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# Emissions and fuel consumption tests

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Summary

This report summarizes the work conducted by EMISIA SA and LAT in the context of a testing campaign and experimental study for Transport & Environment (T&E), supported by the European Commission Life+ Programme in the context of "Close the Gap" campaign. The work is related to the emissions testing on three vehicles of different technology, all of which Euro 6d-temp compliant, and under various driving conditions, both in laboratory and on-road. To this aim, a Portable Emissions Measuring System (PEMS) was employed for RDE measurements, while two driving cycles (NEDC, WLTC) were tested for each vehicle on the chassis dyno of LAT. On-road testing included three different routes, a smooth one being compliant with RDE regulation, a one also being compliant with RDE regulation and an aggressive one characterized by abrupt driving and high altitude. The lab testing included measurements conducted according to the relevant regulations for NEDC and WLTP procedures. All lab testing was conducted using real-world road load, determined by a coast-down test.

Keywords
RDE, PEMS, Emissions measurement, NEDC, WLTP, real-world driving

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# Contents

# 1 Introduction

This report summarizes the work conducted by EMISIA SA and LAT in the context of a testing campaign and experimental study for Transport & Environment (T&E), supported by the European Commission Life+ Programme in the context of "Close the Gap" campaign. The work is related to the emissions testing on three vehicles of different technology, all of which Euro 6d-temp compliant, and under various driving conditions, both in laboratory and on-road using a Portable Emissions Measuring System (PEMS). Emisia is an official spin-off company of the Aristotle University of Thessaloniki/Laboratory of Applied Thermodynamics (LAT/AUTh) and has taken over the area of road transport emission inventories and projections, through a special contract with the Aristotle University of Thessaloniki.

In the following sections of this report, the methodology is described together with its implementation in the testing campaign, followed by the presentation of the results, separately for each vehicle and for all the testing conditions and measurements conducted.

## 1.1 Background

The "Transport and Environment" commissioned laboratory and real-world PEMS emission measurements to monitor the emissions of modern passenger cars, in order to better understand the underlying reasons for the in-use discrepancies, both for $CO_2$ and exhaust emissions and to develop solutions for more realistic vehicle testing in the future. In this context, T & E was particularly interested in better understanding the role of driving styles in compliant RDE routes and additionally to check if extended conditions routes can significantly affect emissions. At the same time, these measurements need to be compared with the chassis dyno testing.

The objective of the study was to collect instantaneous emissions data, including $CO_2$, from a Euro 6d-temp diesel (Segment C), one Euro 6d-temp gasoline GDI (Segment B) and one Euro 6d-temp gasoline MPI (Segment A) passenger cars over a number of representative test routes. The measurements were conducted in accordance to the provisions of the RDE procedure for the compliant routes. The work covered mainly the testing activity. In addition data were collected by chassis dyno testing.

## 1.2 Objectives of the work

The principal objectives of this contract were:

- To assess vehicle behavior and emissions during real-world driving with on-road testing.
- To evaluate the emissions performance of three modern vehicles with different engine and after treatment technologies in chassis dyno testing.
- To properly present the above in a final report.

# 2 Methodology & Implementation

## 2.1 Vehicle sample

The Segment category of the three vehicles tested in this study was chosen by the Transport and Environment and they were sourced by Emisia SA. More specifically the three vehicles tested were:

- Vehicle 1 (Segment C, diesel, NSC+DPF): Honda Civic 1.6 iDTEC
- Vehicle 2 (Segment B, GDI, 3WC+GPF): Ford Fiesta 1.0 EcoBoost
- Vehicle 3 (Segment A, MPI, 3WC): Opel Adam 1.4

All three vehicles were procured by rental companies. It should be mentioned that at the time of measurements, the number of Euro 6d-temp registered vehicles was limited, as the relevant regulation was very recently imposed. So procurement of the vehicles was a major task of this project. In addition, the Segment B and Segment A vehicles were brand new (0 km in odometer) so they were run for a thousand kilometers each, before testing, on T&E's request, on open and public roads during week days with normal driving by following traffic flows in a mix of urban, rural, motorway. More details concerning the technical specifications of each vehicle are provided in the next section, followed by the results and discussion.

## 2.2 Description of the experimental campaign

The present experimental campaign concerned the evaluation of emissions performance of the three vehicles mentioned above. Before starting each test, vehicles were checked for being in good running order (level of operating liquids such as oil and coolant, tyre pressures, error codes on OBD scan tool etc.). OBD readings were made during all tests (on-road and laboratory) to get more information like oil and coolant temperatures, engine speed, vehicle speed etc. The following tests were performed on each vehicle:

- On-road testing over different routes covering both the requirements of the current Real Driving Emissions (RDE) regulation and the conditions of more aggressive driving at higher altitudes. When the requirements of Real Driving Emissions (RDE) regulation were covered, two driving styles were employed (smooth and dynamic).
- Coast-down testing in a suitable track, in order to derive the realistic Road Load (RL) of each vehicle.
- Laboratory testing under the NEDC and WLTP regulation procedures, applying realistic Road Load.

### 2.2.1 On-road testing

The first part of this experimental campaign was the on-road testing of the vehicles. The measurements were conducted with a Portable Emissions Measuring System (PEMS) that is available at LAT (Figure 1). This system consisted of the "AVL GAS PEMS iS" which was measuring the gaseous emissions, the "AVL PN PEMS" for particulate number measurements, the "AVL M.O.V.E. E.F.M." exhaust flow meter and the "AVL M.O.V.E. SYSTEM CONTROL", with main technical features as given in Table 1. All of the technical specifications of the PEMS used are illustrated in Appendix I.

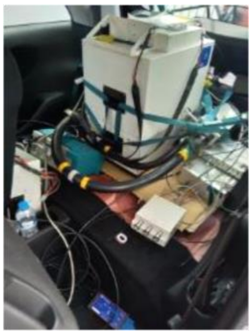
| | |
|---|---|
| <br>Honda Civic 1.6 iDTEC with PEMS | <br>Honda Civic 1.6 iDTEC with PEMS |
| <br>Ford Fiesta 1.0 EcoBoost with PEMS | <br>Ford Fiesta 1.0 EcoBoost with PEMS |
| <br>Opel Adam 1.4 with PEMS | <br>Opel Adam 1.4 with PEMS |

**Figure 1:** PEMS installed on the tested vehicles.

**Table 1:** Main technical characteristic of the PEMS used

| Gas | Range | Accuracy |
|---|---|---|
| CO | Linearized range: 0 – 49999 ppm<br>Display range: 0 – 15% vol | 0-1499 ppm: ±30 ppm abs<br>1500-49999 ppm: ±2% rel. |
| $CO_2$ | 0 – 20% vol | 0-9.99% vol: ±0.1% vol abs<br>10-20% vol: ±2% rel. |
| NO | 0 – 5000 ppm | ±0.2% FS or ±2% rel. |
| $NO_2$ | 0 – 2500 ppm | ±0.2% FS or ±2% rel. |
| $O_2$ | 0 – 25% vol | ±1% FS |

On-road testing was conducted in the city of Thessaloniki (Greece) and its suburbs and included two different trips, as follows:

- One trip complying with the RDE regulation, employing two different driving styles (smooth and dynamic).
- One trip representing the conditions of more aggressive driving at higher altitudes (extended conditions route).

➢ **RDE compliant trips: Smooth and Dynamic RDE trip**

These routes have been designed according to the regulation for RDE testing of light passenger and commercial vehicles. It consists of three separate parts, namely Urban, Rural and Motorway, driven in this order. Figure 2 illustrates this route and Table 2 gives its characteristics for the two different driving styles. In addition, Table 3, illustrates the different driving dynamics of the two compliant routes. The figures of these tables are average values of all the trips conducted. As shown below, the chosen trip meets all the requirements of the regulation. In addition, it has been tested on normal working days and all the characteristics were within the specified limits.


**Figure 2:** The route for measuring RDE emissions, complying with the regulation

**Table 2:** Characteristics of the two compliant RDE routes

| Parameter | RDE Smooth | RDE Dynamic | Regulation limits |
|---|---|---|---|
| Trip distance [km] | 75 | 75.53 | >48 |
| Trip duration [min] | 95.33 | 92 | 90-120 |
| Maximum speed [km/h] | 126.67 | 128.33 | 145 |
| Altitude difference end-start [m] | 52.6 | 54.37 | ±100 |
| Road type sequence | Urban-Rural-Motorway | Urban-Rural-Motorway | Urban-Rural-Motorway |
| Road type distance share (Urban-Rural-Motorway) [%] | 35.67-36.33-28 | 36.67-36.67-27.33 | Approximately 34-33-33 (±10% deviation is allowed) |

**Table 3.** Driving dynamics of the two compliant RDE routes.

| | | Boundaries defined in the regulation | RDE smooth | RDE dynamic |
|---|---|---|---|---|
| RPA | Urban | > 0.13 | 0.18 | 0.24 |
| | Rural | > 0.057 | 0.11 | 0.18 |
| | Motorway | > 0.03 | 0.10 | 0.16 |
| $VA_{pos}$ 95% | Urban | < 18.18 | 10.6 | 13.5 |
| | Rural | < 24.4 | 15.0 | 18.0 |
| | Motorway | < 26.68 | 15.7 | 17.6 |
| Average speeds | Urban | 15-40 km/h | 27 | 28 |
| | Rural | 60-90 km/h | 72 | 76 |
| | Motorway | >90 km/h | 102 | 106 |
| Test Duration | - | 90-120 min | 95 | 92 |
| Maximum Velocity | - | > 110 km/h | 127 | 128 |
| Time Integral of the Velocity >100km/h | - | > 5 min | 6.5 | 8.3 |
| Number of Stops | - | | 19.00 | 19.00 |
| Acceleration Points | Urban | > 150 | 1154 | 1190 |
| | Rural | > 150 | 438 | 504 |
| | Motorway | > 150 | 251 | 303 |

- **<u>Extended conditions driving trip: Non-Compliant RDE route</u>**

This trip has been designed in order to represent a route with more aggressive characteristics than the previous one. It also consists of Urban, Rural and Motorway parts, but these are not necessarily driven in a specified sequence. It includes uphill/mountain driving with the maximum altitude difference between the highest and the lowest point in the order of 890 m. Figure 3 illustrates this route and Table 4 summarizes its average characteristics for all trips conducted.

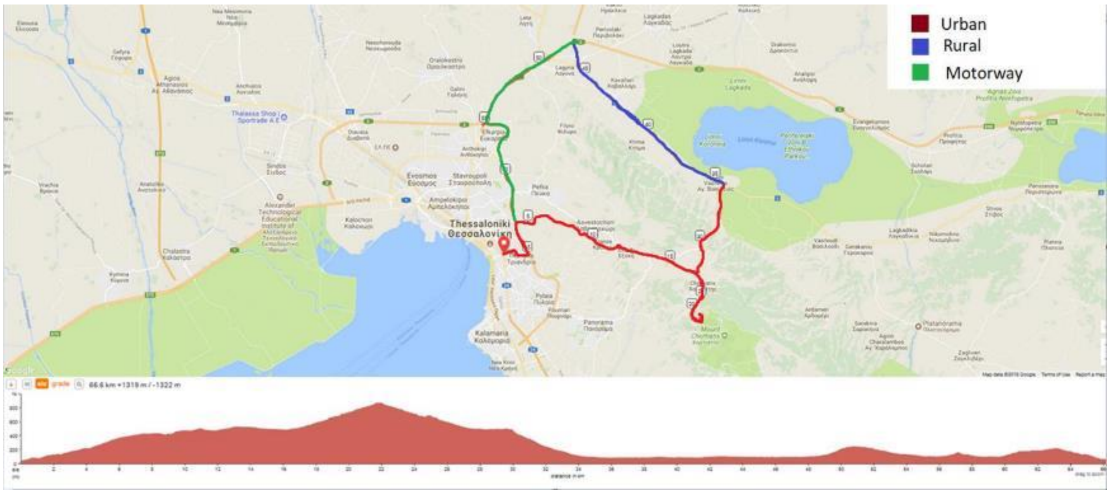



**Figure 3:** The route for measuring RDE emissions during extended conditions driving

**Table 4:** Characteristics of the extended conditions driving trip.

| Parameter | Non-Compliant RDE Route |
|---|---|
| Trip distance [km] | 65.13 |
| Trip duration [min] | 127.71 |
| Average speed [km/h] | 31.15 |
| Maximum speed [km/h] | 139.71 |
| Altitude difference end-start [m] | 5.89 |
| Max Slope (Uphill/Downhill) [%] | 10.15%/13.1% |
| Average Slope [%] | 0% |
| Elevation [m] | 892.73 |

### 2.2.2 Coast-down testing

After completing the on-road testing and before bringing the vehicle in the laboratory, the coast-down test was conducted. This test consists of free deceleration (gearbox in neutral) of the vehicle after having accelerated up to a speed of 130 km/h and it is intended to provide the actual resistance applied on the vehicle during road driving. This resistance is the so-called "realistic RL" and it may differ from the one provided by the manufacturer and used for Type Approval testing (hereinafter called "TA RL") by up to 30-70%, affecting accordingly fuel consumption and $CO_2$ emissions. This deviation between the two RLs is attributed to various reasons, such as different vehicle configuration, affecting aerodynamic resistance and weight, or different tires, affecting rolling resistance.

Coast-down testing was performed in a suitable test track with totally level road. The site which was used for this testing which was consisting of a public road driving to a dead end (Figure 4), without any traffic. The test was conducted in both directions of the road, in order to eliminate any wind effects. Road load using was determined with the NEDC and WLTP-High test masses, as estimated by data declared in the certificates of conformity of the vehicle (Appendix II), and especially by assuming that the test mass declared is more likely to approach the WLTP-Low test mass.

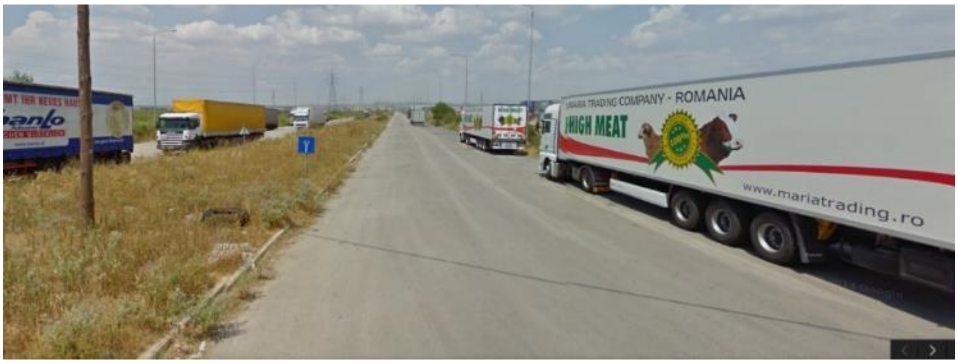



**Figure 4:** The site used for coast-down testing

#### 2.2.3 Laboratory Testing

With the RL determined from the coast-down test, for both NEDC and WLTP-High test masses, the laboratory tests were conducted on the chassis dyno of LAT (Figure 5). The typical test protocol is presented in Figure 6.


**Figure 5:** LAT chassis dyno (left) and chassis dyno control station (right)

| Test details | Dyno Setting Day | Test Day | Dyno Setting Day | Test Day |
|---|---|---|---|---|
| | **Day S1** | **Day T1** | **Day S2** | **Day T2** |
| **Road load** | NEDC Road Load | NEDC Road Load | WLTP-High Road Load | WLTP-High Road Load |
| **Test temperature** | 25 °C | 25 °C | 23 °C | 23 °C |
| **Tests** | coast-down for dyno setting with NEDC road load measured with coast down, using appropriate test mass. | cold NEDC<br>bag analysis | coast-down for dyno setting with WLTP-High road load measured with coast down, using appropriate test mass. | cold WLTC<br>bag analysis |
| **Conditioning for next day** | 3 x EUDC (diesel), 1 x NEDC+ 2 x EUDC (gasoline) | Change of dynamometer mechanical inertia | 1 x WLTC | |
| **Soak temperature for next day testing** | 25°C | 23°C | 23°C | -- |

**Figure 6:** Typical test protocol for laboratory testing

In summary, laboratory testing included the following:

- NEDC tests with NEDC test mass road load.
- WLTC tests with the WLTP High test mass road load.
- Emissions of gas pollutants: $CO_2$, CO, HC, NO/$NO_x$. From the bag values of gas pollutants fuel consumption has also been calculated.
- Particle mass (PM), with the filter paper method, and particle number (PN).

