Department for Transport

Vehicle Emissions Testing Programme - Data

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1. Introduction

1.1 On 21 April 2016 the Department for Transport published the report of their Vehicle Emissions Testing Programme. This programme was commissioned by the Secretary of State for Transport in order to establish whether Defeat Devices were in common use by vehicle manufacturers.

1.2 The programme was also designed to help quantify the divergence of on-road exhaust emissions from those measured in laboratories during the type approval process, and to help understand the variation between the latest emissions standard and its predecessor.

1.3 For a copy of the report please follow the following link:

https://www.gov.uk/government/publications/vehicle-emissions-testing-programme-conclusions

1.4 This second document, *Vehicle Emissions Testing Programme - Data*, complements that report by providing an overview of the individual tests of which each vehicle assessment was comprised. This information is intended to aid understanding of the data collected in the programme.

Detailed data for each of the vehicles assessed in the programme are also available at the following link:

https://www.gov.uk/government/publications/vehicle-emissions-testing-programme-conclusions

2. Description of Tests

Overview

2.1 The measurement of pollutant emissions under a range of driving conditions was central to this programme. Understanding whether or not there was a wider use of defeat devices was the principal question to be answered. The programme was constructed around permutations of the laboratory driving cycle used for Type Approval (New European Driving Cycle (NEDC)) as any defeat device would be designed to function on recognition of this cycle. Testing was undertaken both in emissions measurement laboratories and on a test track. Additional testing, based on the available protocols for the new *Real Driving Emissions (RDE)* test, was performed on public road.

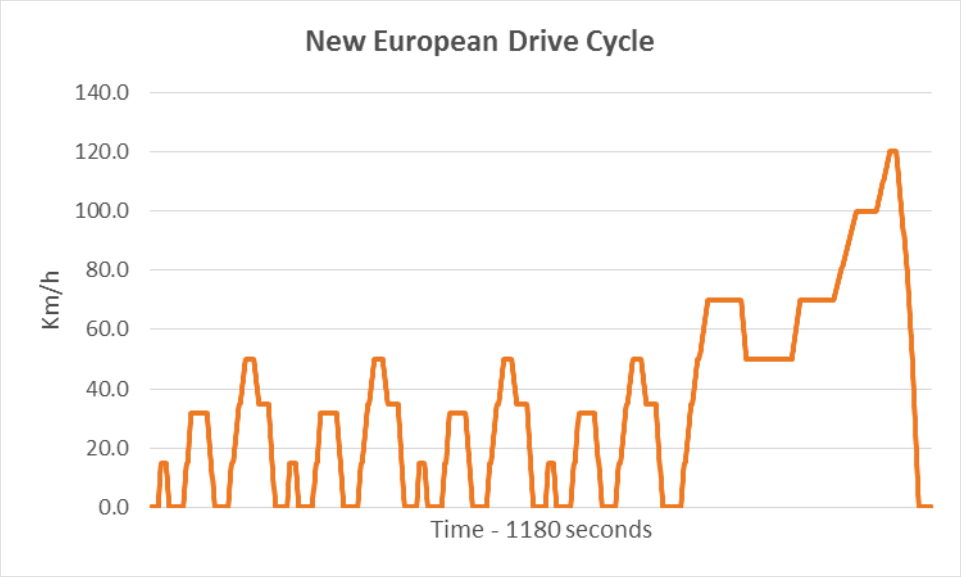
2.2 The New European Drive Cycle comprises two elements. The test starts with a sequence of 4 identical driving cycles, these "elementary Urban Drive Cycles" (UDC) were designed to simulate typical urban driving. These are followed by a further "Extra-Urban Drive Cycle" (EUDC) that imposes higher speeds and longer accelerations on the vehicle under test. These individual cycles are driven in a continuous manner with the engine remaining running, and emissions being measured, throughout the sequence.

