Japan) is not sufficiently sophisticated to effectively maintain these machines, even if the fuel were available. In any case, the cost that these technologies add to the machines would make them unattractive to purchase in regions without the most stringent legislation, compared to simpler (higher emission) products.

The consequence is that most manufacturers are now forced to produce different products for different regions. At a minimum it is necessary to produce a range of stage IIIB/IV CI engines and machines for Europe, USA and Japan, and a second range sulphur-tolerant engines and machines for the rest of the world. Moreover, whilst at the time the non-road emissions directive was developed (1990’s) the most developed parts of the world represented the largest share of the non-road engine and machine market, the most developed parts, including Europe, now represent the smaller share of the market. To further complicate the product requirements, regions such as Turkey demand machines that conform (and are CE marked) to the latest European legislation on noise and safety, whilst the legislated emission level currently remains at stage IIIA, creating local demand for a third category of product, and micro-markets such as Switzerland set additional requirements for the operation of machines in certain environments such as construction sites.

The development of unique emissions legislation for Europe, independent of the other highly regulated markets, whilst potentially satisfying certain micro-markets, would add further product diversity, draining development budgets on the (smaller) European market and making it increasingly difficult to invest in product development for the growth markets elsewhere.

During the six years that have passed since the 2007 review of 97/68/EC commenced, there has been very little interaction between the European Commission and their counterparts in the US Environmental Protection Agency (EPA), with a reliance on the engine and machine industry to feed information on alignment into the EU review process. It is important to note that if the European Commission intend to propose a further level of ambition that is not aligned with those already published by the US Environmental Protection Agency (EPA)**, it is ESSENTIAL that BEFORE any such limit values are finalised the European Commission engage with EPA to discuss how appropriate limits could be jointly determined, both in respect to stringency and timing. To do otherwise would jeopardise the opportunity to develop products for the combined EU and US market and would be in direct contradiction to the objective of the current EU-US transatlantic trade discussions.** Any such further level of ambition must only be introduced after allowing sufficient regulatory lead-time appropriate to the level of ambition proposed, and staggered by power class to avoid the need to simultaneously re-design products across all power classes.

Some stakeholders may use the argument that having more stringent emission legislation in Europe would create growth in the non-road engine and machine markets, because these products could be sold at a premium to other parts of the world. **This argument simply does not stand up to scrutiny.** As explained in the previous paragraphs such machines could not operate in the growth markets, and, as explained in the next section, even if they could, it is unlikely that customers would willingly pay a premium for a further reduction in emissions where it is not required by law.

4. The customer perspective

The customer of the machine manufacturer will generally be an organisation that will use the machine to provide a service, such as road maintenance, or an organisation that will use the machine as part of a production process, such as agriculture, construction or mineral extraction (mines and quarries). The end-consumer will mostly be interested in the cost of the final product or service, (eg food, housing, tax to use/maintain roads, etc) but will have very limited interest in the machines used to provide these. Consequently, machine owners will focus strongly on the ability of the machine to perform the required task, the maximum productivity and reliability of the machine, and especially minimum ownership costs (purchase and operating costs).

The customer of the engine manufacturer is generally a machine manufacturer. In some cases engine and machine manufacture will take place in a vertically integrated enterprise, and in many other cases engine manufacturers are competing with each other to supply independent machine manufacturers. The number of independent machine manufacturers who do not manufacture their own engine is at least two orders of magnitude higher than in the automotive sector. In all cases there will be pressure to deliver an engine system (inclusive of after-treatment where appropriate) that satisfies the applicable legislation at minimum cost (purchase and operating), whilst contributing to the productivity and reliability of the machine.

Whilst there will always be market pressure to reduce fuel consumption (a major element of operating costs) the emissions level of the engine is not a key selling feature. It is highly unlikely that customers will be willing to pay a premium for a further lowering of emissions, unless this new machine decreases the overall cost of the service or production process compared to maintaining the existing machine.

In summary, there will be no contribution from a more ambitious stage of non-road emission regulation if the machines become unattractive for the end-user to purchase, either due to:

- High first cost;
- High cost of ownership; or
- Constrained functionality;

in comparison to maintaining existing machines.

