The Association
of European
Vehicle Logistics

WLTP

Worldwide Harmonised Light Vehicles Test Procedure

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From NEDC to WLTP

The New Test to Measure

CO_2 Emissions and Fuel Consumption of Cars

Introduction

On 1 September 2017, two new European tests came into force: WLTP (Worldwide Harmonised Light Vehicles Test Procedure) and RDE (REAL Driving Emissions) to replace the NEDC (New European Driving Cycle) which was signed in the 1980s and introduced in 1996. The reason for the introduction of these tests is well-understood as the existing NEDC cycle does not accurately reflect the true fuel consumption but some of the implications are less obvious.

WLTP was developed by the United Nations Economic Commission for Europe (UNECE) with the support of the European Commission (EC) to ensure that testing more accurately reflects real world results, especially regarding CO_2 emissions, but also other aspects that are required for vehicle type-approval[1]. As of September 2017, all new cars introduced on to the market for the first time have been tested according to new regulations. The two tests will then be phased-in according to a timeline:

- From 1 September 2017 the WLTP and RDE tests apply to all new car models
- From 1 September 2018 the WLTP test applies to all new car registrations
- From 1 September 2019 the RDE test applies to all new car registrations

However, in addition to the new tests, EU measures allow for a transition period for end-of-series vehicles[2] for a limited number of unsold vehicles in stock that were approved under the old test (NEDC) to be registered until September 2019.

The RDE test is a more realistic emissions test in real driving conditions, for NO_x and other particulate emissions, which are a major cause of air pollution. This test is carried out with a portable emission measuring system (PEMS) that is attached to the car while driving in real conditions on the road[3]. Consequently, the RDE test will complement the WLTP test which is the new improved laboratory test for

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[1] Regulation (EU) 2017/1151, supplementing Regulation (EC) No 715/2007 on "type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information".

[2] 'end-of-series vehicle' means any vehicle that is part of a stock which cannot be registered or sold or entered into service owing to the entry into force of new technical requirements against which it has not been approved. Moreover, 'End-of-Series' shall be restricted in one of the following ways to be chosen by the Member State: 1) the maximum number of vehicles of one or more types may, in the case of category M1, not exceed 10 % and in the case of all other categories not exceed 30 % of the vehicles of all types concerned put into service in that Member State during the previous year. Should 10 %, respectively 30 %, be less than 100 vehicles, then the Member State may allow the putting into service of a maximum of 100 vehicles, 2) vehicles of any one type shall be restricted to those for which a valid certificate of conformity was issued on or after the date of manufacture and which remained valid for at least three months after its date of issue but subsequently lost its validity because of coming into force of a regulatory act.

[3] The PEMS used for regulated emissions are complex pieces of equipment that integrate advanced gas analyzers, exhaust mass flow meters, weather station, Global Positioning System (GPS) and a connection to the vehicle networks. There is no standard PEMS equipment and equipment manufactured by different suppliers can deliver slightly different results. In practice, OEMs must set their design objectives well below the legal limit to be certain of complying and to account for the risk that PEMS on any particular day may have an even higher error margin.

CO_2 emissions and fuel consumption. The key differences between the old NEDC and new WLTP test are that WLTP will:

- test all optional equipment separately,
- include best and worst-case values instead of average values,
- include higher average and maximum speeds,
- include hot and cold engine starts,
- include a greater range of driving situations (urban, suburban, main road, motorway)
- include longer test distances
- include higher average and maximum drive power
- look at harder acceleration and deceleration, and
- have a tougher set-up process for vehicles ahead of the test.

All this means that the tests will take more real-world factors into account which will increase testing in general, as all optional equipment needs to be tested separately, but also the test times will increase by 50% (i.e. from 20 min to 30 min). This has significantly increased demand for testing capacity which is leading to bottle-necks and disruptions in production e.g. Volkswagen Group has announced that production of up to 250,000 cars from its brands will be delayed to a later date than previously planned. In this case the company is responding by halting the production on certain days in August and September 2018 at its Wolfsburg production site.