The analytical equipment available at LAT was employed for the measurements, which have been conducted according to the relevant regulations.

# 3 Results

All three vehicles were tested in the "smooth" and "dynamic" RDE compliant routes, as long as in the extended conditions non-compliant RDE route. For every vehicle, one repetition was conducted for each RDE compliant route two repetitions for the non-compliant RDE route, at least. The aggregated emission results (g/km) of all RDE tests were calculated simply as a division of the cumulative emission mass by the total driven distance. The dry to wet correction according to RDE 3 regulation has been applied to these results and the corrected $CO_2$ and CO emissions are illustrated in Appendix VII for all vehicles. The results presented in the main body of the report as "raw" data did not undergo the above correction. Because of the RDE $4^{th}$ package was not yet published yet in the Official Journal at the time when the testing report was written, focus was made on CLEAR and EMROAD methods instead. So for the compliant RDE tests, the emission results were calculated using the above two methods, as defined in the three first RDE packages.

Figure 7 and Figure 8 depict the measured velocity and altitude profile for the "smooth" and "compliant" RDE routes respectively. All test repetitions with the three selected vehicles followed the same driving route and profiles. In Figure 7 and Figure 8, the urban, rural and motorway parts of the RDE-compliant trips are clearly distinguished from the velocity pattern. The differences between the RDE-compliant and the extended conditions tests can be clearly seen in Figure 9. This route includes driving in higher altitude, meaning uphill and downhill, characterised also by abrupt accelerations, without clear discrimination of urban, rural and motorway parts.

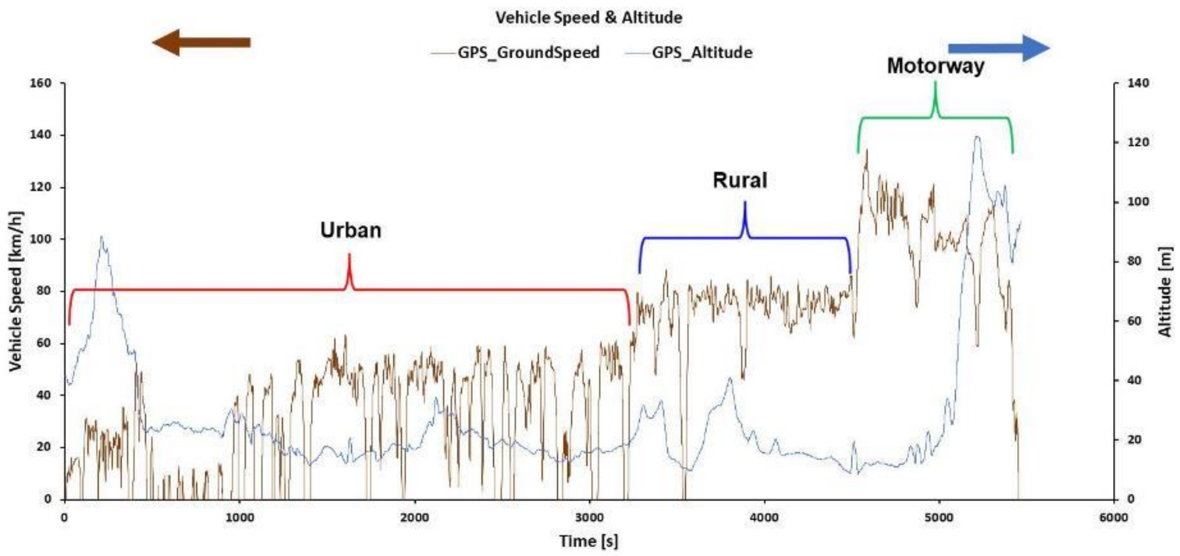



**Figure 7**: Vehicle velocity and altitude profile, following the RDE-compliant "smooth" route

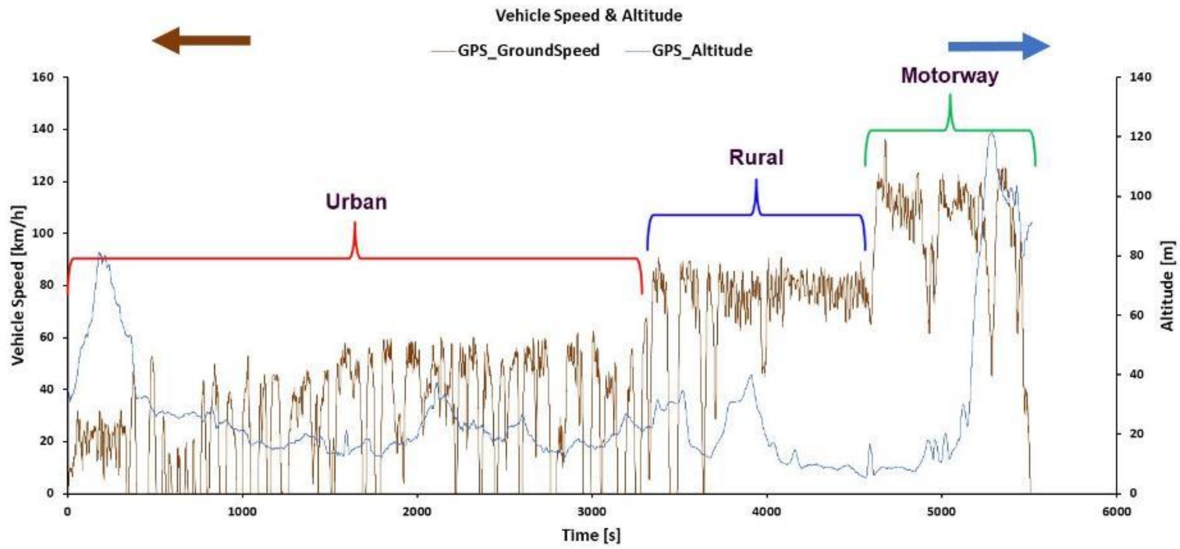



**Figure 8:** Vehicle velocity and altitude profile, following the RDE-compliant "dynamic" route.

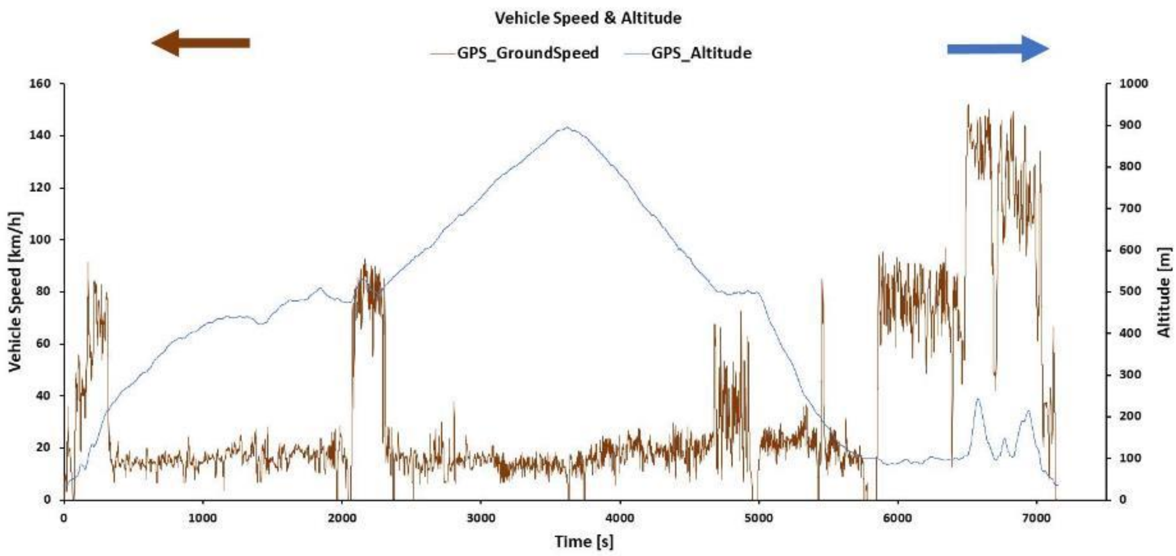



**Figure 9**: Vehicle velocity and altitude profile, following the extended conditions RDE non-compliant route

Concerning laboratory testing, Figure 10 presents the velocity profiles of the driving cycles tested. As stated, previously, cold start tests were conducted for NEDC and WLTC, following the relevant regulation and using different road loads. The following sub-sections present the results for each vehicle, beginning with the on-road tests and continuing with the coast-down and the laboratory tests.

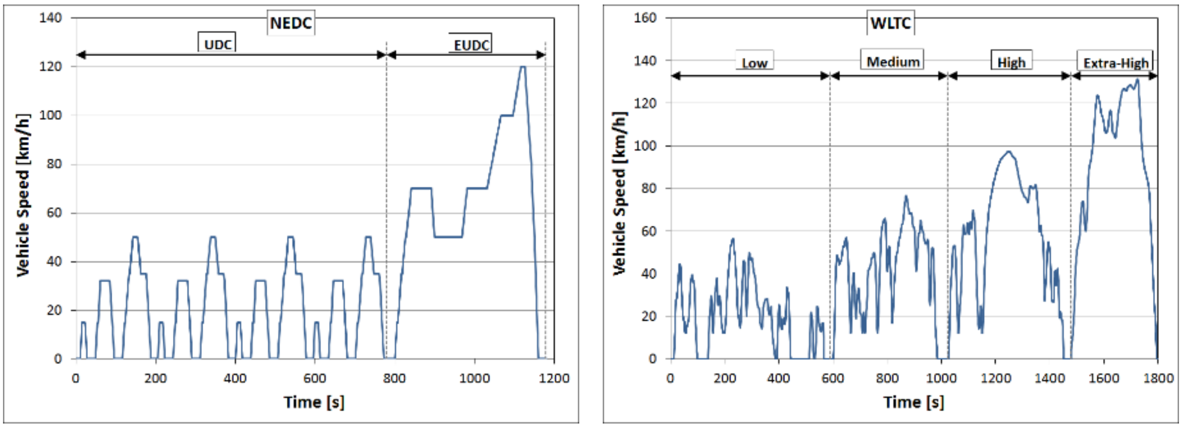



**Figure 10:** Vehicle speed profile for the driving cycles run in laboratory testing

The WLTP instantaneous measurements were used as input to the $CO_2$MPAS tool, to predict the NEDC $CO_2$ emissions.

## 3.1 Vehicle 1: Honda Civic 1.6 iDTEC

### 3.1.1 On-Road Testing

The Honda Civic 1.6 iDTEC was the only diesel vehicle tested in the context of this study. The main technical specifications of this vehicle are presented in Table 5, while Table 6 summarizes the valid on-road tests conducted. The vehicle, by default, had the "start-stop" operation and the "eco" driving mode activated, when the car was switched on. Apart from the standard two compliant and two non-compliant RDE tests, one additional test where regeneration occurred, was included.

**Table 5:** Honda Civic 1.6 iDTEC technical specifications.

| | |
|---|---|
| Car segment | C |
| Fuel type | Diesel |
| Engine architecture | In-line 4 cylinders, turbocharged |
| Engine capacity [$cm^3$] | 1597 |
| Max power [kW] | 88 |
| Start-stop | Yes by default (deactivated during lab testing) |
| Eco Mode | Yes |
| Transmission | Manual, 6 gears |
| Euro standard | Euro 6d-temp |
| After-treatment system | DOC, DPF, LNT |
| Tyres | Continental, Premium Contact 6, 235/45 R17 |
| Tyre pressure (Front / Rear) [psi] | 32 / 32 |
| Registration | March 2018 |

**Table 6**: Honda Civic 1.6 iDTEC test summary

| Date of Test | Mileage (start of testing) [km] | Description of Route | Ambient temperature during test (min-max)/average °C |
|---|---|---|---|
| 18/07/2018 | 7661 | Non-compliant, Extended conditions, Hot start engine (Experimental purposes) | (29.35-38.01)/ 33.14 |
| 19/07/2018 | 7900 | Non-compliant, Extended conditions, Cold start engine | (20.93-29.15)/ 24.65 |
| 21/07/2018 | 8202 | Compliant, Smooth, Cold start engine | (26.05-31.80)/ 30.48 |
| 21/07/2018 | 8335 | Non-compliant, Extended conditions, Cold start engine (regeneration occurred) | (22.40-31.59)/ 26.16 |
| 23/07/2018 | 8579 | Compliant, Dynamic, Cold start engine | (23.46-32.37)/ 28.99 |

Figure 11 summarizes the gaseous emissions raw results for all the tests conducted. It can be seen that for the compliant RDE tests (both smooth and dynamic) all emission values are below the regulation limits while for the extended conditions, non-compliant tests NOx emissions are approximately 9 times higher than the compliant dynamic RDE test. In addition, $CO_2$ emissions of the non-compliant tests are approximately 2 times higher than the $CO_2$ emissions of the compliant tests. The PN emissions are illustrated in Figure 12. It should be noted that in one of the non-compliant, extended conditions measurements regeneration occurred, as identified by the second by second data shown in Figure 13. It can be clearly seen that a sudden increase of the PN emissions occurred between 2500s and 4000s. Considering the duration of this event and the high PN emissions, it can be concluded that DPF regeneration took place. It should be noted that all PN measurements, including the measurement were regeneration occurred are laying below the regulations limits. The second by second data which include the instantaneous gaseous and PN emissions, instantaneous engine and vehicle speed OBD readings, the air-fuel equivalence ratio (λ) and the battery and alternator currents, are given in Appendix III, to help the reader evaluate the results.

