



Real Driving Emissions testing: A game-changer for NO_x to promote cleaner vehicles in the EU

HIGHLIGHTS

- The gap between the goal set by the regulation (i.e. the limits) and the real vehicle emissions on the road was an issue, particularly regarding the excess nitrogen oxides produced by diesel vehicles.
- The issue has been highlighted by Joint Research Centre tests since 2012 and came to the attention of the public during 'diesel-gate' in 2015. Investigations from the European Parliament revealed that the situation was caused by a combination of the weaknesses in both the vehicle emissions testing procedures and the enforcement system.
- Prior to diesel-gate, the European Commission had already launched scientific studies and had been working on more stringent testing procedures for emissions since 2007, based on testing under real driving conditions using portable equipment: the Real Driving Emissions (RDE).
- Euro 6 vehicles type approved applying Real Driving Emissions testing procedure emit substantially less nitrogen oxides (NO_x) than vehicle types approved before the introduction of this new testing procedure.

Do the latest EU emissions standards deliver the goals set by the regulation? This brief is based on the data that have been collected by the Joint Research Centre (JRC) since 2016 within the scope of the European Commission's market surveillance activities.

Policy context

Discrepancy between limits and real emissions

The emissions standards defining the environmental performance of road vehicles are one of the policy instruments to achieve the EU air quality objectives, together with the rapid phasing out of high emitters and the proper maintenance of the running vehicle fleet. Recent history in the EU has highlighted a mismatch between the target set by the emissions regulations and the

actual pollution emitted by the vehicles on the road: this issue peaked during 'diesel gate'. **At that time, EU diesel passenger cars were found to emit far more nitrogen oxides (NO_x) under normal driving conditions than the emissions limits,** while the other regulated pollutants remained controlled. The NO_x issue was the result of combined weaknesses in the testing procedures and the enforcement system [1].

As a first step and even prior to 'diesel gate', the European Commission started to prepare more stringent testing methodologies with the objective of testing vehicles under real driving conditions on the road. During that time, the JRC was involved in conducting pre-normative studies using a Portable Emissions Measurement System (PEMS) [2], [3].

Regulatory actions

Since 1 September 2017, new vehicle models have had to pass the new and more realistic emissions test in real driving conditions on the road (the RDE test) and an improved laboratory test (the Worldwide Harmonised Light Vehicle Test Procedure WLTP) before they can be sold on the European market. **While the RDE test forces car manufacturers to respect limits on NOx and particulate emissions (which are a major cause of air pollution [4]), the WLTP focuses on ensuring that more realistic carbon dioxide (CO₂) and fuel consumption values are provided to car buyers [5].**

In addition, vehicles are checked not only prior to their introduction on the EU market, but also during their life in order to ensure that their environmental performance do not deteriorate unreasonably over time. In 2018 with a new market surveillance Regulation enforcement, control instruments

and responsibilities were clarified and enhanced to ensure that clean vehicles are put on the market and that they do remain clean once they are in-use [6], [7].

Figure 1 – Light-duty vehicle equipped with a PEMS, ready to perform a RDE test



Source: JRC

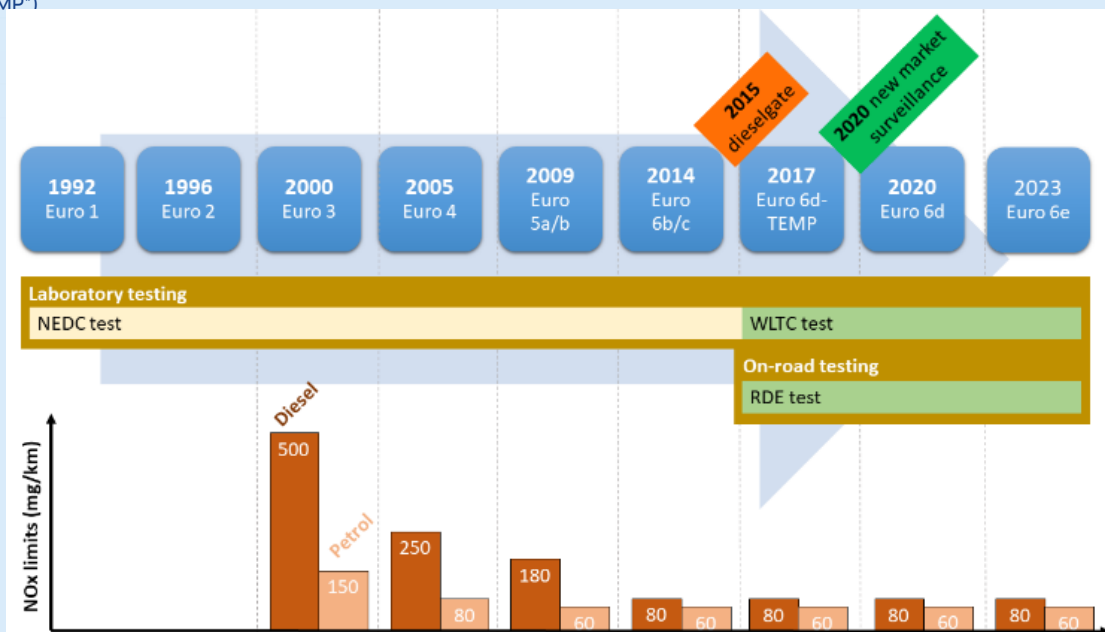
New testing procedures introduced in September 2017

The **RDE test is the official on-road testing procedure assessing the environmental performance of all new car models.** The RDE test was initially a candidate method investigated by the JRC in 2007 as a supplementary measure to ensure that vehicle emissions were appropriately controlled outside standardized laboratory conditions [2].

