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How much difference in type-approval CO_2 emissions from passenger cars in Europe can be expected from changing to the new test procedure (NEDC vs. WLTP)?

J. Pavlovic[a,*], B. Ciuffo[a,*], G. Fontaras[a], V. Valverde[a], A. Marotta[b]

[a] European Commission-Joint Research Centre, Directorate C – Energy, Transport and Climate, Sustainable Transport Unit, via E. Fermi 2749, 21027 Ispra, VA, Italy
[b] European Commission-Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Automotive and Mobility Industries, Brussels, Belgium

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ABSTRACT

After significant efforts from many parties, the World-wide harmonized Light duty Test Procedure (WLTP) has seen its light first as the UNECE Global Technical Regulation and then as the procedure adopted in the type-approval of light-duty vehicles in Europe. The paper focuses its attention on the main procedural differences between the WLTP and the New European Driving Cycle (NEDC), which is the test-procedure currently used in Europe. In general terms the WLTP appears to be a significant improvement compared to the NEDC. The main differences between two test procedures are identified and their impact on CO_2 emissions quantified using the in-house built simulation software CO_2MPAS. On the basis of each of these differences, the paper assesses the potential total impact on the final reported type-approval CO_2 emissions. The biggest impact on CO_2 emissions is coming from the changes in the road load determination procedure (~10% increase). Procedural changes concerning the test in the laboratory will bring another 8% and post-processing and declaration of results will result in difference of approximately 5% (each). Overall, the WLTP is likely to increase the type-approval CO_2 emissions by approximately 25%. Therefore, the WLTP will be able to reduce more than half of the gap identified between the type-approval and real-life figures in Europe. This should be seen as a considerable improvement given the ontological limitations of a laboratory-based test procedure.

1. Introduction

For many years there have been efforts to harmonize testing procedures on the chassis dynamometer for light-duty motor vehicles (LDVs) and to come up with a new test cycle (WLTC) and a new test procedure (WLTP), applicable to LDVs worldwide (Tutuianu et al., 2015; Ciuffo et al., 2015). Following the efforts put forward by the European regulatory bodies and the pressure built up by the diesel emissions scandal in 2015, in July 2017 the WLTP has been adopted as the new test procedure in the European type-approval (TA) system (Regulation 2017/1151, 2017). Since the first publication of the WLTP various experimental studies attempted to compare CO_2 and other pollutant emissions from the former procedure which was based on the NEDC with the new one (Marotta et al., 2015; Bielaczyc et al., 2015; Andersson et al., 2014; May et al., 2014; Favre et al., 2013). Most of these studies were focused only on the driving cycle, while a few of them also took into consideration some aspects of the procedure. As far as local pollutants

* Corresponding authors.
E-mail addresses: jelica.pavlovic@ec.europa.eu (J. Pavlovic), biagio.ciuffo@ec.europa.eu (B. Ciuffo).

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Table 1
Summary of main procedural differences between NEDC and WLTP.

Category	Factor	In NEDC	In WLTP
Road load (RL) Determination	Vehicle test mass	Present	Modified
	Tire selection	Present	Modified
	Tire pressure	Present	Modified
	Tire tread depth	Present	Modified
	Calculation of resistance forces	Present	Corrected
	Inertia of rotating parts	Absent	Introduced
Laboratory test	Driving cycle	Present	Modified
	Test temperature	Present	Modified
	Vehicle inertia	Present	Modified
	Preconditioning	Present	Modified
	Gear shift strategy	Present	Modified
Post-processing test results	Battery State Of Charge (SOC) correction	Absent	Introduced
	Correction of speed and distance	Absent	Under discussion
Declared value	Declaration of CO_2 emissions	Present	Modified

(NO_x, CO, THCs) and particulate matter (mass (PM) and number (PN)) are concerned, WLTP will bring an overall increase in NO_x, PM, and PN emissions and decrease in THC and CO emissions (Bielaczyc et al., 2016, Marotta et al., 2015). In presenting the results, however, many of these studies concluded that NEDC and WLTP will not produce significant differences in terms of CO_2 emissions, with the higher dynamicity of the WLTC compensated by the higher average engine efficiency occurring over the cycle, the new gear-shifting strategy that leads to lower average engine speeds and the reduced contribution of the cold-start in the total emissions. As an overall message, the equivalence between the two cycles would appear quite worrying, because the increasing gap between the certified CO_2 emissions on NEDC and the corresponding real life ones was one of the major reasons for the urgent introduction of the WLTP (Fontaras et al., 2017a; Zacharof et al., 2016; Mock et al., 2012, 2014; Dings, 2013).

In reality, however, the new test procedure is significantly different if compared in details to the former NEDC-based one which was developed in the seventies and does not reflect the state of the art in testing and vehicle technologies of today. As a result of that, when the picture is analyzed in its entirety, vehicles type-approved under the WLTP are expected to show higher CO_2 emissions with respect to the current values for the same pollutant emission levels. Indeed, a number of simulation studies showed that WLTP introduction is expected to bridge about half of the present divergence between laboratory and real world, meaning that the average WLTP-based CO_2 figures will be about 15–20% higher than the current NEDC-TA values (Tsiakmakis et al., 2017; Fontaras et al., 2017b; Pavlovic et al., 2016a; Tsokolis et al., 2016; Ciuffo et al., 2016).

The main differences between the two test protocols can be grouped in four categories (an overview is presented in Table 1):

- Road load determination from the test track
- Laboratory test
- Post-processing of the test results
- Declaration of CO_2 results

Most of the procedures listed in Table 1 were already present in the NEDC. However, due to high tolerances allowed in many factors and some recognized technical errors, each vehicle manufacturer and type approval authority had the possibility to make their interpretation of the “standard NEDC test conditions”. Under the pressure of strict CO_2 standards these tolerances resulted in interpretations that yielded in most cases lower CO_2 emissions and thus had an impact on the European policy for tackling the road transport CO_2. These tolerances have been modified in the WLTP with more strict and precise methods and definitions. Most of these modifications will likely result in an increase in the CO_2 emissions, while for some others the impact will depend on the vehicle characteristics (e.g. the gear shift strategy) and the driving behavior during the test (e.g. correction of speed and distance).

The objective of this paper is to describe in detail the main procedural differences between the NEDC and WLTP and quantify their impacts on CO_2 emissions. The procedural differences described in this paper are focused on the test procedures that apply to conventional vehicles with internal combustion engines only. For hybrid and electric vehicles, on top of the effects that will be discussed in the present study, additional procedural changes introduced with the WLTP will have significant effect on final CO_2 emission results (Pavlovic et al., 2017). The paper is organized as follows. In Section 2 all procedural differences between NEDC and WLTP are identified and a brief qualitative impact assessment on CO_2 emissions is provided. Section 3 presents the results and quantifies the impact of each individual procedural difference to give the reader the possibility to understand the effect of each factor on the final CO_2 emissions. Section 4 describes some other elements that potentially can have impact on CO_2 emissions from the two procedures. The findings presented throughout the paper are summarized in Section 5 with a broader outlook on the underlying consequences.