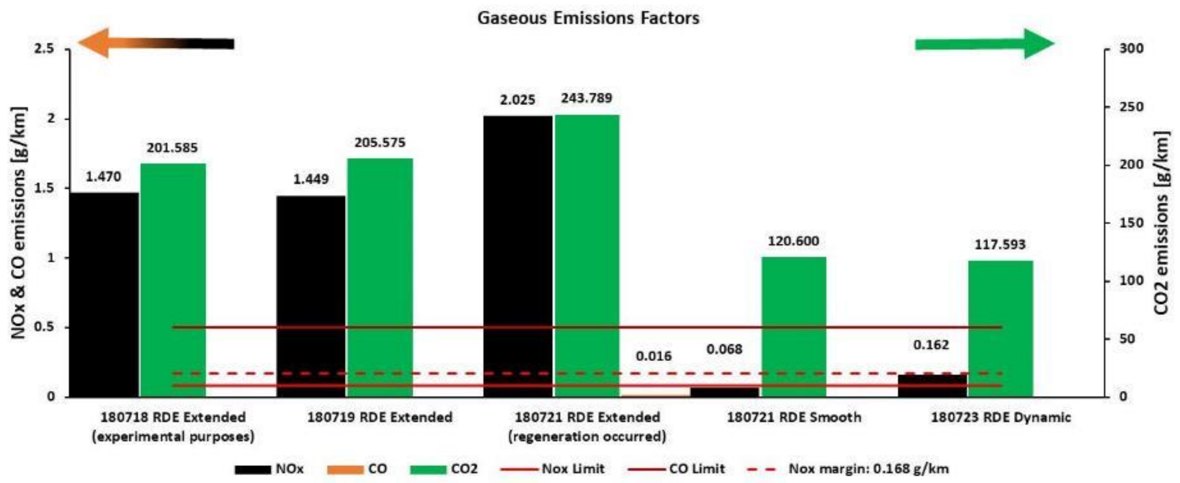



**Figure 11:** Gaseous emissions of the total trip.

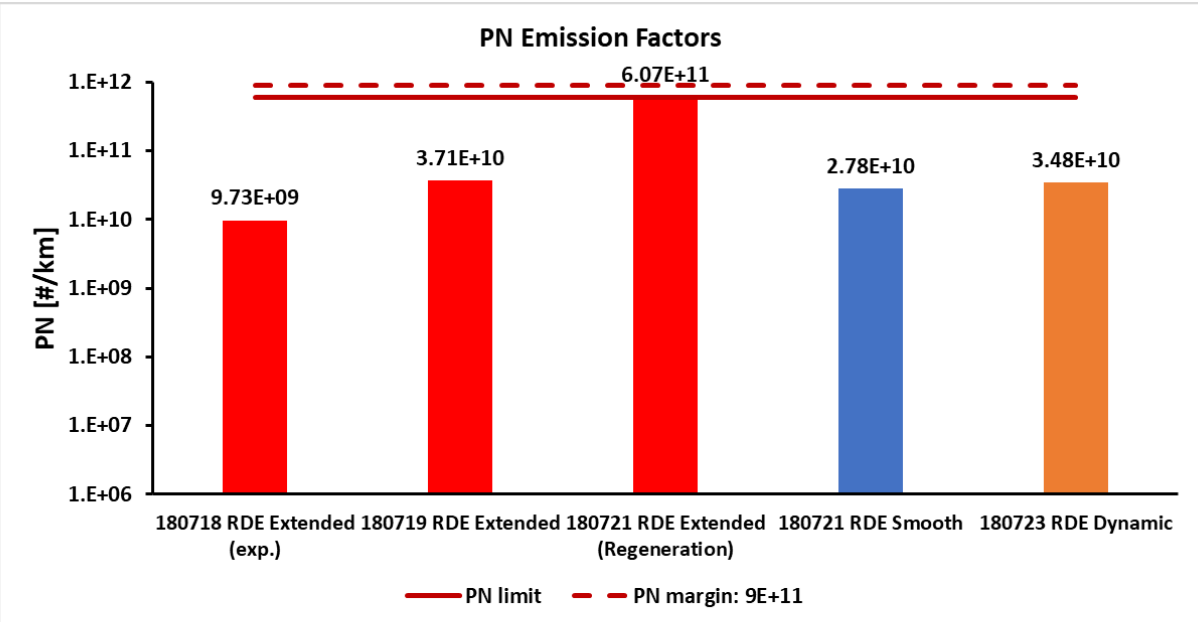



**Figure 12:** PN emissions of the total trip.

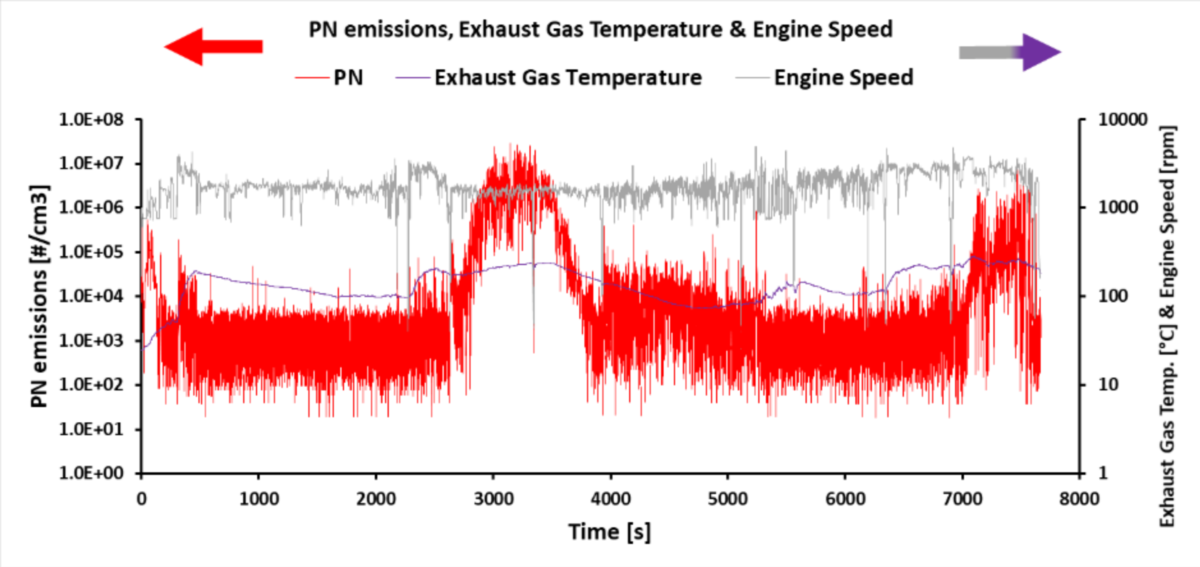



**Figure 13.** Second by second data that show the regeneration event (extended conditions, non-compliant RDE test).

Figure 14 and Figure 15 illustrate the aggregated gaseous emissions (g/km) calculated with the CLEAR and EMROAD methods, for the compliant RDE trips. It can be seen that emissions calculated with these two methods present differences with the emissions calculated by simply the division of the cumulative emission mass by the total driven distance (labelled as "raw"), with the EMROAD method being in better agreement with the raw results. It is worth noting that CLEAR method calculated approximately 40% lower [g/km] NOx and 25% lower [g/km] $CO_2$ in comparison with the raw data.

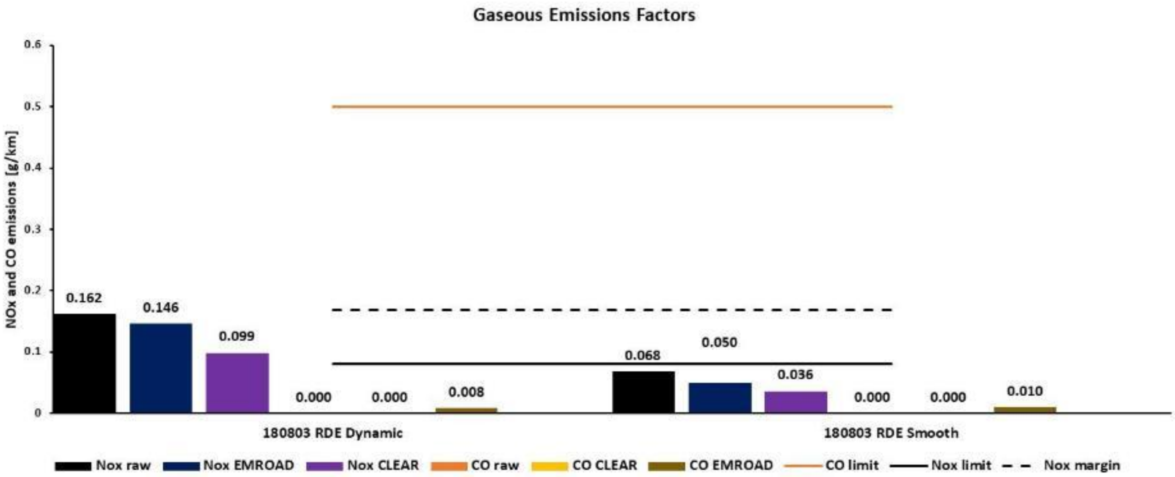



**Figure 14**: Total trip NOx and CO emissions calculated with CLEAR and EMROAD methods.

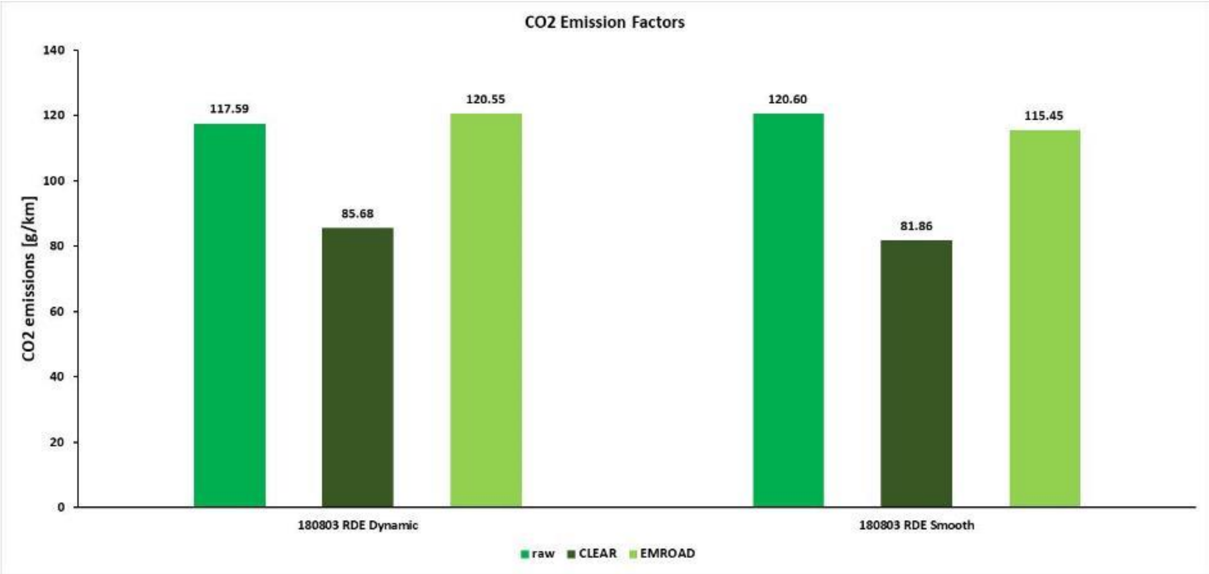



**Figure 15**: Total trip $CO_2$ emissions calculated with CLEAR and EMROAD methods.

PN emissions calculation with CLEAR and EMROAD methods, for the compliant RDE trips, are illustrated in Figure 16. In this case, CLEAR method showed better agreement with the raw results but still there are significant discrepancies especially for the smooth trip.

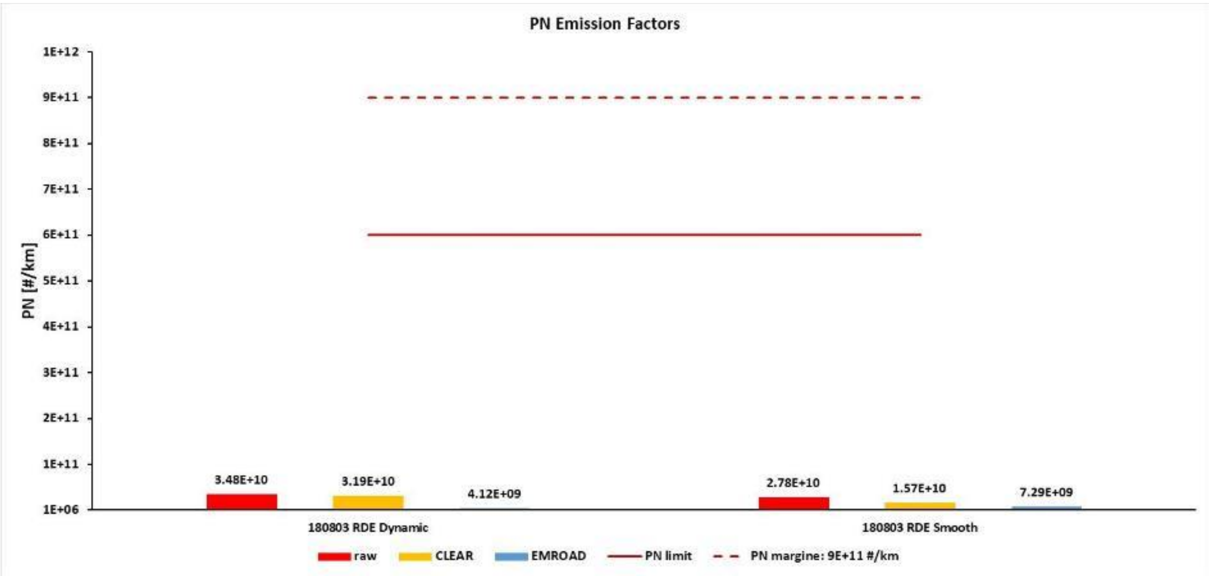



**Figure 16.** Total trip PN emissions calculated with CLEAR and EMROAD methods.

CLEAR and EMROAD methods are also calculating the aggregated emissions per route segment (urban, rural and motorway). In detail, EMROAD calculates the aggregated emissions for all segments while CLEAR method, apart from the total trip emissions, calculates only the urban part emissions of the RDE route, as it should also be below the legislated limit, according to the relevant regulation. Figure 17 and Figure 18, depicts the NOx emissions per route segment. As for the total trip emissions, EMROAD seems to be in better agreement with the raw results, for the urban part of the route also, as this is the only route segment that comparison between these two methods can be conducted. In addition, the NOx emissions level stay below the regulation limits for all route segments in the case of the smooth trip, while for the case of the dynamic trip, the rural part [g/km] NOx are laying above the allowed limit margin given by the legislation.

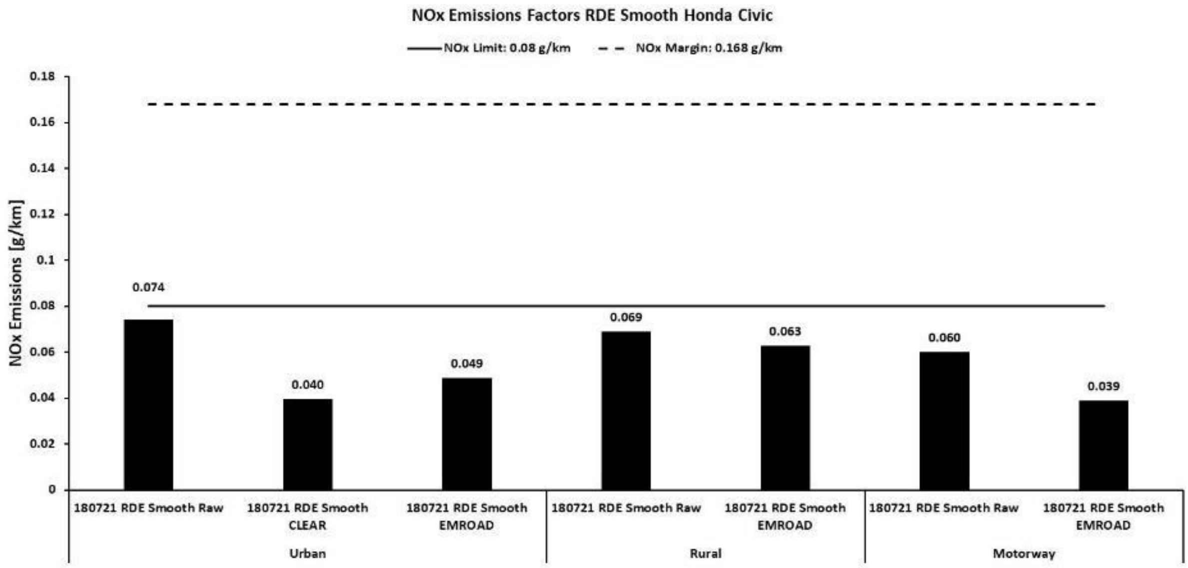



**Figure 17:** Compliant RDE smooth trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

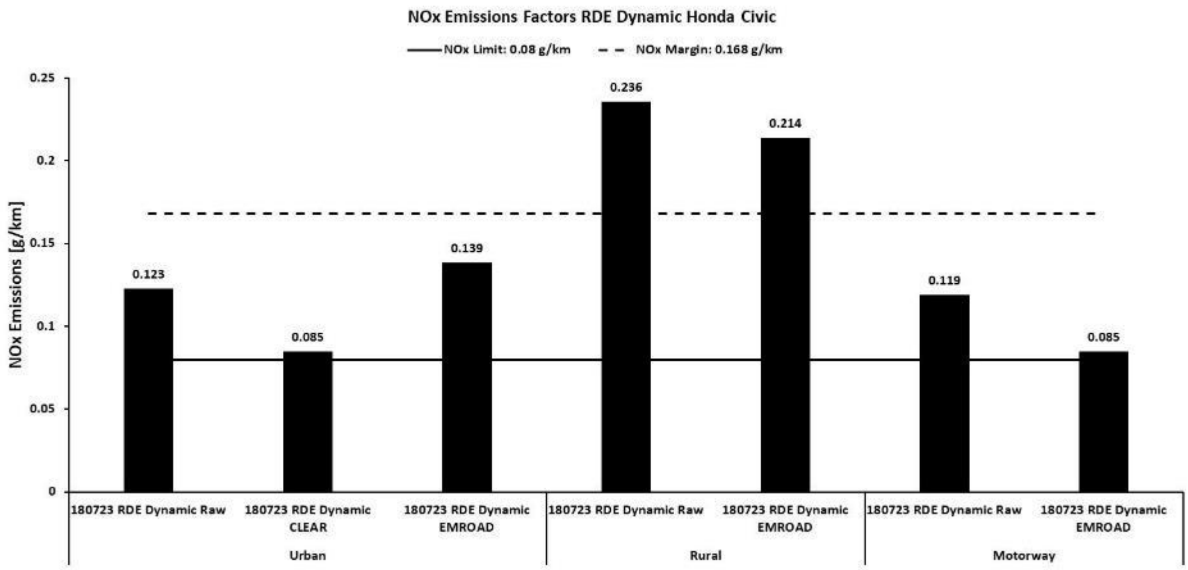



**Figure 18:** Compliant RDE dynamic trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

The comparison between the two methods in the urban part of the route, for $CO_2$ emissions (Figure 19 and Figure 20) is also showing that EMROAD method gives similar values with the raw results. In addition, EMROAD calculated $CO_2$ emissions for the rural part are higher than the raw values, while for the motorway part are lower than the raw values, both for the smooth and the dynamic RDE compliant trips. The CO emissions, presented in Figure 21 and Figure 22, are higher in the motorway part as a result of the less oxygen available in the diesel engine of the vehicle due to the high load, but still they are lying far below the legislated limit. In that case EMROAD calculated CO emissions are higher than the raw results.

