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TNO report

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Road load determination of passenger cars

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Summary

Fuel consumption and CO_2 emissions of new light duty vehicles must be specified according to Type Approval regulations. However vehicle users often obtain much higher realistic fuel consumption in comparison to Type Approval tests. This difference in fuel consumption can be caused by different factors such as vehicle configuration, state of maintenance, test track properties and flexibilities in legislation. Some examples of flexibilities are: optimized tire configurations with low rolling resistances, optimized vehicle configurations (wheel alignment, engine friction) and optimized preconditioning of the vehicle (battery charging before emission testing and a relative high soak temperature).

The Dutch Ministry of Infrastructure and The Environment and the European Climate Foundation have contracted TNO to investigate one of the contributing factors to this gap in fuel consumption between Type Approval and real-world; namely the simulation of the road load curve on a chassis dynamometer during Type Approval testing.

Vehicle manufacturers typically determine the fuel consumption (in liters per 100 km) and CO_2 emissions (in grammes per kilometer) in a test laboratory on a chassis dynamometer. In order to measure representative numbers this dynamometer must correctly simulate the vehicle resistance as function of the vehicle speed. This is performed on the basis of a measured road load curve. Before laboratory testing, determination of the vehicle road load curve takes place on a road or test track according to a legislative procedure. The result is a time-speed trace of the resistive load of the vehicle which must be simulated in the emission test on the chassis dynamometer.

Within this project the main objective is to investigate for a number of vehicles whether the road load curves used for Type Approval testing are representative of commercially available production vehicles sold to customers.

Road load curves of six modern passenger car models (Euro-5/Euro-6) and two older variants (Euro-4) of the same models have been determined on test tracks in The Netherlands and Belgium. The results have been compared to the road load settings used for Type Approval, (as specified by the manufacturer) and are expressed in a Road Load Ratio (see Figure 1).

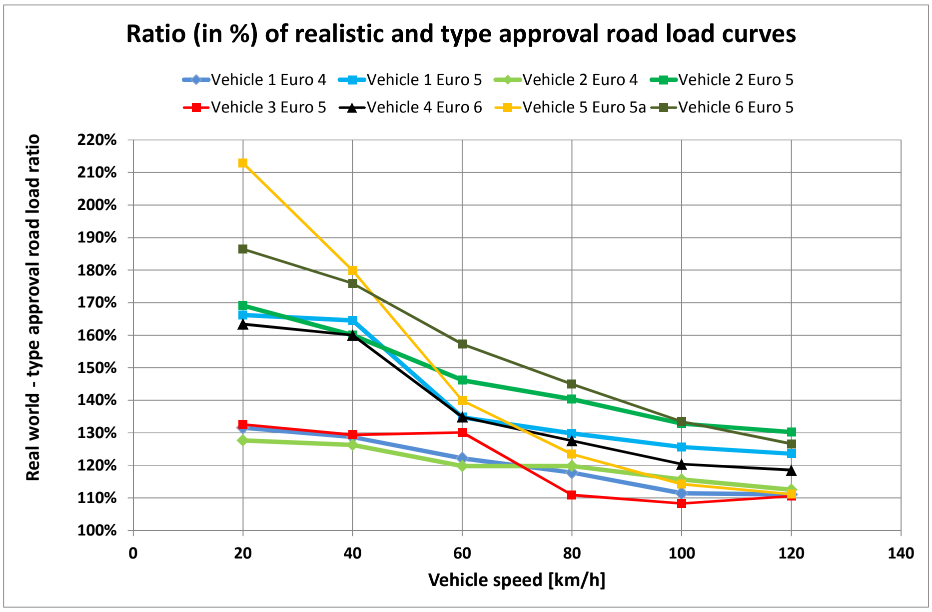

Figure 1: Ratio of realistic and Type Approval road load test results of all tested vehicles

The road loads measured under realistic conditions, representative of in-use vehicles driven in realistic conditions are found to be substantially higher than those of the Type Approval road loads. At high speeds the road load differences are up to 30%. At low speeds, with very low road load forces, these differences are on average up to 70%.

The older models have about half such a difference. For all vehicles the results show the same, with a consistent trend in road load deviation. Based on NEDC (New European Drive Cycle) weighted road loads, the Euro-4 2009 models have a 19% higher road load. The average of the Euro-5/Euro-6 models has a 37% higher road load, with the same weighting (see Figure 2).
This indicates an increasing trend of road load ratios in recent years, in Euro-5 vehicles more flexibilities have been applied than in Euro-4 vehicles. According to model based calculations this average 18% increase of the road load ratio results approximately in an average decrease of the Euro-5 type approval CO_2 emissions of 11% (A Euro-5 vehicle with a Type Approval CO_2 emission of 130 g/km will probably have a CO_2 emission of 146 g/km with Euro-4 Type Approval road load settings).

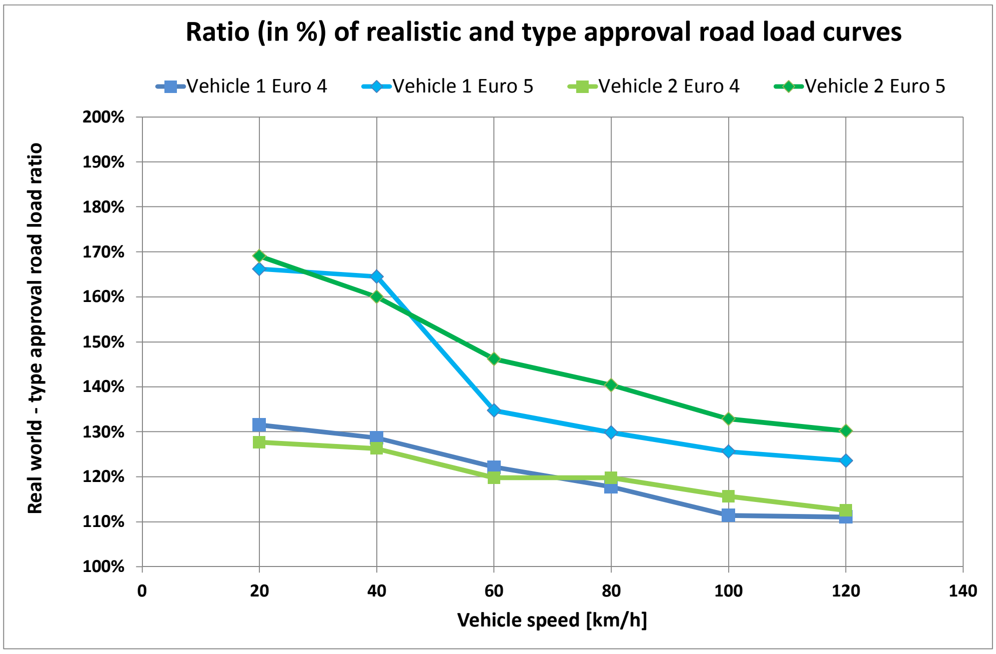

Figure 2: Road Load Ratios of 2 vehicles, both tested as Euro 4 and 5 configuration (TA = 100%)

Comparing the Type Approval road load curves with the independently determined realistic road load curves, the difference is an additional force that only weakly varies across the whole range of vehicle speeds. This suggests a specific type of optimization of the road load curve. Likely candidates for this optimization are reduced rolling resistance of tires (hard and low thread tires, pretreatments), reduced resistances of wheel bearings, optimized warming up procedure of the test vehicle, optimized wheel alignments of the vehicle, optimized resistance of the road surface of the test track and optimized road inclination of the test track.

Emission tests have been carried out on five vehicles to assess the impact of different road load curves on fuel consumption and CO_2 emissions. Chassis dynamometer tests have been carried out with Type Approval road loads and with the independently determined road loads, using the NEDC test cycle.

In Figure 3, the declared and measured CO_2 emission results of NEDC tests with Type Approval and real-world road load settings are reported for Euro 5 and 6 vehicles. NEDC tests with Type Approval road load settings show on average 12% higher CO_2 emission levels than the declared CO_2 emissions of the manufacturer. NEDC tests with realistic road load settings show on average 11% higher CO_2 emission levels than tests carried out with the manufacturer specified road load settings.

NEDC tests of Euro 5 and 6 vehicles with realistic road load settings (which are on average 37% higher than Type Approval road load settings) show on average 23% higher CO_2 emissions than the declared CO_2 emissions of the manufacturer. I.e. the CO_2 emission of a Euro-5 vehicle with realistic road load settings with a Type Approval CO_2 emission of 130 g/km is approximately 160 g/km.

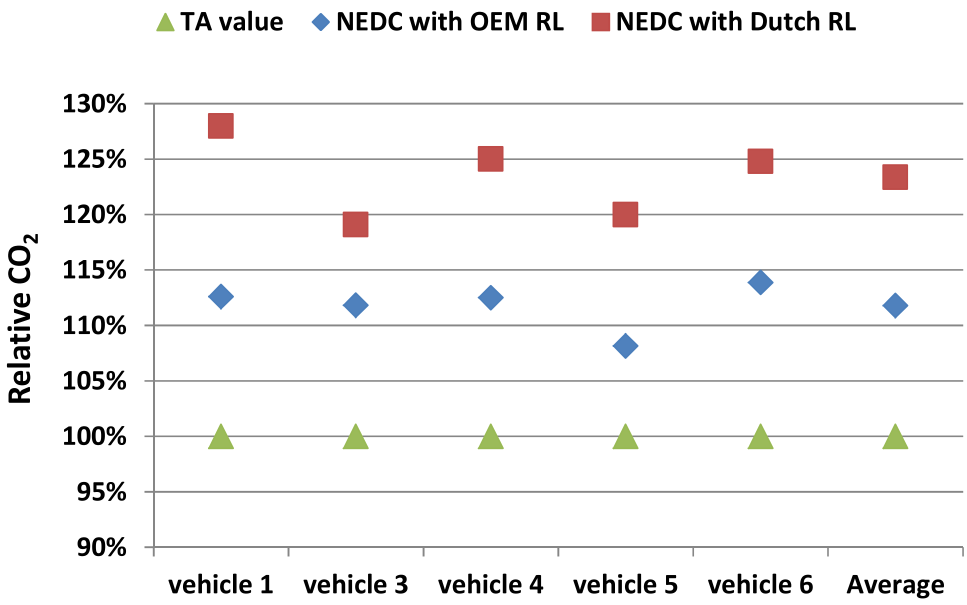

Figure 3: Relative CO_2 emissions of Euro 5 and 6 vehicles in a NEDC test with different road load settings

This study shows that within current road load and CO_2 emission legislative testing procedures vehicle and test conditions can be optimized significantly and a large number of parameters can influence the Type Approval CO_2 emission test result positively (possible parameters are: 4% administrative subtraction, optimized tires, bearings and wheel alignments, soak and preconditioning of the vehicle, test track slopes), while the realistic fuel consumption and CO_2 emissions of vehicles are higher.

In order to obtain a smaller gap between Type Approval and realistic CO_2 emissions future road load and emission test procedures must be improved; many very specific items should be (re)defined and the determination of the road load curve is one of the main issues. Special attention must be paid to configurations and conditions of tires and road surface condition. Furthermore the requirement of road load testing in opposite directions needs an additional requirement. Road load testing must take place in two opposite directions with opposite slopes (‘uphill’ and ‘downhill’).

Contents

1 Introduction

1.1 Background

In the European Union, the fuel consumption and CO_2 emissions of passenger vehicles are commonly measured against the New European Drive Cycle (NEDC) in a simulated laboratory drive cycle. This cycle comprises two parts representing typical 'urban' and 'extra-urban' (higher speed) driving. The test measures fuel consumption in liter per 100 km and derives CO_2 emissions in g/km. These test results can significantly deviate from the “realistic” fuel consumption on the road achieved by most vehicle owners. There are several reasons for this gap, the most important of which are:

- Variations in ambient conditions in the test and those typically experienced outdoors;
- Differences in vehicle configuration. The road load test vehicle has a certain standard configuration which represents a group of vehicles. Other members of the group can have a different configuration and can be equipped with optional items;
- Deviating conditions and driving patterns in the laboratory test. I.e. load settings in the laboratory test are on average lower than the “realistic” road load curve on public roads;

In this project the main focus will be on the determination of realistic road load settings of commercial production vehicles. The gap between realistic road load settings and the Type Approval road load settings in the laboratory is expected to be one of the main causes of the higher fuel consumption under realistic conditions. Type Approval road load settings are commonly determined by manufacturers on dedicated test tracks with defined characteristics and circumstances.

The results of this project will be used for discussions in the development of future vehicle test procedures. Currently a World Harmonized Test Procedure (WLTP) of exhaust emissions of passenger cars is under development and the determination of the road load curve is part of this development.

1.2 Aim and approach

The main objective in this research project was to determine the difference in the vehicle configuration and load settings between vehicles set up as they are sold and driven on the road, and those used for tests. This is expected to be one of the main causes of the lower fuel consumption and CO_2 emissions achieved by test vehicles compared to vehicles representative of realistic use.

1.3 Why is a laboratory needed for a fuel consumption test of a vehicle?

Conditions on the road are not sufficiently consistent to accurately measure and compare vehicle fuel consumption (and CO_2 emissions). For example wind, road conditions, road slopes and ambient temperatures have a great effect on vehicle load and fuel consumption. Standard practice is therefore that vehicles are tested on chassis dynamo-meters in laboratories. In a laboratory environment vehicle load conditions and ambient conditions are consistent and as a consequence test results are stable and reproducible.

The test is conducted by placing the vehicle on a chassis dynamometer (or roller bench) in which the vehicle load (aerodynamic drag, rolling resistance and vehicle mass) can be simulated.

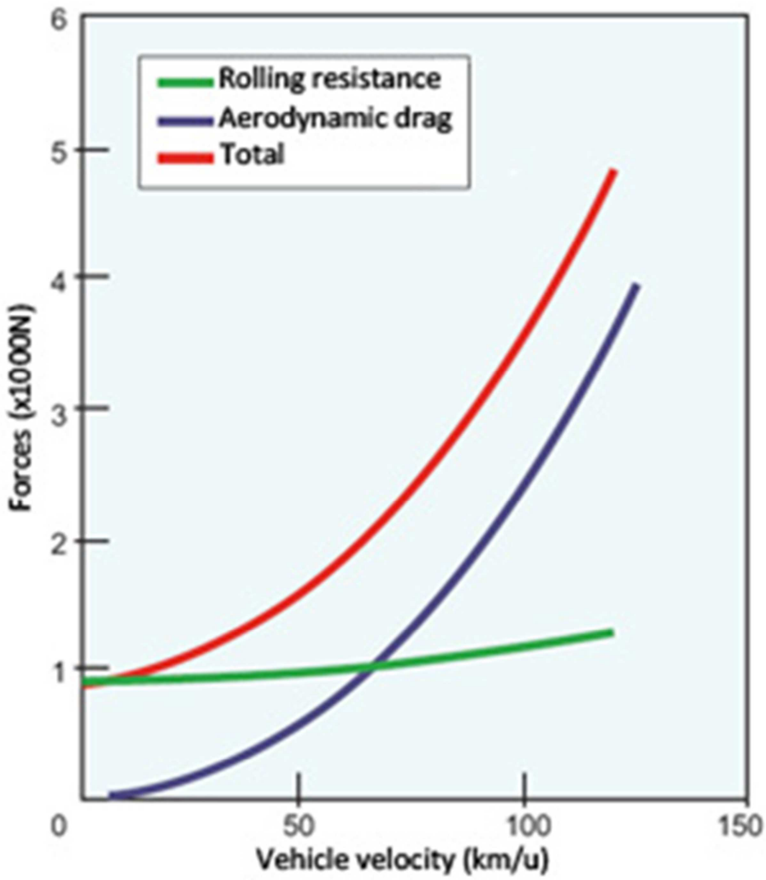

Figure 4: Characteristics of rolling resistance and aerodynamic drag of a vehicle

Over the vehicle speed range the rolling resistance force is fairly constant and only slightly dependent on vehicle speed. However the aerodynamic drag force depends strongly on vehicle speed. Effectively from 0 – 40 km/h the vehicle resistance mainly depends on rolling resistances and at higher speeds (> 80 km/h) the aerodynamic drag is mainly responsible for the total vehicle resistance.

In the emission tests the settings of the chassis dynamometer (or load curve) correspond with the specific vehicle characteristics. During a vehicle test, the dynamometer (see Figure 5) creates a speed dependent load on the rollers which replaces air and rolling resistance of a vehicle and vehicle mass. Ideally, the different vehicles are therefore measured in identical circumstances, which enables for comparison between vehicles. In an emission test the pollutant and CO_2 emissions are measured with dedicated test equipment and fuel consumption is calculated.

Figure 5: Chassis dynamometer or roller bench

1.4 Structure of the report

The background to and objectives of this project have been reported in chapter 1. In chapter 2 the methodology and project activities are described and explained. The generated results of the road load tests and emission tests have been reported in chapter 3. The test results lead to an overall discussion in chapter 4 and finally the conclusions and recommendations have been reported in chapter 5.

2 Testing methods

2.1 Description of activities

To assess the effect on fuel consumption and CO_2 emissions arising from differences in the vehicle configuration and load settings for production vehicles and Type Approval vehicle TNO undertook a series of comparative tests. More detailed specifications of the tests are described in section 2.2. Most vehicles were part of a commercial rental fleet.

The testing work conducted as part of this study comprised of:

1. Selection and preparation of vehicles.
2. Road load tests on a test track according to EC 692/2008 Annex III.
3. Processing of road load test results according to EC 692/2008 Annex III.
4. Fuel consumption tests on a chassis dynamometer according to EC 715/2007 & EC 692/2008.