The same considerations exist in respect to attempting to sell such machines into markets where such emission levels are not legislated. **Where lower cost higher emission machines remain available in the market, there will be little or no demand for the lower emission variants, even if the correct fuel were available.**

5. NRMM CI engines 56 $\leq$ kW < 130 and 130 $\leq$ kW $\leq$ 560

During prior stakeholder discussions and in the European Commission non-road consultation document it was proposed that if a further level of ambition (stage V) were to be introduced it should be restricted to variable speed non-road engines in the range of 56 to 560 kW. Euromot continues to support this position. The machine population data reported in the 2007 JRC review indicated that (for EU 15 in 2005) the power range 56 $\leq$ kW $\leq$ 560 encompassed 98% of all new heavy construction equipment, 43% of new light construction equipment, 98% of new agricultural harvesters and 69% of new agricultural tractors.[1]

From a construction equipment perspective, this power range includes a large proportion of wheeled loaders, tracked hydraulic excavators, backhoe loaders, wheeled excavators, dozers and off-highway dump trucks.

From an agricultural equipment perspective, this power range includes the agricultural tractors that typically have the greatest utilisation at high load (use for ploughing, etc) and almost all harvesters. The most powerful commercially available agricultural tractors in the world do not currently exceed 400 kW, whilst combine harvesters (by far the largest category of harvesters) are generally in the range 120 - 450 kW.

As implied by the data above, it should be noted that the power class 130 $\leq$ kW $\leq$ 560 is a particularly broad range and **the power of the population within this range is not normally distributed across the entire range.** In fact, it is estimated that more than 80 % of the new machines in this power range will have engines < 300 kW and only a very small proportion will have engines close to the 560 kW boundary.

[1] https://circabc.europa.eu/sd/d/36c150d2-0263-4bd9-bc13-226eb42afd0d/Final%20Report%20NRMM%20Review%20Part%20I.pdf and https://circabc.europa.eu/sd/d/d11bead9-9201-449b-aa1c-e006905ee241/Final%20Report%20NRMM%20Review%20Part%20II.pdf

5.1. Addition of a particle number limit (European Commission option 3)

The current published stage IV emission limits for variable speed engines in this power range are well aligned with those of US Tier 4 final, achieving European Commission option 2, the market alignment sought by engine and machine manufacturers. The addition of a particle number limit of 1 x 10^{12} in the EU will disrupt this regulatory alignment if pursued in isolation from the US authorities.

Within this power range the technologies chosen by engine manufacturers to achieve Tier 4 final/stage IV vary. Whilst some manufacturers have already chosen to incorporate a diesel particulate filter (DPF) others have chosen an alternative technology path. It is anticipated that a particle number limit will force the inclusion of a DPF. In consequence, the impact of a number limit will vary considerably from one engine or machine manufacturer to another, and in some cases also between product families for a given manufacturer. In those cases where a DPF is already present for stage IV the impact of a particle number limit may be limited to conducting a new type approval test, whilst for other manufacturers the incorporation of a DPF may require a complete re-design of both engine and machine. The distribution of the impact is consequently likely to be highly bi-modal.

6. NRMM CI engines < 56 kW and > 560 kW

In general it should be noted that whilst the EU limit values are either equal to or more stringent than the US for the power class 37 ≤ kW < 56, the introduction of new EU emission limits for variable speed non-road CI engines < 37 kW and > 560 kW (either for the first time, or as new stages with additional stringency) has not kept pace with the equivalent developments in the USA. Consequently, new US emission limits for these engines have come into force, or will come into force by the start of 2015, without corresponding new stages being introduced in the EU. **As communicated in the Euromot response to the recent European Commission consultation[2] it is the opinion of the engine and machine industries that the fastest action that could be taken by EU for these power ranges would be the introduction of limit values aligned with the US Tier 4 final limits (option 2).** The introduction of these limit values could commence three years after publication in the Official Journal (OJ), staggered by power class, and would provide cost-effective emission reductions whilst achieving a larger aligned market for manufacturers.

