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Directorate C - Energy, Transport and Climate
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Annex To:
Interim Report for AA DG-GROW/JRC
No. SI2.730104 - Task 5.1

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Contents	The present document is the progress report regarding the JRC measurements (anonymized vehicle under non-disclosure agreement, Euro 6, JRC ID XX001 , vehicle technical details in the report). The report contains a summary of the JRC activities, together with the vehicle emissions results on various test cycles, in the laboratory and on the road.
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Background and disclaimer

To support the Member States market surveillance activities regarding emissions of light-duty vehicles, the European Commission has published a Guidance note¹ (hereinafter "the Guidance") to evaluate emissions strategies and to detect the presence of defeat devices. The JRC contributed to the development of the Guidance and provided a testing protocol which the responsible authorities may use to detect illegal Auxiliary Emissions Strategies (AES). The protocol includes three main elements:

- It defines the principles to test vehicles, i.e. to modify certain elements of the standard emissions tests and to assess whether these modifications are likely to influence the behavior of the emissions control technologies;
- It proposes NO_x emissions thresholds for different categories of tests, not with the objective to verify the vehicle compliance but rather to point at suspicious results which might be caused by illegal strategies;
- The Guidance goes further by introducing acceptable and non-acceptable AESs for specific emissions control technologies.

The Guidance was published in January 2017 and is subject to continuous improvements from the lessons learned during the National surveillance programs and the JRC testing. The JRC keeps testing vehicles with the objective to improve the test protocol, in particular its application to a variety of technologies and emissions standards.

The present document is an application of the protocol to a specific vehicle, which might have been tested in one or several European National programs. The JRC results and the information contained herein might be subject to analysis and verification by the responsible authorities. If the vehicle has not been tested in a national program and is found to exhibit anomalous results, the responsible authority shall repeat the tests on a similar vehicle to eliminate the potential uncertainty or the bias inferred from the single vehicle tested at the JRC.

Whenever possible, the report provides detailed information (e.g. functioning of the emissions control technologies and/or second-by-second data) to provide explanations regarding the difference(s) which may appear between the emissions from tests conducted under different conditions.

As the declarations regarding the functioning of the emissions control are under the control of the vehicle Type Approval Authority, the report does not provide any judgement on the legality of the observed AES. The vehicle emission performance is only confronted with the Guidance.

¹ Commission Notice of 26.1.2017 - Guidance on the evaluation of Auxiliary Emission Strategies and the presence of Defeat Devices

Acronyms and abbreviations

AES: Auxiliary Emissions Strategies
CF: Conformity Factor
DOC: Diesel Oxidation Catalyst
DPF: Diesel Particulate Filter
ECE: Economic Commission for Europe
ECS: Emissions Control Systems
ECU: Engine Control Unit
EGR: Exhaust Gas Recirculation
EUDC: Extra-Urban Driving Cycle
JRC: Joint Research Centre
LNT: Lean NO_x Trap
MAW: Moving Average Window
NEDC: New European Driving Cycle
OEM: Original Equipment Manufacturer
RDE: Real Driving Emissions
RL: Road Load
RT: Recommended Threshold
SCR: Selective Catalytic Reduction
WLTC: Worldwide harmonized Light vehicles Test Cycle
WLTP: Worldwide harmonized Light vehicles Test Procedures

Test program overview

The application of the protocol to detect illegal AES is subject to adaptations depending on the vehicle technologies. Table 1 shows the types of tests and their objectives for the vehicle presented in this document.

Table 1: Type of tests and objectives

Type of Test	Category ²	Objectives
NEDC Cold	-	Vehicle emissions compliance under standard conditions
NEDC Hot	2	Emissions performance with hot engine Potential timer or hot vehicle condition triggering AES
NEDC w/o preconditioning Cold	2	Emissions performance on a cold started NEDC driving cycle without pre-conditioning of the vehicle, to check for the presence of a defeat device triggered by the vehicle conditioning
NEDC after grade Hot	2	Emissions performance on a hot started NEDC driving cycle after jacking up the car front, to check for the presence of a defeat device triggered by the vehicle inclination
NEDC +10% Cold	2	Vehicle emissions on a modified NEDC driving cycle driven with 10% higher speed, to check for the presence of a defeat device triggered by the driven distance
NEDC + Load Hot	2	Emissions performance with hot engine and additional engine loads (A/C and lights) Potential use of vehicle systems triggering AES
NEDC +10°C Cold	2	Emissions performance at low ambient temperature Temperature condition potentially triggering AES
NEDC +30°C Cold	2	Emissions performance at high ambient temperature Temperature condition potentially triggering AES
WLTC Cold	3	Emissions performance on WLTC Functioning of the ECS under controlled conditions beyond the NEDC duration and distance (22 minutes)
WLTC Hot	3	Emissions performance on WLTC Effect of hot engine and functioning of the ECS under controlled conditions beyond the NEDC duration and distance (22 minutes)
RDE	3	Emissions performance on road Functioning of the ECS under uncontrolled conditions and beyond the NEDC duration and distance (22 minutes)