The test activities in EC 692/2008 Annex III, EC 715/2007 & EC 692/2008 relate all to UNECE R83.

2.2 Description of the test procedures

In order to obtain reliable, consistent, reproducible and repeatable test results different defined tests must be performed. The sequence of a complete fuel consumption test procedure is:

1. Determination of a vehicle road load curve on a dedicated test track.
2. Simulation of the road load curve on a chassis dynamometer.
3. Fuel consumption and emission test on a chassis dynamometer.

<u>1. Determination of a vehicle road load curve according to UNECE R83 Annex 4a-Appendix 7</u>

For determination of realistic (or real world) road load settings a test program was undertaken on 8 vehicles at test tracks in Lommel (Belgium) and Lelystad (The Netherlands). In Lommel the tests have been carried out at test track Straight Away #3 which has a length of 2300m. In Lelystad the length of the test track was 720m. Each of the tested vehicles were instrumented with a data acquisition system (V-box) that measured time-speed traces on the test track. The vehicle was warmed up thoroughly and accelerated to a speed of 130 km/h. The gear box was then set in the neutral position in order that no further power was available to the wheels. Air and roller resistances lead to a deceleration of the vehicle and the time-speed traces were measured. In order to exclude the effects of wind the tests are carried out in two opposite directions. The actual ambient conditions and wind speeds were taken from the local weather data logging facility.

The measured traces form the basis of the vehicle road load curve used subsequently in fuel consumption and emission tests undertaken on a chassis dynamo-meter. Vehicle manufacturers spend considerable effort optimizing the road load test result. For example most tests are carried out in a summer climate

(25-35°C) on a dedicated test track (although the test result must be corrected to standard conditions).
For the testing undertaken by TNO all vehicles have been checked and weighed before road load testing. Preparation of the vehicle and the testing itself was performed in a way to provide realistic conditions. Unrepresentative vehicle set up, such as with misaligned wheels or preventing any residual brake friction was not introduced. Wheel alignments have been set at specified “mid-settings”. Vehicle body state, tire conditions, rolling resistances, clearances of wheel bearings and parasitic drag of brakes were checked. In case of deviating conditions (excessive wear, too much friction or damage) the vehicle was removed from the selection and replaced by another sample vehicle. Road load test equipment (VBOX II, measuring frequency 20 Hz) was installed in the vehicle. This equipment has a weight of 5 kg.

In order to have representative test conditions, all tests have been carried out on a test track with a dry road surface and minimum wind speeds. The tire pressures were set at user recommended values (printed on stickers in the vehicle). One driver performed the tests and the actual mass of these vehicles were not adapted. All fluid reservoirs (incl. the fuel tank) were 90-100% filled.

According to UNECE R83 the measured time speed traces were processed and the absorbed power was calculated and corrected to reference conditions (air density @ 100 kPa @ 293,2 K).
No corrections in the calculations were made for actual vehicle masses.

In Table 1 an example of the test results is given. According to UNECE R83 the test is based on time (not on force).

Table 1: Example basic test result of road load test

Inertia mass [kg]	1700
Vehicle speed interval	Time period
[km/h]	[s]
125 – 115	8.35
105 – 95	10.88
85 – 75	14.53
65 – 55	19.78
45 – 35	27.00
25 – 15	35.32

After data processing, the measured data is expressed in a power curve (see Table 2) and/or equation which is an input for the chassis dynamometer setting.
The vehicle speed equates with kinetic energy. The decrease is therefore energy loss, or power absorption. In the example above, the kinetic energy at 125 km/h is 1.025 MJ and at 115 km/h is it 0.867 MJ (kinetic energy = ½ x mass x velocity^2). The loss of 0.158 MJ in 8.35 seconds requires an average power absorption of 18.85 kW. Table 2 gives the resulting powers, at each speed, according to the official procedure.

Table 2: Example specification of road load curve

Vehicle speed	Absorbed power
[km/h]	[kW]
120	18.85
100	12.06
80	7.22
60	3.98
40	1.94
20	0.74

The next formulas and calculations are applied:

P = F * v
Power [W] = Force [N] * speed [m/s]

The vehicle load equation: $F = a + b * v + c * v^2$, where the unit of Force (*F*) is Newton (N) and the unit of velocity (*v*) is km/h. This load equation represents the forces of the vehicle rolling resistance and aerodynamic drag.

The calculation of the coefficients *a, b and c* of the vehicle load equation were made by a least squares error fit with a polynomial equation, for Table 2 the numbers are:

a = 114.22, b = 0.3861, c = 0.0281

At a speed of 120 km/h, the force is: F = 114.22 + 46.33 + 404.64 = 563.19 [N].
At a speed of 20 km/h, the force is: F = 114.22 + 7.72 + 11.24 = 133.18 [N].
Hence, four to five times as much force is required at 120 km/h compared to low speeds. This is mainly due to the air resistance which contributes significantly to the coefficient *c* and the velocity dependent rolling resistance, which contributes significantly to the coefficient *b*.

The absorbed power formula: $P = F * v$, where the unit of power (*P*) is Watt (W) and the unit of velocity (*v*) is m/s. Note the different dimension of velocity from above, to arrive at the SI unit of Watts. The small values of these coefficients, indicate the dominant role of the constant rolling resistance, represented by *a*, at low velocities. Either the powers or the coefficients can be used to compare different sources for the road load of the same vehicle. This road load curve must be simulated on the chassis dynamometer.

2. Simulation of the realistic road load curve on a chassis dynamometer

In order to simulate the road load curve of a vehicle on a chassis dynamometer this is configured with the *a, b* and *c* coefficients which correspond with the road load curve of the test vehicle. The vehicle mass can be simulated with flywheels or with an active electrical motor. For each vehicle different *a, b* and *c* parameters of the road load equation and the vehicle mass are programed into the chassis dynamometer. In order to check the programed resistance curve on the chassis dynamometer the vehicle driveline will be set at 130 km/h and the gear box will be set in the neutral position. The chassis dynamometer deceleration curve will be determined and results in a time-speed curve (coast down curve). This must correspond to the road load curve which was measured on the test track. At higher speeds (30-120 km/h) a 5% deviation is allowed and at lower speeds (0-30) this deviation may be 10%. If the repeatability of the chassis dynamometer is less than these allowed deviations a potential allowance is introduced into the test.

3. Execution of a vehicle fuel consumption test

As part of this study for five vehicles additional fuel consumption and emission tests were carried out on a chassis dynamometer by TNO. Figure 5 shows an example of a chassis dynamometer and a test vehicle which was not tested in this project. The fuel economy in urban environment was measured using the test cycle known as ECE-15, introduced by the EEC Directive 90/C81/01 in 1999. It simulates a 4,052 m (2.518 mile) urban trip at an average speed of 18.7 km/h (11.6 mph) and at a maximum speed of 50 km/h (31 mph). The vehicles also performed the extra-urban cycle or EUDC which lasts 400 seconds (6 minutes 40 seconds) and was performed in accordance with requirements at an average speed 62.6 km/h (39 mph) and a top speed of 120 km/h (74.6 mph). The fuel consumption test result was determined according to the “carbon balance method”. All exhaust emissions (CO_2, CO and THC) are measured and fuel consumption calculations are based on these emissions.

2.3 Test vehicles

In Table 3 and Table 4 the main characteristics of the test vehicles of 5 different manufacturers and the performed tests are reported. Most vehicles were part of a commercial rental fleet. The vehicles 1, 2, and 6 were tested on the test circuit in Lommel (Belgium). The vehicles 3,4 and 5 are measured on a test track in Lelystad (The Netherlands).

Table 3: Vehicle samples 1-4

Characteristics				
Sample	1	2	3	4
Vehicle	1	1	2	2
Trade Mark	A	A	B	B
Type	Sedan	Station wagon	Hatchback	Hatchback
Segment	D	D	B	B
Emission class	Euro 4	Euro 5	Euro 4	Euro 5
Empty mass [kg]	1380-1400	1430-1450	1210-1230	1170-1180
Test mass [kg]	1545	1566	1329	1325
Model year	2008	2012	2009	2012
Fuel	Petrol	Diesel	Diesel	Diesel
Max. Power [kW]	115-120	75-80	65-70	65-70
Odometer	92,550	11,000	105,837	5,715
CO_2 emission*	180	116	120	110
Test activities				
Road load test	Yes	Yes	Yes	Yes
Emission test	No	Yes	No	No

*Declared by the manufacturer

Table 4: Vehicle samples 5-8

Characteristics				
Sample	5	6	7	8
Vehicle	3	4	5	6
Trade Mark	C	D	E	B
Type	Hatchback	Sedan	MPV	Sedan
Segment	A	E	C	D
Emission class	Euro 5	Euro 6	Euro 5	Euro 5
Empty mass [kg]	960-970	1880-1900	1380-1400	1370-1390
Model year	2009	2009	2010	2012
Fuel	Petrol	Diesel	Diesel	Petrol
Max. Power [kW]	50-55	150-160	80-85	115-120
Odometer	24,400	9500	27,500	6,910
CO_2 emission*	110	184	135	144
Test activities				
Road load test	Yes	Yes	Yes	Yes
Emission test	Yes	Yes	Yes	Yes

*Declared by the manufacturer

In order to investigate the influence of vehicle pay load the road load tests of vehicle 6 (sample 8) have been carried out with different vehicle masses.

3 Testing Approach and Results

3.1 Study testing method

This section summarizes the test results that are detailed in the Appendices. Detailed information of the specific tests is reported in chapter 2.

In Table 5 an overview of the test program is given. The samples 1,2,4,5 and 7 were rental vehicles and the samples 3,6 and 8 were private owned or company cars. All tests were carried out with one driver.

In order to investigate the road load curves of Euro 4 and 5 vehicles the vehicle models 1 and 2 were tested in Euro 4 and Euro 5 configurations (samples 1,2,3,4). The road load tests of vehicle 6 (sample 8) were performed with three different vehicle masses. Five vehicles were subjected to an emission test program. Tests were carried out with Type Approval and realistic road load settings.

Table 5: Overview test program and tests

Vehicle Model	Sample	Euro Class	Road load test	Emission test
1	1	4	1	No
1	2	5	1	Yes
2	3	4	1	No
2	4	5	1	No
3	5	5	1	Yes
4	6	6	1	Yes
5	7	5	1	Yes
6	8	5	3	Yes

3.2 Road load test results

Eight vehicles were subjected to road load tests, in Table 6 the coefficients a, b and c of the Type Approval and measured (realistic) road load curves of these vehicles are reported. In a first observation one sees that the coefficient a of the realistic curves, which represents a constant force, is greater than in the Type Approval curves. A detailed analysis of these results is given in section 4.

Table 6: Coefficients of Type Approval and realistic road load curves

	Type Approval			Realistic		
	a	b	c	a	b	c
	[N]	[Nh/km]	[Nh^2/km^2]	[N]	[Nh/km]	[Nh^2/km^2]
Sample 1	146	0,39	0,031	196	0,62	0,030
Sample 2	110	0,35	0,028	213	0,31	0,035
Sample 3	95	0,49	0,029	116	1,07	0,028
Sample 4	80	0,38	0,030	139	0,84	0,034
Sample 5	86	0,17	0,032	123	0,28	0,032
Sample 6	157	0,62	0,030	293	0,00	0,033
Sample 7	74	0,53	0,038	208	-0,14	0,039
Sample 8	84	0,55	0,027	156	1,73	0,023

In Figure 6 the Type Approval and realistic road load curves of all tested vehicles are reported on a relative basis (100% is the Type Approval value). The results show clearly that all realistic road load curves have substantial higher values than Type Approval road load curves. Furthermore for all vehicles the relative differences are greater at low vehicle speeds.
These differences could arise from:

1. Different test track configurations (slope, road surface, level).
2. Different ambient conditions (temperature, humidity, wind velocity, wind direction).
3. Different vehicle configuration (tire and tire condition, body type, brakes, wheel alignment, wheel bearings, vehicle options).

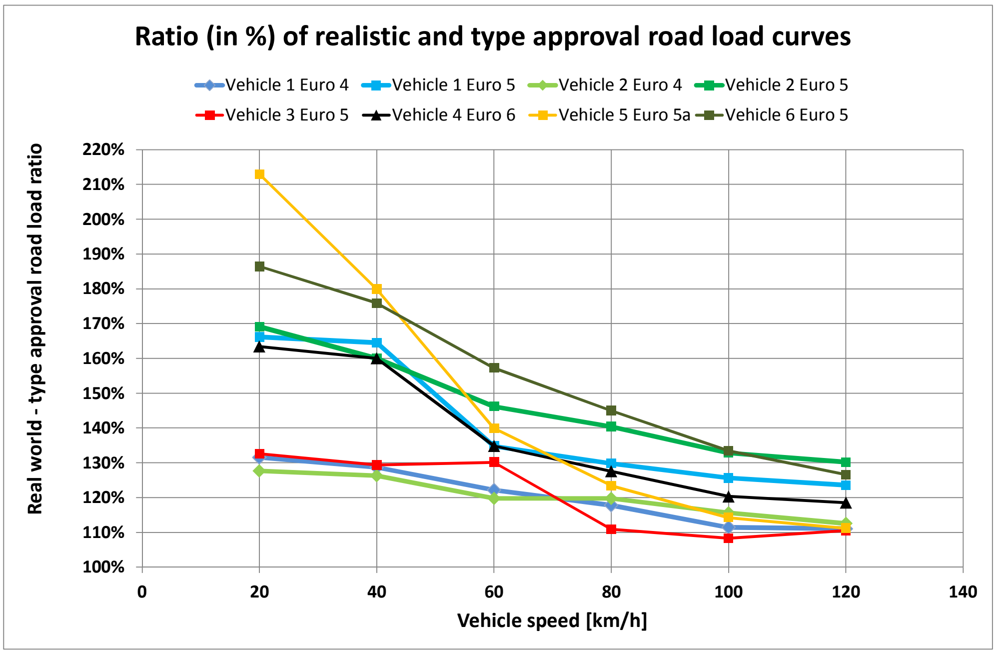

Figure 6: Ratio of TA+RW road load test results of all tested vehicles

A more explicit view is given in Figure 7. The Road Load Ratios (RLR) of the realistic and Type Approval road load curves of Euro 4 and 5 vehicles of the same type are reported. I.e. the two vehicles (1 and 2) are tested in a Euro 4 and Euro 5 configuration. Figure 7 shows:

- At lower vehicle speeds the road load ratio (RLR) is 128-170% and the absorbed power is 0.5 – 1.0 kW (Note: At low absorbed powers differences easily lead to high relative numbers). Air resistance is relatively low and the vehicle resistance is mainly caused by rolling resistances (road-tire resistance, bearing frictions and parasitic drag of brakes). However, many little improvements have a large influence on the relative numbers.
- At higher vehicle speeds RLR is 12%-30% and the absorbed power is 12 – 28 kW. At the higher speeds air resistance is mainly responsible for the total vehicle resistance. Due to the high absolute total vehicle resistances at higher speeds RLR is relatively low.
- The RLR of the Euro 5 vehicles (124%-169%) is higher than the RLR of the Euro 4 vehicles (111%-132%), this difference can be marked as substantial.

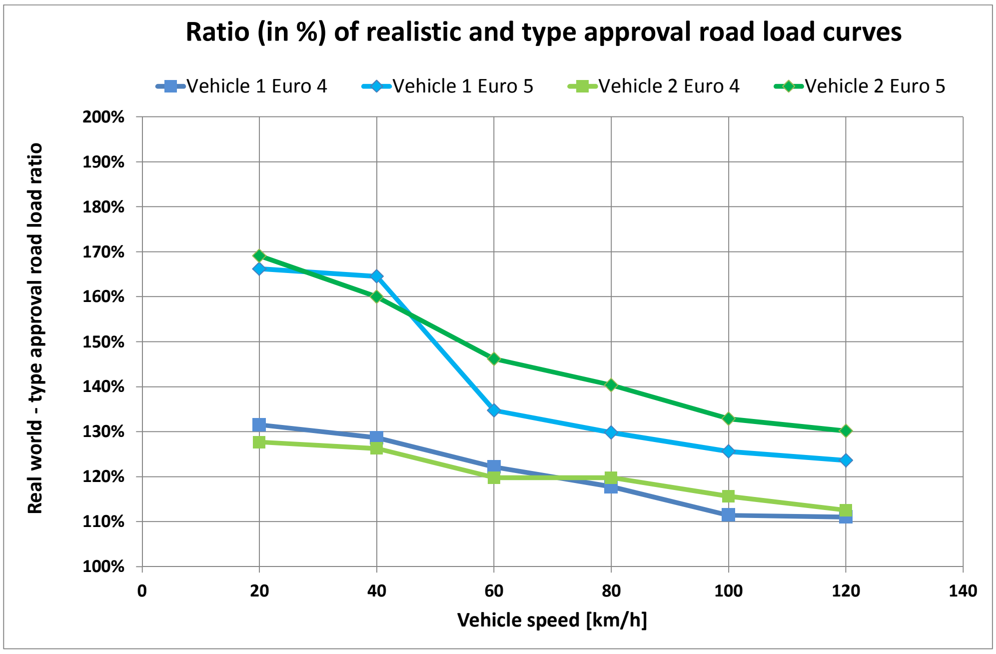

Figure 7: Road Load Ratios of 2 vehicles, both as Euro 4 and 5 configuration (TA = 100%)

Detailed analyses configurations and results Euro 4 and 5 vehicles:
Vehicle 1 (sample 1 and 2) and vehicle 2 (sample 3 and 4) have been tested in two versions: a 2009 model (Euro 4) and a 2012 model (Euro 5). In Table 3 the detailed specifications of the vehicles are reported. The samples 3 and 4 of vehicle 2 are very similar, the samples 1 and 2 of vehicle 1 have a different body type (sedan versus stationwagon). Furthermore the body details of both vehicles have little differences. In the comparison of the older and newer model, the newer model is an improvement upon the older, with a lower Type Approval road load. Indeed sample 2 has an average Type Approval road load which is 18% lower than sample 1. Likewise, sample 4 is 6% lower than sample 3. These trends of lower Type Approval road load curves are not measured in the realistic road loads. I.e. the realistic road load performances of vehicle 1 (samples 1 and 2) @ 80 km/h

decrease from 9,78 to 9.06 kW and these performances for vehicle 2 (samples 3 and 4) @ 80 km/h increase from 8,60 to 9,46 kW.
The comparison of different models has some confounding factors. For example, for vehicle 1 there is:
- A relative low ambient temperature of the test of sample 2, the 2012 model (3 °C). Consequently the power correction (to reference conditions) probably is less accurate than in the test of the 2009 model (16 °C).
- The 2012 model (sample 2, Euro 5) has been equipped with 195/55R16 tires (width 195 mm, d = 513.7 mm) and the 2009 model (sample 1, Euro 4) with 185/65R15 tires (width 185 mm, d = 501.3 mm). Probably the tires of the 2012 model create slightly more rolling resistance. During Type Approval tests the 185/65R15 tires were mounted.
- The different brand and model of the tires.
- The relative low mileage of the 2012 model (5,500 km), the running in of the vehicle might be not completed. The 2009 model has a mileage of 106,000 km and these bearings might be better stabilized.
- The relative new tires of the 2012 model. It is well known that new tires have some more rolling resistance than used tires.