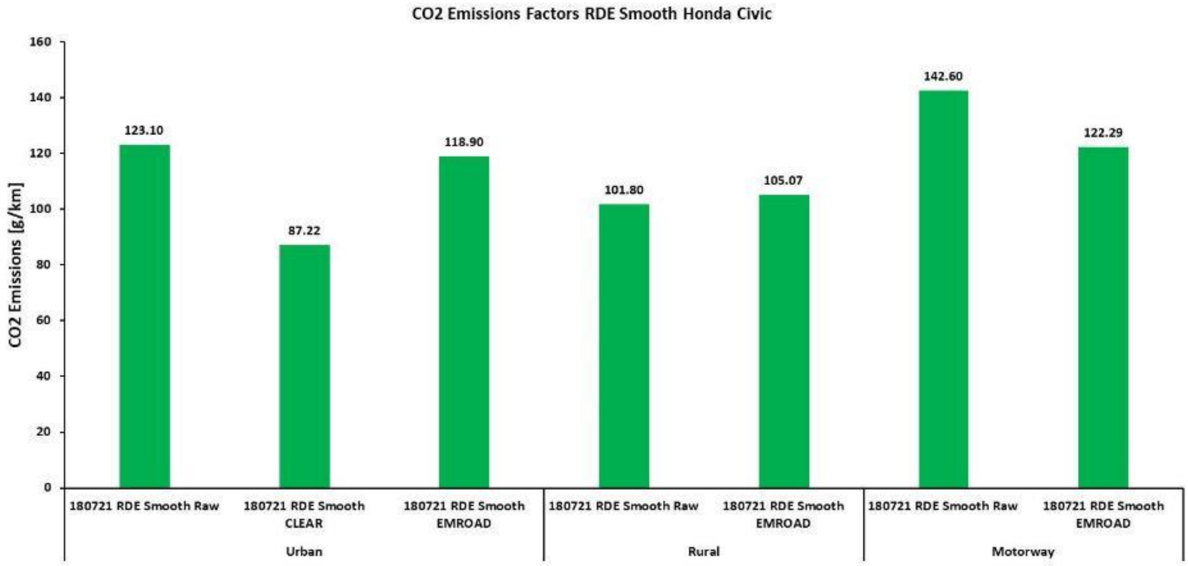



**Figure 19**: Compliant RDE smooth trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

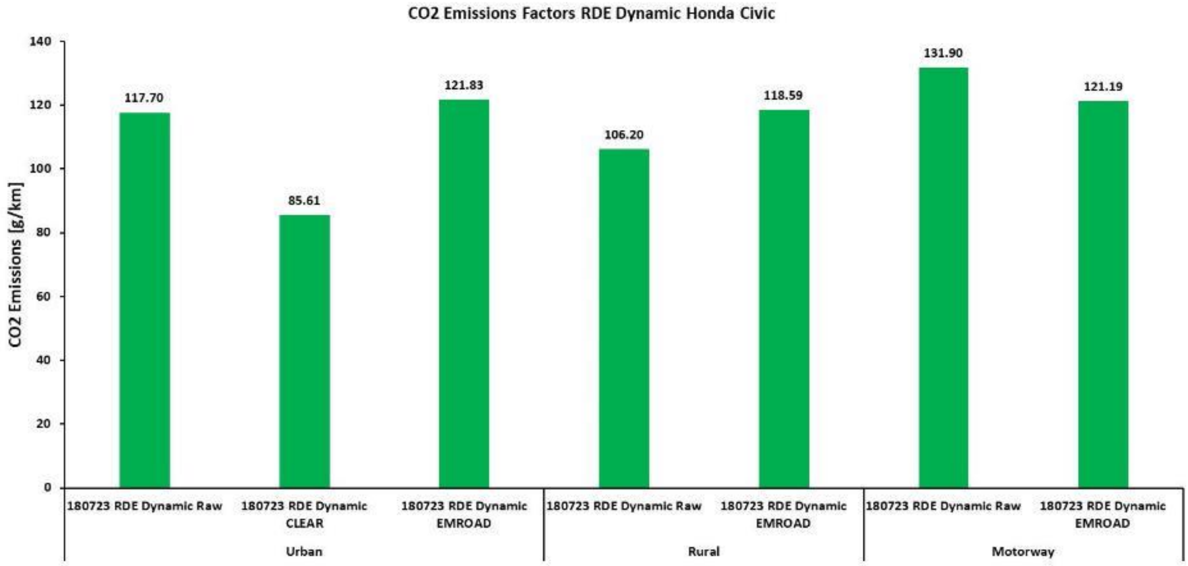



**Figure 20:** Compliant RDE dynamic trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

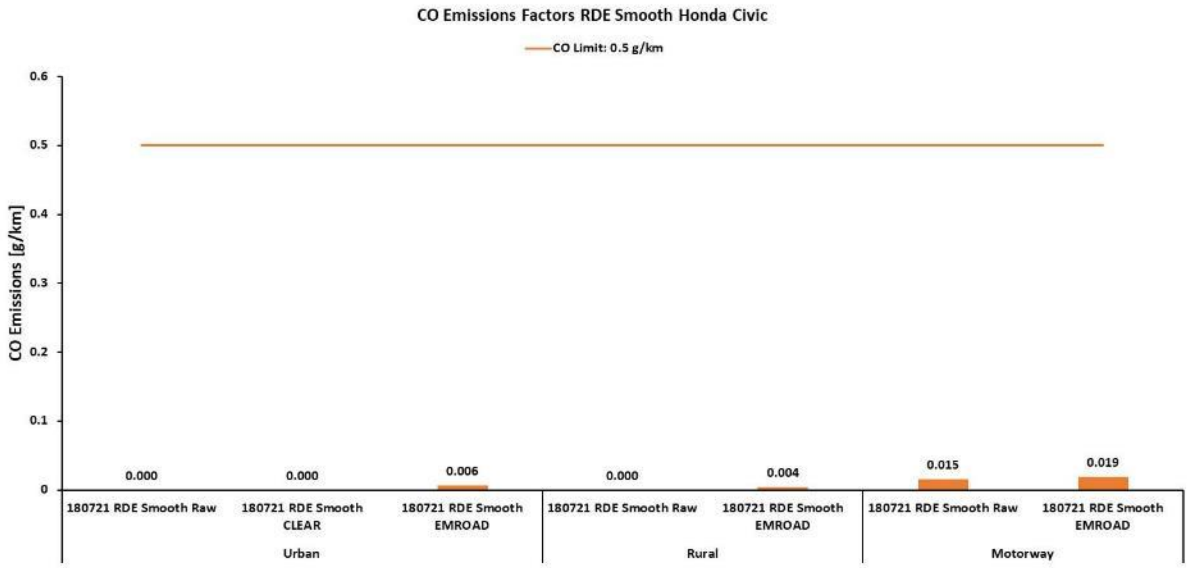



**Figure 21:** Compliant RDE smooth trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

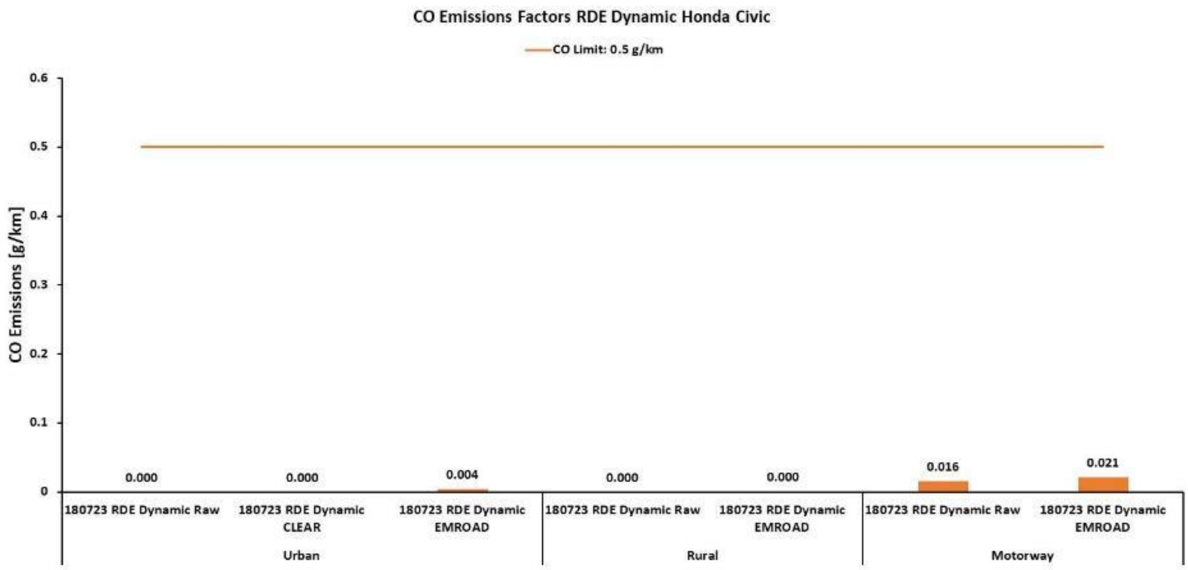



**Figure 22:** Compliant RDE dynamic trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

Finally, the PN emissions presented in Figure 23 and in Figure 24, are mainly concentrated at the urban part of both RDE compliant routes, where CLEAR method seems to perform better, if comparison is conducted with the raw results. The same conclusion can be drawn when the PN emissions of the total trip is considered. As expected, PN emissions are higher for the dynamic route, but in all cases they are much lower than the legislated limit.

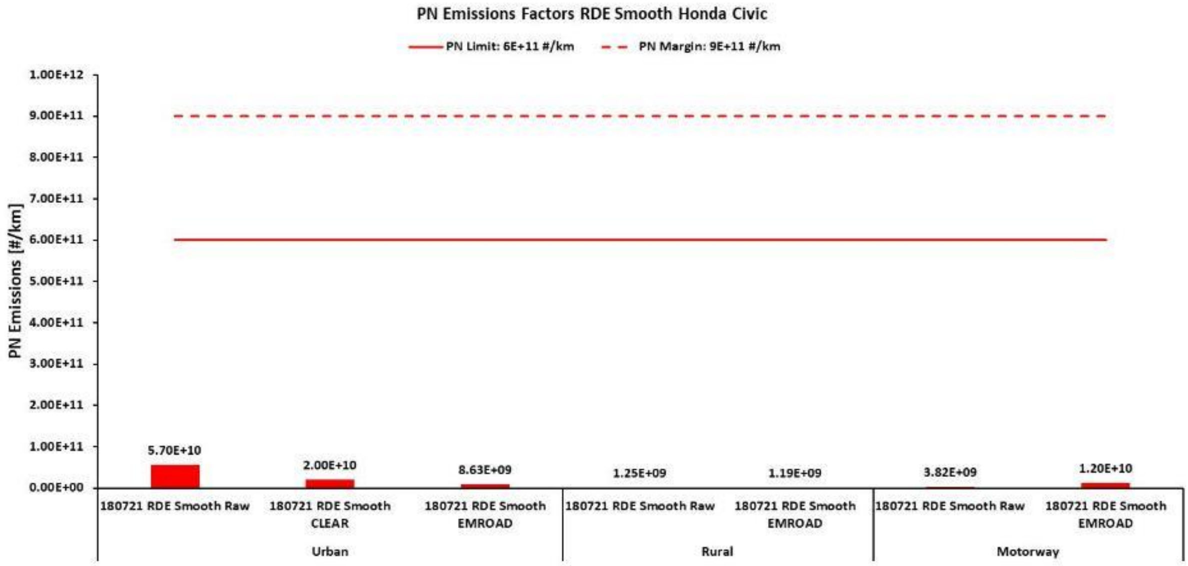



**Figure 23:** Compliant RDE smooth trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

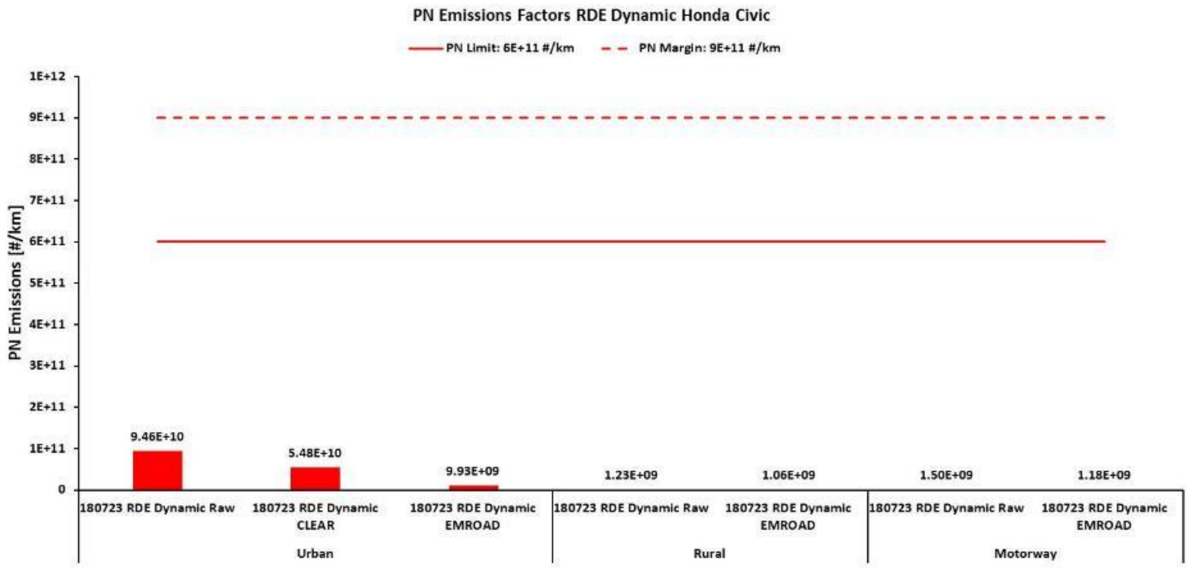



**Figure 24:** Compliant RDE dynamic trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

Concluding the on road measurements of the segment C vehicle, it should be mentioned that for the dynamic RDE compliant route the NOx emissions measured are similar (160 mg/km) with the RDE value declared in the certificate of conformity of the vehicle (168 mg/km) while the PN emissions measured ($3.48\times10^{10}$ #/km) are much lower than the RDE PN value declared in the certificate of conformity ($6\times10^{11}$ #/km).

In addition to the above data, the "raw" aggregated emissions results per route segment are illustrated in Appendix VI for all the vehicles tested.

### 3.1.2 Coast-down and Laboratory Testing

Before running the laboratory tests, a coast-down was conducted in order to determine the real world road load using the NEDC and WLTP-High test masses, as estimated by data declared in the certificate of conformity of the vehicle, and especially by assuming that the test mass declared is more likely to approach the WLTP-Low test mass. These loads were used on the chassis dyno measurements according to the relevant procedures. Figure 25 presents the result of this coast-down, together with the final deceleration times for NEDC and WLTP-High test masses. In addition Table 7 illustrates the test masses and the values of the coefficients of the second order polynomial function describing the total force exerted on the vehicle. It is observed that the final realistic coast-down time is very close between the two different test masses.

