FAQ on the proposed EU Regulation for non-road Mobile Machinery Engines
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1. General Context

- When did exhaust emissions regulation for machinery first take effect, and what happened since? How much were emissions already reduced through the existing regulation?

The EU non-road emission directive 97/68/EC was first published in 1997 and compliance with this directive first became mandatory for placing non-road machines on the European Community market on 01 January 1999. Both NOx and PM mass limits of EU Stage IV that applies from 01 January 2014 are now more than 95 percent lower than pre-regulated engine emission levels, which is a massive reduction in just 15 years.
• **What kind of construction equipment is covered by the proposed regulation? What is not?**

The term ‘construction equipment’ is generally used for a very wide range of machines used in applications from construction of buildings and roads through to huge machines used for extraction of minerals in mines and quarries. To be precise, the regulation applies to new engines used in the machines, rather than the machines themselves. Engines for use in all mobile or transportable construction equipment are included in scope. This includes machines that many people would instantly recognise, like excavators, loaders, road planers, pavers & rollers, through to a wide range of specialized machines like rock drills, tunneling equipment, and mining equipment. The only construction equipment for which the engines would not be subject to this regulation would be any already covered by vehicle emission regulations or non-mobile equipment used in fixed (stationary) applications.

• **How many companies are affected by the new regulation?**

It is difficult to give an exact number. The regulation applies to engines placed on the EU market, so European and non-European manufacturers who export to Europe, are affected.

European construction equipment industry consists of around 1200 companies. However, not all of them produce machines that are subject to the new regulation (e.g. construction hoists that do not have an engine which could be subject to the regulation).

• **What power ranges is construction equipment in?**

The full range of construction equipment stretches from less than 8 kW with total engine cylinder capacity of a fraction of a litre, through to around 3500 kW with a total engine cylinder capacity in excess of 100 litres. This range of power and cylinder capacity far exceeds the range for all on-road motorcycles, cars, buses and trucks combined. In fact, even the largest heavy-duty on-highway trucks generally use engines of less than 500 kW with a typical capacity not exceeding 16 litres.

• **Can you give examples of typical construction machines in each power range?**

There are so many different machines it is not possible to mention them all, but some of the more recognizable types encountered in daily life can be used for illustration. *Pictures of the type of equipment mentioned here are provided in Annex II.*

Starting at the lower end, a machine that often has a power of less than 19 kW is a mini excavator. These are the type of machines you might find being used on groundwork for extending or re-furbishing existing domestic houses and are sized to fit through doorways and operate in very confined spaces. Compact machines such as skid-steer loaders and larger mini excavators can be found in the power range 19 – 56 kW.
The type of ‘general purpose’ excavator with wheels to drive on the road, or back-hoe loaders which also drive on the road and have a loading shovel on the front and an excavator arm on the back are mostly in the 56 – 130 kW power range, together with many of the tracked excavators (up to around 30 tonnes operating mass) wheeled loaders and asphalt pavers that might be used on a range of building and general road construction/repair activities. Compactors (rollers) can span all these aforementioned power ranges, depending upon size.

Road planers or road milling machines that mill away the surface of existing roads ready for a new surface to be laid consume rather a lot of power for their size and are typically in the 130 – 560 kW power range. Much of the remaining equipment in the 130 – 560 kW power range can be characterized as being equipment typically used on larger construction sites and in small/medium sized quarries. This includes rugged trucks used for hauling materials within a worksite, large tracked excavators and large wheeled loaders. Whilst some machines in this power class could be found on urban construction sites, the largest excavators in this power range can be up to around 95 tonnes operating mass and the largest wheeled loaders up to around 80 tonnes operating mass, capable of moving 10 cubic metres of material in one 4.6 metre wide scoop, which is far larger than needed for a typical building site.

Such machines are difficult to transport by road due to their size, so the largest machines in this power category will not normally be seen working in cities. To put this into context the maximum loaded mass for an on-highway truck & trailer combination that can be used throughout the EU road network is 44 tonnes with a normal width of 2.6 metres.