2.3 A Portable Emissions Measuring System (PEMS) was installed in each vehicle before any testing was undertaken. Horiba OBS 1 equipment was used for all of the vehicles assessed. PEMS was not used to establish emission values during the laboratory tests but was used in parallel to the laboratory equipment during one test to establish correlation and hence the validity of measurements taken during the track and road tests.

Laboratory Tests

2.4 Emission test laboratories were employed to evaluate each vehicle's emission performance. The inertia and coast down values used to simulate the forces that the vehicle has to overcome in the real world (rolling resistance and aerodynamic resistance) were those employed during Type Approval of the vehicle. These values were obtained from the Type Approval Authority responsible for the approval of each of the vehicles tested.

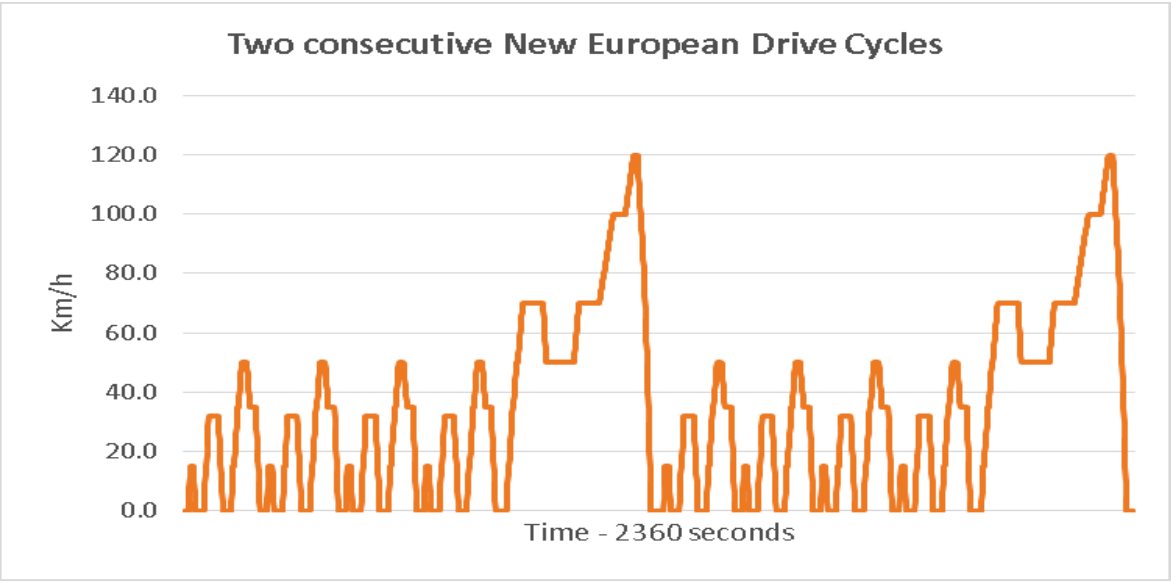
2.5 A standard *Type I* regulatory test (Cold NEDC) was conducted to establish the performance of the vehicle relative to the type approval requirement. This test helped ensure that there were no significant issues with the vehicle's emission performance that could render it unsuitable for assessment. This test included all of the routine preparation that would be undertaken for Type Approval, including preconditioning and temperature stabilisation. Air-conditioning systems were turned off, daytime running lights (DRLs) were turned on and stop-start systems were set to default mode.



Representation of the standard driving cycle used.