These results show greater Road Load Ratios for Euro 5 vehicles than Euro 4 vehicles and this indicates that Euro 5 vehicles have more optimized Type Approval road load curves than Euro 4 vehicles.

3.3 Emission test results

Five vehicles for which realistic road load tests were performed were subsequently tested to determine their actual emissions in a New European Driving Cycle (NEDC-test). This NEDC test is the official Type Approval test cycle. The results are shown in Figure 8. Per vehicle different test conditions have been applied.
The conditions are:
1. Type Approval conditions and specifications (green)
2. TNO test results with Type Approval road load settings (blue)
3. TNO test results with realistic road load settings (red)

The relative CO_2 test results in Figure 8 show
- With equal road load settings (compare green and blue markers) 8-14% higher measured CO_2 emissions than the declared CO_2 emissions of the manufacturer (average 11.8%,). This difference of 11.8% might be caused by a 4% administrative correction, increased internal frictions and resistances of the in-use vehicles, dedicated driving of the test cycle and battery charging during the soak period of the Type approval test.
- NEDC tests with realistic road load settings show on average 11.6% higher CO_2 emission levels than tests carried out with the manufacturer specified road load settings (compare blue and red markers). These test results show the single effect of realistic road load curves and have a great impact on measured CO_2 emissions in the chassis dynamometer emission test.
- Adding the former two effects results in 19-28% higher measured CO_2 emissions with realistic road load settings than the specified CO_2 emissions of the manufacturer (average 23.4%).

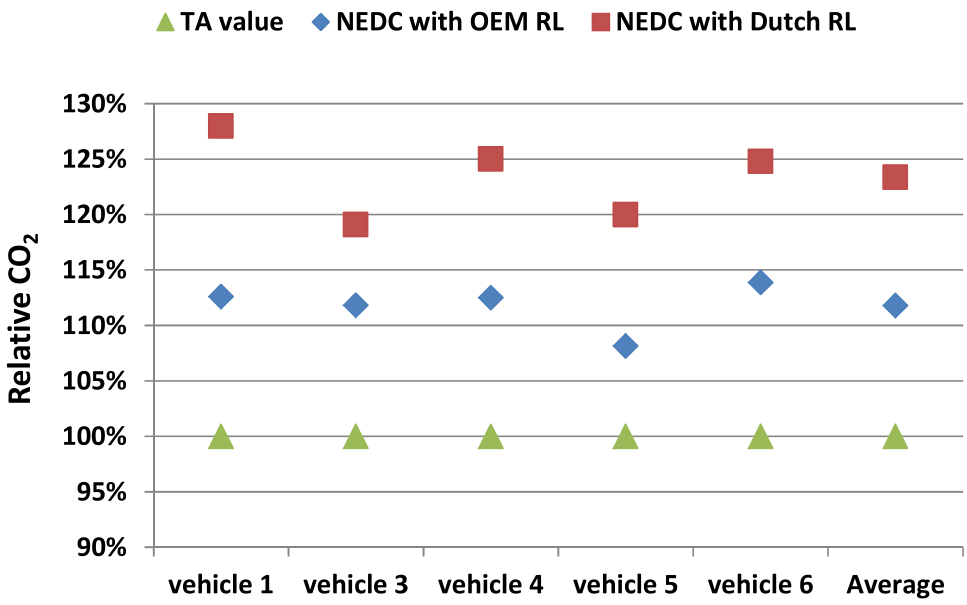

Figure 8: NEDC CO_2 emissions of Euro 5 and 6 vehicles with different road load settings

3.4 Effect of changing vehicles mass on road load test results

Vehicle 6 (sample 8) has been subjected to road load tests with different vehicle masses. In Table 7, Table 8 and Figure 9 the road load test results are reported. The TNO measured realistic road load curve (vehicle mass 1523 kg) is 27-85% higher (4.83 – 0.51 kW) than the Type Approval curve (1475 kg).

With the lowest weight of 1523 kg the road loads are 27%-86% higher than the values of the Type Approval road load curve. With an increasing vehicle masses the road load increases. A mass increase of 201 kg results in a 30%-114% higher road load.

From the realistic road load test results of Table 7 it can be concluded that an increase of vehicle mass leads to increase of the total vehicle road load resistance. I.e. @ 80 km/h a vehicle mass increase from 1523 to 1724 kg (+ 13.2%) results in an increase of road load performance from 9.77 to 10.29 kW (5.3%).

Table 7: Overview road load test results vehicle 6 with different masses

V	P	P	P	P
[km/h]	[kW]	[kW]	[kW]	[kW]
	Type approval	Realistic	Realistic	Realistic
	1475 kg	1523 kg	1638 kg	1724 kg
20	0.59	1.10	1.23	1.26
40	1.66	2.92	3.05	3.21
60	3.60	5.66	5.89	6.07
80	6.74	9.77	9.73	10.29
100	11.47	15.30	15.40	15.69
120	18.14	22.97	23.33	23.63
Load curve coefficients				
a	84,0	155,5	194,0	188,4
b	0,55	1,73	0,91	1,54
c	0,027	0,023	0,027	0,023

Table 8: Overview relative road load test results vehicle 6 with different vehicle masses

V	P	P	P	P
[km/h]	[%]	[%]	[%]	[%]
	Type approval	Realistic	Realistic	Realistic
	1475 kg	1523 kg	1638 kg	1724 kg
20	100%	186%	208%	214%
40	100%	176%	184%	193%
60	100%	157%	164%	169%
80	100%	145%	144%	153%
100	100%	133%	134%	137%
120	100%	127%	129%	130%

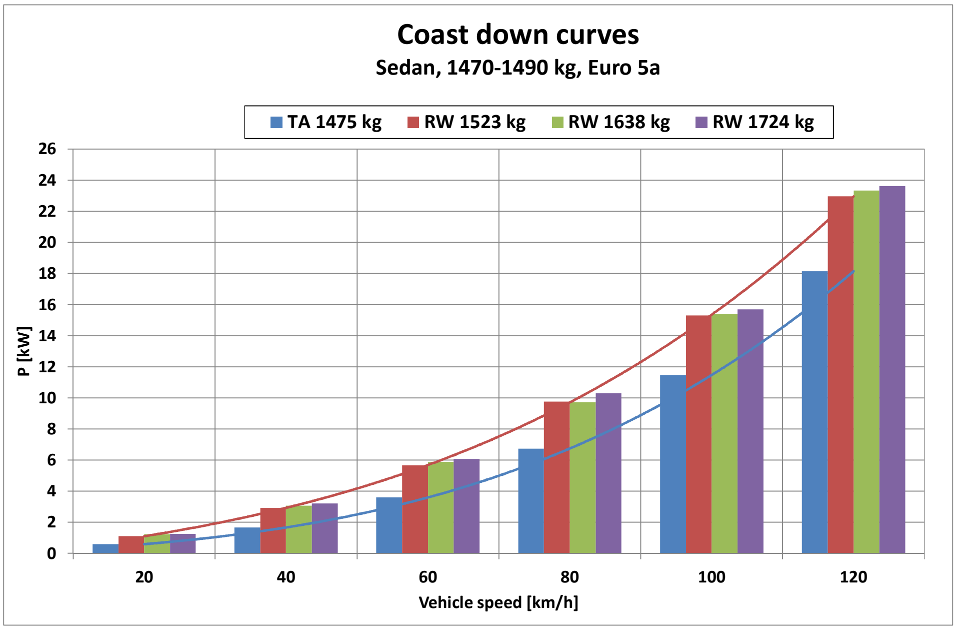

Figure 9: Type approval and realistic road load curves with different vehicle masses of vehicle 6

The results in Figure 10 show the relative effect of vehicle mass on the road load curves. The road load seems to increase almost proportionally with the change in total mass. This corresponds with the formula of rolling resistance: $F = f * g * m$ in which the vehicle mass m has a first-order effect.
Clearly, from these results, weight reduction seems an effective measure to reduce vehicle resistance and fuel consumption.

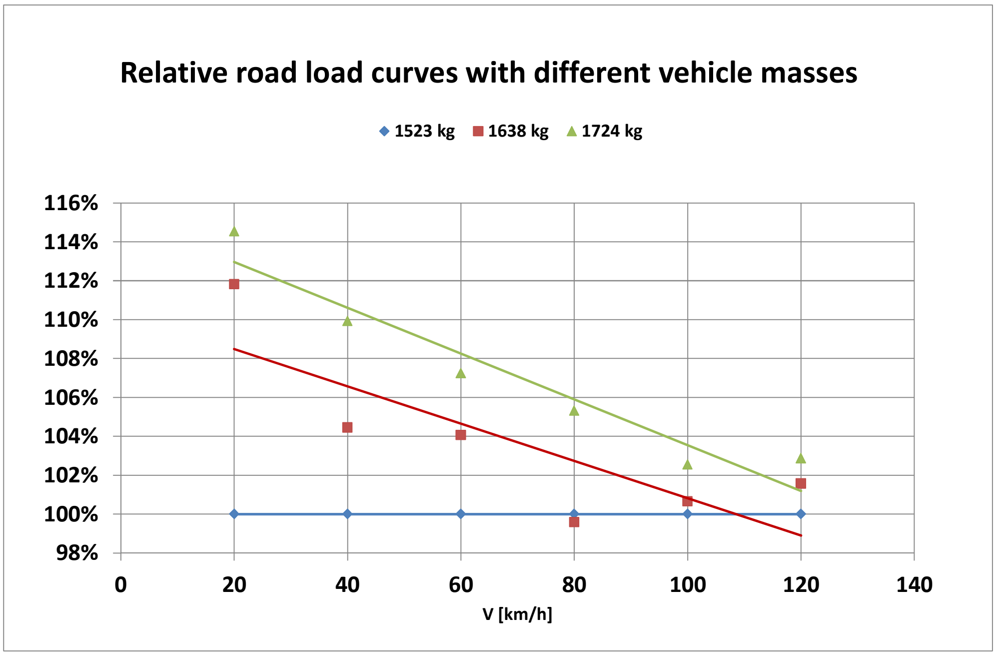

Figure 10: Relative differences road load curves (vehicle mass 1523 kg = 100%)

What is the theoretical effect of changing vehicle masses on Work?
In Table 9 and Table 10 the calculated work of this vehicle is shown, based on the measured road load curves with different vehicle masses.

Table 9: Calculated work of vehicle 6 in a NEDC test (vehicle mass is 1523 kg)

Velocity bin [km/h]	time [s]	Paverage [kW]	Work [kJ]	Work [%]
0-30	186	1.10	205	5
30-50	273	2.92	797	18
50-70	149	5.66	843	19
70-90	113	9.77	1104	25
90-110	59	15.30	903	20
110-130	25	22.97	574	13
Total work NEDC:	time x	power =	**4426**	**100**

Table 10: Calculated work of vehicle 6 in a NEDC test (vehicle mass is 1724 kg)

Velocity bin [km/h]	time [s]	Paverage [kW]	Work [kJ]	Work [%]
0-30	186	1.26	234	5
30-50	273	3.21	876	19
50-70	149	6.07	904	19
70-90	113	10.29	1163	25
90-110	59	15.69	926	20
110-130	25	23.63	591	13
Total work NEDC:	time x	power =	**4694**	**100**

In the test with the lowest mass the total work in the NEDC test cycle is 4426 kJ and with the highest mass the work is 4694 kJ. A mass increase of 201 kg (13.2%) results in a work increase of 6.1%. One should keep in mind that the increase of the fuel consumption in the NEDC test is less than 6.1% because the periods of engine idling (in which no work is delivered) should be taken into account. The calculated energy consumption of the engine idling is 12%. It is expected that the mass increase of 13.2% will result in an increase of fuel consumption of 5%.

4 Detailed analysis results and discussion

4.1 Theoretical analysis power, work and CO_2 emission in the NEDC test

In this sections the main contributing factors on fuel consumption (and CO_2 emissions) in the NEDC test have been analysed with theoretical calculations. Special attention has been paid to the role of the road load on fuel consumption.

What are the causes of fuel consumption in a NEDC test?
The fuel consumption and CO_2 emissions of a vehicle without start-stop system in a NEDC test is caused by
- Road load forces (i.e. air and roller resistances) 63%
- Inertial forces (i.e. accelerations of vehicle mass) 25%
- Engine losses (i.e. idling @ 0 km/h) 12%

These percentages are based on the average data of the eight tested vehicles.

Detailed analysis of the NEDC test characteristics
What is the role of road load forces in the NEDC test on the CO_2 emissions?
The road load forces of a vehicle which are normally caused by rolling and air drag resistances and inertial forces are simulated on the chassis dynamometer.
This vehicle load curve is expressed in the equation: $F = a + b * v + c * v^2$ (see section 2.2), where the unit of Force (F) is Newton (N) and the unit of velocity (v) is km/h. The product of the speed and road load force is the absorbed power (P = F * v). See Figure 11.

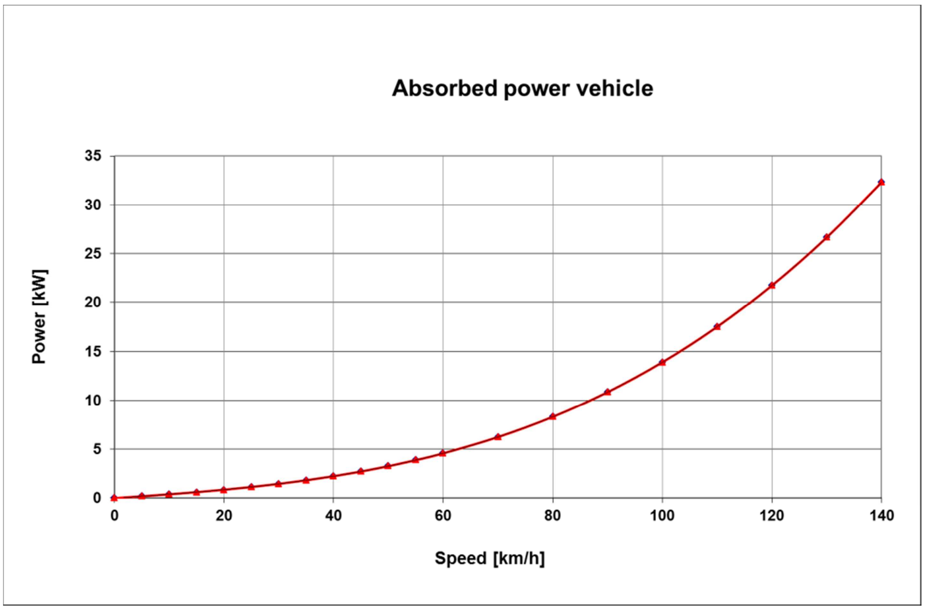

Figure 11: Example vehicle absorbed power curve

Since the major factor in the fuel-consumption is the power consumption (load forces), it is relevant to decompose the NEDC test in the aspects that make up the power absorption. The New European Driving Cycle (NEDC test of 1180 s) consists of an engine start (cold start), accelerations, decelerations, constant speed intervals and idling periods. In the first 780 seconds urban driving is simulated and in the final

400 seconds rural and highway driving, this is called the extra-urban part (see Figure 12).