The **WLTP test is the official laboratory testing procedure to assess the energy efficiency and environmental performance of all new car models.** The WLTP test is a globally harmonised testing procedure developed within the UN Economic Commission for Europe with the support of the European Commission. The WLTP replaced the New European Drive Cycle (NEDC), which no longer adequately reflected real driving conditions or vehicle technologies.

Timeline of emissions Standards and NOx limits for passenger cars

Since 1992, several European emissions standards (Euro standards) have been adopted with the objective of lowering vehicle tailpipe emissions: hydrocarbons (as total or non-methane hydrocarbons), carbon monoxide (CO), particulate matter (in mass and number) and NOx. **The NOx emissions limits – one of the main concerns for urban air quality – have been reduced from 500 mg/km to 80 mg/km for diesel vehicles, and from 150 mg/km to 60 mg/km for petrol vehicles.** The Euro 6 standard was introduced in 2014 (as Euro 6b). In 2017, new and more robust testing procedures in laboratories (the WLTP test), and on the road (the RDE test) were adopted to verify compliance with the Euro 6 limits (vehicles were type-approved as "Euro 6d-TEMP")



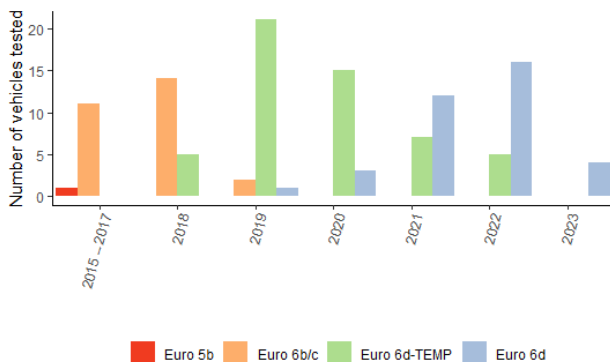
Market surveillance – role of the Joint Research Centre

Regulation (EU) 2018/858 requires both Member States and the European Commission to carry out a series of tests (in the laboratory and on the road) to check the environmental and safety compliance of vehicles against type approval regulations during the vehicles' normal life times. In addition, this regulation introduced also the verification of the absence of defeat devices [7]. Vehicle market surveillance requires testing a defined number of in-use vehicles from the market and verifying that they comply with the emissions limits, the safety and defeat device requirements, as approved by the type approval authority for the prototype vehicle before the model was introduced to the market. Since 2015, the JRC has been conducting market surveillance activities on behalf of the European Commission. **Since September 2020, the Commission (through the JRC) has been tasked with conducting verifications.** So far, the JRC's Vehicle Emission Laboratories have tested circa 120 in-use vehicles [8]–[12].

Impact of the RDE regulation

The distribution of vehicles per Euro standard tested by the JRC per year is shown in Figure 2. This test fleet was designed to be representative of the EU market, as the models were selected based on a risk assessment that considered the vehicle technology, the number of sales and the main group of manufacturers.

Figure 2 – Number of vehicles tested by the JRC by Euro standards and by year (prior to and since the official market surveillance activity).



Source: JRC market surveillance annual reports [8]–[12].

The testing was done according to the applicable type approval emissions tests for checking the compliance with the emissions limits.

From Euro 5 vehicles and up to Euro 6c vehicles, the only type approval test was the NEDC. From Euro 6d-TEMP vehicles onwards, vehicle type approval testing included both the WLTP test and on-road testing following the RDE rules. The emissions limits had to be fulfilled for both tests. **In addition, for vehicles that were not type-approved using the RDE requirements (i.e. those approved prior to the entry into force of the RDE test), the JRC systematically conducted on-road testing following the RDE methodology. In total, 117 cars have been tested on the road for emissions since 2015 (25% were Euro 5b/6b/6c vehicles 75% were Euro 6d-TEMP/6d vehicles).** This database of real-world NO_x emissions results provides a consistent and representative baseline against which to assess the evolution over time of the environmental performance of vehicles following emissions standards from the pre-RDE-test period to the post-RDE-test period, as described below:

- Euro 5b/6b/6c. These are vehicles for which on-road testing (the RDE test) was not mandatory.
- Euro 6d-TEMP. These are vehicles for which both new laboratory testing (the WLTP test) and on-road testing (the RDE test) were mandatory. For the RDE test, a temporary conformity factor (CF) of 2.1 was in force for NO_x emissions.
- Euro 6d. These vehicles had the same requirements as described for Euro 6d-TEMP, but with a lower CF of 1.43 in force for NO_x emissions.