² The categorization of the various types of tests is made by the responsible testing entity and should be based on the lessons learned from its own testing activities and/or the publicly available information. It is subject to adaptations and revisions depending on the emissions control technology.

Main results

Table 2 shows the main emissions findings when applying the test protocol to the vehicle.

Table 2: Tailpipe emissions performance

Type of test [Category]	Remarks	Comp. ³ or CF ⁴
NEDC cold	The vehicle is compliant for all pollutant emissions	Compliance OK
NEDC Hot [2]	The average CF for the NO _x emissions over hot NEDC cycles is 1.8 Under these conditions, the average NO _x emissions were higher when compared to the values obtained over a standard cold NEDC by a factor of ca. 3. This could be attributed to the lower EGR rates (See Figure 1)	CF Not OK RT _{NO_x} = 1.5 CF _{NO_x} = 1.8
NEDC w/o preconditioning Cold [2]	The average CF for the NO _x emissions over cold NEDC cycles is 0.8	OK RT _{NO_x} = 1.5 CF _{NO_x} = 0.8
NEDC after grade Hot [2]	The average CF for the NO _x emissions over hot NEDC cycles is 1.6 Under these conditions, the average NO _x emissions were comparable to those observed over the hot NEDC.	CF Not OK RT _{NO_x} = 1.5 CF _{NO_x} = 1.6
NEDC +10% Cold [2]	The average CF for the NO _x emissions modified cold NEDC cycles (+10% speed) is 1.1	OK RT _{NO_x} = 1.5 CF _{NO_x} = 1.1
NEDC + Load Hot [2]	The average CF for the NO _x emissions over hot NEDC cycle with additional engine load (A/C and lights on) is 1.4	OK RT _{NO_x} = 1.5 CF _{NO_x} = 1.4
NEDC +10°C Cold [2]	The average CF for the NO _x emissions over cold NEDC cycles at 10°C is 2.4 Under these conditions, the average NO _x emissions were higher when compared to the values obtained over a standard cold NEDC (at +23°C) by a factor of ca. 4. This could be attributed to the EGR valve functioning.	CF Not OK RT _{NO_x} = 1.5 CF _{NO_x} = 2.4
NEDC +30°C Cold [2]	The average CF for the NO _x emissions over cold NEDC cycles at 30°C is 1.7 Under these conditions, the average NO _x emissions were higher compared to the values obtained over a standard cold NEDC (at +23°C) by a factor of ca. 3. This could be attributed to the lower EGR rates (See Figure 1).	CF Not OK RT _{NO_x} = 1.5 CF _{NO_x} = 1.7
WLTC Cold [3]	The average CF for the NO _x emissions over cold WLTC cycle is 1.9	OK RT _{NO_x} = 5 CF _{NO_x} = 1.9
WLTC Hot [3]	The average CF for the NO _x emissions over hot WLTC cycle is 2.4	OK RT _{NO_x} = 5 CF _{NO_x} = 2.4
RDE [3]	The CF for the NO _x emissions over RDE routes varies between 3.6 and 3.8	OK RT _{NO_x} = 5 min. CF _{NO_x} = 3.6 max. CF _{NO_x} = 3.8

³ Compliance (Comp.) on Type 1 test versus the applicable limits

⁴ NO_x Conformity Factor (CF) versus the thresholds recommended in the Guidance. CFs exceeding the thresholds are indicative but may point at problematic emissions strategies

Additional information regarding the AES

Over the hot start NEDC driving cycles (types of test NEDC Hot and NEDC after grade Hot), and over the test conducted with +10°C and +30°C driving ambient temperature, this vehicle exhibited NOx emissions above the thresholds recommended in the Guidance.