6.1. NRMM CI engines 19 ≤ kW < 37 and 37 ≤ kW < 56

In general the majority of engines in this power class will be used in compact equipment designed to operate in confined spaces, and consequently any changes that require additional space will have a major impact on the feasibility of the machine to perform its intended function. The machine population data reported in the 2007 JRC review indicated that (for EU 15 in 2005) the power range 19 ≤ kW < 37 encompassed 30% of new small construction equipment, 20% of new light construction equipment and 2% of new agricultural tractors. The corresponding data for 37 ≤ kW < 56 was 17% of light construction equipment and 20% of agricultural tractors.[3]

[2] https://circabc.europa.eu/sd/d/011f08f8-d692-4e5b-b52c-ae1fd054db28/Euromot%20-%20European%20Association%20of%20Internal%20Combustion%20Engine%20Manufacturers%20-%20Main.pdf and https://circabc.europa.eu/sd/d/70e7327b-b13a-43f8-8fb4-66a431a05fe2/Euromot%20-%20European%20Association%20of%20Internal%20Combustion%20Engine%20Manufacturers.pdf

[3] https://circabc.europa.eu/sd/d/36c150d2-0263-4bd9-bc13-226eb42afd0d/Final%20Report%20NRMM%20Review%20Part%20I.pdf and https://circabc.europa.eu/sd/d/d11bead9-9201-449b-aa1c-e006905ee241/Final%20Report%20NRMM%20Review%20Part%20II.pdf

One very common example is a mini-excavator. This may be designed to fit though domestic doorways (limiting width and height) and operate within a small overall radius (limiting length), whilst requiring a low centre of gravity for stability and excellent all-round operator visibility for safety. This severely limits the opportunity to increase the size of the propulsion system.

This small equipment will generally be of low cost compared to larger equipment, with the engine being a larger part of the entire machine cost than would be the case for larger machines. The machines in which the engines are installed may have little or no electronic control systems, and are likely to be designed for a wider range of operators than larger equipment, with many machines being used on a short contract/hire basis. Consequently, simplicity of operation is also a key need.

In addition, this is a power range where there will be alternative forms of power source available, including SI engines operated on gasoline or on gaseous fuels, such as liquid petroleum gas (LPG), which are not currently regulated in Directive 97/68/EC.

As a consequence of the above factors there will be a high sensitivity to both the additional cost of more ambitious emission reductions and the impact upon the machine design. The continued demand for these products may be impacted by the ambition for further emission reductions and it is especially important to ensure that a thorough cost-benefit analysis specific to this power category is conducted prior to proposing more ambitious limit values than those aligned with the US.

In respect to the actual level of emissions to the atmosphere, such equipment as mini-excavators tend to spend a large proportion of their life non-operational, either being transported between jobs, or on the job-site awaiting use. The operational life also tends to be shorter than for larger machines. This is recognised, at least in part, by the shorter emission durability period (useful life) for variable speed CI engines $19 \leq kW < 37$ of 5000 hours (compared with 8000 hours for larger engines).

6.1.1. Addition of particulate number limit of 1×10^{12} (Option 3a)

The addition of such a limit in the EU will disrupt regulatory alignment if pursued in isolation from the US authorities. As is the case for the engines in the power range 56 – 560 kW, the technologies chosen by engine manufacturers to achieve the US Tier 4 final limit values for these smaller engines vary. Whilst some manufacturers have already chosen to incorporate a diesel particulate filter (DPF) some have chosen an alternative technology path. **In those cases where a DPF will already be fitted to comply with US Tier 4 final limits (option 2) the incremental impact of a particle number limit (option 3a) may be relatively small, but for engines and machines using a different technology path the incorporation of a DPF may require a complete re-design with associated high cost and packaging challenges.**

6.1.2. Addition of particle number limit of 1×10^{12} plus reduction of NOx to 0.4 g/kWh (Option 3b)

Installing a DPF to achieve the proposed particle number limit AND reducing NOx to 0.4 g/kWh for the power class has certainly NEVER been anticipated by the engine and machine industry. It should be noted that this concept was not contained in the January 2013 European Commission Consultation Document, a document that represented a culmination of six years of discussion within GEME. There is currently nowhere in the world foreseen to require such low NOx levels from these small non-road engines and consequently there is very little data or projections available on the potential compliance impact.

The current expectation of machine and engine manufacturers is that the limits proposed by this option would require separate DPF and SCR systems. Whilst there are systems under development that may incorporate part of the SCR catalyst on the DPF (so-called SCR on filter), it is not currently expected that viable systems will emerge that could integrate both functions within the SAME space that is required for a DPF alone.

