AN INTRODUCTION TO PASSENGER CAR EMISSIONS AND TEST CYCLES

— BACKGROUND

Transportation, amongst other sectors and including road and non-road vehicles, aviation, rail and marine contributes to air quality and greenhouse gas emissions in Europe.

In order to ensure that road and off-highway vehicles have satisfactory performance with regards to exhaust emissions in Europe, they are required to pass emissions tests, the procedures for which have developed over the years. Testing occurs during the vehicle development stage as well as during use. The former kind of tests are usually based on vehicle types (“type approval”) while the latter is described as “in-service conformity”.

Regulated Emissions and Vehicles/After-treatment Systems

Testing relates to regulated emissions which consist of carbon dioxide (CO_2), Nitrogen oxides (NO_x), particulate matter (PM), particulate number (PN), carbon monoxide (CO), and non-methane hydrocarbons (NMHC). In addition, fuel economy can also be measured or calculated.

— Particulate Matter

Particulate matter is more closely associated with diesel vehicles as in the past (before the introduction of clean diesel vehicles with diesel particulate filters (DPF), diesel vehicles produced more particulate than gasoline. The DPF is more than 99% efficient at removing diesel particulate. Going forward less and less particulate is expected to come from exhaust emissions. Non-exhaust emissions from brake-wear and tyre wear are expected to be the dominant source of particulate emissions from road transportation. Gasoline vehicles generally produce less particulate matter (PM) compared with diesel engine-out emissions (i.e. before after-treatment system).

— Particulate Number

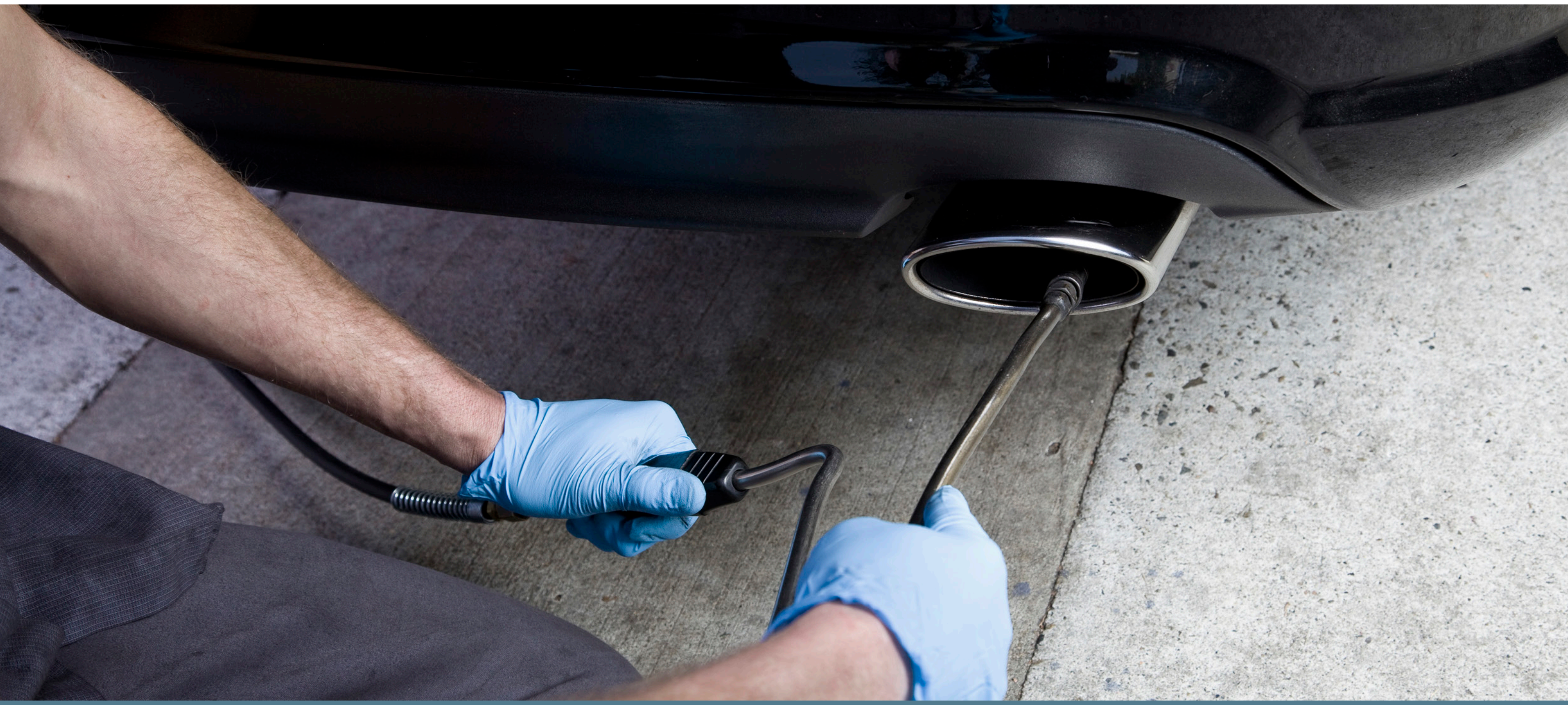
In addition to PM there is also a Particulate Number (PN) requirement for gasoline and diesel. The PN limit in terms of number of particles/km currently for the vehicle run over the NEDC test cycle (see section on drive cycles below) is only required for compression ignition (diesel) vehicles and spark ignition (gasoline) direct injection (GDI) vehicles as the latter are more prone to large numbers of particulates than port fuel or indirect injection spark ignition vehicles. PN from gasoline vehicles can be reduced with the use of gasoline particulate filters (GPF) which are also being developed although there are few used on commercial vehicles at present. From September 2017 there will be a ten-fold reduction in the PN limit for gasoline direct injection which will go down from 6×10^{12} to 6×10^{11} particles/km. This will mean that the limit for GDI will be the same as that for diesel vehicles.