Figure 1 shows the cumulative EGR usage over these tests together with the EGR usage over the cold started NEDC (shown in red).

For the cold start tests performed at +10°C and +30°C (Figure 1 - left panels), the cumulative NOx emissions was 4 and 3 times higher than those obtained at 23°C under standard condition (cf. Cumulative NOx in g). This difference can be explained by the lower usage of the EGR valve (cf. Cumul. EGR), with a decrease of 35% and 20% at +10°C and +30°C respectively compared to the tests done at +23°C.

For the hot start tests (NEDC Hot and NEDC after grade Hot, Figure 1 – right panels), the cumulative NOx emissions was ca. 3 times higher than those obtained over the cold started NEDC at 23°. This difference can also be explained by the lower usage of the EGR valve, with a decrease of 35% compared to the cold started NEDC done at +23°C.

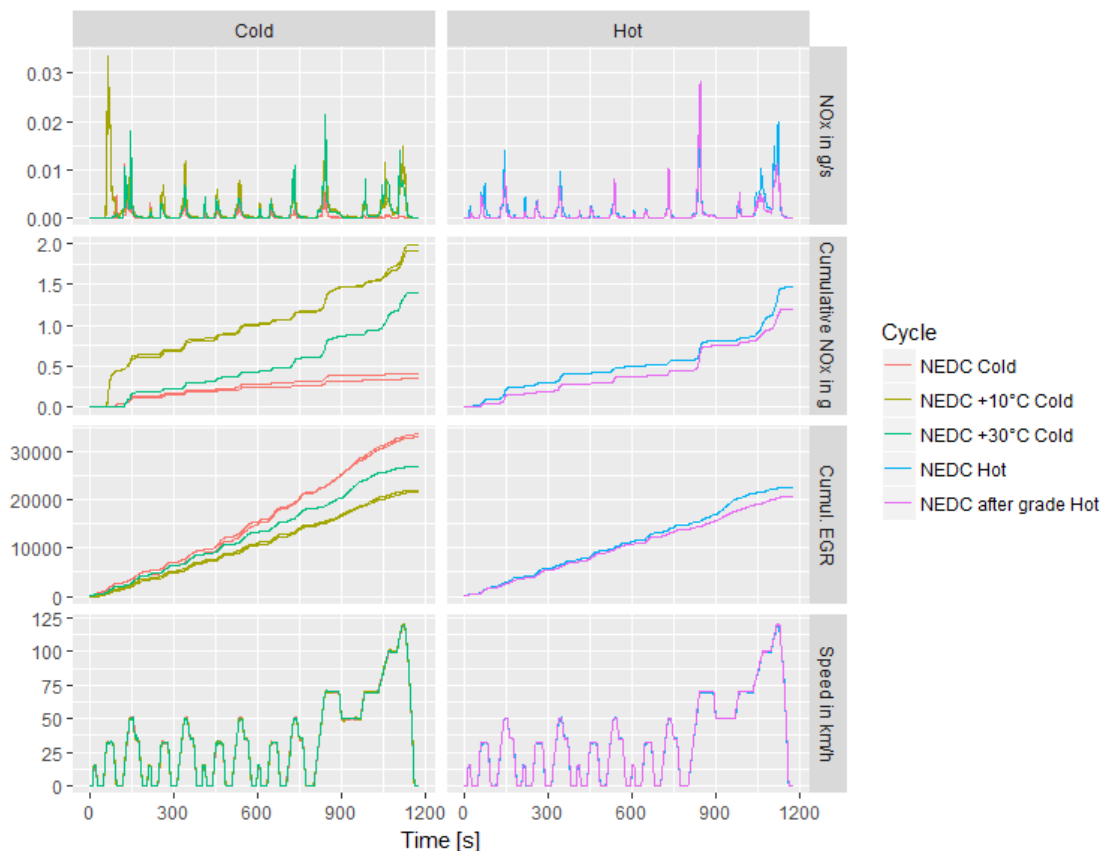


Figure 1: NOx emission (first row), NOx cumulative emission (second row), cumulative EGR (third row) and velocity (fourth row) of the vehicle over the cold started (left column) and hot started (right column) NEDC tests.