What is very clear is that this scenario would result in the highest overall space requirement for the engine system (inclusive of after-treatment) and no engine or machine manufacturer is currently thought to have a line-of-sight to a viable technical solution for packaging such a system within the most compact non-road mobile machines. Even if technology becomes available to integrate a particle filter and SCR catalyst into a more compact space than is currently commercially possible, there will still be an additional space requirement for the urea storage and dosing system. Furthermore, the cost and complexity would be unacceptable for this range of engine power and the machines into which they would be installed. The quest for a viable, simple, compact solution to reduce NOx would require a long-term research activity that would necessitate a considerable delay in the implementation of a new stage. A major re-design of the engine system will be required. Such an activity is NOT recommended, but if contemplated by European Commission should only proceed in conjunction with the US authorities, in order to maintain regulatory alignment.

It is the opinion of engine manufacturers that option 3b for these power classes would be totally disproportionate, particularly given the limited incremental real-world emission benefit that would result. This could result in diesel-fuelled CI engines no longer being a commercially viable choice for powering the corresponding size of NRMM, with the result that existing machines with prior stage diesel engines remain in service for longer and/or new machines enter into service with a different power source. This would clearly have a major impact on the manufacturers of such CI engines, most of which are based in or have manufacturing sites in Europe.

6.2. NRMM CI engines > 560 kW

The machine population data reported in the 2007 JRC review indicated that (for EU 15 in 2005) the power range > 560 encompassed only 2% of all new heavy construction equipment and only 2% of new agricultural harvesters.[4] There are no known combine harvesters > 560 kW and it was subsequently determined during the work of Arcadis[5] that the 2% (attributed to forage harvesters) was incorrect and agricultural harvesters were excluded from subsequent analyses. Up until now it has not been considered that the proportion of machines > 560 kW placed on the market in the EU warranted regulation. Whilst the US will have been through several emission steps prior to reaching the most stringent Tier 4 final limit values it is proposed that the EU aligns with these limits in one step. The data collected by Arcadis[6] indicated that **aligning with US in this power class (option 2) gave the highest ratio of environmental gain to compliance cost (almost 12:1). This is the option supported by both the engine and machine industry**

It is important to understand the use and scale of the machines that would fall into this category. The majority will be used for mass excavation and material handling associated with mineral extraction, such as large quarries and open mines. These sites will typically be remote

[4] https://circabc.europa.eu/sd/d/36c150d2-0263-4bd9-bc13-226eb42afd0d/Final%20Report%20NRMM%20Review%20Part%20I.pdf and https://circabc.europa.eu/sd/d/d11bead9-9201-449b-aa1c-e006905ee241/Final%20Report%20NRMM%20Review%20Part%20II.pdf
[5] https://circabc.europa.eu/sd/d/d9ade144-c9ed-441d-858e-f9b4e8570cff/IA%20Study%20on%20NRMM-%20Executive%20Summary%20EN%20FR%20DE%20ARCADIS.pdf and https://circabc.europa.eu/sd/d/ceb966f2-f2f9-465d-b2b3-c12cdf64efc6/IA%20Study%20on%20NRMM-%20Final%20Report%20-%20ARCADIS.pdf
[6] ibid.

from areas of population and closed to pedestrian access (for safety reasons), such that the only workers near these machines when in operation will be the machine operators sitting in closed ventilated cabins. Very few machines will be small enough to be transported on the road without being dismantled and most will be assembled on site and remain at a single quarry or mine for their entire working life. **These are certainly NOT normally found working in towns and cities.**

The engines tend to fit into two groups, namely those that are in the range up to around 800 kW, mostly powering large wheeled loaders, excavating shovels and dump trucks in the larger quarries, and those for machines at the very largest surface mine sites with engines up to around 3500 kW installed in mining shovels and the very largest dump trucks. Only a limited number of EU member states will have mine sites large enough to need such machines, with the largest trucks capable of hauling a payload in excess of 350 tonnes in a single trip. **In some cases, especially at the high end of the power scale, the average number of machines placed on the EU market will be measured in years elapsed per machine sold rather than machines sold per year, making the recovery of investment in a unique engine/machine for the EU highly doubtful, with the prospect that it becomes more cost-effective to maintain machines with existing (unregulated) engines, compared to replacement with new products. In this case the adoption of overly ambitious limit values could be counter-productive and actually result in higher overall emissions to the atmosphere than would be achieved with less ambitious limits.**

Whilst it could be considered that a large machine would have more space for after-treatment systems, and could use 'on-highway technology', it must be noted that the size of the after-treatment will also increase with the size of the engine. **Euro VI on-highway solutions will be designed for engines that are in some cases an order of magnitude lower in power than those at the top end of the non-road power range,** and whilst the basic operating principles may be similar, **the physical mounting and encapsulation of the core components would bear limited resemblance to the smaller on-highway systems. After-treatment dimensions would be measured in metres rather than millimetres or centimetres and the systems would be largely bespoke productions and not benefit from the cost reductions possible in high volume markets.**

Finally, it is important to note that if the European Commission intend to propose a further level of ambition for > 560 kW non-road CI engine regulation in the EU against the recommendations of the engine and machine industry, it should be subsequent to, and not instead of, EU alignment with the US Tier 4 final limits, and be developed in conjunction with the US EPA.