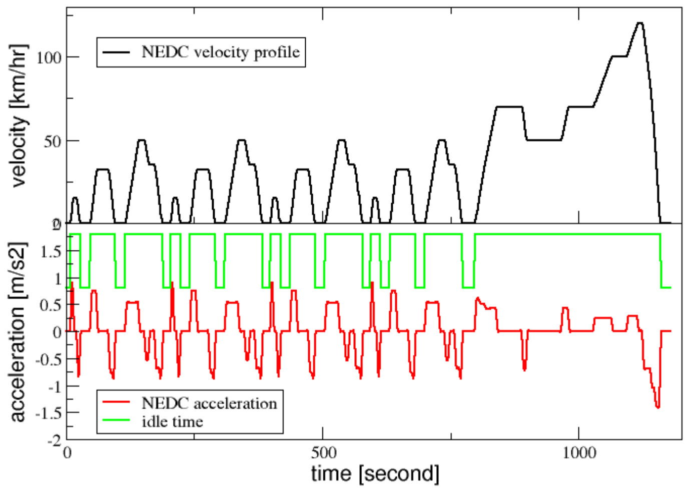

Figure 12: The velocity, acceleration, and idle times of the NEDC test

At what speeds in the NEDC test is the work done?
An appropriate weighting of the road loads with time, for a generic example, shows that most work in the NEDC-test is done at low and intermediate speeds (Table 11).

Table 11: Example distribution of work over velocities in the NEDC, low speed and idle time are not included, vehicle mass is 1500 kg

Velocity bin [km/h]	time [s]	Paverage [kW]	Work [kJ]	Work [%]
0-30	186	1	186	4
30-50	273	3	819	18
50-70	149	6	894	20
70-90	113	10	1130	25
90-110	59	15	885	20
110-130	25	23	575	13
Total work NEDC:	time x	power =	**4489**	**100**

Theoretical amount of work for accelerations of the vehicle:
The multiple stops and accelerations to a fixed speed also require energy. The total energy per kg of vehicle weight is: 1207.6 J per kg. This is composed in 559.4 J per kg for the urban part and 648.2 J per kg for the extra-urban part. This is the ideal physical number, without associated losses and reduced efficiencies. For a vehicle of 1500 kg the theoretical energy needed to accelerate in the NEDC-test is 1811 kJ, not taking into account the additional drive train losses and the rotating parts inertia. Hence in this example, the road loads, with 4489 kJ, account for more than two-thirds of the power consumption.

Theoretical calculation and aspects of CO_2 emissions of the vehicle:
Assuming a generic CO_2 emission of 600 g per kWh, the total CO_2 emission on the test is 1050 g, which corresponds to 95 g/km, as an ideal result. Here the term

'ideal' is meant in the sense of neglecting idling emissions, transmission losses, auxiliaries, and lower engine efficiency at low loads. If the vehicle would be 200 kg heavier or lighter (13% mass shift), the CO_2 emission would shift about 4%.

What is the role of engine idling in the NEDC test on the CO_2 emissions?
There is a substantial idling time of 323s in the NEDC test (27% on time basis). Hence the minimal fuel consumption to keep the engine running may play a role in the total power consumption over the test. These aspects complicate the attribution of the fuel consumption to specific causes. A change of the idling fuel consumption will have a substantial effect, even though the fuel consumption at idling is low.

At what speed intervals is the contribution to the total CO_2 emission dominant?
The road loads can be used to determine the total road-load power consumption, or work, over the NEDC test. This can be either through: *Work* = *Power* x *time* or through: *Work* = *Force* x *distance.* For completeness sake both the time at a certain speed and the distance at a certain speed is given in Figure 13, such that both with the power and with the force the total work can be determined. From Figure 13 it is clear that road loads at 30, 50 and 70 km/h dominate the result, i.e. at these speeds the most significant part of the total NEDC CO_2 emission is produced.

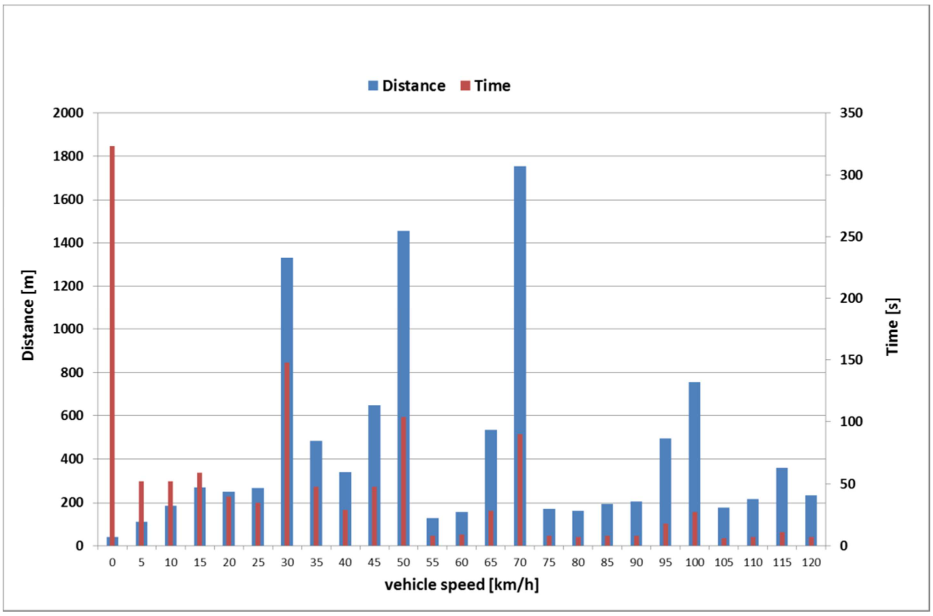

Figure 13: The distribution of distance and time over each velocities in the NEDC test

What causes the CO_2 emission in a NEDC test?
Combining road load, inertial forces, and engine losses in simulations they account for roughly 63%, 25%, and 12% of power consumption (and CO_2 emissions) on the NEDC, respectively, i.e. an average increase of 10% of the road load leads to a power consumption increase of 6.3%. If the assumed engine efficiency stays constant the CO_2 emission will increase 6.3% as well. This is an example indication based on the generic figures. However, it clarifies the central role of road loads in the fuel consumption, as it is directly related to the power consumption. However, the inertial effect is smaller, and weight reduction will also have, apart from reduced inertial forces, its effects on the road load. Furthermore, reducing the engine losses

which have effect can be substantial due to the low load in the NEDC, and can also make a difference to the results.

4.2 Road load test results:

The realistic road load test results provide a consistent picture across several vehicles of different OEMs, see Figure 6. The Road Load Ratio shows the same trend (in relative terms) for all vehicles: a large deviation which decreases with increasing speed. All the realistic road load curves have substantial higher values than the Type Approval road load curves. The trend of an average 61% higher load for 20 km/h to an 18% higher load for 120 km/h indicates the difference between Type Approval road load and realistic road load to be mainly in the constant part of the rolling resistance (in factor a of the equation).
Indeed half vehicles have a constant difference in force (see Figure 14) between the Type Approval value and the test. For the other half the maximum variation over the speed range of 20-120 km/h is a factor 2 (i.e. the Force increases from 70 – 140 N).

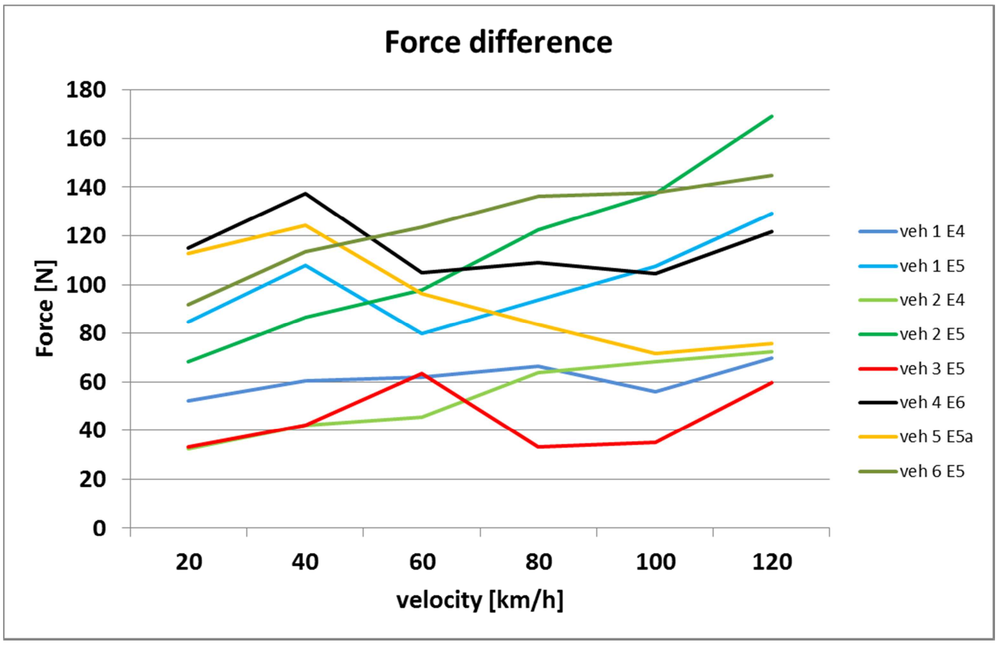

Figure 14: The force difference between the Type Approval value and the tests, the Euro-4 vehicles (1 and 2) have a force difference between 30 and 70 N, while most modern vehicles have values typically twice this value, with the exception of vehicle 3.

The force difference is substantial and mainly part of the *a* coefficient, i.e. 80 N difference and some in the *b* coefficient: between 0 and 0.4 [N]/[km/h] difference. I.e. An assumed force difference of 100 N would yield about 17 g/km CO_2. Hence via this route the 10% to 14% additional fuel consumption due to the change in road load settings is easily explained.

This difference in force can be explained by the next factors:
- Optimized rolling resistance of tires (hard and low thread tires, pretreatments),
- Optimized resistances of wheel bearings
- Optimized warming up procedure of the test vehicle

- Optimized wheel alignments of the vehicle
- Optimized resistance of the road surface of the test track
- Optimized road inclination of the test track. A 1,5% allowed road inclination in the coast-down track would produce a constant force of 221 N for a 1500 kg vehicle, which is larger than differences seen in the tests. I.e. An assumed force difference of 221 N would yield about 37 g/km CO_2. The gravitational force acts as a small power source in the down-sloping part of the coast down. Using the margins of the test procedure, for example through a track with a central bluff, would in both runs generate a low-speed coast down advantage, where the effect is most dominant. Due to the low-velocity focus of the NEDC test, it directly affects the total fuel consumption. Current legislation (UNECE R83 Annex 4A – Appendix 7) allows a road slope of 1.5%, it should be constant to within +/- 0.1%. The test should be performed in two opposite directions but nothing is mentioned about opposite slopes. Effectively both directions can be carried out with the same downhill slope. This loophole needs attention in future legislation. In Table 12 some data of relevant test tracks are reported. Due to the confidential character of these test tracks certain data are not available. Significant differences of the test tracks might be expected for the next items: the condition of the road surfaces, road slopes and average ambient conditions.

Table 12: Test track data

		Netherlands	Belgium	SPAIN	Germany
		Lelystad	Lommel	IDIADA	Ehra-Lessien
Length track	[m]	720	2300	2000	9000
Slope	[%]	0	?	0,3	?
Surface	[µ]	0,6	?	?	?

Furthermore, the force difference between the Type Approval value and the realistic tests might be caused by aerodynamic streaming and surface polishing, minimized brake contact and special lubricants. Together they can add up to a significant number. Moreover utilizing discrete classes, such as weight classes, and rounding procedures can bring the value down a further few per cent.
This indicates that for Type Approval purposes optimization of vehicles and more favorable allowed test conditions were applied

Road load curves of Euro 4 and Euro 5 vehicles:
The increase in Type Approval and measured road load between the older 2009 and newer 2011 models is significant. The 2009 realistic road loads clearly have a smaller deviation from the Type Approval value than most of the 2011 models. Based on NEDC weighted road loads, the Euro-4 2009 models have a 19% higher road load which causes approximately 12% higher CO_2 emissions. The average of the Euro-5/Euro-6 models has a 37% higher road load, with the same weighting (time based). This 37% higher road load causes approximately a CO_2 increase of 23%. The standard deviation is 12% for the latter group of 6 vehicles, makes a coincidental increased difference from 19% to 37% unlikely. For the whole group of vehicles the road load difference is 33%.

Theoretical relationship chassis dynamometer settings and CO_2 emissions:
The CO_2 emissions at lower velocities are higher with the power demand. As can be seen from all the road load settings, the typical power demand run from 1 kW to 22 kW between 20 km/h and 120 km/h. The typical power demand on the NEDC corresponds to a velocity of about 40 km/h, which is below 10% of the rated power of all vehicles.

Based on the power consumption, a maximum of 63% of the total fuel consumption can be attributed to the road load. An estimate that account for idling and low load would be in the range 55%-65%. Consequently, a 33% higher road load would yield 20% higher fuel consumption. The fact that a lower difference of 12% on average between realistic road load and Type Approval road loads is found, might be due to idling and auxiliaries in combination with more efficient engine operation at these higher loads. Due to the large variation of the power with the vehicle speed, there is another inaccuracy in this estimate.

Associating the measured force difference directly with work and CO_2 does produce the same result as seen in the tests. The additional CO_2 based on the additional work of 80 to 120 N force difference over 1 km is 13 to 20 g/km CO_2. The latter method is a more direct and robust consequence of the road-load tests and less prone to modeling bias.

Measured versus declared CO_2 emissions:
The declared Type Approval CO_2 emissions are a further 10% lower that as is typically measured in the laboratory with the road load settings of the Type Approval. The difference is due to the flexibilities in the chassis dynamometer test. Battery charge, auxiliaries power demand, test velocity margins, tire types and settings, administrative issues (4% subtraction) and many other aspects can be individually optimized to arrive at the lower value in the Type Approval test. Analysing these effects is not part of this study.

Realistic CO_2 emissions:
Realistic CO_2 emissions of modern cars are typically 18% to 20% higher than the Type Approval value, see Figure 8. A different study confirms this number[1]. This number is not a simple addition of effects. NEDC will yield typically larger low load and cold start effects, but smaller air resistance and road loads, as shown in this report. The weight and use of auxiliaries is higher in day-to-day use. The road is less smooth and more curved than on the test. The velocity is higher, in part this this will lower the fuel consumption per kilometer, as the engine load is more appropriate for the rated power. However, with velocities over the 100 km/h, the additional air resistance will affect the fuel consumption negatively. Altogether the comparison between NEDC test values and realistic CO_2 emission is complex.

Discussion:
Current financial incentives and or penalties for consumers and manufacturers stimulate the production and use of vehicles with low Type Approval CO_2 emissions. This study shows that within current road load and CO_2 emission legislative testing procedures vehicle and test conditions can be optimized

[1] Fuel consumption and emissions of modern passenger cars
TU Graz, Report No. I-25/10 Haus-Em 07/10/676 29.11.2010

significantly and a large number of parameters can influence the Type Approval CO_2 emission test result positively. However the realistic fuel consumption and CO_2 emissions of vehicles are higher. In order to obtain a smaller gap between Type Approval and realistic CO_2 emissions future road load and emission test procedures must be improved; many very specific items should be (re)defined and the determination of the road load curve is one of the main issues.

5 Conclusions and recommendations

This report describes a road load and emission test program of the Dutch Ministry of Infrastructure and the Environment and the European Climate Foundation. The purpose was to determine the effect of different road loads on vehicle CO_2 emissions of two Euro 4 and six Euro 5 light duty vehicles. The test program was carried out to quantify the differences in Type Approval (manufacturer declared) and realistic measured road load curves and CO_2 emissions. Realistic measured and Type Approval road load curves were applied as input for emission tests on a chassis dynamometer. From the road load and emission tests the conclusions are:

1. The weighted realistic road load settings of the two Euro 4 vehicles are 19% higher than the settings of their Type Approval road load curves. The weighting of the individual road loads is according to the velocities as they appear in the NEDC.

2. The weighted realistic road load settings of the six Euro 5/Euro 6 vehicles are 37% higher than the settings of their Type Approval road load curves.

3. Based on NEDC weighted road loads, the Euro-4 2009 models have a 19% higher road load. The average of the Euro-5/Euro-6 models has a 37% higher road load, with the same weighting. This indicates an increasing trend of road load ratios in recent years. According to model based calculations this average 18% increase of the road load ratio results approximately in an average decrease of the Euro-5 type approval CO_2 emissions of 11% (A Euro-5 vehicle with a Type Approval CO_2 emission of 130 g/km will probably have a CO_2 emission of 146 g/km with Euro-4 Type Approval road load settings)

4. The apart from the test optimization, and utilizing the margins available, the most likely causes for the differences between the Type Approval road load and the current road load test results are:
   - Optimized rolling resistance of tires (hard and low thread tires, pretreatments),
   - Optimized resistances of wheel bearings
   - Optimized warming up procedure of the test vehicle
   - Optimized wheel alignments of the vehicle
   - Optimized resistance of the road surface of the test track
   - Optimized road inclination of the test track.

5. Road load tests with one vehicle with different vehicle masses show an increase of the vehicle road load with higher masses. A mass increase of 201 kg (13.2%) of a 1523 kg vehicle results in an increase of the theoretical work in a NEDC test of 6.1 %. Due to the idling periods the corresponding expected increase of fuel consumption is approximately 5%.

6. NEDC tests of Euro 5 and 6 vehicles with Type Approval road load settings show on average 11.8% higher CO_2 emission levels than the declared CO_2 emissions of the manufacturer. This might be caused by a 4% administrative correction, higher internal frictions and resistances of the in-use vehicles, dedicated driving of the test cycle and battery charging during the soak period of the Type approval test.

7. The applied road load curve in a chassis dynamometer test has a major influence on CO_2 emissions. NEDC tests with realistic road load settings show on average 11.6% higher CO_2 emission levels than test carried out with the manufacturer specified road load settings.

8. NEDC tests with realistic road load settings of in-use Euro 5 and 6 vehicles show on average 23.4% higher CO_2 emissions than the declared CO_2 emissions of the manufacturer.