Appendix - Vehicle Report - Anonymized Vehicle [XX001]

November 22, 2017

A. Vehicle details

Table 1: Vehicle specification. RL stands for road load, with Inertia, F0, F1 and F2 in kg, N, N/(km/h) and N/(km/h)² respectively. NA stands for not available (vehicle covers by a non-disclosure agreement).

Vehicle OEM:	NA
Vehicle Model:	NA
Vehicle Class:	M1
Vehicle Code:	XX001
Fuel Type:	Diesel
Injection:	Common Rail
Emissions Control Technologies:	DOC+EGR+SCR+DPF
Model Year:	2017
Vehicle Identification Number:	NA
Homologation Number	NA
Emissions Standard:	Euro6b
Odometer Reading:	6479
Transmission Type:	Automatic
Number of Gears:	8
Engine Capacity in cm3:	2967
Rated Power in kW:	193
Tyre Dimensions:	NA
RL coefficients NEDC	Inertia: 2270, F0: 134.5, F1: 0.36, F2: 0.056
RL coefficients WLTC	Inertia: 2390, F0: 194, F1: 0.37, F2: 0.059
Declared CO2 value in g/km:	179

B. Tests conducted

Table 2: Laboratory tests conducted

Type	Repeats	Category of procedure
Standard NEDC acc. ECE R83	3	Reproducing the Type 1 test
NEDC - Hot vehicle	2	Category 2
NEDC w/o conditioning - Cold vehicle (+4h)	2	Category 2
NEDC after applying grade - Hot vehicle	2	Category 2
NEDC with +10% speed - Cold vehicle (+4h)	2	Category 2
NEDC with load (A/C) - Hot vehicle	2	Category 2
NEDC @ +10°C - Cold vehicle (+4h)	2	Category 2
NEDC @ +30°C - Cold vehicle (+4h)	2	Category 2
WLTC - Cold vehicle	2	Category 3
WLTC - Hot vehicle	2	Category 3

Table 3: On-road tests conducted

Type	Repeats	Category of procedure
RDE Route 1 (Esperia)	2	Category 3
RDE Route 2 (Labierna)	2	Category 3

Categories of procedure included in Tables 2 and 3 are those proposed in the Commission Guidance (Commission Notice of 26.1.2017 - Guidance on the evaluation of Auxiliary Emission Strategies and the presence of Defeat Devices).

Generic test protocol: Version 10/08/2016

Application by the JRC: Version 10/08/2016

C. Laboratory Emissions Results

- Average results for the repeated tests

Table 4: Average laboratory emissions.

Type	NOx [mg/km]	THC [mg/km]	CO [mg/km]	CO2 [g/km]	PN [E+9/km]
NEDC Cold	47.1	14.8	156	202	10.4
NEDC Hot	146	3	20.4	185	28
NEDC w/o preconditioning Cold	61.7	14	130	203	70
NEDC after grade Hot	128	3.3	20.7	189	49.5
NEDC +10% Cold	89.8	11.2	144	218	18
NEDC + Load Hot	114	3.4	7	213	61.2
NEDC +10°C Cold	194	12.1	155	217	23
NEDC +30°C Cold	134	9.9	157	194	13.1
WLTC Cold	155	4.6	155	222	26.7
WLTC Hot	196	1.2	62.6	216	55.2