Another impact might come through higher taxes that vary depending on the CO_2-tax scheme of each country. Analysis by JATO Dynamics predicts in general higher taxes for SUVs but smaller increases for sportscars. However, the EC has clearly stated that the move to the new WLTP test should not negatively impact vehicle taxation by increasing costs for consumers. Nevertheless, as taxation is a national competence, it is up to each Member State to implement changes to their tax systems as they see fit.

On the positive side, the WLTP will become the standard fuel economy and emissions test for not only for all the EU countries, but also India, South Korea and Japan have implemented the same test process. This means that OEMs can use the same test results for type-approval in all these different regions which will in turn reduce the cost and time taken to get type-approval because there will no longer be a need to perform multiple tests in each of these countries separately. Consequently, this will also reduce the costs of R&D for OEMs and suppliers in designing vehicles and parts, because having a single test for numerous different markets negates the need for example different powertrain calibrations.

RDE and the Type-Approval of Cars

The type-approval describes the process applied by national authorities to certify that a model of a vehicle meets all EU safety, environmental and conformity of production requirements before authorising it to be placed on the EU market. One of these requirements – pollutant emission testing – is regulated by the 'Euro emissions standards' – that sets the emission limits for cars for regulated pollutants, in particular for nitrogen oxides (NO_x), so that the combined emissions of NO and NO_2 are below 80mg/km[4].

However, given the novelty of RDE test measurements and the technical limits to improve the real-world emission performance of current production diesel cars in the short-term Member States agreed, in October 2015, a phasing-in period. This will reduce the divergence between the regulatory limit measured

[4] Regulation (EC) 2007/715, "On type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information".

in laboratory conditions and the values of the RDE procedure[5]. The agreement foresees a two-step approach:

1. In the first phase manufacturers will have to bring down the discrepancy to a conformity factor of a maximum of 2.1 (i.e. 168mg/km NO_x instead of 80mg/km) for new models by September 2017 (for all new vehicle registrations by September 2019).
2. In the second phase, the conformity factor will be brought down to 1.5 (i.e. 120mg/km NO_x instead of 80mg/km), by January 2020 for all new models (by January 2021 for all new vehicle registrations)[6].

Consequently, to cope with the new values, OEMs need to adopt efficient systems to reduce these emissions such as the adoption of an AdBlue system e.g. selective catalytic reduction (SCR) for diesel engines and particulate filters for petrol cars. However, these solutions can actually increase the CO_2 emissions. For example, when BMW introduced its AdBlue system to the model X1 1y6d in March 2018, the old NEDC CO_2-value of 104g/km jumped to 118g/km WLTP-derived NEDC value. This is because the SCR technology uses a chemical reaction to reduce the levels of NO_x but, in so doing, it also releases nitrogen, water and small amounts of CO_2 to achieve this. This technology can thus achieve NO_x emission reductions of as much as 90% but can increase CO_2 emissions.

Finally, if the new test results differ significantly from the old ones it could have an impact on the type approval of cars. In the worst case, some cars previously type approved with the old test might not get approved by the new tests if they breach their pollutant emission limits too severely[7]. This is because to certify a vehicle under the RDE rules an OEM must confirm – undertaken by an approved test facility or by the OEM themselves - that it complies and achieves a certain performance level with all RDE conditions, which include now a broader set of parameters such as, year-round temperatures (-7 C to + 35 C), altitude (of up to 1,300 m), and high speeds (up to 131km/h). Under the RDE a vehicle is driven on public roads (instead of laboratory testing) and over a wide range of different conditions to verify that legislative caps for pollutants such as NO_x are not exceeded. So far, BMW has announced in May 2018 that it would temporarily stop production of some models until they can be made to comply with the RDE on-road emissions tests.