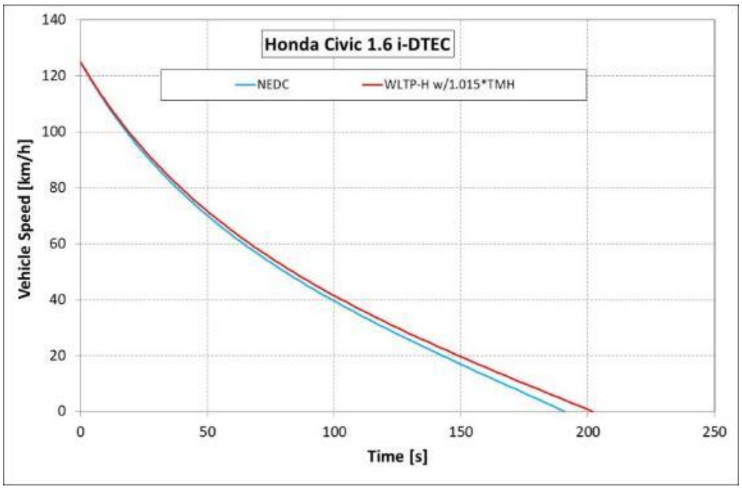



**Figure 25:** Coast down curves for the NEDC and the WLTP-High dynamometer settings

**Table 7:** Coast down test masses and coefficients.

| | NEDC | WLTP-H | WLTP-TA |
|---|---|---|---|
| Test mass [kg] | 1470 | 1567 | 1503 |
| F0 [N] | 169 | 162.7 | 83.5 |
| F1 [N/(km/h)] | -0.4951 | -0.0841 | 0.4 |
| F2 [N/(km/h)^2] | 0.0355 | 0.03380 | 0.03031 |

For the faultless operation of the vehicle on the dyno, the dyno mode of the vehicle was applied, following a specific procedure. This was necessary, since the vehicle was tested on a 1-axis chassis dyno but the start/stop function has been deactivated when this mode was applied.

Figure 26 presents the comparison of $CO_2$ and CO emissions between the two procedures followed. As expected, WLTP-High $CO_2$ emissions are slightly higher than the NEDC $CO_2$ emissions. When comparing with the certificate of conformity of the vehicle (WLTP $CO_2$ value 118 g/km), the difference is more significant. This might reflect the fact that the test mass declared in the certificate of conformity is 1503 kg, while our test mass was 1567 kg, as illustrated in Table 7.

Figure 27 presents the comparison of $NO_x$ and NO emissions between the two procedures followed. Especially for NOx, WLTP-High value (90.5 mg/km) is much higher than the NEDC one, and above the limit of 80 mg/km. It should also be mentioned that the NOx emissions value declared in the certificate of conformity of the vehicle (57.2 mg/km), is also lower than the WLTP-High value measured. Again this might reflect the fact that the test mass declared in the certificate of conformity is 1503 kg, while our test mass was 1567 kg.

The particle emissions of the vehicle are depicted in Figure 28. It is worth noting that the measured PM value (0.13 mg/km) is exactly the same as the type approval PM value declared in the certificate of conformity of the vehicle. In addition PN value of WLTP is 10 times lower than the NEDC and this might be due to the different loading of the DPF during these two measurements.

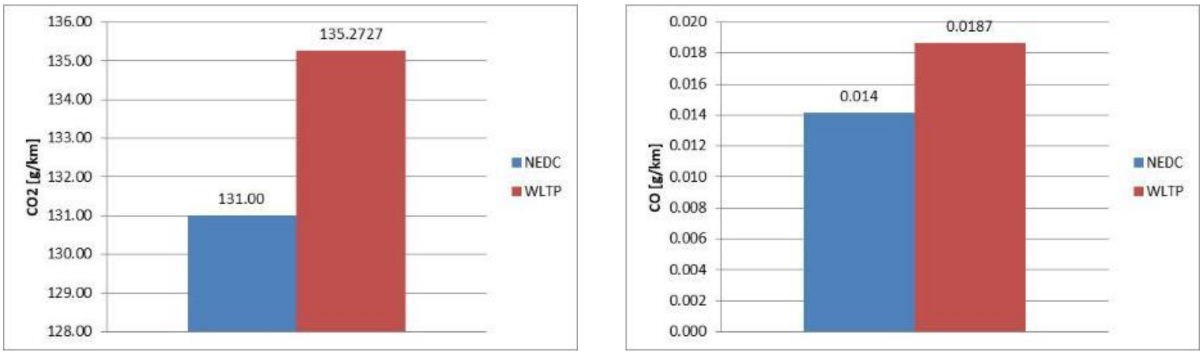



**Figure 26:** $CO_2$ emissions in NEDC and WLTP-High (left) and CO emissions in NEDC and WLTP-High (right)

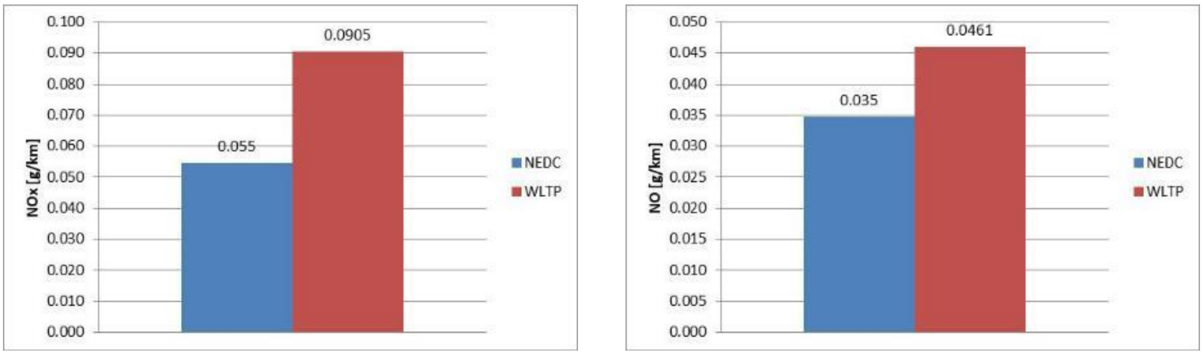



**Figure 27:** $NO_x$ emissions in NEDC and WLTP-High (left) and NO emissions in NEDC and WLTP-High (right)

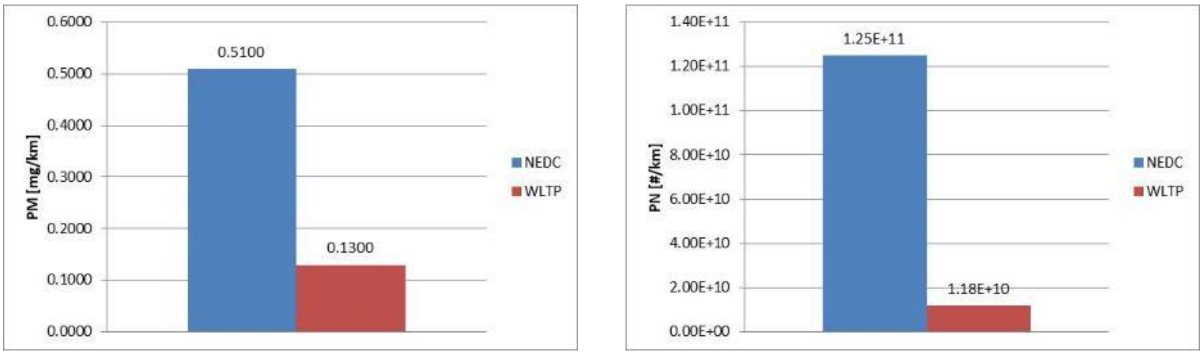



**Figure 28:** PM emissions in NEDC and WLTP-High (left) and PN emissions in NEDC and WLTP-High (right)

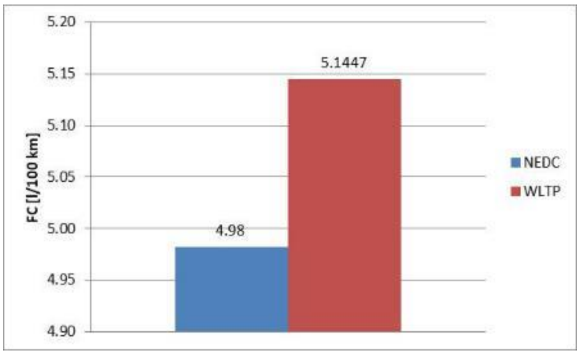



**Figure 29:** Fuel consumption in NEDC and WLTP-High

Finally, comparison of the fuel consumption between the two different procedures followed is illustrated in Figure 29. As expected due to the $CO_2$ emissions presented earlier, WLTP –High fuel consumption (5.15 l/100 km) is slightly higher than the NEDC (4.98 l/100 km). At the same time it is higher than the declared value in the vehicle certificate of conformity for the WLTP (4.5l/100 km) which may be attributed, to the higher test mass used during measurements. The emissions results per cycle segment are summarized in Table 8 for NEDC procedure and in Table 9 for the WLTP.

**Table 8:** Summary of NEDC emissions.

| | UDC | EUDC | NEDC |
|---|---|---|---|
| CO2 [g/km] | 157.63 | 115.47 | 131.00 |
| CO [g/km] | 0.025 | 0.008 | 0.014 |
| NOx [g/km] | 0.046 | 0.060 | 0.055 |
| NO [g/km] | 0.031 | 0.037 | 0.035 |
| FC [l/100 km] | 6.00 | 4.39 | 4.98 |
| PM [mg/km] | | | 0.51 |

**Table 9:** Summary of WLTP emissions.

| | WLTC Low | WLTC Medium | WLTC High | WLTC Extra High | WLTC |
|---|---|---|---|---|---|
| CO2 [g/km] | 166.88 | 130.96 | 120.10 | 139.03 | 135.2727 |
| CO [g/km] | -0.005 | 0.006 | 0.009 | 0.043 | 0.0187 |
| NOx [g/km] | 0.051 | 0.124 | 0.109 | 0.070 | 0.0905 |
| NO [g/km] | 0.033 | 0.061 | 0.053 | 0.036 | 0.0461 |
| FC [l/100 km] | 6.35 | 4.98 | 4.57 | 5.29 | 5.1447 |
| PM [mg/km] | | | | | 0.1300 |

The instantaneous WLTP measurements, along with the bag results presented above, were also used in the tool $CO_2$MPAS to check the accuracy of the prediction of the NEDC $CO_2$ emissions. The results are illustrated in Figure 30 and it can be seen that the NEDC $CO_2$ emissions are better predicted without including the ki factor, which is accounting for the fuel penalty during regeneration events. It should be mentioned, that no regeneration event occurred during lab testing.

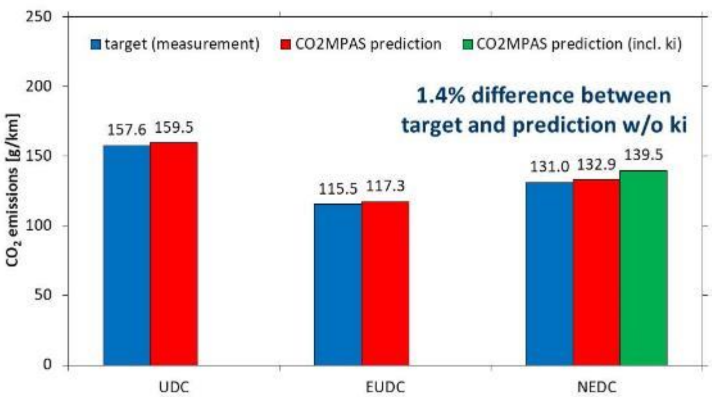



**Figure 30:** $CO_2$MPAS results for segment C vehicle.

## 3.2 Vehicle 2: Ford Fiesta 1.0 EcoBoost

### 3.2.1 On-Road Testing

The Ford Fiesta was the second vehicle tested. It had a Gasoline Direct Injection engine and it was equipped with GPF. The vehicle, by default, had the "start-stop" operation activated and the "eco" driving mode deactivated, when the car was switched on. The main technical specifications of this vehicle are presented in Table 10.

**Table 10:** Ford Fiesta 1.0 EcoBoost technical specifications.

| | |
|---|---|
| Car segment | B |
| Fuel type | Gasoline |
| Engine architecture | In-line 3 cylinders, GDI turbocharged |
| Engine capacity [$cm^3$] | 998 |
| Max power [kW] | 74 |
| Start-stop | Yes by default (deactivated during lab testing) |
| Eco Mode | No |
| Transmission | Manual, 6 gears |
| Euro standard | Euro 6d-temp |
| After-treatment system | TWC, GPF |
| Tyres | Michelin, Xgreen, 195/55 R16 |
| Tyre pressure (Front / Rear) [psi] | 30 / 26 |
| Registration | July 2018 |

Table 11 summarizes the valid on-road tests conducted. It is reminded that this vehicle was brand new when rented and were driven during 1,000 km by EMISIA SA and LAT personnel on T&E's request before testing. In total, two RDE-compliant and two extended conditions tests were conducted, together with another test following the RDE dynamic compliant route but the temperature during test has risen above 35°C.

**Table 11**: Ford Fiesta 1.0 EcoBoost test summary

| Date of Test | Mileage (start of testing) [km] | Description of Route | Ambient temperature during test (min-max)/average °C |
|---|---|---|---|
| 31/07/2018 | 1074 | Non-compliant, Extended conditions, Cold start engine | (19.02-26.50)/ 22.25 |
| 01/08/2018 | 1140 | Compliant, Smooth, Cold start engine | (22.80-28.20)/ 26.30 |
| 01/08/2018 | 1228 | Non-compliant, Extended conditions, Cold start engine | (24.24-32.37)/ 28.35 |
| 02/08/2018 | 1296 | Dynamic, Cold start engine (over-extended conditions) | (24.47-38.55)/ 33.76 |
| 02/08/2018 | 1385 | Compliant, Dynamic, Cold start engine | (22.65-26.91)/ 24.20 |

Figure 31 summarizes the gaseous emissions raw results for all the tests conducted. It can be seen that for all RDE tests (both compliant and non-compliant) all emission values are below the regulation limits except from one case of an extended conditions, non-compliant RDE test that the CO limit is slightly higher than the legislated limit. It can be observed, that during extended conditions, non-compliant RDE tests the CO emissions are many times higher than the corresponding emissions of the compliant trips. In addition, $CO_2$ emissions of the non-compliant tests are approximately 2 times higher than the $CO_2$ emissions of the compliant tests. It is also worth noting that the "180802 RDE Dynamic (Over Extended Cond.)", has started as a compliant trip but during measurement the temperature has risen above 35°C. It seems that the extended ambient temperature did not affect the measurement, as the gaseous emissions are comparable with the emissions of the rest of the compliant trips.

The PN emissions are illustrated in Figure 32. It can be clearly seen that in most of the cases, measurements are near the legislated limit, with the compliant dynamic test lying slightly above. The non-compliant tests PN values are clearly above the legislated limit. The second by second data which include the instantaneous gaseous and PN emissions, instantaneous engine and vehicle speed OBD readings, the air-fuel equivalence ratio (λ) and the battery and alternator currents, are given in Appendix IV, to help the reader evaluate the results.