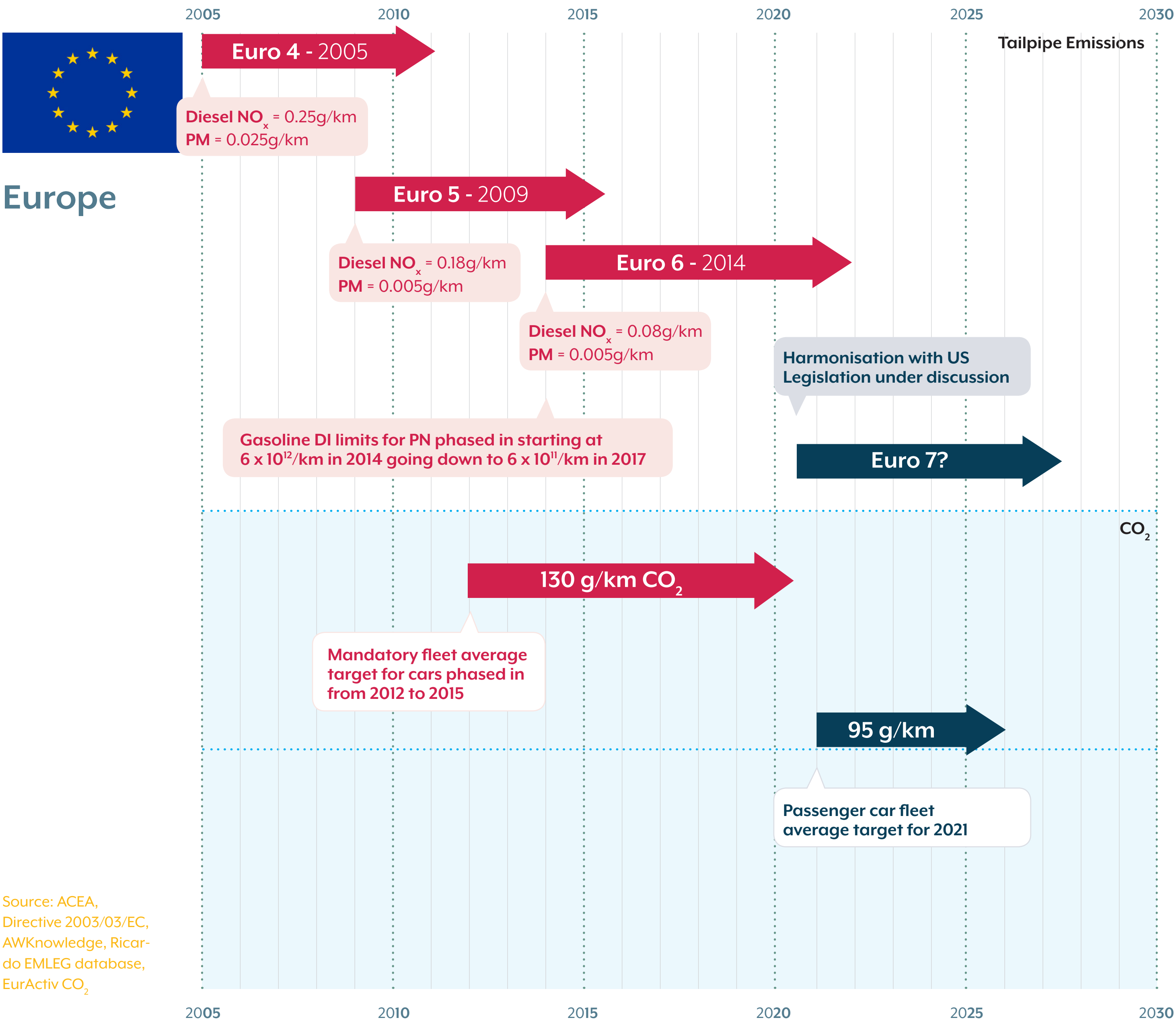
— Nitrogen Oxides

In general, NO_x emissions from gasoline vehicles are much lower than those from diesel vehicles. The reason for this is that gasoline operates under stoichiometric conditions (air/ fuel ratio = 1) whereas diesel runs under lean conditions (air/fuel ratio >1). This allows the effective operation of a three way catalyst in gasoline vehicles which reduces NO_x amongst other emissions. There are also ways to reduce diesel NO_x emissions using technologies such as exhaust gas recirculation (EGR), selective catalytic reduction (SCR) and lean NO_x trap (LNT). EGR can be used in combination with either of the other two as well as a diesel oxidation catalyst (DOC) and diesel particulate filter (DPF). SCR catalysts are common on heavy duty vehicles and are becoming increasingly common on light duty vehicles. They require the use of “Adblue”, a urea-based reducing agent which allows the SCR to function. LNT is used for smaller vehicles as it does not use a separate reducing agent.

Euro Standards

There are different test procedures for light duty and heavy duty vehicles and there are defined limits for each of the regulated emissions according to standards which have been developed. For light duty the standards are described as Euro x (where x is a number with the latest standard, as of publication of this factsheet in June 2017, being Euro 6). There are also sub versions of each Euro standard which denote temporary versions or addenda to the standard e.g. Euro 6b includes the temporary higher limit on particulate number (PN) for spark ignition direct injection (DI) vehicles which will go down to the permanent limit for Euro 6c. For heavy duty vehicles x is denoted a Roman numeral and the latest standard is Euro VI. The attached chart shows how the Euro passenger car standards for NO_x, PM, PN and CO_2 have reduced with time from Euro 4 to Euro 6.