The regulatory governance will be completed from 1 September 2020 with a new EU vehicle type-approval framework. The new rules were proposed by the EC in the wake of the so-called 'Dieselgate', and a compromise with the European Parliament and Council was finally reached on December 2017[8]. The European Parliament voted on the amended proposal on 19 April 2018, and the Council is expected to

[5] Contrary to a pre-defined laboratory test cycle, the intrinsic characteristics of the PEMS measurement equipment in RDE tests lead to a higher variation and wider range of the quantitative emission results of different RDE trips. With a conformity factor, the focus is put on the vehicle's average compliance with emission limits. For example, regulatory emission limits may be exceeded when driving up a steep hill, which then must be compensated by emissions below the regulatory emission limits under different conditions, such as driving moderately in the city, so that the average emissions, when weighting these conditions according to their statistical occurrence, are not above the limits.

[6] To take account of future improvements of the measuring technology, this factor will be subject to annual reviews starting in 2017 and as the technology improves, the conformity factor will be reduced further with the aim of bringing it to 1 as soon as possible and at the latest by 2023.

[7] Directive 2007/46/EC, "Establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (Framework Directive)".

[8] Regulation (EU) 2016/14, "on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles".

formally adopt the legislation sometime afterwards, following which the Regulation will be published in the Official Journal.

These new rules will significantly raise the quality level and independence of vehicle type-approval and testing, increase checks of cars that are already on the EU market and strengthen the overall system with European oversight. These check obligations will require each Member State to conduct a minimum number of checks on vehicles each year from which at least 20 % of the checks will have to be emission-related tests, with verification of emissions under real driving conditions. In addition, the EC will be enabled to carry out tests and inspections of vehicles to verify compliance and react to irregularities immediately. In case of non-compliance of a vehicle, the EC can impose administrative fines of up to €30,000 per non-compliant vehicle on manufacturers and importers.

Impact of WLTP and higher CO_2 emission measurements

The WLTP test ties in with Regulation (EC) 2009/443 that sets manufacturer-specific targets according to a limit-value line, proportional to the sales-weighted average mass of their fleet and a target of fleet-wide sales-weighted average CO_2 emissions from passenger cars to 95 g CO_2/km for 2021[9]. This translates to a fuel consumption of around 4.1 l/100 km of petrol or 3.6 l/100 km of diesel. Moreover, these manufacturer-specific targets vary as they have been made based on the competitiveness and diversity among different manufacturers and can be seen in the Annex of Regulation (EC) 2009/443. This means that every manufacturer has its own unique target for sales weighted average CO_2 emissions which it needs to achieve.

According to the European Environment Agency (EEA), the overall average CO_2 emissions in the industry has been decreasing steadily, but for the last three years this decrease has been very marginal (one or two points only) and in 2017 increased by 0.4 g/km to 118.5 g/km[10]. The reasons are, at least, two-fold:

1. The general decrease in the use of diesel cars[11]
2. The increase in SUVs which are expected to have a third of the market share in EU27 by 2020[12].

Consequently, if the European fleet average CO_2 emissions exceed 95 g/km by 2021 (i.e. each manufacturer is adjusted to this target based on its own manufacturer-specific target), manufacturers failing to achieve their targets will be subject to costly fines of €95 per gramme per registered new car for every gramme their average is over the limit[13]. Furthermore, the new WLTP results could make this target even harder to achieve (we don't have the figures of 2018 yet).

The CO_2 targets that car manufacturers must meet by 2021 are based on the old NEDC test and, since September 2017, the WLTP-CO_2 values have been translated back to NEDC-equivalent values to monitor compliance against the CO_2 targets set by the EU. However, as it is desirable to limit the testing burden for both manufacturers and type-approval authorities, the EC provided the possibility to determine the

[9] Regulation (EC) 2009/443, "setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles".
[10] EEA, (2018), data found in: www.eea.europa.eu/data-and-maps/data/co2-cars-emission-14
[11] Latest data can be found from Eurostat:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqs_carmot&lang=en
[12] JATO Dynamics, (2017)," The future of the car industry as WLTP bites".
[13] Three different flexibilities, eco-innovations, super credits and pooling, can introduce a maximum of 14.5 g/km per year deduction in fleet average CO_2 emissions per manufacturer.

reference NEDC-CO_2 emission values by way of simulations[14]. When these simulations are not able to deliver NEDC-CO_2 values with sufficient accuracy, the manufacturer has the possibility to perform a physical NEDC test. However, since this will be an updated version of NEDC (i.e. with tightened test set-up conditions), new cars that are type-approved under WLTP will have WLTP-CO_2 values and NEDC-CO_2 values that are both higher than the equivalent 'old' NEDC values.