9. In order to obtain a smaller gap between Type Approval and realistic CO_2 emissions future road load and emission test procedures must be improved; many very specific items should be (re)defined and the determination of the road load curve is one of the main issues. Special attention must be paid to configurations and conditions of tires and road surface condition. Furthermore the requirement of road load testing in opposite directions needs an additional requirement. Road load testing must take place in two opposite directions with opposite slopes (‘uphill’ and ‘downhill’).

6 Signature

Delft, October 29th, 2012

Gerrit Kadijk
Author

Norbert Ligterink
Author

A Detailed specifications of test vehicles

Sample	1
Trade mark	A
Vehicle type	1
Segment	D
Body type	Sedan
Model year	2008
Fuel type	Petrol
Emission class	Euro 4
Gear box	Manual
Odometer [km]	92,550
Max. Engine power	118
Tire	Continental
Tire type	Premium Contact 3
Tire size	235/45 R 17
Tire pressure front [kPa]	230
Tire pressure rear [kPa]	230
Tire profile depth front [mm]	3
Tire profile depth rear [mm]	3
Vehicle mass measured* [kg]	1465
Vehicle mass specified* [kg]	1380-1400
Vehicle test mass [kg]	1545
Coast down type approval	[s]
Tire Size	215/55 R 16
Tire make	?
Tire pressure [kPa]	310
125-115 km/h	6.45
105-95 km/h	8.32
85-75 km/h	10.96
65-55 km/h	14.62
45-35 km/h	19.40
25-15 km/h	24.56
Vehicle inertia [kg]	1470

* Vehicle mass measured without driver

Sample	2
Trade mark	A
Vehicle type	1
Segment	D
Body type	Stationwagon
Model year	2012
Fuel type	Diesel
Emission class	Euro 5b
Gear box	Manual 6
Odometer [km]	11,000
Max. Engine power	77
Tire	Continental
Tire type	Contact Premium
Tire size	205/55R16
Tire pressure front [kPa]	220
Tire pressure rear [kPa]	220
Tire profile depth front [mm]	8
Tire profile depth rear [mm]	8
Vehicle mass measured* [kg]	1479
Vehicle mass specified* [kg]	1430-1450
Vehicle test mass [kg]	1566
Coast down type approval	[s]
125-115 km/h	8.62
105-95 km/h	11.24
85-75 km/h	15.04
65-55 km/h	20.55
45-35 km/h	28.17
25-15 km/h	37.08
Vehicle inertia [kg]	1700

* Vehicle mass measured without driver

Sample	3
Trade Mark	B
Vehicle type	2
Segment	B
Body type	Hatchback
Model year	2009
Fuel type	Diesel
Emission class	Euro 4
Gear box	M5
Odometer [km]	105837
Max. Engine power [kW]	66
Tire	Michelin
Tire type	Energy Saver
Tire size	185/65R15
Tire pressure front [kPa]	240
Tire pressure rear [kPa]	240
Tire profile depth front [mm]	6
Tire profile depth rear [mm]	4
Vehicle mass measured* [kg]	1241
Vehicle mass specified* [kg]	1210-1230
Vehicle test mass [kg]	1329
Coast down type approval	[s]
125-115 km/h	6,55
105-95 km/h	8,65
85-75 km/h	11,70
65-55 km/h	16,38
45-35 km/h	23,41
25-15 km/h	32,37
Vehicle inertia [kg]	1360

* Vehicle mass measured without driver

Sample	4
Trade mark	B
Vehicle type	2
Segment	D
Body type	Hatchback
Model year	2012
Fuel type	Diesel
Emission class	Euro 5b
Gear box	Manual 5
Odometer [km]	5,500
Max. Engine power	68
Tire	Continental
Tire type	Premium Contact 2E
Tire size	195/55R16
Tire pressure front [kPa]	230
Tire pressure rear [kPa]	220
Tire profile depth front [mm]	8
Tire profile depth rear [mm]	8
Vehicle mass measured* [kg]	1243
Vehicle mass specified* [kg]	1170-1180
Vehicle test mass [kg]	1325
Coast down type approval	[s]
Tire Size	185/65R15
Tire make	Michelin Energy Saver 1
Tire pressure [kPa]	240
125-115 km/h	6,34
105-95 km/h	8,49
85-75 km/h	11,72
65-55 km/h	16,81
45-35 km/h	24,72
25-15 km/h	35,80
Vehicle inertia [kg]	1250

* Vehicle mass measured without driver

Sample	5
Trade mark	C
Vehicle type	3
Segment	A
Body type	Hatchback
Model year	2009
Fuel type	Petrol
Emission class	Euro 5a
Gear box	Automatic 5
Odometer [km]	24,400
Max. Engine power	51
Tire	Michelin
Tire type	Energy Saver
Tire size	185/55 R15
Tire pressure front [kPa]	
Tire pressure rear [kPa]	
Tire profile depth front [mm]	5
Tire profile depth rear [mm]	6
Vehicle mass measured* [kg]	1026
Vehicle mass specified* [kg]	960-970
Vehicle test mass [kg]	
Coast down type approval	
Tire Size	?
Tire make	?
Tire pressure [kPa]	?
125-115 km/h	5,01
105-95 km/h	6,72
85-75 km/h	9,34
65-55 km/h	13,45
45-35 km/h	19,74
25-15 km/h	27,80
Vehicle inertia [kg]	1020

* Vehicle mass measured without driver

Sample	6
Trade mark	D
Vehicle type	4
Segment	E
Body type	Sedan
Model year	2009
Fuel type	Diesel
Emission class	Euro 6
Gear box	Automatic 6
Odometer [km]	9500
Max. Engine power [kW]	155
Tire	Continental
Tire type	Contisportcontact 3
Tire size	245/45 R17
Tire pressure front [kPa]	260
Tire pressure rear [kPa]	270
Tire profile depth front [mm]	7
Tire profile depth rear [mm]	7
Vehicle mass measured* [kg]	1950
Vehicle mass specified* [kg]	1880-1900
Vehicle test mass [kg]	1962
Coast down type approval	?
Tire Size	?
Tire make	?
Tire pressure [kPa]	?
125-115 km/h	8,17
105-95 km/h	10,43
85-75 km/h	13,56
65-55 km/h	17,85
45-35 km/h	23,41
25-15 km/h	29,59
Vehicle inertia [kg]	1930

* Vehicle mass measured without driver

Sample	7
Trade mark	E
Vehicle type	5
Segment	C
Body type	MPV
Model year	2010
Fuel type	Diesel
Emission class	Euro 5a
Gear box	Manual 6
Odometer [km]	27,500
Max. Engine power [kW]	81
Tire	Michelin
Tire type	Energy Saver
Tire size	205/60R16
Tire pressure front [kPa]	230
Tire pressure rear [kPa]	230
Tire profile depth front [mm]	7
Tire profile depth rear [mm]	7
Vehicle mass measured* [kg]	1559
Vehicle mass specified* [kg]	1380-1400
Vehicle test mass [kg]	1640
Coast down type approval	
Tire Size	?
Tire make	?
Tire pressure [kPa]	?
125-115 km/h	6,00
105-95 km/h	8,12
85-75 km/h	11,44
65-55 km/h	16,86
45-35 km/h	25,96
25-15 km/h	41,14
Vehicle inertia [kg]	1470

* Vehicle mass measured without driver

Sample	8
Trade Mark	B
Vehicle type	6
Segment	D
Body type	Sedan
Model year	2012
Fuel type	Petrol
Emission class	Euro 5
Gear box	M6
Odometer [km]	6910
Max. Engine power [kW]	115
Tire	Michelin
Tire type	Primacy HP
Tire size	215/55 R17
Tire pressure front [kPa]	250-250
Tire pressure rear [kPa]	230-250
Tire profile depth front [mm]	7
Tire profile depth rear [mm]	7
Vehicle mass measured* [kg]	1475
Vehicle mass specified* [kg]	1370-1390
Vehicle test mass [kg]	1523-1724
Coast down type approval	[s]
Tire	Michelin
Tire type	Energy Saver
Tire size	225/60 R16
125-115 km/h	7.52
105-95 km/h	9.91
85-75 km/h	13.48
65-55 km/h	18.97
45-35 km/h	27.32
25-15 km/h	38.73
Vehicle inertia [kg]	1470

* Vehicle mass measured without driver

B Detailed test results load road and emission tests

Sample 1: Vehicle 1 my2008

Test date: May 14th, 2012.
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 1 model year 2008

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	6,50	5,15	5,83	8,40	6,80	7,60	9,35	9,30	9,32	14,30	10,20	12,25		13,15		18,70	19,30	19,00
2	6,40	5,70	6,05	7,85	7,15	7,50	9,85	8,95	9,40	14,20	10,40	12,30	17,25	13,35	15,30	18,95	18,50	18,72
3	6,80	5,30	6,05	8,75	6,90	7,83	9,95	8,80	9,37	13,30	10,65	11,98	17,15	13,35	15,25	19,35	18,45	18,90
4	7,00	5,05	6,02	8,75	6,65	7,70	10,00	8,75	9,37	13,30	10,75	12,02	17,00	13,65	15,32	19,35	18,35	18,85
5	6,75	5,20	5,97	8,20	6,95	7,57	10,10	8,60	9,35	13,20	11,05	12,13		13,65		19,70	18,30	19,00
6	6,45	5,00	5,72	7,30	6,55	6,92	10,20	8,55	9,37	13,20	11,05	12,12	16,15	13,75	14,95	19,70	18,10	18,90
7	5,95	5,30	5,62	8,45	7,05	7,75	10,40	8,40	9,40	13,10	11,25	12,18	16,05	14,20	15,13		17,45	
8	6,30	5,05	5,67	7,95	7,05	7,50	10,45	8,25	9,35	12,75	11,40	12,08	15,95	14,25	15,10		17,45	
9	6,40	5,50	5,95	8,15	7,05	7,60	11,30	8,05	9,67	12,65	11,55	12,10	15,70	14,90	15,30	20,15	17,40	18,77
10	6,35			8,50						12,05	11,60	11,82	15,45				16,50	
11				8,20						11,70						19,75		
12													18,10			19,80		
13													16,20					
14																		
15																		
average			**5,88**			**7,55**			**9,40**			**12,10**			**15,19**			**18,88**
stdev			0,17			0,26			0,10			0,14			0,14			0,10
coëfficient t			2,3			2,3			2,3			2,3			2,5			2,5
# of tests (n)			9			9			9			10			7			7
accuracy factor p			0,76%			1,50%			0,76%			1,20%			2,00%			1,86%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions									
vehicle description		VW Passat tsi 2008						check	
			unit						
vehicle reference mass		M	kg	1492					
ambient temperature		T	°C	16,5	=	289,65	K		
reference temperature		To	°C	20	=	293,15	K		
ambient barometric pres.		P	mBar	1010					
reference barometrix pres.		Po	mBar	1000					
ambient air density		ρ	kg/m3	1,214726				OK	
reference air density		ρo	kg/m3	1,188339					
Kr factor		Kr		0,00864					
Molar mass of Earth's air		M	kg/mol	0,028964					
gas constant		R		8,314462					
wind speed			m/s	4,6				NOK	<= 3 m/s
wind speed maximums			m/s	4,6				OK	<= 5 m/s
wind component right angled to road			m/s	2				OK	<= 2 m/s

correction to reference conditions						
according to 70/220/EEG						
Vehicle 1 model year 2008						
Kr	0,00864			ρ0/ρ	0,978278	
speed	interval	Rr/RT	K	uncorrecte	uncorrecte	**corrected**
				CD time [s	Power [kW	**Power [kW]**
120	(125-115)	0,1400	0,999	5,88	23,50	**23,48**
100	(105-95)	0,1800	0,998	7,55	15,24	**15,22**
80	(85-75)	0,2300	0,998	9,40	9,79	**9,78**
60	(65-55)	0,3300	0,997	12,10	5,71	**5,69**
40	(45-35)	0,5400	0,995	15,19	3,03	**3,02**
20	(25-15)	0,8200	0,993	18,88	1,22	**1,21**

Table 13: Road load test results of vehicle 1 (my 2008 sedan)

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	0.92	1.21	100%	132%
40	2.34	3.01	100%	129%
60	4.65	5.68	100%	122%
80	8.28	9.75	100%	118%
100	13.63	15.19	100%	111%
120	21.10	23.43	100%	111%

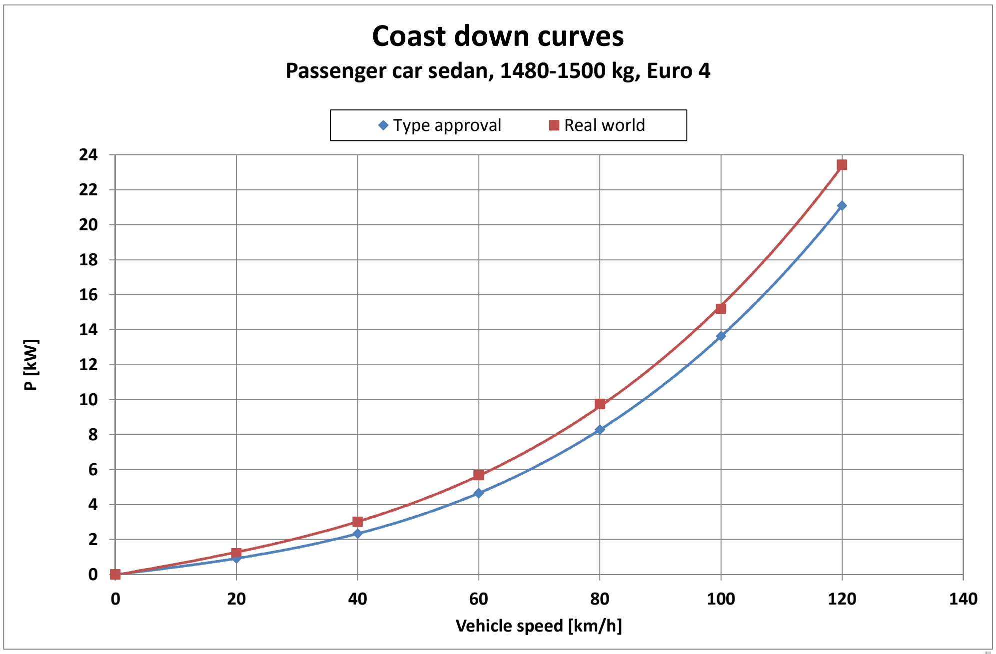

Figure 15: Type Approval and realistic road load curve of vehicle 1 (my 2008)

Sample 2: Vehicle 1 my2012

Test date: November 18th, 2011.
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 1 model year 2012

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	6.45	5.80	6.13	8.10	7.70	7.90	10.05	9.65	9.85	14.41	12.75	13.58	15.85	14.10	14.98	20.85	17.85	19.35
2	6.50	5.90	6.20	8.15	7.80	7.97	11.00	9.85	10.43	14.01	12.95	13.48	16.05	13.85	14.95	19.95	18.85	19.40
3	6.50	5.90	6.20	8.40	7.50	7.95	10.80	10.05	10.43	14.63	12.40	13.52	16.50	13.60	15.05	20.10	18.80	19.45
4	6.70	5.80	6.25	8.65	7.50	8.07	10.85	10.00	10.43	14.41	12.75	13.58	15.85	14.60	15.23	21.10	17.70	19.40
5	6.75	5.80	6.28	8.40	7.45	7.92	11.20	9.80	10.50	14.01	12.95	13.48	15.80	14.90	15.35	20.55	18.60	19.58
6	7.00	5.70	6.35	8.75	7.45	8.10	11.05	9.65	10.35	14.63	12.40	13.52	16.10	13.70	14.90	20.50	18.30	19.40
7	6.90	5.80	6.35	8.65	7.45	8.05	11.00	9.85	10.43				15.50	14.75	15.13	19.75	18.95	19.35
8	6.65	5.75	6.20	8.85	7.25	8.05	11.15	9.45	10.30									
9	6.80	5.80	6.30	8.70	7.35	8.02		9.60										
10	7.00	5.75	6.38	8.65	7.55	8.10		9.55										
11	7.00	5.80	6.40	8.90	7.50	8.20		9.30										
12								9.55										
13																		
14																		
15																		
	6.75	5.80		8.56	7.50		10.89	9.69		14.35	12.70		15.95	14.21		20.40	18.44	
average			**6.28**			**8.03**			**10.34**			**13.52**			**15.08**			**19.42**
stdev			0.09			0.09			0.21			0.05			0.16			0.08
coëfficient t			2.2			2.2			2.4			2.6			2.5			2.5
# of tests (n)			11			11			8			6			7			7
accuracy factor p			0.37%			0.47%			1.80%			0.65%			2.31%			1.42%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**NOK**			**OK**

Test conditions							
vehicle description	Vehicle 1 (my 2012)					check	
		unit					
vehicle reference mass	M	kg	1566				
ambient temperature	T	°C	6.29	279.44	K	OK	
reference temperature	To	°C	20	293.15	K		
ambient barometric pres.	P	mBar	1013.47			OK	
reference barometrix pres.	Po	mBar	1000				
ambient air density	ρ	kg/m3	1.263434	6.3%		OK	
reference air density	ρo	kg/m3	1.188339				
Kr factor	Kr		0.00864				
Molar mass of Earth's air	M	kg/mol	0.028964				
gas constant	R		8.314462				
wind speed		m/s	1.34			OK	<= 3 m/s
wind speed maximums		m/s	2.51			OK	<= 5 m/s
wind component right angled to road		m/s	1.3			OK	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0.3859	0.977	6.28	23.11	**22.58**
100	(105-95)	0.4353	0.974	8.03	15.04	**14.66**
80	(85-75)	0.5197	0.969	10.34	9.35	**9.06**
60	(65-55)	0.6369	0.962	13.52	5.36	**5.16**
40	(45-35)	0.7890	0.953	15.08	3.20	**3.06**
20	(25-15)	0.9334	0.945	19.42	1.24	**1.18**