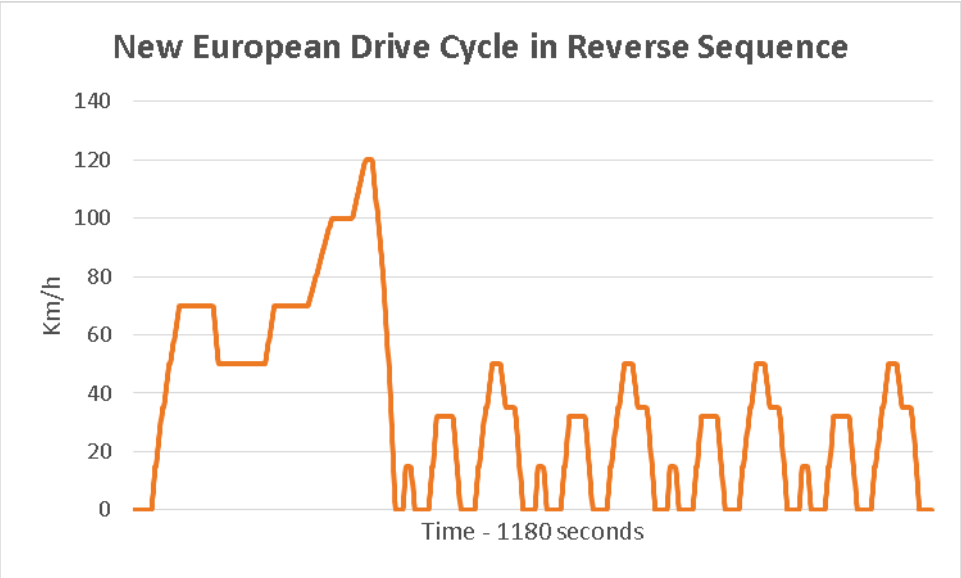
2.6 Following the Cold NEDC confirmatory test each vehicle was subjected to 3 further "hot" tests; the vehicle was not temperature conditioned but was tested with the engine, coolant and lubricant at normal operating temperature (Hot tests). These tests comprised:

- Following the regulatory (NEDC) drive cycle, (the PEMS equipment was used to measure the emissions in parallel with the laboratory equipment to establish the correlation of measurement). This hot test was undertaken to establish whether the vehicle had a strategy that responded to the preconditioning procedure used in Type Approval.
- Two consecutive journeys following the NEDC cycle. The engine remained running throughout this extended test. This test explored whether the vehicle changed its emission management once the duration of the regulatory test was exceeded.



Representation of extended time driving using NEDC.

2.7 Each vehicle was further subjected to the profile of the NEDC but with the phases reordered such that the faster, extra urban cycle, was driven before the four elementary drive cycles. This test was used to understand whether the vehicle had a strategy that identified the use of the NEDC by means of measurement of the distance travelled in respect to time (under the changed conditions the vehicle would travel further in the initial part of the cycle).



Representation of NEDC with sequence of driving reversed.

2.8 For some vehicles, primarily those that are approved to Euro 6 emission limits, the opportunity was taken to measure the emission when following the driving pattern for the new World Light Duty Driving Cycle (WLTC). These data are provided with this report but were not used in the assessment of the vehicle.

Track Tests

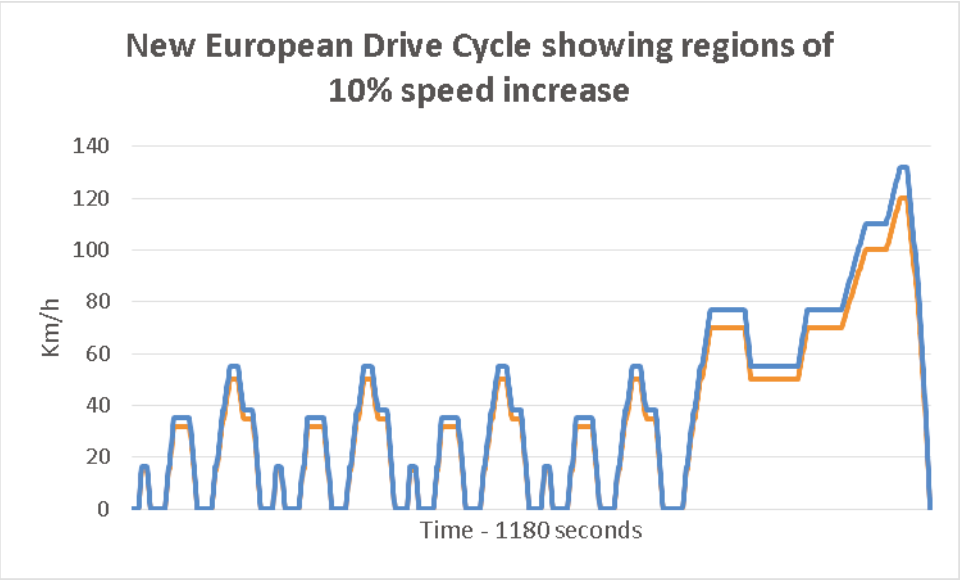
2.9 The track test element of the programme was designed to replicate, as far as practicable, the driving pattern followed in the laboratory.