Chassis Dynamometer Drive Cycles for Emissions Testing

Traditionally light duty emissions testing has been carried out on a piece of equipment called a chassis dynamometer (or rolling road) which absorbs the energy that the vehicle produces. The vehicle is run according to a test cycle which mimics conditions which it may experience while running on the road. The vehicles can either be driven by human drivers or more recently, robots which have started to be employed to more closely follow the speed-time curves that describe the test cycle.

Until recently European passenger car approvals have been run according to the New European Driving Cycle (NEDC) which has several parts relating to urban and highway (extra urban) driving. However, there have been criticisms that the NEDC does not represent real world driving. As a result a UNECE[1] group was formed to develop a new chassis dynamometer test cycle which is the Worldwide Harmonized Light Duty Test Cycle (WLTC) which is part of the Worldwide Harmonized Light Duty Test Procedure (WLTP). This cycle will be the principle tool used to measure CO_2 going forward and will be applied from September 2017 for type approval and September 2018 for first registration (first entry into service). The test will also be used to measure the other regulated emissions

[1] United Nations Economic Commission for Europe World Forum on Harmonization of Vehicles (WP29)

mentioned above. The WLTP is a longer procedure than the NEDC at 1800 seconds versus 1200 seconds. It is also a more transient test and the WLTP has also been developed to try to improve certain aspects of the current test cycle by putting tighter controls on such things as vehicle weight and temperature. As a result it is expected that the test will be more severe in terms of CO_2 and NO_x than the NEDC.

In terms of meeting limits the current NEDC CO_2 limits will apply with WLTP test results being recalculated using a programme called CO2MPASS. After 2020 a WLTP-based limit will be used for compliance.

Real Driving Emissions

In addition to the new chassis dynamometer test, a Real Driving Emissions (RDE) test is also under development for approval of new passenger cars from September 2017. This test is focussed on NO_x and PN. Data is generated on the road using a portable emissions measurement system (PEMS) which is carried in the back of the vehicle as the test is carried out. The route which the vehicle drives has to be a defined route which consists of one third urban driving, one third extra-urban and one third highway. The data is processed to check that it meets these requirements to verify that the test is valid.

Conformity Factors in Relation to RDE Emissions

It has been found that diesel vehicles, including early stage Euro 6 vehicles driven over the RDE cycle have higher NO_x emissions than under previous test conditions. As a result the amount of NO_x generated by diesel passenger cars in real world conditions has been under estimated. The ratio of the RDE emission to the limit defined under the NEDC cycle is called the conformity factor. The emissions regulations have been temporarily revised to allow NO_x emissions for new vehicles to be brought down in steps until they fully meet the existing regulations. For NO_x, a temporary conformity factor of 2.1 will be put in place from 2017 onwards (Euro 6-dTEMP), reducing to 1.5 in 2020 (Euro 6d). For PN an initial conformity factor of 1.5 has been agreed. Although it is still early days there are indications that some vehicles meeting these standards can meet the NO_x emissions limits under RDE-type conditions. Meeting Euro 6c/d standards is key as this will make a significant contribution to achieving ambient air quality targets according to a recent study conducted by Concawe.

For more information and other fact sheets visit **www.concawe.eu**

About Concawe

The scope of Concawe's activities has gradually expanded in line with the development of societal concerns over environmental, health and safety issues. These now cover areas such as fuels quality and emissions, air quality, water quality, soil contamination, waste, occupational health and safety, petroleum product stewardship and cross-country pipeline performance.

Our mission is to conduct research programmes to provide impartial scientific information in order to:

- Improve scientific understanding of the environmental health, safety and economic performance aspects of both petroleum refining and the distribution and sustainable use of refined products;
- Assist the development of cost-effective policies and legislation by EU institutions and Member States;
- Allow informed decision making and cost-effective legislative compliance by Association members.

Concawe endeavours to conduct its activities with objectivity and scientific integrity. In the complex world of environmental and health science. Concawe seeks to uphold three key principles: sound science, transparency and cost-effectiveness.