Table 14: Road load test results of vehicle 1 (my 2012 station wagon)

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	0.71	1.18	100%	166%
40	1.86	3.06	100%	165%
60	3.83	5.16	100%	135%
80	6.98	9.06	100%	130%
100	11.67	14.66	100%	126%
120	18.27	22.58	100%	124%

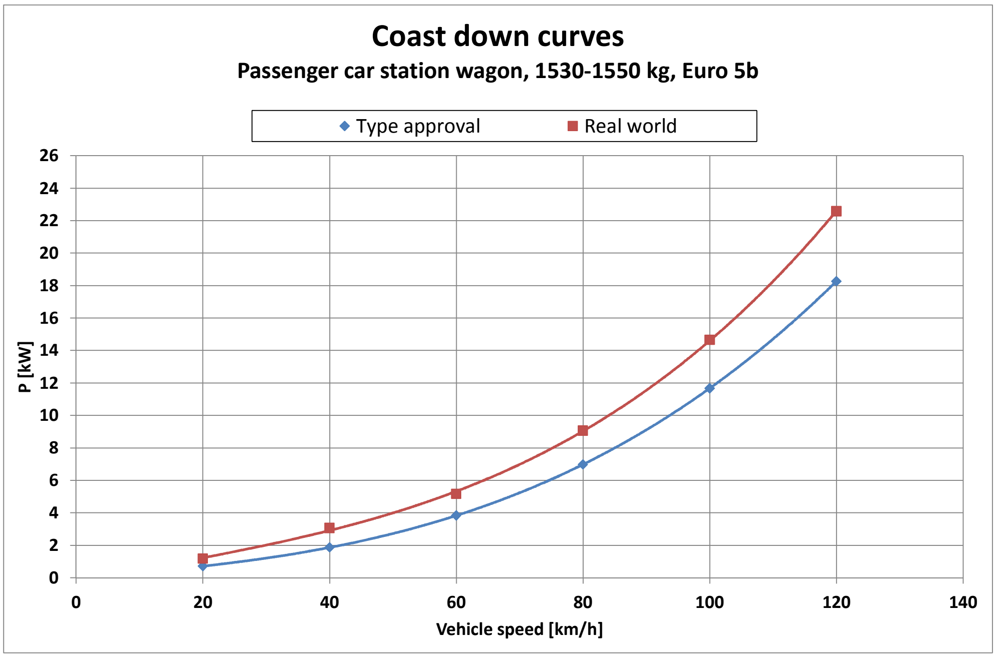

Figure 16: Type Approval and realistic road load curve of vehicle 1 (my2012)

Sample 3: Vehicle 2 my2009

Test date: March 22nd, 2012.
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 2 model year 2009

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	5.35	5.4	5.37	6.65	7.25	6.95	8.3	9.95	9.12		13.2	13.20	15.45	20.15	17.80			
2	5.25	6.25	5.75	6.7	7.75	7.23	8.95	10.2	9.58	12.2	14.3	13.25	15.95	19.75	17.85			
3	5.1	5.8	5.45	6.8	8.15	7.48	8.8	10.25	9.53	11.9	14.9	13.40	16.35	19.65	18.00	22.05	26.7	24.37
4	5.5	5.85	5.67	6.7	8.2	7.45	9	9.9	9.45	12.2	14.6	13.40	16.5	19.6	18.05	22.05	26.65	24.35
5	5.25	6.05	5.65	6.55	7.9	7.22	8	10.5	9.25	12.05	14.75	13.40	16.55	19.55	18.05	22.50	26.35	24.43
6	5.4	6	5.70	6.95	8.05	7.50	8.65	10.75	9.70	12.15	13.85	13.00	16.6	19.55	18.07			
7	5.55	6	5.77	6.75	7.55	7.15	8.65	10.55	9.60	12.6	13.4	13.00	16.85	19.35	18.10	23.2	25.75	24.48
8	5.4	5.95	5.67	6.85	7.3	7.07	8.6	10.3	9.45	12.35	14.25	13.30	17	19.25	18.12	23.25	25.70	24.47
9	5.25	5.9	5.57	7	7.9	7.45	8.35	10.25	9.30	12.25	14		17.4	18.95	18.17	23.75	25.20	24.48
10	5.45	6.05	5.75	7		7.00	8.4	10.8	9.60	11.75	15.35	13.55	17.95	18.2	18.07	24.05	24.85	24.45
11	5.45			6.85			8.05											
12																		
13																		
14																		
15																		
average			**5.64**			**7.25**			**9.46**			**13.28**			**18.03**			**24.43**
stdev			0.13			0.21			0.18			0.19			0.12			0.05
coëfficient t			2.3			2.3			2.3			2.3			2.3			2.5
# of tests (n)			10			10			10			9			10			7
accuracy factor p			0.55%			1.09%			1.25%			1.91%			1.55%			1.19%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions							
vehicle description	Vehicle 2 (my 2009)					check	
		unit					
vehicle reference mass	M	kg	1316				
ambient temperature	T	°C	16.1	289.25	K		
reference temperature	To	°C	20	293.15	K		
ambient barometric pres.	P	mBar	1024.8				
reference barometrix pres.	Po	mBar	1000				
ambient air density	ρ	kg/m3	1.23423	1.0989	1.2771	OK	
reference air density	ρo	kg/m3	1.188339				
Kr factor	Kr		0.00864				
Molar mass of Earth's air	M	kg/mol	0.028964				
gas constant	R		8.314462				
wind speed		m/s	2.8			OK	<= 3 m/s
wind speed maximums		m/s	3			OK	<= 5 m/s
wind component right angled to road		m/s	1			OK	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0.3466	1.001	5.64	21.61	**21.64**
100	(105-95)	0.3945	1.001	7.25	14.01	**14.03**
80	(85-75)	0.4735	1.002	9.46	8.59	**8.60**
60	(65-55)	0.5879	1.002	13.28	4.59	**4.60**
40	(45-35)	0.7492	1.003	18.03	2.25	**2.26**
20	(25-15)	0.9153	1.003	24.43	0.83	**0.83**

Table 15: Road load test results of vehicle 2 (my2009)

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	0.65	0.83	100%	128%
40	1.79	2.26	100%	126%
60	3.84	4.60	100%	120%
80	7.18	8.60	100%	120%
100	12.13	14.03	100%	116%
120	19.23	21.64	100%	113%

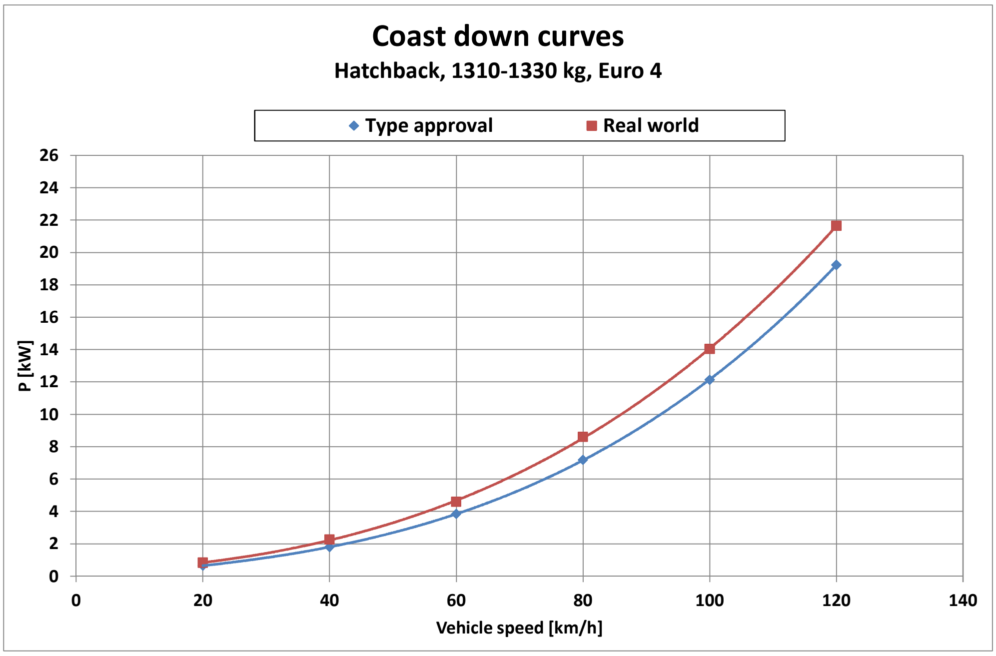

Figure 17: Type Approval and realistic road load curves of vehicle 2 (my2009)

Sample 4: Vehicle 2 my2012

Test date: January 17th, 2012.
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 2 model year 2012

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	4.85	4.45	4.65	6.50	5.75	6.12	8.05	7.55	7.80	11.05	10.20	10.62	14.50	14.40	14.45	18.40	20.85	19.63
2	4.85	4.60	4.73	6.35	6.05	6.20	8.20			11.30	10.75	11.03	14.35	14.80	14.58	20.70	19.55	20.12
3	4.90	4.65	4.77	6.10	6.00	6.05	8.00	8.10	8.05	11.30	10.90	11.10	15.35	14.00	14.68	19.50	19.95	19.73
4	5.00	4.60	4.80	6.15	6.35	6.25	8.15	7.95	8.05	11.00	10.85	10.92	15.85	13.85	14.85	19.30	20.40	19.85
5	4.95	4.35	4.65	6.20	6.15	6.17	8.20			11.40	10.70	11.05	14.85	14.30	14.57	20.15	19.85	20.00
6	4.65	4.65	4.65	6.40	6.10	6.25	8.10	7.90	8.00	11.10	10.90	11.00	15.60	14.15	14.87	20.35	19.60	19.97
7	4.95	4.70	4.83	6.20	6.40	6.30	8.20	8.20	8.20	11.65	10.85	11.25	14.90	13.90	14.40	20.10	19.55	19.82
8	5.25			6.40	6.15	6.28	8.20			11.40	10.75	11.08	14.40	14.75	14.57	20.80	18.95	19.87
9	5.10	4.70	4.90	6.30	6.10	6.20	8.25	8.05	8.15	11.35	10.80	11.07	14.80	14.05	14.42	19.85	20.10	19.97
10				6.40	6.15	6.28	8.20	8.00	8.10		11.05		16.10			20.15	19.95	20.05
11							8.20	8.15	8.18							20.70	19.40	20.05
12																		
13																		
14																		
15																		
average			**4.75**			**6.21**			**8.07**			**11.01**			**14.60**			**19.92**
stdev			0.09			0.08			0.13			0.17			0.17			0.15
coëfficient t			2.4			2.3			2.4			2.3			2.3			2.2
# of tests (n)			8			10			8			9			9			11
accuracy factor p			0.38%			0.35%			0.87%			1.44%			1.93%			2.00%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions							
vehicle description	Vehicle 2 (my 2012)					check	
		unit					
vehicle reference mass	M	kg	1277				
ambient temperature	T	°C	2.9	276.05	K	OK	
reference temperature	To	°C	20	293.15	K		
ambient barometric pres.	P	mBar	1023.43			OK	
reference barometrix pres.	Po	mBar	1000				
ambient air density	ρ	kg/m3	1.291519	8.7%		Not OK	
reference air density	ρo	kg/m3	1.188339				
Kr factor	Kr		0.00864				
Molar mass of Earth's air	M	kg/mol	0.028964				
gas constant	R		8.314462				
wind speed		m/s	1			OK	<= 3 m/s
wind speed maximums		m/s	3.2			OK	<= 5 m/s
wind component right angled to road		m/s	1			OK	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0.3405	0.977	4.75	24.91	**24.33**
100	(105-95)	0.3882	0.974	6.21	15.87	**15.45**
80	(85-75)	0.4662	0.968	8.07	9.77	**9.46**
60	(65-55)	0.5803	0.961	11.01	5.37	**5.16**
40	(45-35)	0.7430	0.950	14.60	2.70	**2.56**
20	(25-15)	0.9125	0.938	19.92	0.99	**0.93**

Table 16: Road load test results vehicle 2 (my2012)

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	0.55	0.93	100%	169%
40	1.6	2.56	100%	160%
60	3.53	5.16	100%	146%
80	6.74	9.46	100%	140%
100	11.63	15.45	100%	133%
120	18.69	24.33	100%	130%

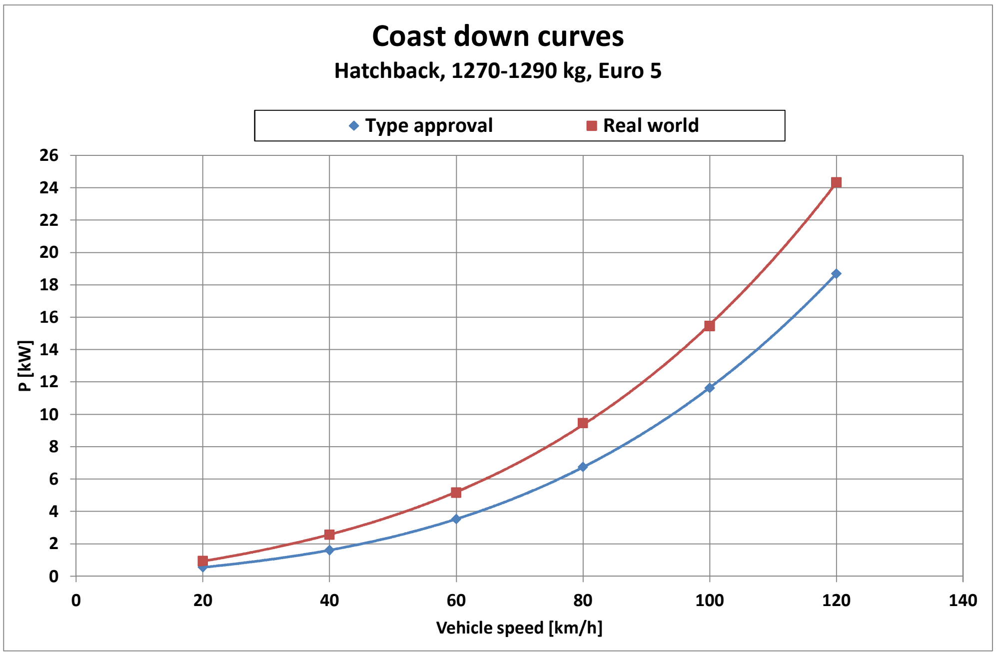

Figure 18: Type Approval and realistic road load curve of vehicle 2 (my2012)

Sample 5: Vehicle 3

Test date: November 22th, 2010
Location: Lelystad (NL)

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	4,81	4,39	4,60	7,45	5,74	6,60	9,61	7,93	8,77	11,37	10,59	10,98						
2	5,42	4,15	4,79	7,55	5,58	6,57	9,77	7,93	8,85	11,40	10,56	10,98	16,86	15,12	15,99			
3	5,29	4,08	4,68	7,02	5,58	6,30	10,27	7,82	9,05	11,71	10,56	11,13	17,05	14,75	15,90	21,90	21,23	21,57
4	5,41	4,48	4,94	7,08	5,74	6,41	10,36	7,72	9,04	12,04	9,17	10,61	17,42	14,30	15,86	23,13	20,14	21,64
5	5,73	4,46	5,10	7,65	5,71	6,68	10,81	7,60	9,21				17,59	14,28	15,94	24,20	19,02	21,61
6	5,29	4,10	4,69	7,68	5,86	6,77		7,41								24,59	18,41	21,50
7	5,65	4,25	4,95	7,61	5,77	6,69		7,37										
8	6,04	4,64	5,34	8,07	5,94	7,00		7,19										
9	5,53	4,12	4,82	7,92	5,86	6,89		6,92										
10		4,28			5,65													
11																		
12																		
13																		
14																		
15																		
average			**4,88**			**6,66**			**8,98**			**10,93**			**15,92**			**21,58**
stdev			0,23			0,22			0,17			0,23			0,06			0,06
coëfficient t			2,3			2,3			2,8			3,2			3,2			3,2
# of tests (n)			9			9			5			4			4			4
accuracy factor p			0,87%			1,13%			1,94%			3,94%			1,40%			2,04%
accuracy OK?			**OK**			**OK**			**OK**			**NOK**			**OK**			**NOK**

Test conditions								
vehicle description	Vehicle 3						**check**	
		unit						
vehicle reference mass	M	kg	1124					
ambient temperature	T	°C	5,5	=	278,65	K		
reference temperature	To	°C	20,0	=	293,15	K		
ambient barometric pres.	P	mBar	1005,00					
reference barometrix pres.	Po	mBar	1000,00					
ambient air density	ρ	kg/m3	1,256				**OK**	
reference air density	ρo	kg/m3	1,188					
Kr factor	Kr		0,00864					
Molar mass of Earth's air	M	kg/mol	0,028964					
gas constant	R		8,314462					
wind speed		m/s					**OK**	<= 3 m/s
wind speed maximums		m/s					**OK**	<= 5 m/s
wind component right angled to road		m/s					**OK**	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0,3165	0,978	4,88	21,33	**20,85**
100	(105-95)	0,3632	0,974	6,66	13,03	**12,69**
80	(85-75)	0,4379	0,969	8,98	7,72	**7,48**
60	(65-55)	0,5503	0,961	10,93	4,76	**4,58**
40	(45-35)	0,7187	0,949	15,92	2,18	**2,07**
20	(25-15)	0,9014	0,936	21,58	0,80	**0,75**