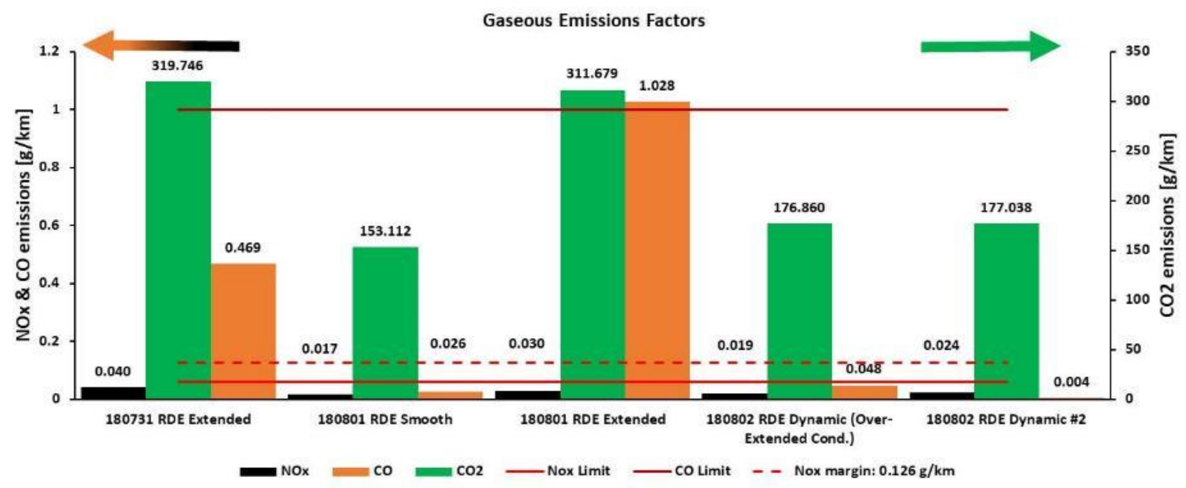



**Figure 31:** Gaseous emissions of the total trip.

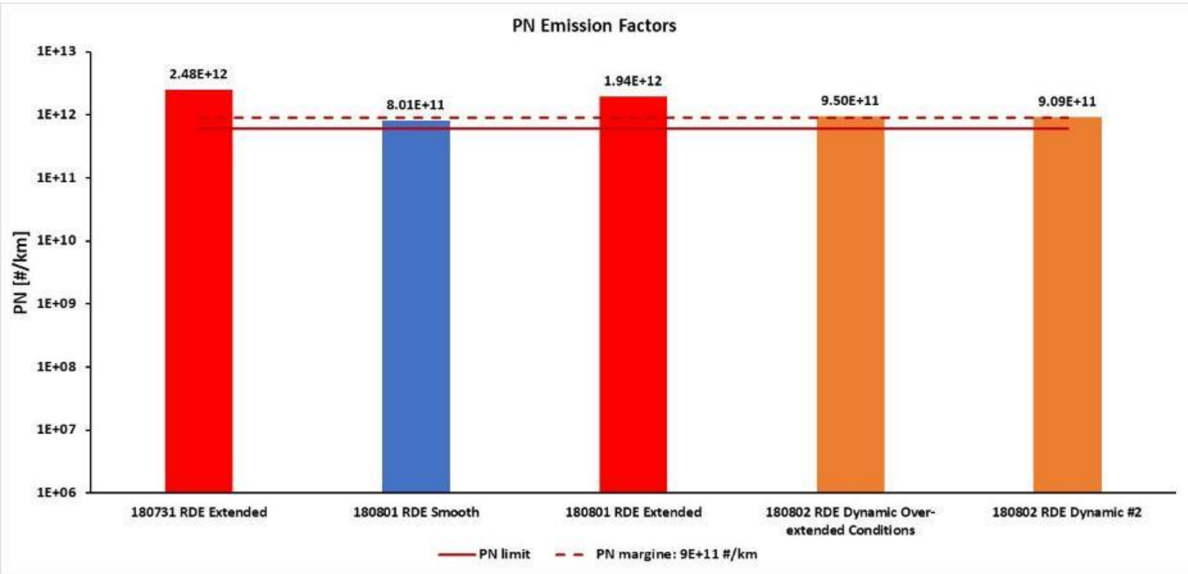



**Figure 32:** PN emissions of the total trip.

Figure 33 and Figure 34 illustrate the aggregated gaseous emissions (g/km) calculated with the CLEAR and EMROAD methods, for the compliant RDE trips. It can be seen that NOx and CO emissions calculated with these two methods are very close to the raw data. For $CO_2$ emissions, the CLEAR method is in better agreement with the raw data, with EMROAD method giving 10-15% lower emissions than the raw data.

PN emissions calculation with CLEAR and EMROAD methods, for the compliant RDE trips, are illustrated in Figure 35. In this case, CLEAR method seems to overestimate the PN emissions in comparison with the raw data, while EMROAD method gives slightly lower values. Checking the differences in the PN emissions values, EMROAD method is in closer agreement with the raw data.

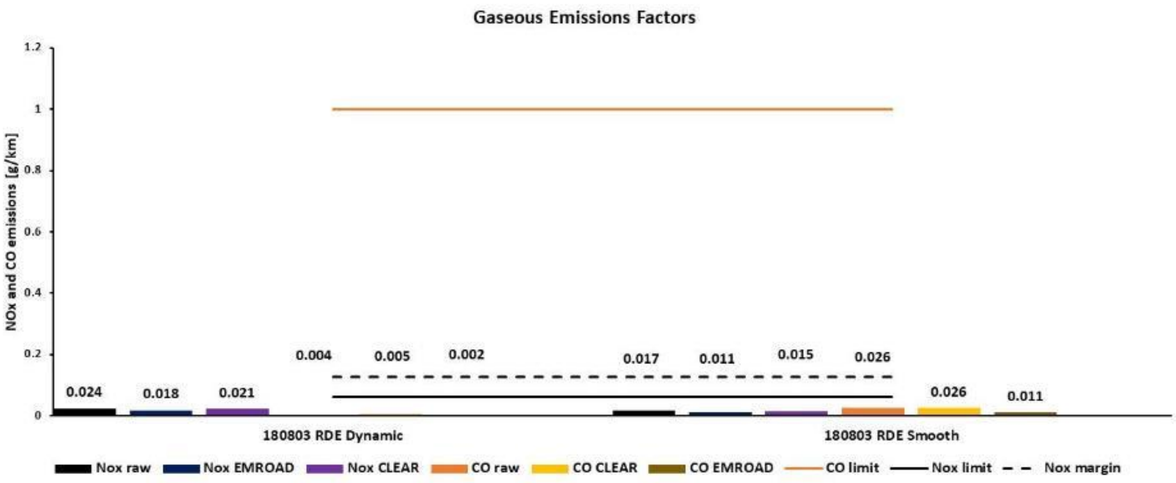



**Figure 33**: Total trip NOx and CO emissions calculated with CLEAR and EMROAD methods.

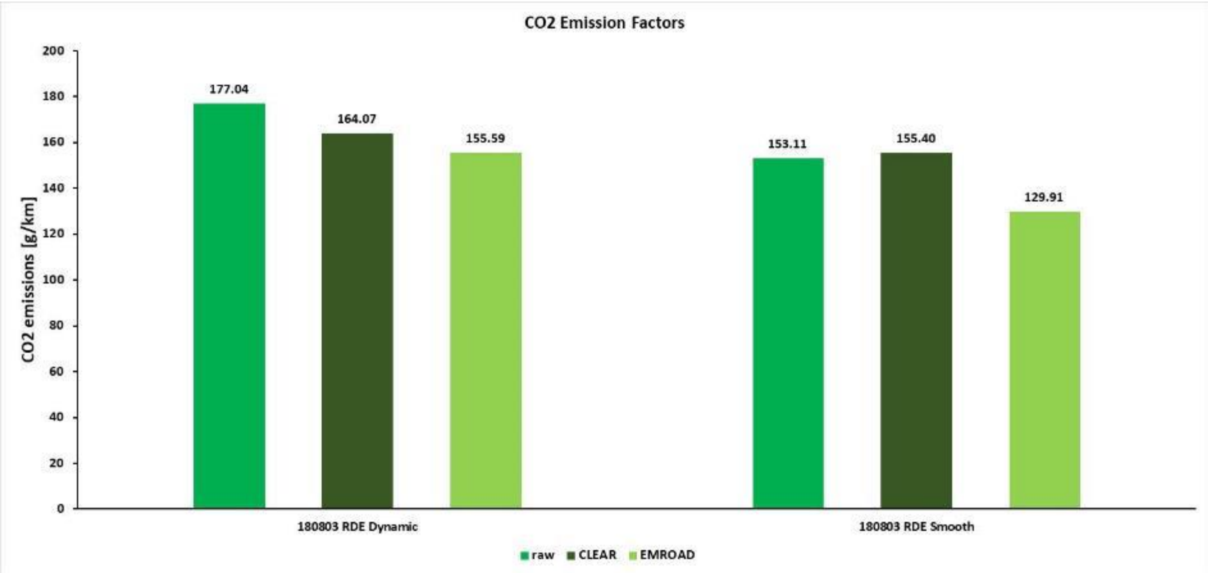



**Figure 34**: Total trip $CO_2$ emissions calculated with CLEAR and EMROAD methods.

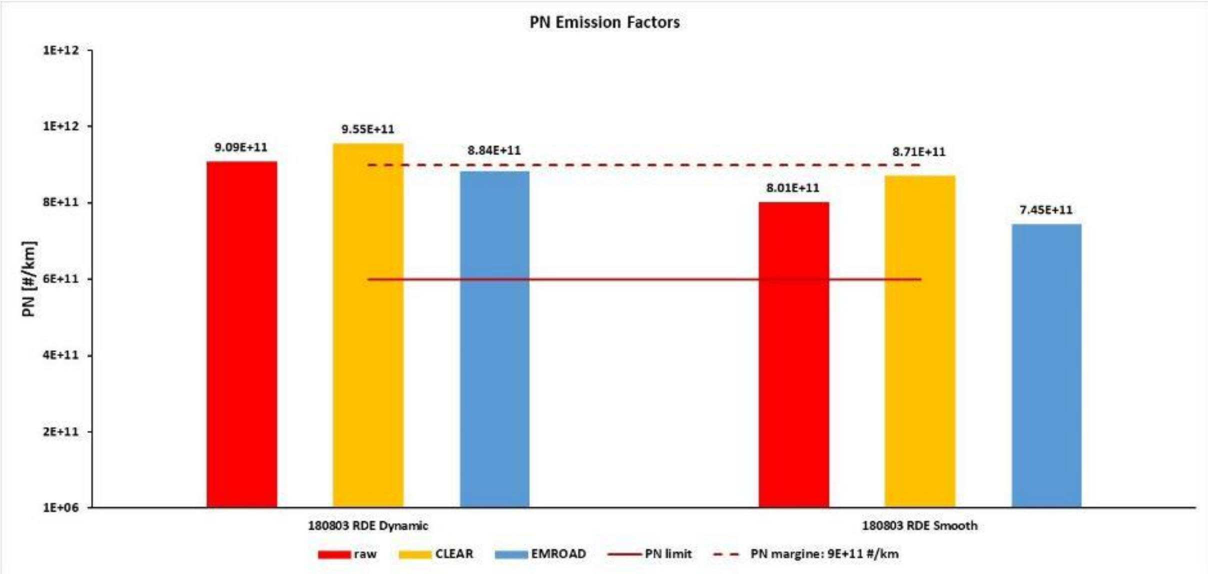



**Figure 35.** Total trip PN emissions calculated with CLEAR and EMROAD methods.

Figure 36 and Figure 37, depicts the NOx emissions per route segment. As for the total trip emissions, there are only insignificant differences between the two methods. CLEAR seems to be in better agreement with the raw results, for the urban part of the route, as this is the only route segment that comparison between these two methods can be conducted. EMROAD calculates approximately half the raw NOx emissions both for the case of the smooth and the dynamic trip. It should be mentioned that for all cases and route segments, NOx emissions stay far below the legislated limit.

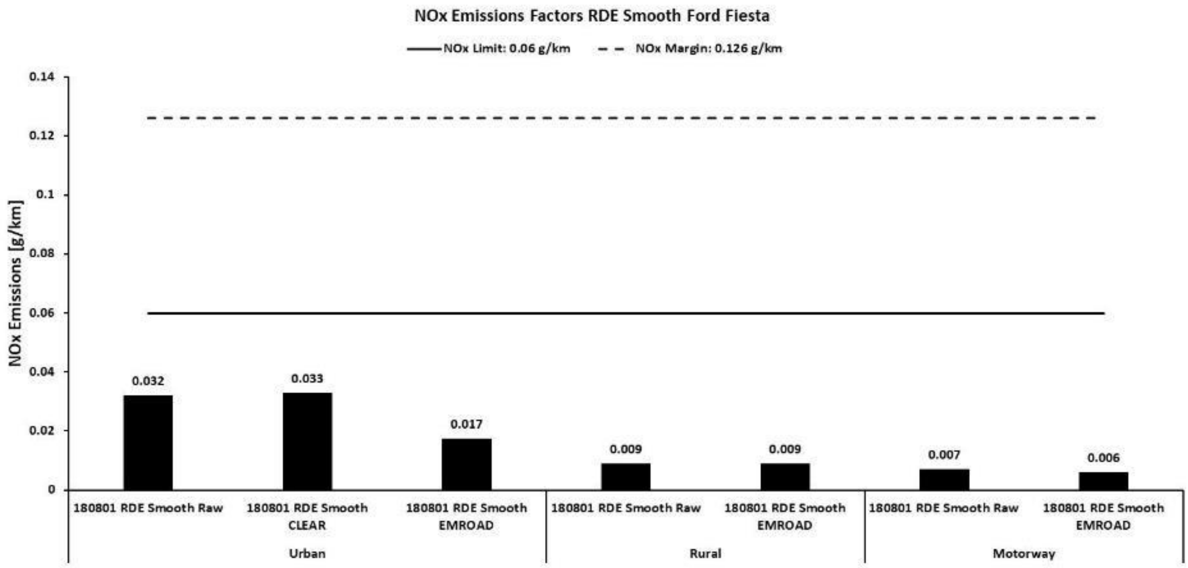



**Figure 36:** Compliant RDE smooth trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

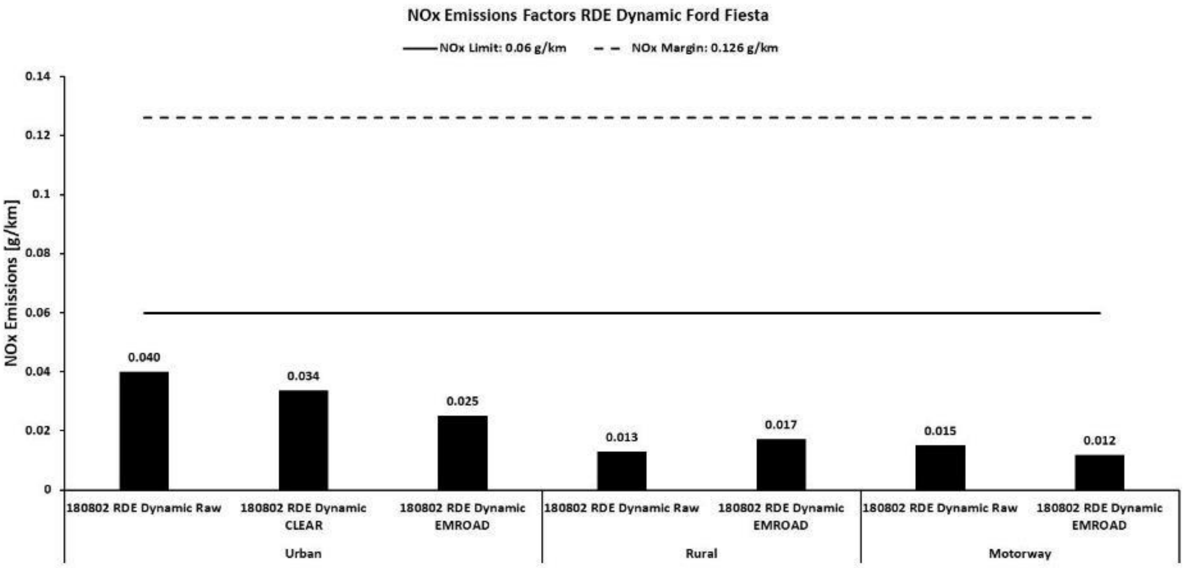



**Figure 37:** Compliant RDE dynamic trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

The comparison between the two methods in the urban part of the route, for $CO_2$ emissions (Figure 38 and Figure 39) is also showing that CLEAR method gives similar values with the raw results in the case of the smooth RDE compliant route, while for the dynamic route; both methods give 10% lower values. In addition, EMROAD calculated $CO_2$ emissions for the rural and the motorway part are lower than the raw values, both for the smooth and the dynamic RDE compliant trips. The CO emissions calculated with these two methods are presented in Figure 40 and Figure 41. Again, CLEAR method is in closer agreement with the raw results for the urban part of both RDE compliant trips.