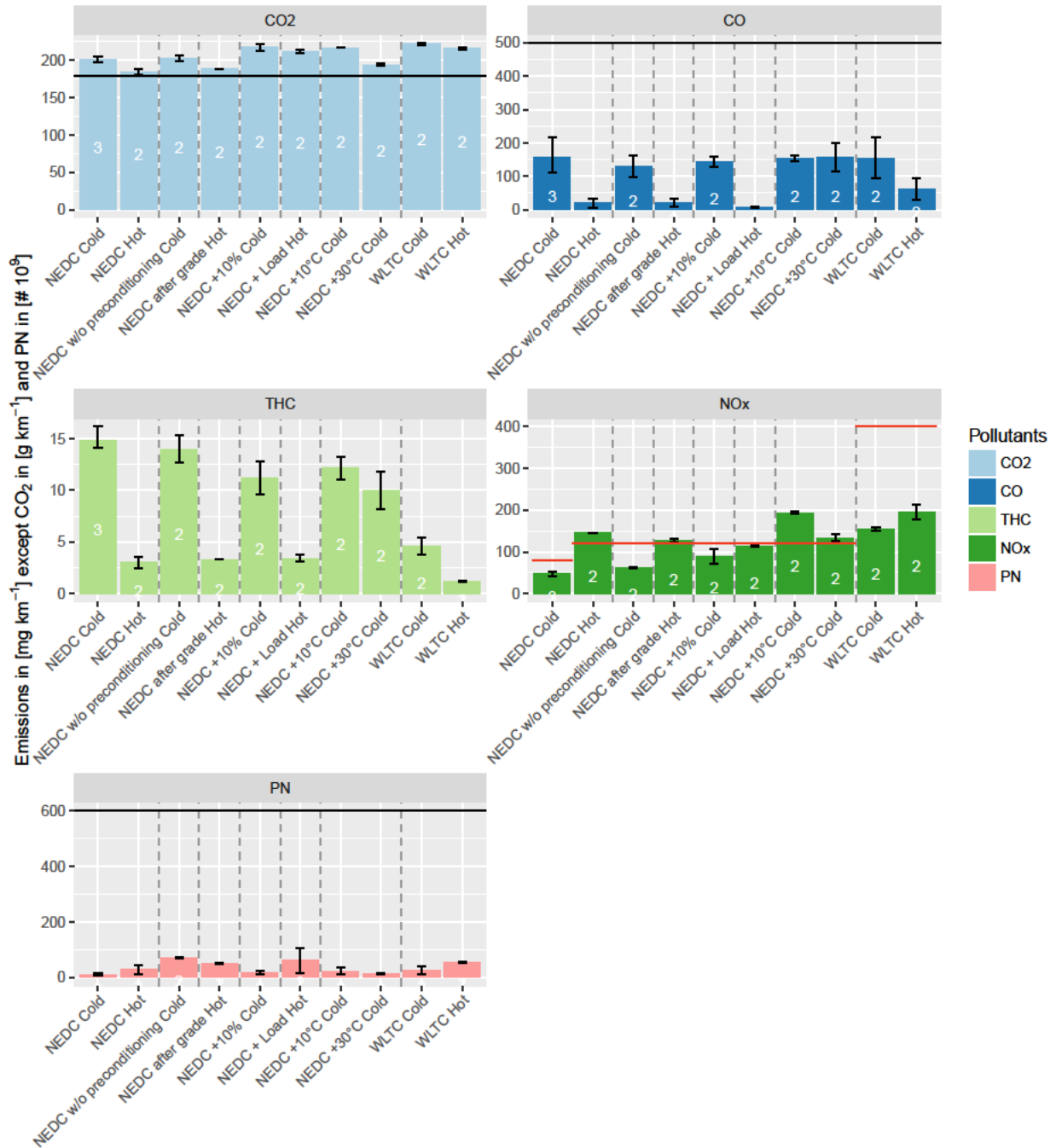


Figure 1: Emissions measured during laboratory tests. Error bars stand for min and max values. Numbers in the bars stand for the number of test. The horizontal line displayed on the CO₂ panel stands for the declared CO₂ emission factor displayed in the type approval certificate of the vehicle (179 g/km). The horizontal lines displayed on the CO and PN panels stand for Euro6 standards (500 and 6x10¹¹ #/km respectively). The red horizontal lines displayed on the NO_x panel stand for Euro6b standards including the indicative thresholds proposed in the Commission Guidance.