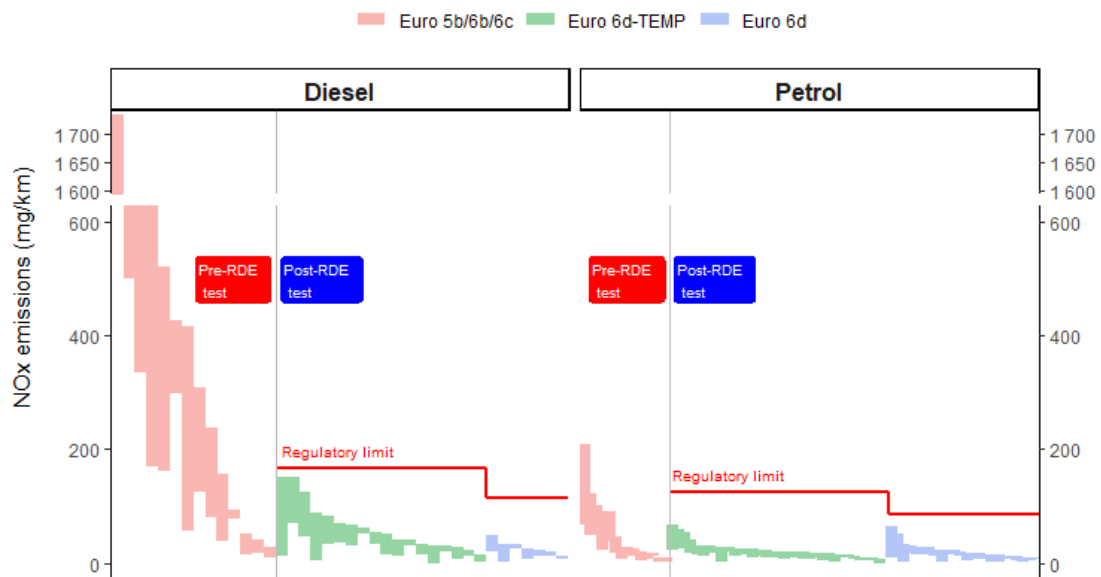
Figure 3 shows the minimum and maximum RDE NO_x emissions obtained for all the vehicles tested and collected by the JRC since 2015. By applying the same methodology consistently to obtain values for the on-road emissions of these vehicles, the effect of the new testing procedures for type approval is clearly visible for Euro 6d-TEMP and Euro 6d vehicles, in particular for diesel vehicles.

For all vehicles type-approved using the RDE requirements (approximately 90 Euro 6d/6d-TEMP vehicles), the tests performed by the JRC demonstrated that all of them fulfilled the NO_x regulatory limits for RDE tests when the vehicles were driven under real conditions (i.e. environmental temperature, altitude, driving dynamics), as described in the RDE regulation.

Real driving emissions conformity factors

The CF was introduced to establish the allowed discrepancy between the regulatory emissions limit that is tested in laboratory conditions and the values recorded in the RDE test procedure when the car is driven by a real driver on a real road [13]. The first temporary CF was defined for NO_x emissions and put in place until 2020 to reflect the statistical uncertainty of both the test procedure and the PEMS equipment. The objective was to progressively reduce this discrepancy based on the latest improvements in the measuring technology used on the road and the corresponding reduction in the additional uncertainty. **Consequently, the CF has been progressively reduced since 2020, from 2.1 for the Euro 6d-TEMP standard to 1.43 for Euro 6d standard. In September 2023, the CF was reduced to 1.1 for the Euro 6e standard.**

Figure 3 – Effect of the Euro 5/6 regulatory standards on the on-road (RDE) NOx emissions from passenger cars. Each bar represents one vehicle. Limits displayed with red solid lines include the CFs. On the x-axis, vehicles are sorted in descending order of maximum NOx emissions.



Source: JRC RDE data acquired during the on-road testing of 117 petrol and diesel vehicles (tested since 2015).

Most pre-RDE diesel vehicles measured on the road exhibited NOx emissions up to several grams per kilometre whereas the applicable laboratory limits for Euro 5 and Euro 6 were 180 mg/km and 80 mg/km respectively. For post-RDE petrol vehicles, an improvement of the environmental performance was also observed, but to a lesser extent. **The RDE regulation has forced car manufacturers to improve their after-treatment technologies and to have them properly functioning for all conditions defined in the RDE rules.** With the introduction of the RDE, the European Commission established a more stringent procedure to complement the laboratory testing, with the objective of promoting clean mobility. From the JRC dataset, it can be seen that the target has been achieved and **Euro 6 vehicles type-approved under the RDE regulation are much cleaner than those approved previously.**

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Data used to produce this briefing are available through the JRC data catalogue [14]–[16].

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