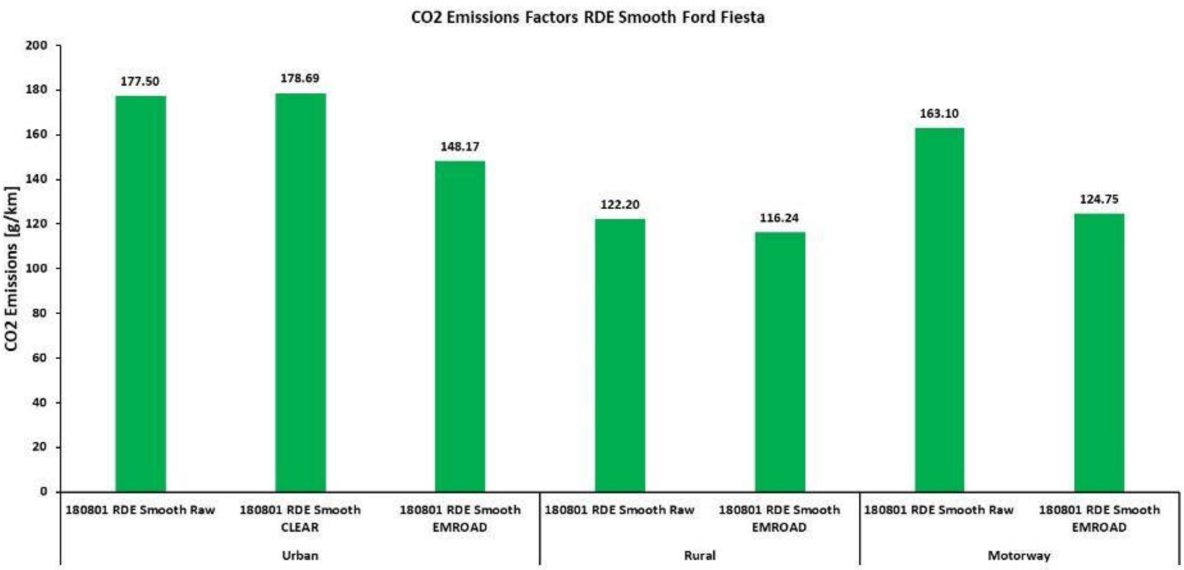



**Figure 38**: Compliant RDE smooth trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

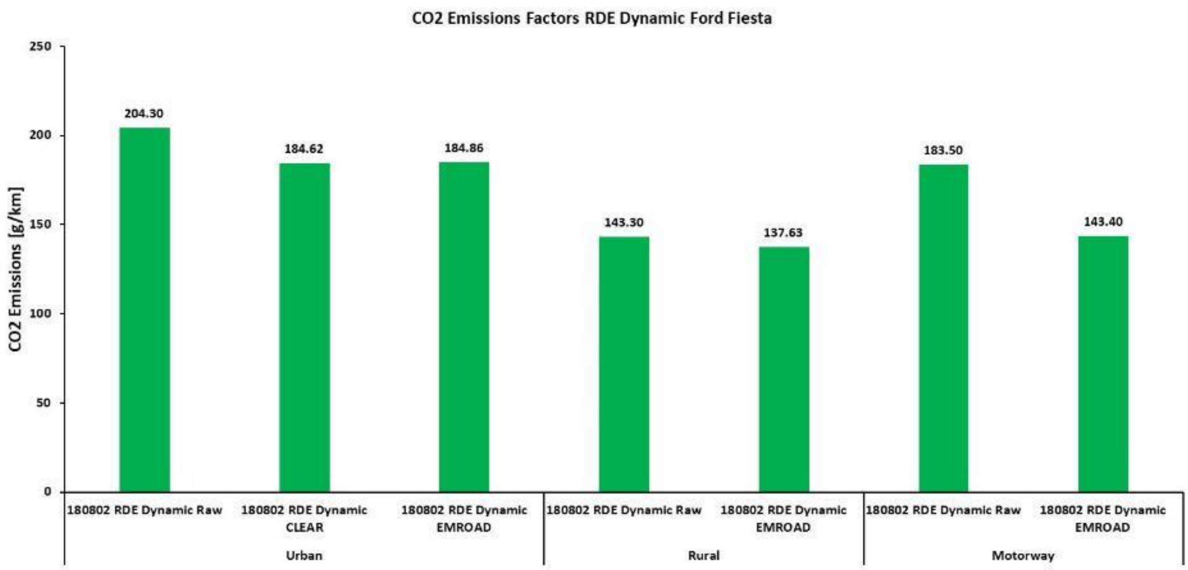



**Figure 39:** Compliant RDE dynamic trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

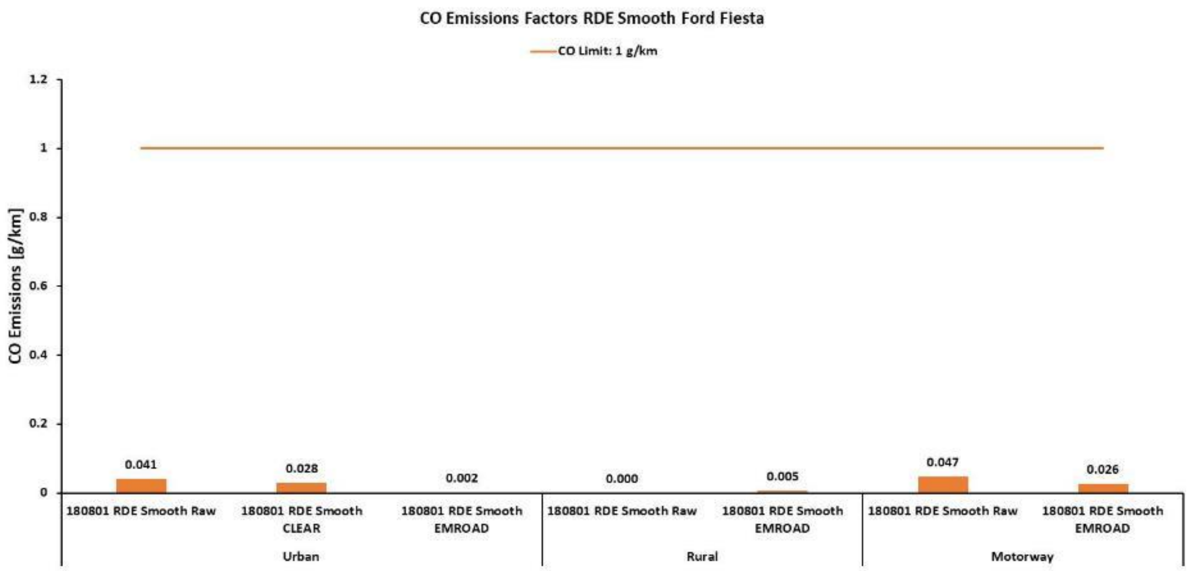



**Figure 40:** Compliant RDE smooth trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

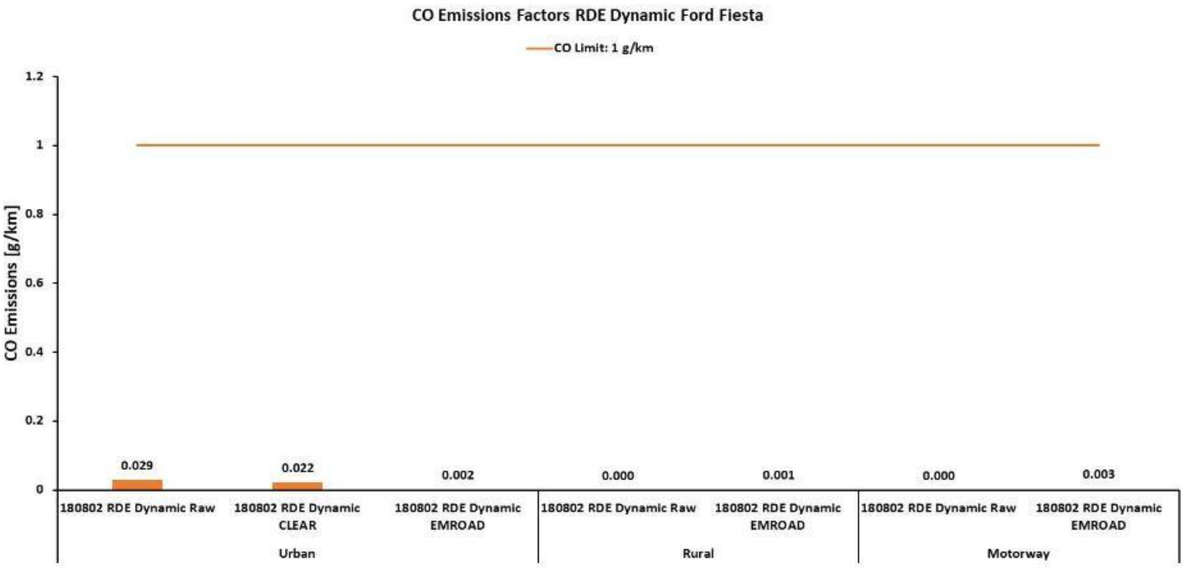



**Figure 41:** Compliant RDE dynamic trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

Finally, the PN emissions presented in Figure 42 and in Figure 43, are higher in the rural part of the smooth RDE compliant route, and in the motorway part of the dynamic route. In the urban part of the smooth trip CLEAR method seems to perform better if comparison is conducted with the raw result (16.6% difference for CLEAR and 19.7% difference for EMROAD), while for the dynamic trip EMROAD is in closer agreement with the raw data (3.6% difference for CLEAR and 2.7% difference for EMROAD). It should be mentioned that the urban part dynamic trip PN emissions for this vehicle are double the smooth trip PN emissions. When the motorway part of the routes is considered, again PN emissions are higher for the dynamic trip, while for the rural part, the smooth trip presents higher PN emissions.

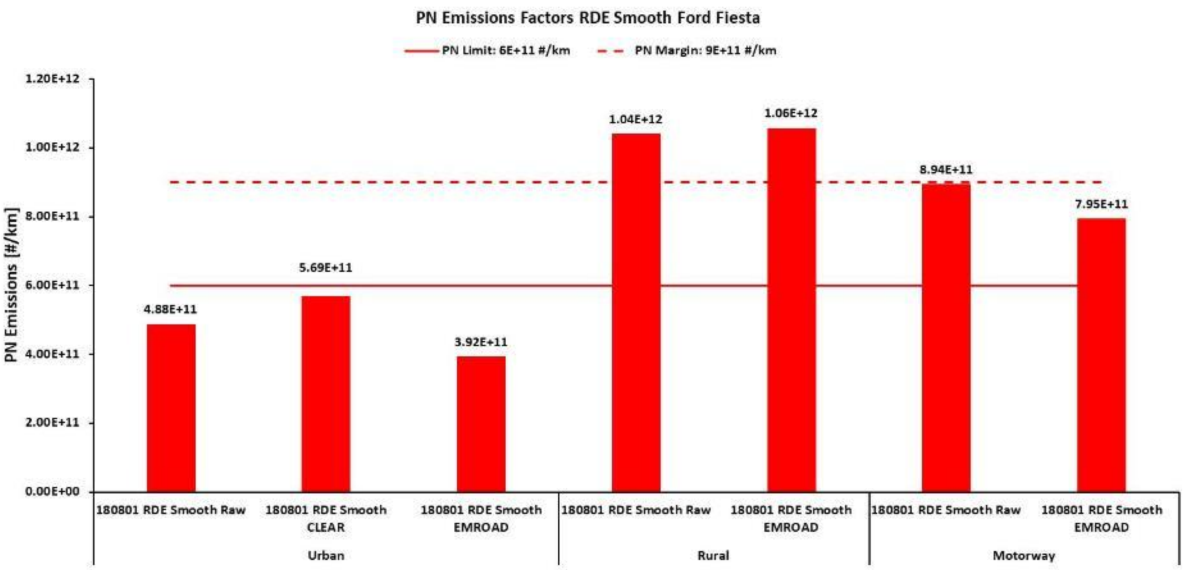



**Figure 42:** Compliant RDE smooth trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

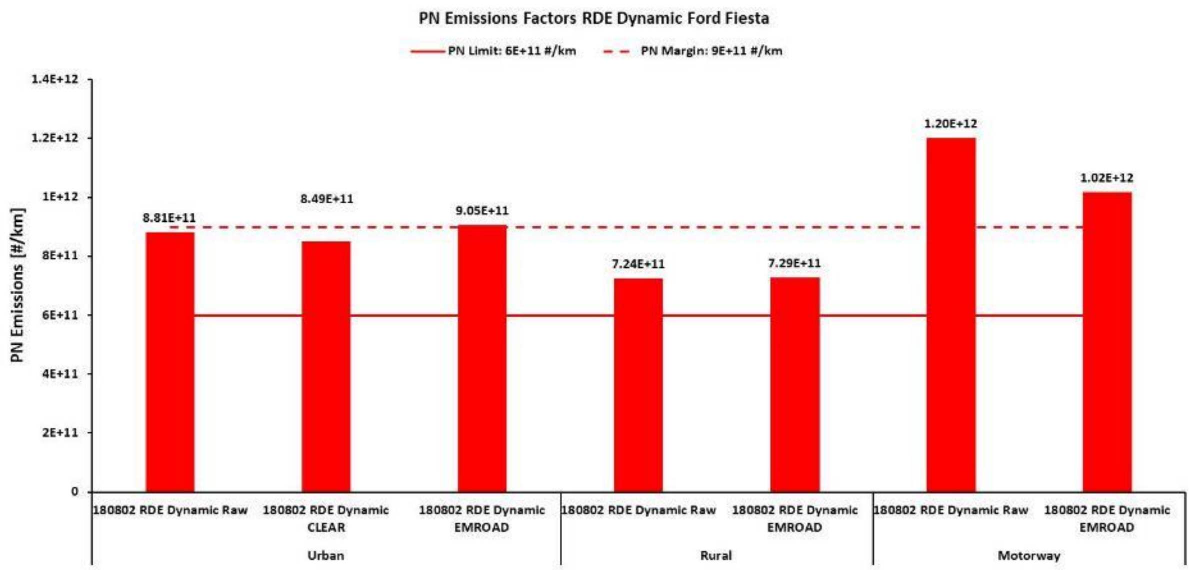



**Figure 43:** Compliant RDE dynamic trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

Concluding the on road measurements of the segment B vehicle, it should be mentioned that for the smooth and the dynamic RDE compliant routes, the NOx emissions measured (20 mg/km) are much lower than the RDE value declared in the certificate of conformity of the vehicle (128 mg/km) while the PN emissions measured are closer to the RDE PN value declared in the certificate of conformity ($9\times10^{11}$ #/km), with the smooth compliant test value ($8.01\times10^{11}$ #/km) lying below the declared value, and the dynamic compliant test value ($9.09\times10^{11}$ #/km) lying slightly above the declared value.

### 3.2.2 Coast-down and Laboratory Testing

Before running the laboratory tests, a coast-down was conducted in order to determine the real world road load using the NEDC and WLTP-High test masses, as estimated by data declared in the certificate of conformity of the vehicle, and especially by assuming that the test mass declared is more likely to approach the WLTP-Low test mass. These loads were used on the chassis dyno measurements according to the relevant procedures. Figure 44 presents the result of this coast-down, together with the final deceleration times for NEDC and WLTP-High test masses. In addition Table 12 illustrates the test masses and the values of the coefficients of the second order polynomial function describing the total force exerted on the vehicle. It is observed that the final realistic coast-down time is very close between the two different test masses.

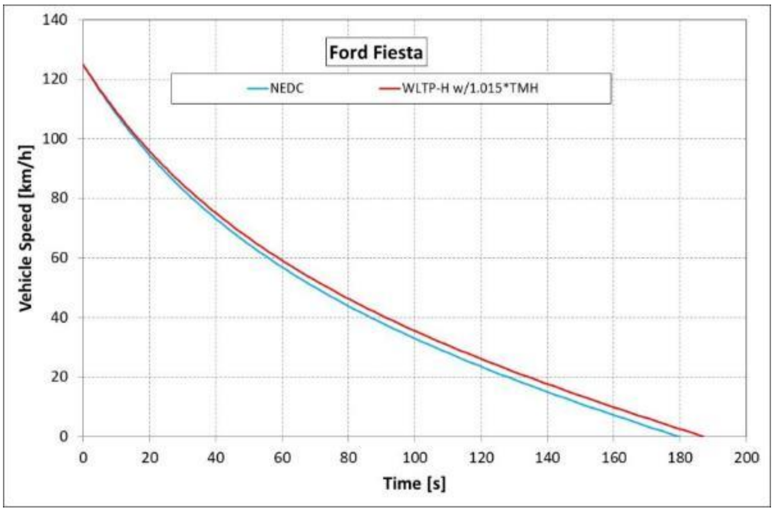



**Figure 44:** Coast down curves for the NEDC and the WLTP-High dynamometer settings

**Table 12:** Coast down test masses and coefficients.

| | NEDC | WLTP-H | WLTP-TA |
|---|---|---|---|
| Test mass [kg] | 1250 | 1400 | 1311 |
| F0 [N] | 125.24 | 140.4 | 119.69647 |
| F1 [N/(km/h)] | 0.5415 | 0.4629 | 0.601 |
| F2 [N/(km/h)^2] | 0.0285 | 0.03140 | 0.02935 |

For the faultless operation of the vehicle on the dyno, the dyno mode of the vehicle was applied, following a specific procedure. This was necessary, since the vehicle was tested on a 1-axis chassis dyno but the start/stop function has been deactivated when this mode was applied.