D. PEMS Emissions Results

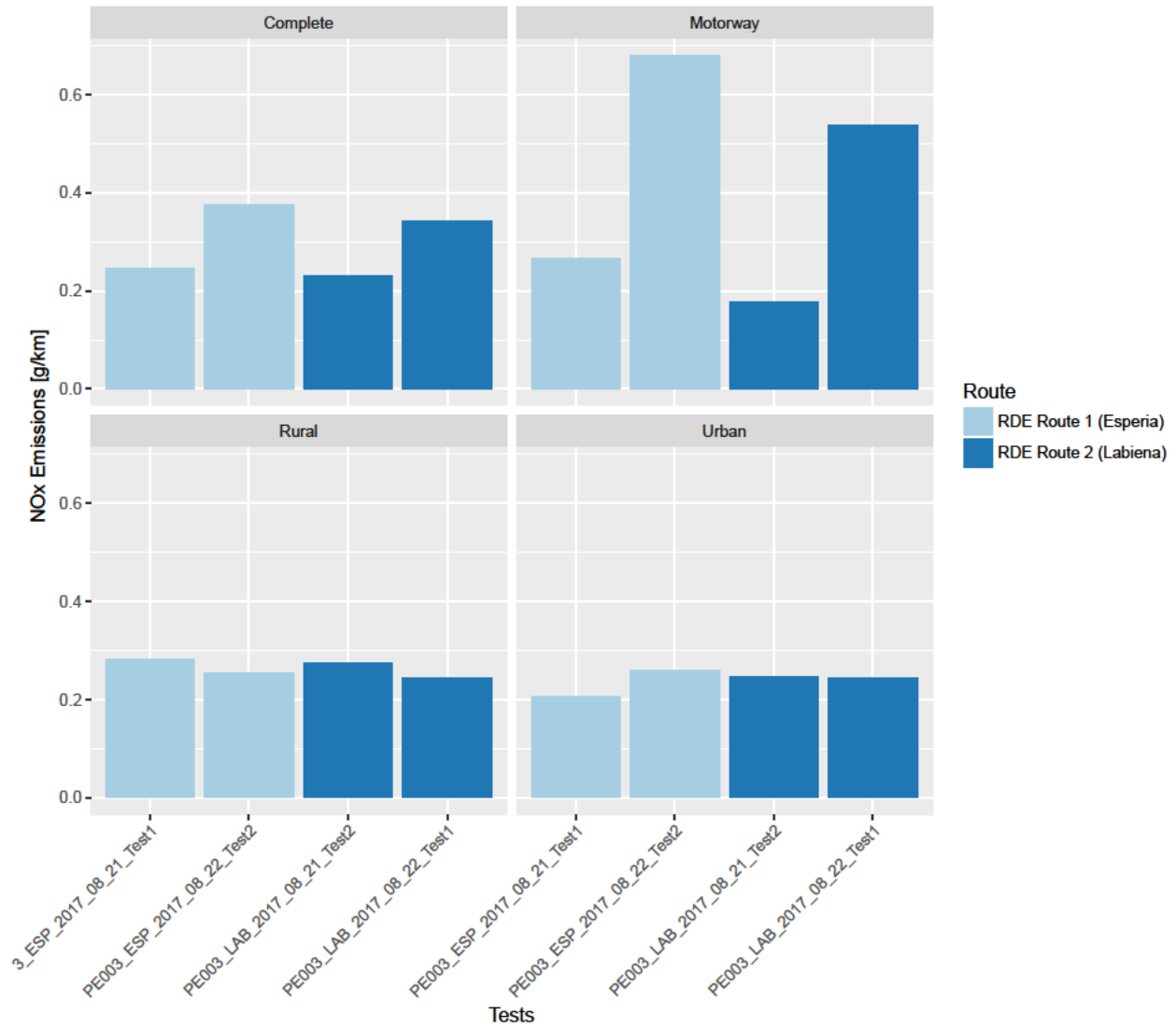


Figure 2: Emissions measured during on-road tests. The complete panel displays the overall NO_x emissions obtained during the complete routes (not processed according to the RDE rules). The Urban, Rural and Motorway panels display the detailed NO_x emissions over the different phases of the routes.

E. Comparison of Laboratory and PEMS results

Table 5: Average laboratory and PEMS emissions. NO_x emissions display for RDE tests were processed according to the RDE3 rules. ‘CF NO_x’ stands for NO_x conformity factor (NO_x emissions/NO_x Euro6 standards). ‘RT NO_x’ are the recommended thresholds proposed in the Commission Guidance. ‘CO₂ diff.’ stands for the relative difference between the CO₂ measured and the declared CO₂ emission.