2.10 For safety reasons the test facility used for the track assessment requires that vehicles must have their lights on at all times when on the track. Air conditioning was turned off and the heater set to a normal use position. The heater fan may have been used if it was necessary, for example to retain a clear windscreen for example, and the windscreen wipers were used if needed. Heated seats etc. were all switched off and the stop-start systems set in default mode.

2.11 As with the laboratory test, the driver was provided with a visual display on which the NEDC driving cycle was displayed. GPS data were used to enable the vehicle movement to be overlaid on the driving trace. No connection was made with the vehicle electronics, the CAN bus or the on-board diagnostic (OBD) port.

2.12 Repeating the laboratory tests on a track enabled any dynamic data inputs that the vehicle would produce in normal use to be generated, e.g. individual wheel speed data, steering input, yaw values, etc.; the absence of these inputs in the laboratory could be used to indicate that the vehicle was undergoing a test and therefore have potential to be used to manage the emissions control system.

2.13 An additional test was introduced in the track sequence. This again was based upon the NEDC profile but at each of the points at which the cycle reaches a speed plateau the speed was raised by 10%, effectively taking the vehicle "off-cycle".



Representation of NEDC with 10% speed increase plateaus

Road Tests

2.14 This element involved exercising the vehicle for a period of approximately 1.5 hours over a test route that satisfied the general requirements of the new Real Driving Emission (RDE) test. In general this process followed the proposed RDE procedures but, as these procedures were not finalised and not all vehicles had been subjected to a representative WLTP precursor, this test cannot be truly considered as a valid RDE assessment. Nevertheless energy input levels were monitored to maintain inputs within the prescribed limits.

2.15 Air-conditioning systems were set to default mode and heater controls set to normal positions. Lighting and windscreen wipers were set to automatic mode. As with other test, stop-start systems were set to the default mode.

3. Vehicles Assessed in the Programme

Euro 5 Vehicles

Make	Model	Engine Size	Recorded Mileage
Citroen	C4	1569	21482
Ford	Mondeo	2000	21072
Honda	CRV	2200	2734
Hyundai	iX35	1685	7310
Hyundai	i30 (automatic)	1582	21461
Hyundai	Santa Fe (4WD)	2199	7794
Kia	Sportage (4WD)	1995	4427
Land Rover	Freelander (4WD)	2179	2431
Mercedes	E250	2100	11031
Nissan	Qashqai	1461	19011
Nissan	Qashqai	1598	22973
Peugeot	208	1398	15543
Range Rover	Sport (4WD)	2993	23576
Range Rover	Sport HSE (4WD)	2993	13705
Skoda	Octavia	1600	4759
Vauxhall	Insignia	1956	24706
Vauxhall	Astra	1686	41994
Vauxhall	Corsa	1300	25092
Volvo	V40	1560	2625

Euro 6 Vehicles

Make	Model	Engine Size	Recorded Mileage
Audi	A3	1598	2315
BMW	X5 (4WD)	2993	2734
BMW	320X (4WD)	1995	1033
Ford	Mondeo	2000	9337
Ford	Focus	1499	6612
Honda	CRV (4WD)	1600	4654
Hyundai	i30	1582	6039
Jaguar	XE	1999	1115
Kia	Sportage	1685	8096
Mazda	6	2191	17921
Mercedes	A180	1461	2105
Mini	Countryman	1598	2262
Peugeot	3008	1560	2098
Renault	Megane	1461	3549
Skoda	Octavia	1600	4759
Toyota	Avensis	1998	941
Vauxhall	Insignia	2000	2461
Vauxhall	Mokka	1589	3405
Volkswagen	Golf	2000	10175

4. Interpretation of Data

4.1 The data files associated with Vehicle Emissions Test Programme include results under both laboratory and dynamic conditions. The laboratory conditions, including the dynamometer inertia and coast-down values, replicated those used during the type approval of each of the models tested.