This difference between the NEDC and WLTP measurement of CO_2 emissions of light-duty vehicles has been estimated by the EC's Joint Research Centre who used a combination of simulations at individual vehicle level across a fleet of 1,200 cars[15]. Results (*see Table 1*), show an average WLTP to NEDC CO_2 emissions ratio in the range 1.1 - 1.4 depending on the powertrain and on the NEDC CO_2 emissions (e.g. a figure of 1.22 would mean a vehicle measured at 100 g/km under NEDC would be 122g/km under WLTP). In particular, the ratio tends to be higher for vehicles with lower NEDC CO_2 emissions in all powertrains, the only exception being plug-in hybrid electric vehicles (PHEVs). In this case, indeed, the WLTP to NEDC CO_2 emissions ratio quickly decreases to values that can be also lower than 1 as the electric range of the vehicle increases.

Furthermore, a report conducted by Transport & Environment (T&E), addresses the issue by looking at each OEM separately[16]. This research puts the OEMs into three different groups based on their progress towards achieving their 2021 targets (*see Table 2*). In the first group of 9 OEMs you have companies such as Peugeot-Citroën, Toyota and Daimler who are in a good position to respect their targets. The second group consists of BMW, Ford and Volkswagen who are, according to T&E, one or two years behind target, assuming that there will be no use of flexibilities and acceleration in the up-take of electric vehicles. Finally, the third group consists of eight OEMs - Hyundai, Fiat-Chrysler, Honda, Subaru, Kia, Opel-Vauxhall, Mazda and Suzuki – who are furthest from their targets. From this group, the first three in particular may face severe challenges in reaching their targets and avoiding large penalties. However, with the flexibilities in place (i.e. super-credits, eco-innovations and pooling) T&E concludes that in the end most of the OEMs will probably achieve their targets.

Conclusion

The conclusion of all this for the automotive industry could be that some manufacturers might have to stop selling certain car models or derivatives that emit high levels of emissions and push to bring more hybrids, especially PHEVs, and full battery electric vehicles (BEVs) to the market in order to first comply with the new type-approval and secondly to avoid costly fines from 2021 onwards. According to JATO, the automotive industry would need fully electric vehicles to account for 15% of the market in 2021 to meet the 95g/km CO_2 target[17] while T&E estimates a more modest market share required of 5-7%[18]. Nevertheless, this will be quite a leap forward as the market share in the EU in 2018 remains around 1%. There is thus a serious risk for disruptions in the whole product cycle – from design of new vehicles to

[14] Regulation (EU) No 1152/2017, "setting out a methodology for determining the correlation parameters necessary for reflecting the change in the regulatory test procedure with regard to light commercial vehicles and amending Implementing Regulation (EU) No 293/2012; Regulation (EU) No 1153/2017, "setting out a methodology for determining the correlation parameters necessary for reflecting the change in the regulatory test procedure and amending Regulation (EU) No 1014/2010.

[15] JRC, (2017), "From NEDC to WLTP: effect on the type-approval CO_2 emissions of light-duty vehicles", JRC Science for Policy Report.

[16] Transport and Environment, (2018), "CO2 Emissions from Cars: the facts", report published in April 2018.

[17] JATO Dynamics, (2017)," The future of the car industry as WLTP bites".

[18] Transport and Environment, (2018), "CO2 Emissions from Cars: the facts", report published in April 2018.

production and eventually to sales of these vehicles. Some OEMs will comply better to these changes than others. The positive outcome on the other hand is that with a more universal test standard that is now being used in the EU, Japan, India and South Korea even more countries and regions could eventually join this group which in turn will simplify the type approval process for OEMs and thus lower their costs when entering markets with new car models.