Table 17: Road load test results vehicle 3

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	0,57	0,75	100%	133%
40	1,60	2,07	100%	129%
60	3,52	4,58	100%	130%
80	6,75	7,48	100%	111%
100	11,72	12,69	100%	108%
120	18,86	20,85	100%	111%

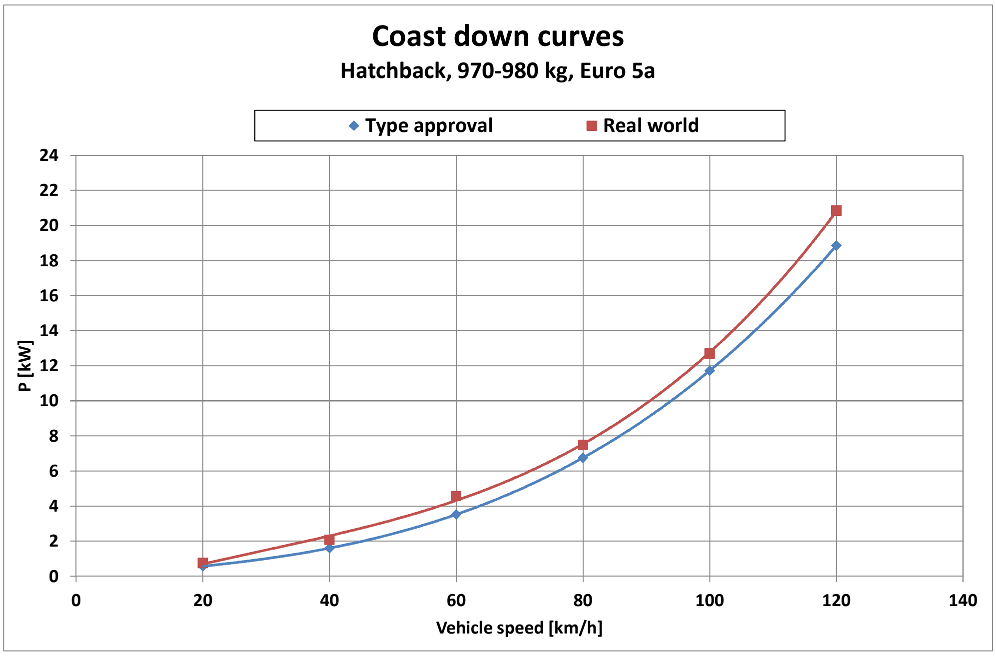

Figure 19: Type Approval and realistic road load curve of vehicle 3

Sample 6: Vehicle 4

Test date: June 11th, 2010
Location: Lelystad (NL)

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	8,22	5,88	7,05	9,93	7,78	8,86	12,55	8,80	10,68	14,74	12,47	13,61	16,46	14,08	15,27	19,76	17,67	18,72
2	8,29	6,12	7,21	10,08	7,72	8,90	12,46	9,21	10,84	14,86	12,45	13,66	16,52	13,76	15,14	19,77	17,53	18,65
3	8,27	5,30	6,79	10,2	7,66	8,93	12,89	8,87	10,88	14,90	12,38	13,64	16,61	13,47	15,04	19,86	17,47	18,66
4	8,59	4,25	6,42	10,29	7,42	8,86	12,81	9,23	11,02	14,93	12,28	13,61	16,93	13,10	15,02	20,11	17,22	18,67
5	8,40	5,78	7,09	10,31	7,38	8,85	12,01	9,14	10,58	15,09	12,11	13,60	16,97	13,07	15,02	20,28	17,16	18,72
6	8,48	6,05	7,26	10,34	7,28	8,81	12,46	9,69	11,08	15,11	11,92	13,52	17,02	13,02	15,02			
7	8,34	6,14	7,24	10,61	7,27	8,94	12,64	9,72	11,18				17,15	12,94	15,05			
8	8,30	6,11	7,20	10,64	7,16	8,90	12,22	9,40	10,81				17,33	12,75	15,04			
9	8,28	6,15	7,22		7,01		12,82	9,38	11,10									
10	8,18	6,00	7,09		5,77			9,44										
11																		
12																		
13																		
14																		
15																		
average			**7,06**			**8,88**			**10,91**			**13,60**			**15,07**			**18,68**
stdev			0,26			0,05			0,20			0,05			0,09			0,03
coëfficient t			2,3			2,4			2,3			2,6			2,4			2,8
# of tests (n)			10			8			9			6			8			5
accuracy factor p			1,36%			0,34%			1,70%			0,70%			1,14%			0,75%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions								
vehicle description	Vehicle 4						check	
		unit						
vehicle reference mass	M	kg	1962					
ambient temperature	T	°C	20,0	=	293,15	K		
reference temperature	To	°C	20,0	=	293,15	K		
ambient barometric pres.	P	mBar	1016,00					
reference barometrix pres.	Po	mBar	1000,00					
ambient air density	ρ	kg/m3	1,207				OK	
reference air density	ρo	kg/m3	1,188					
Kr factor	Kr		0,00864					
Molar mass of Earth's air	M	kg/mol	0,028964					
gas constant	R		8,314462					
wind speed		m/s					OK	<= 3 m/s
wind speed maximums		m/s					OK	<= 5 m/s
wind component right angled to road		m/s					OK	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0,4480	1,007	7,06	25,74	**25,93**
100	(105-95)	0,4998	1,008	8,88	17,05	**17,18**
80	(85-75)	0,5930	1,009	10,91	11,11	**11,21**
60	(65-55)	0,7146	1,011	13,60	6,68	**6,75**
40	(45-35)	0,8520	1,013	15,07	4,02	**4,07**
20	(25-15)	0,9620	1,015	18,68	1,62	**1,65**

Table 18: Road load test results vehicle 4

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Realistic	Type approval	Realistic/TA
20	1,01	1,65	100%	163%
40	2,54	4,07	100%	160%
60	5,01	6,75	100%	135%
80	8,79	11,21	100%	128%
100	14,28	17,18	100%	120%
120	21,87	25,93	100%	119%

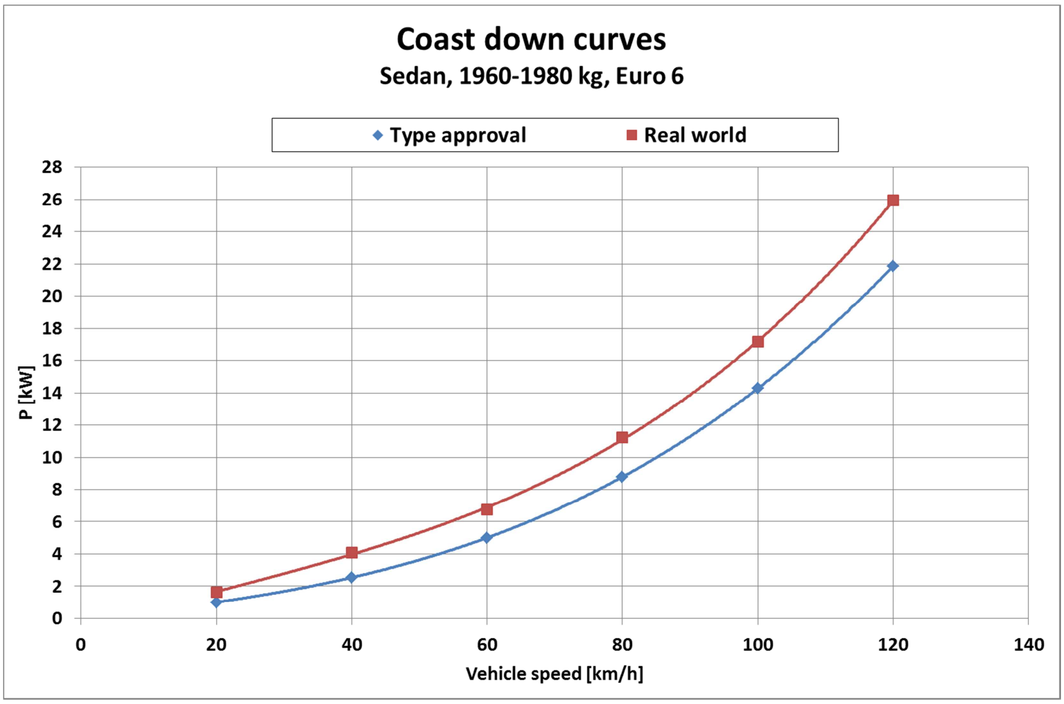

Figure 20: Type Approval and realistic road load curve of vehicle 4

Sample 7: Vehicle 5

Test date: November 22nd, 2010
Location: Lelystad (NL)

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	6,04	5,50	5,77	8,13	7,40	7,76	10,67	8,98	9,83				15,25	16,4	15,83	19,39	21,46	20,43
2	6,36	5,79	6,07	8,10	7,37	7,74	10,57	9,42	10,00	12,69	13,23	12,96	15,45	15,71	15,58	20,17	20,72	20,45
3	6,26	5,57	5,92	8,22	7,32	7,77	10,50	10,42	10,46	13,69	12,09	12,89	15,49	15,15	15,32	20,38	19,91	20,15
4	6,46	5,81	6,14	8,21	7,00	7,61	10,51	9,42	9,97	13,84	11,9	12,87	15,54	15,09	15,32	20,41	19,65	20,03
5	6,39	5,62	6,01	8,40	7,39	7,90	10,63	9,54	10,09	14,4	11,88	13,14	16,02	14,51	15,27	21,06	19,26	20,16
6	5,99	5,00	5,50	7,93	7,30	7,61	10,22	9,43	9,83	14,4	11,81	13,11	16,89	14,3	15,60	22,59	17,20	19,90
7	6,26	5,63	5,95	8,14	7,33	7,73	10,65	9,55	10,10	14,46	11,22	12,84				22,32		
8							9,85	9,93	9,89									
9								9,70										
10																		
11																		
12																		
13																		
14																		
15																		
average			**5,91**			**7,73**			**10,02**			**12,97**			**15,48**			**20,18**
stdev			0,22			0,10			0,21			0,13			0,22			0,22
coëfficient t			2,5			2,5			2,4			2,6			2,6			2,6
# of tests (n)			7			7			8			6			6			6
accuracy factor p			1,21%			0,73%			1,76%			1,75%			3,61%			4,65%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**NOK**			**NOK**

Test conditions									
vehicle description		Vehicle 5						check	
			unit						
vehicle reference mass		M	kg	1652					
ambient temperature		T	°C	5,5	=	278,65	K		
reference temperature		To	°C	20,0	=	293,15	K		
ambient barometric pres.		P	mBar	1005,00					
reference barometrix pres.		Po	mBar	1000,00					
ambient air density		ρ	kg/m3	1,256				OK	
reference air density		ρo	kg/m3	1,188					
Kr factor		Kr		0,00864					
Molar mass of Earth's air		M	kg/mol	0,028964					
gas constant		R		8,314462					
wind speed			m/s					OK	<= 3 m/s
wind speed maximums			m/s					OK	<= 5 m/s
wind component right angled to road			m/s					OK	<= 2 m/s

speed	interval	Rr/RT	K	uncorrected CD time [s]	uncorrected Power [kW]	**corrected Power [kW]**
120	(125-115)	0,3994	0,972	5,91	25,90	**25,16**
100	(105-95)	0,4493	0,968	7,73	16,49	**15,96**
80	(85-75)	0,5356	0,962	10,02	10,18	**9,79**
60	(65-55)	0,6538	0,954	12,97	5,90	**5,62**
40	(45-35)	0,8027	0,943	15,48	3,29	**3,11**
20	(25-15)	0,9396	0,933	20,18	1,26	**1,18**

Table 19: Road load test results vehicle 5

V	P	P		
[km/h]	[kW]	[kW]		
V	Type approval	Real world	Type approval	Real world/TA
20	0,55	1,18	100%	213%
40	1,73	3,11	100%	180%
60	4,02	5,62	100%	140%
80	7,93	9,79	100%	123%
100	13,97	15,96	100%	114%
120	22,63	25,16	100%	111%

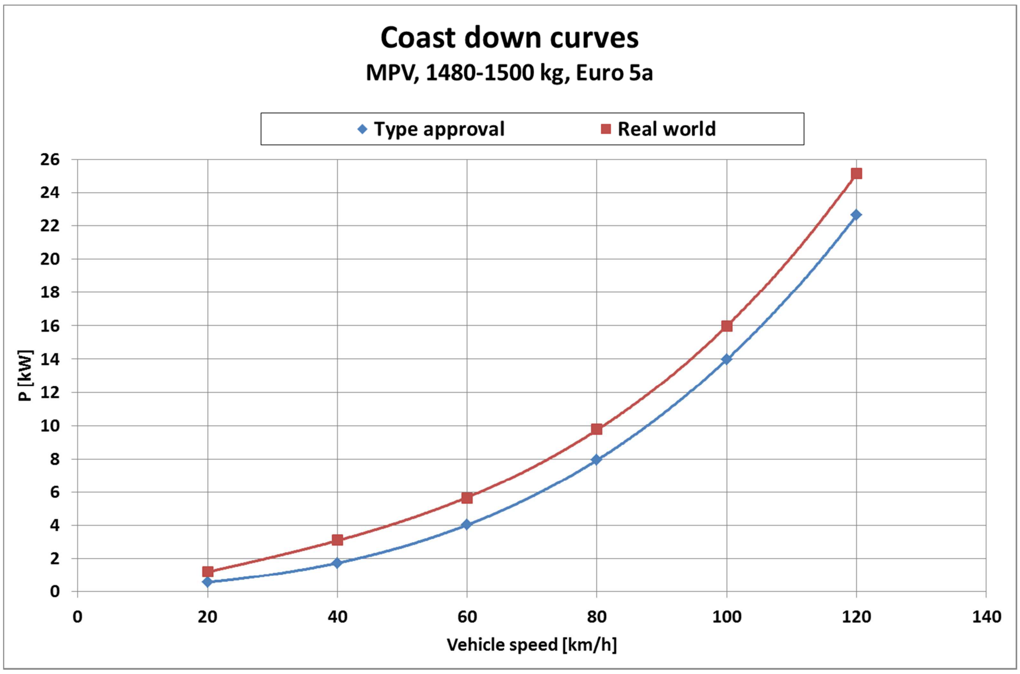

Figure 21: Type approval and realistic road load curve of vehicle 5

Sample 8: Vehicle 6 (1523 kg)

Test date: June 11th, 2012
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 8

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	5,85	6,2	6,03	7,15	8,1	7,63	8,55	10,35	9,45	11,5	13,05	12,27	14,75	17,05	15,90	19,95	21,75	20,85
2	5,55	6,15	5,85	7,25	7,9	7,58	8,75	10,2	9,47	11,5	12,95	12,22	15,2	16,85	16,03	20,45	21,7	21,08
3	5,8	6,35	6,07	7,15	7,7	7,42	9,15	10,05	9,60	11,7	12,85	12,28	15,4	16,05	15,73	20,5	21,4	20,95
4	5,95	6,55	6,25	7,15	8	7,57	9,15	9,95	9,55	11,85	12,75	12,30	15,6	15,9	15,75	20,5	21,2	20,85
5	6	6,4	6,20	7,4	8,2	7,80	9,2	9,65	9,42	11,85	12,5	12,17	16	14,8	15,40	20,75	20,4	20,57
6				7,5			9,35			12,05								
7				7,3			9,4			12,3			15,6			20,7		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
average			**6,08**			**7,60**			**9,50**			**12,25**			**15,76**			**20,86**
stdev			0,16			0,13			0,07			0,05			0,23			0,18
coëfficient t			2,8			2,8			2,8			2,8			2,8			2,8
# of tests (n)			5			5			5			5			5			5
accuracy factor p			1,20%			1,28%			0,87%			0,77%			4,64%			4,81%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**NOK**			**NOK**

Test conditions									
vehicle description		Vehicle 8						check	
			unit						
vehicle reference mass		M	kg	1523					
ambient temperature		T	°C	12,8	=	285,95	K		
reference temperature		To	°C	20,0	=	293,15	K		
ambient barometric pres.		P	mBar	1013,00					
reference barometrix pres.		Po	mBar	1000,00					
ambient air density		ρ	kg/m3	1,234				OK	
reference air density		ρo	kg/m3	1,188					
Kr factor		Kr		0,00864					
Molar mass of Earth's air		M	kg/mol	0,028964					
gas constant		R		8,314462					
wind speed			m/s	1,0				OK	<= 3 m/s
wind speed maximums			m/s	1,0				OK	<= 5 m/s
wind component right angled to road			m/s	1,0				OK	<= 2 m/s

correction to reference conditions						
according to 70/220/EEG						
Vehicle 8						
Kr	0,00864			ρ0/ρ	0,962921219	
speed	interval	Rr/RT	K	uncorrected	uncorrected	corrected
				CD time [s]	Power [kW]	Power [kW]
120	(125-115)	0,379	0,990	6,08	23,19	22,97
100	(105-95)	0,428	0,989	7,60	15,46	15,30
80	(85-75)	0,512	0,987	9,50	9,90	9,77
60	(65-55)	0,629	0,984	12,25	5,76	5,66
40	(45-35)	0,782	0,980	15,76	2,98	2,92
20	(25-15)	0,930	0,977	20,86	1,13	1,10

Sample 8: Vehicle 6 (1634 kg)