Type	Repeats	NO _x [mg/km]	CF NO _x	RT NO _x	CO ₂ [g/km]	CO ₂ diff. [%]
NEDC Cold	3	47.1	0.6	1	202	12.8
NEDC Hot	2	146	1.8	1.5	185	3.2
NEDC w/o preconditioning Cold	2	61.7	0.8	1.5	203	13.3
NEDC after grade Hot	2	128	1.6	1.5	189	5.4
NEDC +10% Cold	2	89.8	1.1	1.5	218	21.7
NEDC + Load Hot	2	114	1.4	1.5	213	18.8
NEDC +10°C Cold	2	194	2.4	1.5	217	21.2
NEDC +30°C Cold	2	134	1.7	1.5	194	8.4
WLTC Cold	2	155	1.9	5	222	24.1
WLTC Hot	2	196	2.4	5	216	20.5
RDE Route 1 (Esperia)	2	303	3.8	5	214	19.7
RDE Route 2 (Labierna)	2	286	3.6	5	215	20.1

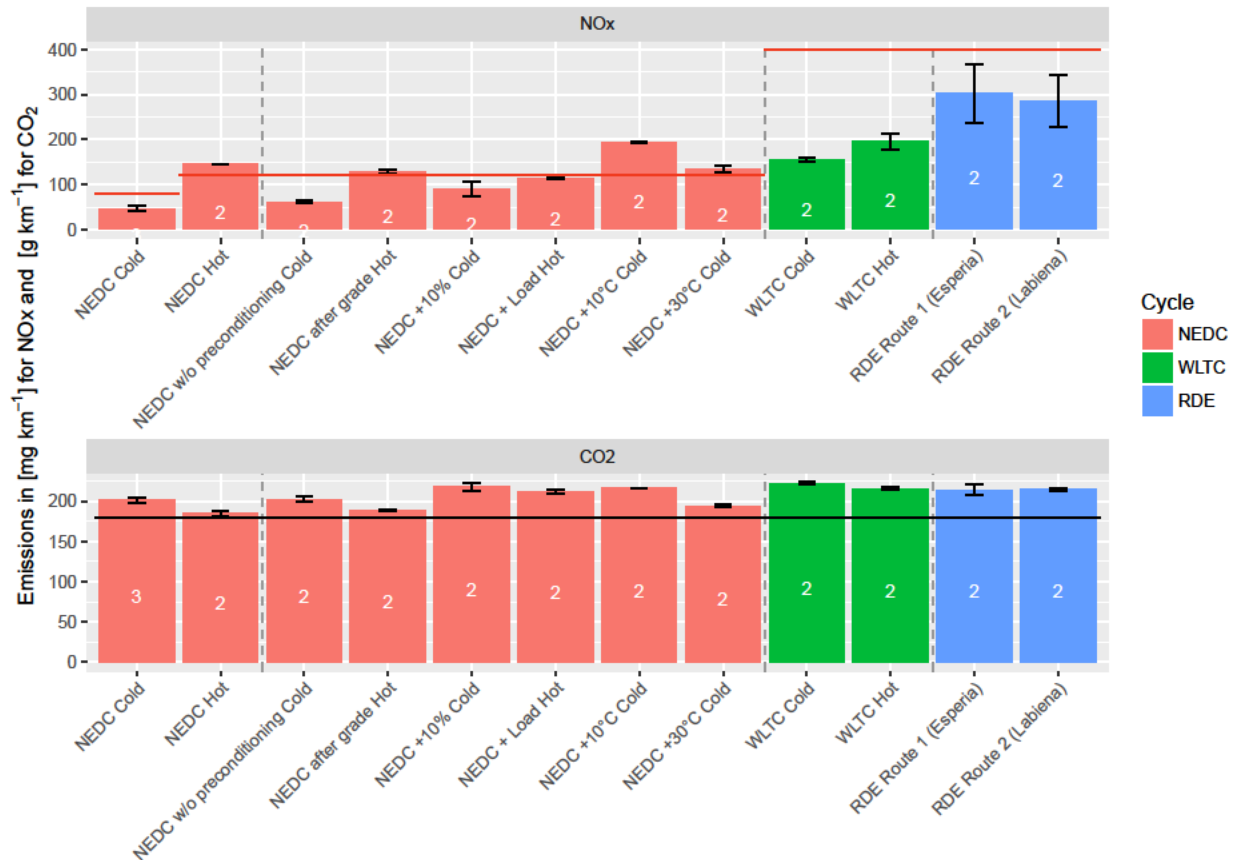


Figure 3: Emissions measured during laboratory and on-road tests. Error bars stand for min and max values. Numbers in the bars stand for the number of test. On the top panel, the horizontal red lines stand for Euro6 standards and the recommended thresholds proposed in the Commission Guidance. On the bottom panel, the horizontal line stands for the declared CO₂ emission factor displayed in the type approval certificate of the vehicle (179 g/km).