6.2.1. Addition of particulate number limit of 1×10^{12}

Generally, diesel particulate filters are not foreseen as the technology of choice for these very large engines. To achieve the US Tier 4 final limit values some combination of internal engine measures, exhaust gas recirculation (EGR), diesel oxidation catalyst (DOC) and/or selective catalytic reduction (SCR) will be used in order to provide the required emission reduction with the smallest overall package size and the lowest operating costs. Accommodating a DPF in order to comply with a particle number limit would increase the space required for the engine system to the extent that the entire machine will likely require to be re-designed. Designing the engine system to ensure a reliable and safe controllable regeneration of the filter for each machine type and real-world operating scenario presents a further huge challenge that would remain to be solved.
Such major machine re-design for a power class of machines where the EU market is so small is unlikely to be an attractive commercial opportunity with the risk that new products of this size cease to be available on the EU market.

6.2.2. Addition of particle number limit of 1 x 10^{12} plus reduction of NOx to 0.4 g/kWh

Installing a filter to achieve the proposed particle number limit AND reducing NOx to 0.4 g/kWh (or to a similarly demanding value such as 0.67 g/kWh) for the entire > 560 kW power class has certainly NEVER been anticipated by the engine and machine industry. Consequently there is very little data or projections available on the potential compliance impact.

What is very clear is that this scenario would result in the highest overall space requirement for the engine system (inclusive of after-treatment) and no engine or machine manufacturer is currently thought to have a line-of-sight to a viable technical solution for packaging such a system within a piece of self-propelled non-road mobile machinery.

It should be noted that whilst for the US there is a 0.67 g/kWh limit for Tier 4 final genset engines, this limit value (even without a particulate number limit) was only considered viable due to the fact that gensets, whilst being mobile transportable equipment, are not self-propelled, not subject to very harsh shock and vibration experienced by self-propelled equipment of this size class and not operated over a wide range of engine speed. In fact, these gen-sets operate at a single speed (typically 1800 rpm for US and 1500 rpm for Europe, to match the 60Hz and 50Hz electrical power respectively) and will normally be stationary during operation. This means the air handling systems (turbochargers, etc) can be optimised for a single speed and the very large after-treatment systems required to comply with the limit values do not need to withstand high shock and vibration levels nor fit within the envelope of a self-propelled mobile machine. Indeed, the after-treatment could even be detached during transportation and re-attached for operation. Such large systems are not a viable solution for non-genset engines, such as those used for self-propelled non-road mobile machinery.

Even if a way to package the required systems within a self-propelled mobile machine is found, as observed previously, such major machine re-design for a power class of machines where the EU market is so small is unlikely to be an attractive commercial opportunity with the risk that new products of this size cease to be available on the EU market.

7. In-service conformity (ISC)

Euromot members have been supporting the development of appropriate in-service conformity (ISC) measurement and analysis procedures for variable speed non-road engines 56 – 560 kW via the JRC PEMS pilot programme.

Most importantly, whilst Euromot continues to support this activity, it notes that there remains a current lack of any formal proposal from Commission in respect to concluding the open policy items within the draft protocol, nor any proposal as to how and when such measures would be implemented. As such information is critical in order to be able to assess the impact of introducing ISC, **Euromot still believes it is essential for Commission to provide further information in this regard before completing the impact assessment and draft legal act.** It should be noted that conducting testing for ISC is an expensive and time consuming process. Employing staff, procuring and maintaining expensive test equipment, identifying candidate engines to test, transporting equipment to the test site, installing and de-installing PEMS equipment (which will require the hire of access platform and lifting equipment for the larger machines), and the impact on the machine owner, must all be taken into consideration. **Without further information on the proposed implementation it is impossible to judge the cost-effectiveness to society of introducing ISC.**

7.1. Understanding of ISC by respondents to Commission Consultation

It is important to highlight that whilst some respondents to the European Commission consultation clearly understood the purpose and limitation of ISC, it is clear that the majority of respondents did not understand certain fundamental aspects. Most specifically, it appears that much of the apparent support for ISC came from respondents that mistakenly understood this activity to be a process to check that an engine (complete with its after-treatment system) is being maintained correctly and free of tampering in-service.