Test date: June 14th, 2012
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 8

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	6,2	6,65	6,42	7,9	8,4	8,15	9,8	11,3	10,55	12,05	13,85	12,95	15	17,9	16,45	18,75	21,65	20,20
2	6,45	6,65	6,55	7,9	8,3	8,10	9,8	10,85	10,33	12,05	13,55	12,80	15,05	17,55	16,30	19	21,55	20,27
3	6,3			7,95			9,9	11,1	10,50	12,05	13,5	12,77	15,25	17,4	16,32	19,2	21,4	20,30
4	6,3	6,65	6,47	8	8,55	8,27	9,7	11,15	10,42	12,25	13,25	12,75	15,45	17,3	16,37	19,35	21,4	20,37
5	6,1	6,75	6,42	7,95	8,65	8,30	9,45	11,25	10,35	12,3	13,1	12,70	15,55	17,1	16,32	19,55	21,15	20,35
6	6,35	6,6	6,47	7,8	8,5	8,15	9,6	10,6	10,10	12,3	13	12,65	15,65	17	16,32	19,6	21	
7	6,25	6,5	6,37	7,95	8,45	8,20	9,45	10,6	10,02	12,4	12,95		16,2	16,85	16,52	19,8	20,95	20,37
8	6,4	6,75	6,57	7,95	8,15	8,05	9,65	11	10,32	12,45	12,9	12,67	16,55	16,7	16,62	20,1	20,55	20,33
9	6,3	6,55	6,42	7,95	8,05	8,00	9,9	10,55	10,22	12,6	12,75	12,67		16,15	16,15		20,55	20,55
10				7,75			9,7				12,4			15,9				
11																		
12																		
13																		
14																		
15																		
average			**6,47**			**8,15**			**10,31**			**12,75**			**16,38**			**20,34**
stdev			0,07			0,10			0,17			0,10			0,14			0,10
coëfficient t			2,4			2,4			2,3			2,4			2,3			2,4
# of tests (n)			8			8			9			8			9			8
accuracy factor p			0,37%			0,72%			1,37%			1,06%			1,74%			1,75%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions									
vehicle description		Vehicle 8						**check**	
			unit						
vehicle reference mass		M	kg	1638					
ambient temperature		T	°C	14,9	=	288,05	K		
reference temperature		To	°C	20,0	=	293,15	K		
ambient barometric pres.		P	mBar	1013,00					
reference barometrix pres.		Po	mBar	1000,00					
ambient air density		ρ	kg/m3	1,225				**OK**	
reference air density		ρo	kg/m3	1,188					
Kr factor		Kr		0,00864					
Molar mass of Earth's air		M	kg/mol	0,028964					
gas constant		R		8,314462					
wind speed			m/s	1,3				**OK**	<= 3 m/s
wind speed maximums			m/s	1,0				**OK**	<= 5 m/s
wind component right angled to road			m/s	1,0				**OK**	<= 2 m/s

according to 70/220/EEG						
Vehicle 8						
Kr	0,00864			ρ0/ρ	0,969992856	
speed	interval	Rr/RT	K	uncorrected	uncorrected	corrected
				CD time [s]	Power [kW]	Power [kW]
120	(125-115)	0,40	0,99	6,47	23,46	23,33
100	(105-95)	0,45	0,99	8,15	15,50	15,40
80	(85-75)	0,53	0,99	10,31	9,80	9,73
60	(65-55)	0,65	0,99	12,75	5,95	5,89
40	(45-35)	0,80	0,99	16,38	3,09	3,05
20	(25-15)	0,94	0,99	20,34	1,24	1,23

Sample 8: Vehicle 6 (1724 kg)

Test date: June 11th, 2012
Location: Lommel (B)

accuracy check and average cd-time determination according to 70/220/EEG

Vehicle 8

speed	120			100			80			60			40			20		
interval	(125-115)			(105-95)			(85-75)			(65-55)			(45-35)			(25-15)		
direction	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg	to	fro	T avg
test #																		
1	6,85	6,25	6,55	8,15	8,1	8,12	10,2	10,6	10,40	12,5	13,55	13,02	16,1			19,5		
2	7,05	6,5	6,78	8,7	8,4	8,55	10,5	9,95	10,23	12,95	13	12,97	16,1	16,65	16,37	19,85	21,15	20,50
3	6,6	6,4	6,50	8,4	8,3	8,35	10,25	9,9	10,07	13,25	12,9	13,07	16,1	16,45	16,27	20,1	21,05	20,58
4	6,85	6,55	6,70	8,65	8,15	8,40	10,25	10,4	10,32	13,45	12,65	13,05	16,15	16,35	16,25	20,25	21	20,62
5	6,9	6,75	6,82	8,85	8,2	8,52	10,2	9,85	10,02	13,45	12,15	12,80	16,25	16,05	16,15	20,25	20,95	20,60
6	6,95	6,6	6,77	8,7	7,9	8,30	10,3	9,9	10,10	13,65	12,15	12,90	16,4	15,9	16,15	20,3	20,85	20,57
7	6,85	6,55	6,70	8,8	8	8,40	10,35	10,25	10,30	13,7	11,65	12,67		15,45		20,3		
8	6,85	6,45	6,65	8,6	8,15	8,37	10,45	9,8	10,12	13,7				15,3		20,6		
9	6,85			8,35			10,55			13,8				15,05			19,95	
10	6,8			8,4			10,2											
11																		
12																		
13																		
14																		
15																		
average			**6,68**			**8,38**			**10,20**			**12,93**			**16,24**			**20,57**
stdev			0,11			0,13			0,14			0,15			0,09			0,05
coëfficient t			2,4			2,4			2,4			2,5			2,8			2,8
# of tests (n)			8			8			8			7			5			5
accuracy factor p			0,64%			0,94%			1,17%			1,79%			1,92%			1,20%
accuracy OK?			**OK**			**OK**			**OK**			**OK**			**OK**			**OK**

Test conditions								
vehicle description	Vehicle 8						**check**	
		unit						
vehicle reference mass	M	kg	1724					
ambient temperature	T	°C	12,8	=	285,95	K		
reference temperature	To	°C	20,0	=	293,15	K		
ambient barometric pres.	P	mBar	1013,00					
reference barometrix pres.	Po	mBar	1000,00					
ambient air density	ρ	kg/m3	1,234				**OK**	
reference air density	ρo	kg/m3	1,188					
Kr factor	Kr		0,00864					
Molar mass of Earth's air	M	kg/mol	0,028964					
gas constant	R		8,314462					
wind speed		m/s	1,0				**OK**	<= 3 m/s
wind speed maximums		m/s	1,0				**OK**	<= 5 m/s
wind component right angled to road		m/s	1,0				**OK**	<= 2 m/s

correction to reference conditions							
according to 70/220/EEG							
Vehicle 8							
Kr	0,00864			ρ0/ρ	0,962921219		
speed	interval	Rr/RT	K	uncorrected	uncorrected	**corrected**	
				CD time [s]	Power [kW]	**Power [kW]**	
120	(125-115)	0,4107	0,990	6,68	23,88	**23,63**	
100	(105-95)	0,4610	0,988	8,38	15,88	**15,69**	
80	(85-75)	0,5489	0,986	10,20	10,44	**10,29**	
60	(65-55)	0,6679	0,983	12,93	6,17	**6,07**	
40	(45-35)	0,8141	0,980	16,24	3,28	**3,21**	
20	(25-15)	0,9448	0,976	20,57	1,29	**1,26**	

Table 20: Road load test results vehicle 6

V	P	P	P	P
[km/h]	[kW]	[kW]	[kW]	[kW]
	Type approval	Realistic	Realistic	Realistic
	1475 kg	1523 kg	1638 kg	1724 kg
20	0.59	1.10	1.23	1.26
40	1.66	2.92	3.05	3.21
60	3.60	5.66	5.89	6.07
80	6.74	9.77	9.73	10.29
100	11.47	15.30	15.40	15.69
120	18.14	22.97	23.33	23.63

Table 21: Relative road load test results vehicle 6

V	P	P	P	P
[km/h]	[%]	[%]	[%]	[%]
	Type approval	Realistic	Realistic	Realistic
	1475 kg	1523 kg	1638 kg	1724 kg
20	100%	186%	208%	214%
40	100%	176%	184%	193%
60	100%	157%	164%	169%
80	100%	145%	144%	153%
100	100%	133%	134%	137%
120	100%	127%	129%	130%

C Detailed test results emission tests

Emission tests of vehicle 1 model year 2012

In Table 22 the results of different New European Driving Cycles of vehicle 2 (my2012) have been reported. The columns in the table contain

- Type approval limit values
- Type approval specified values (TA)
- TNO measured test results with Type Approval road load settings (green cells)
- TNO measured test results with realistic road load settings (blue cells)

Table 22: NEDC emission test results vehicle 2 (my 2012)

Vehicle 2 model year 2012 NEDC test results

Source		Limit	TA	TNO	TNO	TNO	TNO	TNO	TNO
Date			-	05/12/2011	05/12/2011	13/12/2011	Average	29/11/2011	30/11/2011
Ambient temp.	[°C]		25	25	25	25	25	25	25
Toil	[°C]		25	25	25	25	25	25	25
Ch. Dyno setting			1	1	1	1	1	2	3
Inertia	[kg]		1700	1700	1700	1700	1700	1590	1590
CO	[g/km]	0.500	0.141	0.196	0.151	0.190	0.179	0.236	0.190
CO2	[g/km]	-	116.6	135.7	135.0	123.2	131.3	131.7	149.2
THC	[g/km]	-	0.031	0.029	0.023	0.028	0.027	0.036	0.027
NOx	[g/km]	0.180	0.101	0.120	0.138	0.105	0.121	0.107	0.126
NO2	[g/km]	-							
THC+NOx	[g/km]	0.230	0.132	0.148	0.162	0.133	0.148	0.143	0.153
PM	[g/km]	0.005	0.020	0.000	0.000	0.000	0.000	0.000	0.000
PN	[-/km]	6.0E+11	1.2E+10	2.7E+10	7.0E+08	9.6E+09	1.2E+10	7.7E+09	3.5E+09
FC	[l/100 km]	-	4.50	5.07	5.04	4.60	4.90	4.93	5.57

Chassis dyno setting	
Type approval	1,2
Real world	3

The NEDC test results of vehicle 2 (my 2012) with Type Approval road load settings in Table 22 show CO, NOx, THC+NOx, PM and PN emissions that are below the limit values.

1. Measured CO_2 emissions that are 13% higher than the Type Approval CO_2 emissions (131.3 versus 116.6 g/km).
2. A relative wide band of CO_2 emissions (123.2 – 135.7 g/km). The regeneration of soot in the Diesel Particulate Filter might be the cause of this spread.
3. No CO_2 emission difference in the two inertia classes (1590 and 1700 kg)

The NEDC test results of vehicle 2 (my 2012) with realistic road load settings in Table 22 show CO, NOx, THC+NOx, PM and PN emissions that are below the limit values.

1. Measured realistic CO_2 emissions that are 28% higher than the Type Approval CO_2 emissions (149.2 versus 116.6 g/km).
2. An increase of CO_2 emissions of 13% (149.2 versus 131.7 g/km) compared to Type Approval road load settings.

Emission tests of vehicle 3

In Table 23 the results of different New European Driving Cycles of vehicle 3 have been reported.
The columns in the table contain

- Type Approval limit values
- Type Approval specified values (TA)
- TNO measured test results with Type Approval road load settings (TA)
- TNO measured test results with realistic road load settings (RW)

Table 23: NEDC test results vehicle 3

		limit	TA		
Test type		NEDC	NEDC		
Date				Road load	
Ch. Dyno setting				TA	RW
Inertia	[kg]			1020	1020
CO	[g/km]	1,000		0,245	0,259
CO2	[g/km]	-	110,0	123,0	131,0
THC	[g/km]	0,100		0,053	0,051
NOx	[g/km]	0,060		0,031	0,033
NO2	[g/km]	-		0,028	0,030
THC+NOx	[g/km]	-		0,084	0,084
PM	[g/km]	-		0,001	0,001

The NEDC test results of vehicle 3 with Type Approval road load settings in Table 23 show

1. CO, NOx and THC emissions that are below the limit values.
2. Measured CO_2 emissions that are 12% higher than the Type Approval CO_2 emissions (123.0 versus 110.0 g/km).

The NEDC test results of vehicle 3 with realistic road load settings in Table 23 show

1. CO, NOx and THC emissions that are below the limit values.
2. Measured realistic CO_2 emissions that are 19% higher than the Type Approval CO_2 emissions (131.0 versus 110.0 g/km).
3. An increase of CO_2 emissions of 7% (131.0 versus 123.0 g/km) compared to Type Approval road load settings.

Emission tests of vehicle 4

In Table 24 the results of different New European Driving Cycles of vehicle 4 have been reported. The columns in the table contain

- Type Approval limit values
- Type Approval specified values (TA)
- TNO measured test results with Type Approval road load settings (TA)
- TNO measured test results with realistic road load settings (RW)

Table 24: NEDC test results vehicle 4

		limit	TA		
Test type		NEDC	NEDC		
Date				Road load	
Ch. Dyno setting				TA	RW
Inertia	[kg]			2040	2040
CO	[g/km]	0,500		0,244	0,143
CO2	[g/km]	-	184,0	207,0	230,0
THC	[g/km]	-		0,031	0,024
NOx	[g/km]	0,080		0,066	0,046
NO2	[g/km]	-		0,009	0,002
THC+NOx	[g/km]	0,170		0,097	0,071
PM	[g/km]	0,005		0,001	0,000
PN	[-/km]	6,0E+11		-	-

The NEDC test results of vehicle 4 with Type Approval road load settings in Table 24 show

1. CO, NOx, THC and PM emissions that are below the limit values.
2. Measured CO_2 emissions that are 13% higher than the Type Approval CO_2 emissions (207.0 versus 184.0 g/km).

The NEDC test results of vehicle 4 with realistic road load settings in Table 24 show

1. CO, NOx, THC and PM emissions that are below the limit values.
2. Measured realistic CO_2 emissions that are 25% higher than the Type Approval CO_2 emissions (230.0 versus 184.0 g/km).
3. An increase of CO_2 emissions of 11% (230.0 versus 207.0 g/km) compared to Type Approval road load settings.

Emission tests of vehicle 5

In Table 25 the results of different New European Driving Cycles of vehicle 5 have been reported.
The columns in the table contain

- Type Approval limit values
- Type Approval specified values (TA)
- TNO measured test results with Type Approval road load settings (TA)
- TNO measured test results with realistic road load settings (RW)

Table 25: NEDC test results vehicle 5

		limit	TA		
Test type		NEDC	NEDC		
Date				Road load	
Ch. Dyno setting				TA	RW
Inertia	[kg]			1470	1470
CO	[g/km]	0,500		0,273	0,204
CO2	[g/km]	-	135,0	146,0	162,0
THC	[g/km]	-		0,024	0,020
NOx	[g/km]	0,180		0,321	0,396
NO2	[g/km]	-		0,068	0,087
THC+NOx	[g/km]	0,230		0,345	0,416
PM	[g/km]	0,005		0,000	0,000

The NEDC test results of vehicle 5 with Type Approval road load settings in Table 25 show

1. CO and PM emissions that are below the limit values.
2. THC+NOx emissions that exceed the limit values
3. Measured CO_2 emissions that are 8% higher than the Type Approval CO_2 emissions (146.0 versus 135.0 g/km).

The NEDC test results of vehicle 5 with realistic road load settings in Table 25 show

1. CO and PM emissions that are below the limit values.
2. THC+NOx emissions that exceed the limit values
3. Measured realistic CO_2 emissions that are 20% higher than the Type Approval CO_2 emissions (162.0 versus 135.0 g/km).
4. An increase of CO_2 emissions of 11% (162.0 versus 146.0 g/km) compared to Type Approval road load settings.

Emission tests of vehicle 6

In Table 26 the results of different New European Driving Cycles of vehicle 6 have been reported.
The columns in the table contain

- Type Approval limit values
- Type Approval specified values (TA)
- TNO measured test results with Type Approval road load settings (TA)
- TNO measured test results with realistic road load settings (RW)

Table 26: Emission test results vehicle 6

Vehicle 6 NEDC test results					
		Limit	TA		
Test type		NEDC	NEDC		
Date				Road load	
Ch. Dyno setting				TA	RW
Inertia	[kg]			1470	1538
				TNO	TNO
CO	[g/km]	1.000	0.564	0.257	0.234
CO2	[g/km]	-	144.0	164.0	179.7
THC	[g/km]	0.100	0.031	0.051	0.024
NOx	[g/km]	0.060	0.013	0.060	0.021
NO2	[g/km]	-		0.000	0.000
THC+NOx	[g/km]	-	0.044	0.111	0.046
PM	[g/km]	-	0.001	0.002	0.002
PN	[-/km]			1.7E+12	1.3E+12

The NEDC test results of vehicle 6 with Type Approval road load settings in Table 26 show

1. CO, THC and NOx emissions that are below the limit values.
2. Measured CO_2 emissions that are 14% higher than the declared type approval CO_2 emissions (164.0 versus 144.0 g/km)

The NEDC test results of vehicle 6 with realistic road load settings in Table 26 show

1. CO and PM emissions that are below the limit values.
2. THC and NOx emissions that are below the limit values
3. Measured realistic CO2 emissions that are 25% higher than the Type Approval CO_2 emissions (179.7 versus 144.0 g/km).
4. An increase of CO_2 emissions of 10%(179.7 versus 164.0 g/km) compared to Type Approval road load settings.