4.2 It should be noted that testing on the track and on the road introduced some routine and some random variables that could affect the measured exhaust emission.

4.3 Vehicle mass. The Portable Emissions Measuring Equipment, and an additional vehicle occupant, increased the mass of the vehicle by approximately 220kg. This increases the amount of work that the engine has to do and hence CO2 and pollutant emissions are likely to be higher than when measured in the laboratory. Based upon modelling conducted by the Transport Research Laboratory (TRL) on Euro 4 vehicles, this mass effect could add approximately 10% to the pollutant emission values over the NEDC cycle.

4.4 Meteorological Variance. Testing was conducted through late autumn and winter and the meteorological conditions were subject to significant change - particularly in respect to ambient temperature. Humidity, atmospheric pressure, wind speed and wind direction were also subject to change and could influence the emission outcome. These confounding factors have to be considered when interpreting the data in this report, particularly if comparing different models and makes of vehicles.

4.5 The exposure of the vehicle to these real world conditions rather than the controlled laboratory conditions used for type approval was important. In particular ambient temperature was shown to be significant with regard to the operation of exhaust gas recirculation systems. This temperature sensitivity has to be considered when comparing the measured emission of one vehicle with another where the test temperatures differed.

4.6 The table of values that prefaces each vehicle data file indicates the average emissions recorded over the particular test cycle. The detailed data files permit a more complete understanding of the behaviour of the vehicle during the testing period. A review of the detailed data permits the reader to identify emission functions such as “catalyst desulphurisation” and to rationalise individual results in this context.

4.7 CO2 values were calculated as part of the programme and, as fuel consumption can be related to the work done by the vehicle, provide insight to the test results. However, the inertia settings used for CO2 measurement at type approval may be different to those used for the measurement of regulated pollutants; the inertia values used to establish official CO2 emissions were not verified during this programme.

5. Data Sheets

5.1 Data for each of the vehicles tested in the programme are provided separately on discrete data sheets in the next section of this report. The following guide explains the construction of the data tables and their association with the individual tests used in the assessment.

5.2 Atmospheric pressure (kPa), humidity (%) and temperature (°C) are shown in the data sheet for each of the laboratory, track and road phases of the assessment.

Atm. Press		Humidity		Temp.	

Laboratory Tests

5.3 Column 1 - Cold NEDC

The standard regulatory test.

NEDC	Cold	PEMS	Hot	A	B	A+B	Rev.
CO2							
NOx							
HC							
HC + NOx							
CO							
Particle #							

5.4 Column 2 & 3 – NEDC PEMS and Hot NEDC

A single (hot) test following the Cold NEDC test. Test cell conditions remain unchanged but oil, coolant etc. are at normal operating temperatures when the engine is started.

Simultaneous emission measurement from the laboratory constant volume sampling system (CVS) and PEMS are taken to ensure acceptable correlation of the PEMS for use during the track and the road exercises.

NEDC	Cold	PEMS	Hot	A	B	A+B	Rev.
CO2							
NOx							
HC							
HC + NOx							
CO							
Particle #							

5.5 Columns 4, 5 & 6 – NEDC-A, NEDC-B and NEDC-A+B

A single (hot) test, comprising two NEDC cycles run back to back with no key-off between tests. The emissions were measured separately during NEDC-A and NEDC-B with the cumulative value used for "A+B".

NEDC	Cold	PEMS	Hot	A	B	A+B	Rev.
CO2							
NOx							
HC							
HC + NOx							
CO							
Particle #							

5.6 Column 7 – NEDC Rev.

This (hot) test reverses the order of the NEDC test phases. An extra urban phase is followed by 4 elementary urban phases.