For the vehicle logistics sector possible consequences could include:

- **Increased demand for storage capacity** - Some OEMs are already stockpiling vehicles in the countries where they plan to sell them under the end-of-series allowance if they need to be 'in country' before September 2018. In addition to this, the shortage in testing capacity may result in bottlenecks and delays in type approval which could cause stock build-up of vehicles post-September until they gain approval and can be registered.

- **Delays in production and vehicle approval** – The bottlenecks in testing capacity are resulting in some OEMs temporarily halting production of some models/derivatives in order to avoid building vehicles that cannot be sold.

- **Ending production of some car models/engines** – The new RDE and tougher NO_x targets could mean some engines or car models might not get type approval under the new rules as the costs would be prohibitive, so some OEMs are already believed to be planning to cease sales of certain models or derivatives.

- **Customer pull forward** – If the WLTP testing scheme results in the expected increased CO_2 results then, unless Member States adjust their taxation systems to allow for this the taxes, and therefore prices on some car models will rise. Dealers usually anticipate such changes beforehand and pull retail customers forward. This could result in higher than expected demand before September with a consequent drop off afterwards.

- **Change in demand pattern** – As above, taxation changes both up and down may also affect longer term demand patterns and therefore vehicle flows.

- **Post-production options (PPO)** – Some OEMS are looking at where this activity is best carried out in the future under the new regime (i.e. at dealers or in their hubs) so changes may occur in the supply chain, and therefore, in the services required of LSPs.

Table 1: Relationship between WLTP and NEDC CO_2 emissions for different passenger cars

Passenger Cars		NEDC Type Approval Emissions (g/km) (official 2015 data)	Ratio WLTP/NEDC
All ICEV		123	1.21
Gasoline	**All**	125	1.22
	< 1.4 l	115	1.24
	1.4-2.0 l	148	1.15
	> 2.0 l	225	1.07
Diesel	**All**	121	1.20
	< 1.4 l	93	1.26
	1.4-2.0 l	114	1.21
	> 2.0 l	159	1.14
LPG		116	1.16
Gas		104	1.36
HEV Gasoline	**< 1.4 l**		1.37
	1.4-2.0 l		1.32
	> 2.0 l		1.23
HEV Diesel	**< 1.4 l**		1.38
	1.4-2.0 l		1.34
	> 2.0 l		1.30
PHEV			1.00
BEV/FCV*	**Small**		1.258
	Medium		1.283
	Large		1.299

Source: JRC (2017)

Table 2: Influence of the use of flexibilities on the CO_2 compliance year

	Without using flexibilities	With using flexibilities		
		Minimum level	Moderate level	Maximum level
Volvo	2017	2017	2017	2017
Mitsubishi	2018	2018	2017	2017
Toyota-Lexus	2019	2018	2017	2017
Daimler	2020	2019	2019	2017
Jaguar-Land Rover*	2020	2019	2019	2018
Peugeot	2020	2019	2018	2017
Citroën-DS	2020	2019	2018	2017
Nissan-Infiniti	2020	2019	2018	2017
Renault Group	2021	2020	2019	2017
Volkswagen Group	2022	2021	2020	2018
BMW Group	2023	2022	2021	2018
Ford	2023	2022	2021	2018
Suzuki*	2025	2024	2022	2020
Mazda*	2026	2024	2023	2021
Opel-Vauxhall	2027	2026	2024	2021
Kia	2028	2026	2025	2022
Subaru*	2028	2026	2025	2022
Honda	2029	2028	2026	2023
Fiat-Chrysler	2030	2028	2026	2022
Hyundai	2033	2030	2028	2024

*Manufacturers with a niche derogation target

Note: dates before 2020 are illustrative – super-credits cannot be earned and used before 2020

Source: T&E (2018)

(Minimum level of flexibilities = 3.5g/km; Moderate level of flexibilities = 7g/km; Maximum level of flexibilities = 14.5g/km)