So-called construction equipment with engines in the power range greater than 560 kW is generally not used for construction at all (except a few types of large road milling machines and in-situ road recycling machines), but is used in large quarries and mines. The largest of this equipment includes hydraulic mining shovels that have an operating weight in the region of 600 tonnes and can load more than 30 cubic metres (or 60 tonnes) of material in one scoop, and mining trucks that can have an operating mass of more than 600 tonnes and can carry a payload in excess of 350 tonnes in a single journey. The width of such a truck is around 10 metres, more than 3.5 times the width of an on-highway truck. These largest machines can have engine power up to around 3500 kW and are actually quite rare in Europe. In fact, it is estimated that less than a quarter of all member states have any mine sites that are large enough to need machines with engine power greater than 800 kW.

- **How many machines are sold per power class/year?**

CECE collects historic sales data on the EU market for construction equipment. The most recent data available is for 2012 and this data has been used to derive the chart shown in annex I.
2. European Commission Stage V Proposal

- **What is in the Stage V proposal?**

  Stage V will result in the EU having overall the most stringent emission limit values for construction equipment of all the major world economies.

  There are three main aspects to the proposed EU regulation that impact construction machine manufacturers, namely expansion of EU regulation to include the smallest (less than 19 kW) and largest (greater than 560 kW) machines for the first time, setting a minimum stringency over the entire power range no less than that which applies in the USA (Tier 4 final), and then overtaking the USA by setting even more stringent requirements for particle mass and particle number over the engine power range 19 – 560 kW. Whilst the proposed regulation (appropriately) does not mandate a specific technology to comply with the proposed particle number limit, as with on-road heavy-duty Euro VI regulation, it is widely anticipated that this will result in the widespread application of diesel particulate filters (DPFs) on construction equipment across the power range to which it applies.

  The technologies chosen by engine and machine manufacturers to achieve Tier 4 final/stage IV vary. Whilst some manufacturers have already chosen to incorporate a DPF, others have chosen an alternative technology path. In consequence, the impact of a particle number limit will vary considerably from one 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 new documentation for the engine, whilst for other manufacturers the incorporation of a DPF may require a complete re-design of the machine. The distribution of the impact is consequently likely to be highly bi-modal.

- **By how much will the limits reduce in each power range at Stage V?**

  The amount of reduction from the current in-force emission stage to stage V will vary by power range. The largest reductions in the actual mass of emissions will be for those categories where the current EU stage is not yet aligned with the corresponding US emission mass limits, especially for 19 – 37 kW and greater than 560 kW. In the latter case the emission limits are changing from being completely unregulated to matching the latest US Tier 4 final emission level, which is the most stringent in the world for that power category of construction equipment. On the other hand, although there is a 60 percent reduction in particulate mass emissions across the power ranges 37 –560 kW, the starting point is already very low (0.025 g/kWh), so the absolute incremental reduction in mass is actually very small.
Why does the proposed regulation differentiate between power ranges? Why do they have different introduction dates?

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 proposed non-road regulation includes in scope engines for a huge range of construction equipment with engine power from less than 8 kW to around 3500 kW, with total engine cylinder capacity ranging from a fraction of a litre to more than 100 litres. It is necessary to recognise that there is no single technical solution that is optimum or even suitable for this entire range. As a consequence, historically (and globally), the emission limit values, associated test cycles and other technical requirements have been differentiated by engine power.

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 all engine (and machine) sizes. The availability of certain key technologies (such as particulate filters and NOx after-treatment) is not 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 ranges.

Considerations during the adaptation process include:

- Design changes to withstand the appropriate non-road conditions, including long-term exposure to more aggressive environments, high shock loading and vibration compared with on-highway applications.
- Physical shape & 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 & after-treatment system to ensure acceptable transient response and minimize fuel & reagent consumption.

Consequently, whilst engine & machine manufacturers support the objective of emission reductions, with associated air quality and health benefits, the technical impact and cost-effectiveness of a given emission limit value MUST be individually assessed for different power classes. It is unacceptable to consider the entire range of power classes en bloc. Furthermore, it is impractical for manufacturers to simultaneously re-design all of their machines across all power ranges and it is appropriate to provide some stagger in the introduction dates. In this
instance the proposed stagger is minimal, with stage V for all power ranges applying on 01 Jan 2019, except for the range 56 – 130 kW which is one year later in 2020.