NEDC	Cold	PEMS	Hot	A	B	A+B	Rev.
CO2							
NOx							
HC							
HC + Nox							
CO							
Particle #							

5.7 Column 8 - WLTC.

This test is used primarily on a sample of Euro 6 models.

Pre-conditioning and ambient soak is observed prior to this test.

	WLTC
CO2	
NOx	
HC	
HC + NOx	
CO	
Particle #	

Track Tests

5.8 Hydrocarbon (HC) emission and particle number (Particle #) count do not form part of the standard capability for the PEMS equipment and were therefore not measured during the track and road tests.

5.9 Data for carbon monoxide emissions (CO) during the track and road tests have not been included in this report. They were captured during the testing programme and are available in the full data files (recorded at a minimum of 1Hz) that are available from https://www.gov.uk/government/publications/vehicle-emissions-testing-programme-conclusions. Due to a combination of the low values of CO produced by some engines, and the measuring capability of the PEMS equipment, meaningful values averaged over the period of the test cycle could not be determined for all vehicles.

5.10 Column 1 - Hot NEDC

These data can be compared with column 2 and 3 of the laboratory sequence.

NEDC	Hot	A	B	A+B	Rev.	+10%
CO2						
NOx						
HC						
HC + NOx						
Particle #						

5.11 Columns 2, 3 & 4 - NEDC-A, NEDC-B and NEDC A+B

These data can be compared with columns 4, 5 and 6 of the laboratory sequence.

NEDC	Hot	A	B	A+B	Rev.	+10%
CO2						
NOx						
HC						
HC + NOx						
Particle #						

5.12 Column 5 – NEDC Rev.

These data can be compared with column 7 of the laboratory sequence.

NEDC	Hot	A	B	A+B	Rev.	+10%
CO2						
NOx						
HC						
HC + NOx						
Particle #						

5.13 Column 6 – NEDC +10%

This is an additional test with no laboratory equivalence.

NEDC	Hot	A	B	A+B	Rev.	+10%
CO2						
NOx						
HC						
HC + NOx						
Particle #						

Road Tests

This test followed the principles of the Real Driving Emission test and involved a 90 minute drive on public roads with a balance of urban, rural and motorway conditions. However, it should not be understood as qualifying as an “RDE” test as the full procedures for this new test were still under development while the testing programme was undertaken.

	Road
CO2	
NOx	

6. Fuel Analysis

6.1 For Type Approval a specified reference fuel is used to ensure comparability of results from wherever the vehicle is tested. For this Emission Test Programme a common batch of winter grade (BSEN 590) diesel fuel was used for all of the vehicles tested. The analysis of this fuel is shown below.

CORYTON advanced fuels

Certificate of Analysis

Fuel Blend No:	CAF-LG15/035 Diesel sample ex	**Contact:**	Dominic Johnstone
Fuel Type:	Mahle Powertrain Northampton	**Order No:**	4700023823
Customer:	Mahle	**Date:**	27/10/2015

Test	Method	Unit	Limit		Result
			Min	Max	
Appearance	Visual		Report		C&B
Cetane Number	ASTM D613		Report		51.8
Density @ 15°C	ASTM D4052	kg/L	Report		0.8400
CFPP	EN 116	°C	Report		-21
Sulfur	IP 490	mg/kg	Report		7.9
FAME Content	EN 14078	% v/v	Report		1.0
Carbon	ASTM D5291	% m/m	Report		86.48
Hydrogen	ASTM D5291	% m/m	Report		13.00
Oxygen	EN 14078	% m/m	Report		0.52
Gross Calorific Value	ASTM D240	MJ/kg	Report		45.85
Net Calorific Value	ASTM D240	MJ/kg	Report		43.09

Sample Received Condition: Good (No Seal)
Date Sample Received: 27/10/2015

Notes:

Date:	02/11/2015
Authorised by: M Rodriguez *Blend Formulator*	

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