It should be made clear to all parties that ISC, as currently developed, is NOT a method to ensure that engines are being MAINTAINED correctly nor to ensure they have not been TAMPERED, but is a method to ensure that engines have been DESIGNED and MANUFACTURED correctly so that IF they are maintained correctly they will control emissions to the level prescribed by the type approval requirements for the required period of time.

Engine manufacturers would agree that it is essential that engines are properly maintained and not tampered in service, but ISC is not the process for this purpose. Indeed, improperly maintained or tampered engines are excluded from the ISC programme because no engine manufacturer will take responsibility for the emissions from an incorrectly maintained or tampered engine.

Consequently, care should be taken not to over-estimate the support for ISC in the Commission consultation, versus support to ensure that engines are properly maintained and not tampered in-service.

7.2. Expansion of ISC to other power classes and engine applications

Euromot would like to make clear that its support for the ISC program has so far been limited to variable speed non-road engines 56 – 560 kW. Euromot understands that the European Commission is considering a proposal to expand ISC to other power classes and engine applications. Euromot does not support this action without an assessment of the practical implications and development of an appropriate test methodology for each power class and application.

It is critical to understand that, due to the fact the work-based-window (WBW) ISC test methodology is not a 1:1 match to the type approval test methodology it will most likely be necessary to adapt the prescribed test method where it is used on engines with different type approval requirements (eg different type approval test cycle requirements).

Both larger and smaller machines present particular challenges. From a practical perspective it will be extremely difficult or even impossible to safely mount the required PEMS unit on most machines with engines < 56 kW. For the tiny proportion of machines with engines > 560 kW the sheer size, with high exhaust mass flows, large exhaust diameters and multiple exhausts make testing using the prescribed exhaust mass flow devices impractical. The size also makes removal of the engines for bench testing entirely impractical. Furthermore the harsh environments, near continuous operation and restrictions on access to the machines by pedestrians and service vehicles present major logistical challenges for testing engines in large mining equipment. Inland waterway and rail engines also present specific challenges, but these will not be covered by this document.

8. Transitional provisions

As stated in the Euromot's response to the Commission consultation,[7] from an engine manufacturer's perspective it is most important to provide transition provisions that:

- Enable the placing on the market of engines without also promoting abnormal levels of engine inventory. This minimises peaks and troughs in engine production.
- Notwithstanding the need to avoid abnormal inventory, set a clear date for end of engine PRODUCTION, followed by sufficient time to place engines on market, regardless of location of engine or machine plants.
- Above all, provide provisions that are clear and can be uniformly enforced.

Euromot is concerned that whilst the European Commission has indicated that it will make changes to transitional provisions it has not yet come forward with any detailed proposal as to how it would implement such changes.

Euromot would like to stress the need for great care to be taken when making changes to the legal act. A further element of the global nature of the market is the complex supply chains that can result. There will be flows of engines, machines and partially-constructed machines (PCM) flowing into and out of Europe. The introduction of change to the way in which placing on the market is permitted at the transition between emission stages could introduce unintended commercial consequences and lead to inequalities between manufacturers based upon manufacturing location if not drafted with utmost care. Consequently, Euromot urges the European Commission to work closely with industry and other stakeholders to ensure any revised regulatory text delivers the intended result.

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For more information please contact:

European Association of Internal Combustion
Engine Manufacturers – EUROMOT
Dr Peter Scherm, +49 69 6603-1354, peter.scherm@euromot.eu
EU Transparency Register ID number: 6284937371-73

[7] https://circabc.europa.eu/sd/d/011f08f8-d692-4e5b-b52c-ae1fd054db28/Euromot%20-%20European%20Association%20of%20Internal%20Combustion%20Engine%20Manufacturers%20-%20Main.pdf and https://circabc.europa.eu/sd/d/70e7327b-b13a-43f8-8fb4-66a431a05fe2/Euromot%20-%20European%20Association%20of%20Internal%20Combustion%20Engine%20Manufacturers.pdf

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