- Why is it necessary to have a transition period?

The EU NRMM machine market is a substantially smaller market than the heavy-duty on-road engine market with much wider variation in installed power, applications and usage. There are thousands of applications, many in niche markets of less than one hundred sales units per year. Furthermore, whilst some manufacturers produce both engines and non-road machines, a large number of manufacturers only produce machines and purchase their engines from the market.

For each machine there will be a development process that relies upon timely information and prototype engines being provided by the engine manufacturer, prior to completion of the machine re-design. The machine manufacturer is entirely dependent upon its supplier before it can conduct its product re-design which normally takes several years.

While up to Stage IIIA compliance with emission regulation could be achieved by engine internal modifications with almost no impact to the base machine design, this completely changed with Stage IIIB. Stage IIIB engine integration into the machines required in general larger engine installation space, e.g. for larger coolers and also larger exhaust gas after treatment components, causing major redesigns of the complete machine. So from Stage IIIB onwards it is not “only” an engine exchange, but a complete machine redesign, where health and safety aspects like visibility and access systems must be reconsidered completely.

This challenge of major machine modifications is even bigger if the manufacturer has a large variety of machine models to re-design, relying on timely information for a variety of different engine models.

It is consequently totally unrealistic to expect that all new machine types can be ready to commence production on a single date. Appropriate transitional provisions are necessary as they provide additional time to enable machine manufacturers to integrate new engine & after-treatment systems that require more space on the machines.
CECE collects historic sales data on the EU market for construction equipment. The most recent data available is for 2012 and this data has been used to derive the chart below:

**Explanation to the Chart**

The blue bars provide an estimate of 2012 European machine sales demand (number of units sold) divided into power classes. The sales data has been divided into a number of engine power classes using a range of publicly available manufacturers marketing literature that indicates the size of engine installed in certain classes of construction machine. The typical machine types associated with the different power classes are also indicated.
Importantly, it should be noted that the proportion of construction machines in each of the regulatory power classes align well with the 2005 population data used in the 2007 JRC report, indicating that the distribution of construction machine sales as determined in 2005 remains valid today. The $56 \leq kW < 130$ and $130 \leq kW \leq 560$ regulatory power classes have been subdivided into smaller divisions in order to illustrate more clearly the distribution of machines within these broad regulatory power classes. The strong reduction in quantity of machines as the engine power increases from 130 kW to 560 kW is very apparent, as is the smaller reduction as the power decreases from 75 kW to 19 kW.

The purple line provides an estimate of the cumulative number of hours per year that the entire cohort of machines in each power class operates. This line was established using manufacturers data on the number of hours per day that different types of machine are typically operated. When the data point on the purple line is high in comparison to the corresponding blue bar the operating hours are higher than average and when the data point on the purple line is low in comparison to the corresponding blue bar the operating hours are lower than average. At the high power end of the chart, large mining equipment works long hours, but the quantity of machines is so low that the cumulative total is very small. As engine power decreases below 56 kW, whilst the number of machines is still relatively high, the purple line falls quickly, which is indicative of the much lower hours worked by these small machines.
Annex II

Construction Equipment in the scope of the proposed EU Regulation on Exhaust Emissions

1. Less than 19 kW

   Mini Excavators

   Vibratory Plates

2. 19-56 kW

   Skid-steer loaders

   Wheel Loader
3. 56-130 kW

Loaders

Backhoe Loader

Tracked Excavator

Compactors (landfill compactors & rollers compactors)

Drilling Machines

Milling Machine
4. 130-560 kW

Wheeled Excavator

Drilling Machine

Wheeled Paver

Milling Machine

Dozers

Dumper
Mobile Crusher

Stabilizer/Recycler

Pipelayers

Cable Excavator

Excavator

Wheeled Excavator
5. Above 560 kW

Articulated Hauler

Motor Grader

Dumpers
CECE is the recognized organization representing and promoting European construction equipment and related industries. CECE represents 16 national associations from 14 countries. The industry behind CECE comprises of 1200 companies employing directly around 130000 people with a total turnover of 25 billion Euros from European production in 2013.