Figure 45 presents the comparison of $CO_2$ and CO emissions between the two procedures followed. It seems that WLTP-High $CO_2$ emissions are very near to the NEDC $CO_2$ emissions (less than 2% difference) with the NEDC value lying slightly higher. Comparing with the certificate of conformity of the vehicle (WLTP $CO_2$ value 128 g/km), the difference is more significant. This might reflect the fact that the test mass declared in the certificate of conformity is 1311 kg, while our test mass was 1400 kg, as illustrated in Table 12

Figure 46 presents the comparison of $NO_x$ and NO emissions between the two procedures followed. Especially for NOx, NEDC value (17 mg/km) is higher than the WLTP-High value (12.6 mg/km), both of them below the current regulated limits. It should also be mentioned that the type approval NOx emissions value declared in the certificate of conformity of the vehicle (22.2 mg/km), is higher than both values measured.

The particle emissions of the vehicle are depicted in Figure 47. Both PM and PN are slightly higher for the NEDC. The type approval PM and PN values (0.18 mg/km and $1.96\times10^{11}$ #/km respectively) are lower than the values measured, and this might again be a consequence of the higher test mass applied.

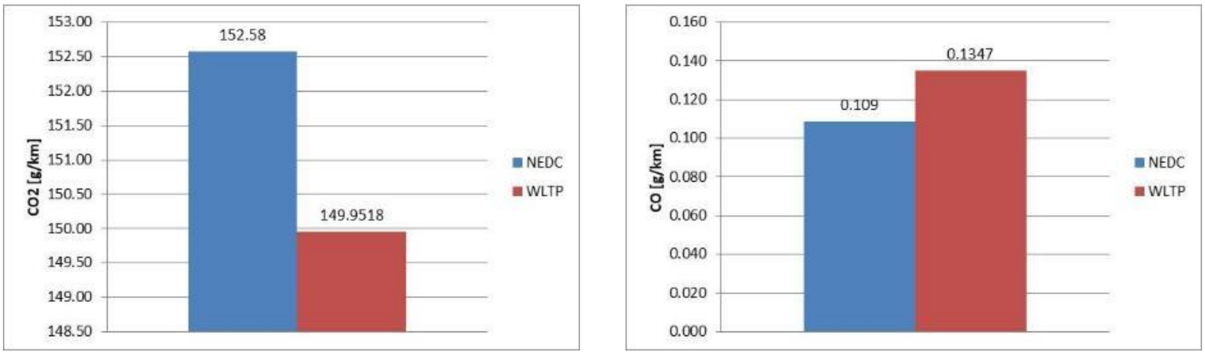



**Figure 45:** $CO_2$ emissions in NEDC and WLTP-High (left) and CO emissions in NEDC and WLTP-High (right)

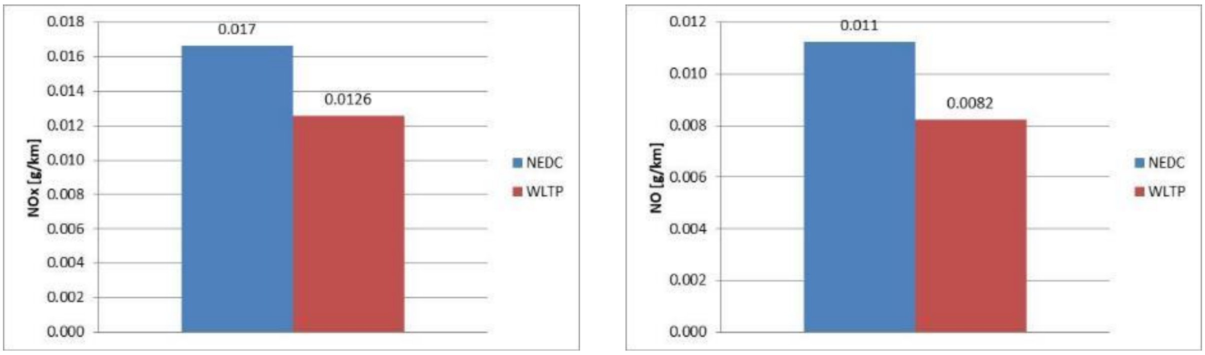



**Figure 46:** $NO_x$ emissions in NEDC and WLTP-High (left) and NO emissions in NEDC and WLTP-High (right)

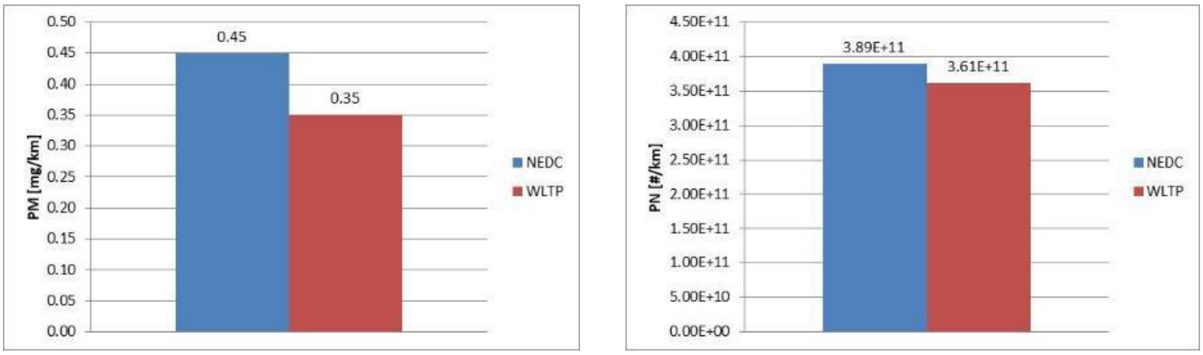



**Figure 47:** PM emissions in NEDC and WLTP-High (left) and PN emissions in NEDC and WLTP-High (right)

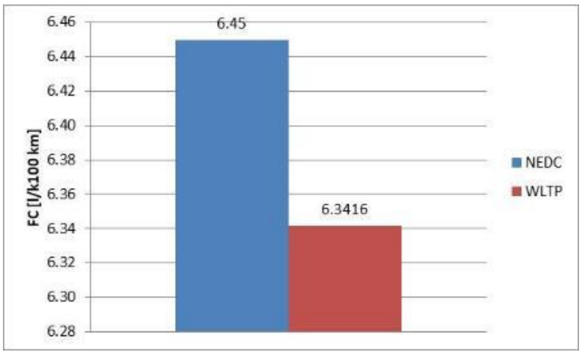



**Figure 48:** Fuel consumption in NEDC and WLTP-High

Finally, comparison of the fuel consumption between the two different procedures followed, is illustrated in Figure 48. As expected due to the $CO_2$ emissions presented earlier, NEDC fuel consumption (6.45 l/100 km) is slightly higher than the WLTP-High fuel consumption (6.34 l/100 km). At the same time it is higher than the declared value in the vehicle certificate of conformity for the WLTP (5.7 l/100 km) which may be attributed, to the higher test mass used during measurements. The emissions results per cycle segment are summarized in Table 13 for NEDC procedure and in Table 14 for the WLTP.

**Table 13:** Summary of NEDC emissions.

| | UDC | EUDC | NEDC |
|---|---|---|---|
| **CO2 [g/km]** | 205.90 | 121.49 | 152.58 |
| **CO [g/km]** | 0.274 | 0.012 | 0.109 |
| **NOx [g/km]** | 0.044 | 0.000 | 0.017 |
| **NO [g/km]** | 0.029 | 0.001 | 0.011 |
| **FC [l/100 km]** | 8.72 | 5.13 | 6.45 |

**Table 14:** Summary of WLTP emissions.

| | WLTC Low | WLTC Medium | WLTC High | WLTC Extra High | WLTC |
|---|---|---|---|---|---|
| **CO2 [g/km]** | 212.00 | 155.26 | 133.21 | 138.13 | 149.9518 |
| **CO [g/km]** | 0.629 | -0.007 | 0.033 | 0.119 | 0.1347 |
| **NOx [g/km]** | 0.056 | 0.014 | 0.006 | 0.002 | 0.0126 |
| **NO [g/km]** | 0.036 | 0.009 | 0.004 | 0.001 | 0.0082 |
| **FC [l/100 km]** | 9.01 | 6.56 | 5.63 | 5.84 | 6.3416 |

The instantaneous WLTP measurements, along with the bag results presented above, were also used in the tool $CO_2$MPAS to check the accuracy of the prediction of the NEDC $CO_2$ emissions. The results are illustrated in Figure 49 and it can be seen that the NEDC $CO_2$ emissions are better predicted by including the ki factor, which is accounting for the fuel penalty during regeneration events. It should be mentioned, that this vehicle had a GPF.

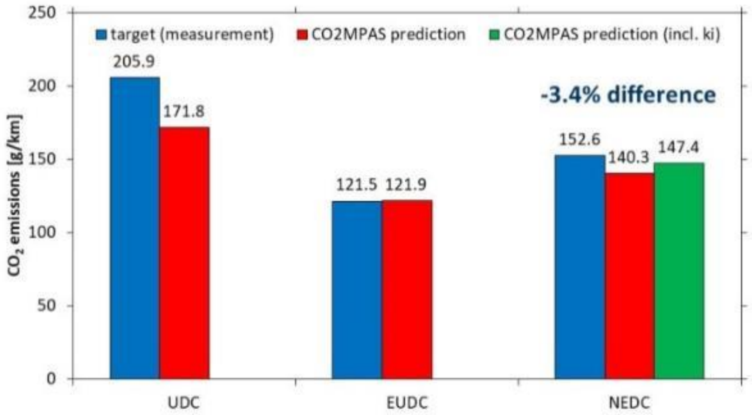



**Figure 49:** $CO_2$MPAS results for segment B vehicle.

## 3.3 Vehicle 3: Opel Adam 1.4

### 3.3.1 On-Road Testing

The Opel Adam was the third vehicle tested in the context of this study. It was a gasoline vehicle equipped with an MPI engine. The main technical specifications of this vehicle are presented in Table 15, while Table 16 summarizes the valid on-road tests conducted. It should be reminded that this vehicle was brand new when rented and were driven during 1,000 km by EMISIA SA and LAT personnel on T&E's request before testing. In total, two RDE-compliant and two extended conditions tests were conducted.

**Table 15:** Opel Adam 1.4 technical specifications

| | |
|---|---|
| Car segment | A |
| Fuel type | Gasoline |
| Engine architecture | In-line 4 cylinders, MPI naturally aspirated |
| Engine capacity [$cm^3$] | 1398 |
| Max power [kW] | 64 |
| Start-stop | No |
| Eco Mode | No |
| Transmission | Manual, 5 gears |
| Euro standard | Euro 6d-temp |
| After-treatment system | TWC |
| Tyres | Continental, ContiEcoContact, 215/45 R17 |
| Tyre pressure (Front / Rear) [psi] | 32 / 29 |
| Registration | July 2018 |

**Table 16**: Opel Adam 1.4 test summary

| **Date of Test** | **Mileage (start of testing) [km]** | **Description of Route** | **Ambient temperature during test (min-max)/average °C** |
|---|---|---|---|
| 03/08/2018 | 1044 | Compliant, Dynamic, Cold start engine | (25.56-34.36)/ 31.40 |
| 03/08/2018 | 1129 | Compliant, Smooth, Cold start engine | (21.30-25.16)/ 23.10 |
| 04/08/2018 | 1217 | Non-compliant, Extended conditions, Cold start engine | (24.55-31.38)/ 27.30 |
| 04/08/2018 | 1289 | Non-compliant, Extended conditions, Cold start engine | (20.90-30.36)/ 24.83 |

Figure 50 summarizes the gaseous emissions raw results for all the tests conducted. It can be seen that for the compliant RDE tests all emission values are below the regulation limits while for the non-compliant RDE tests the CO emissions values are increased. It can be observed, that during extended conditions, non-compliant RDE tests the CO emissions are 3-5 times higher than the corresponding emissions of the compliant trips. In addition, $CO_2$ emissions of the non-compliant tests are approximately 100 – 160 g/km higher than the $CO_2$ emissions of the compliant tests. The PN emissions are illustrated in Figure 51. It can be clearly seen that in most of the cases measurements are lower than the legislated limit. The second by second data which include the instantaneous gaseous and PN emissions, instantaneous engine and vehicle speed OBD readings, the air-fuel equivalence ratio (λ) and the battery and alternator currents, are given in Appendix V, to help the reader evaluate the results.

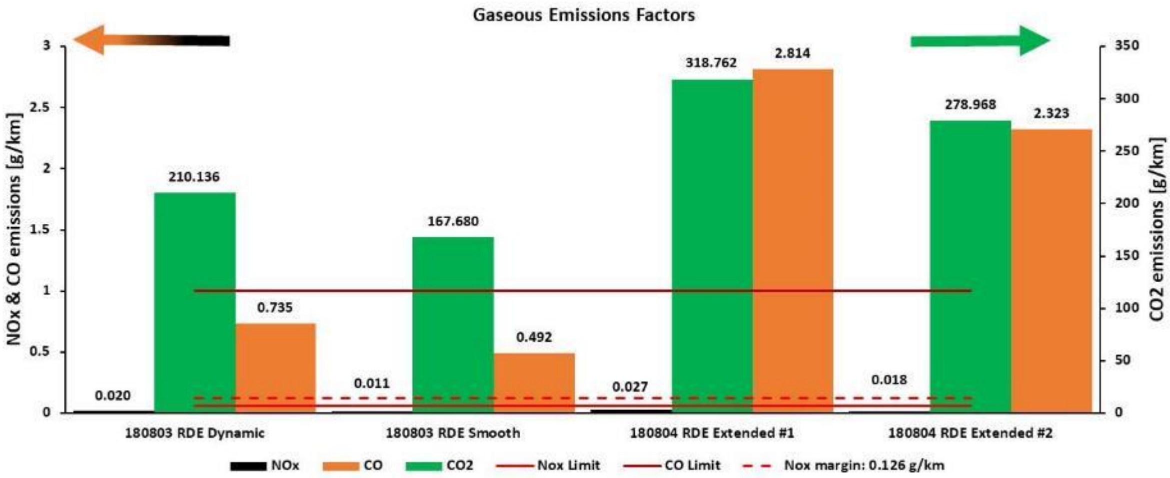



**Figure 50:** Gaseous emissions of the total trip.

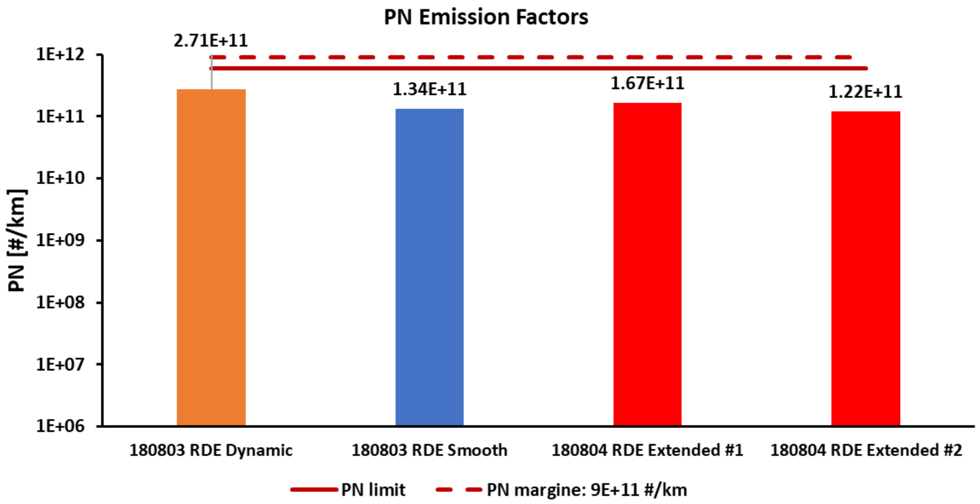



**Figure 51:** PN emissions of the total trip.

Figure 52 and Figure 53 illustrate the aggregated gaseous emissions (g/km) calculated with the CLEAR and EMROAD methods, for the compliant RDE trips. While for NOx emissions, which are very low (10-20 mg/km), both methods closely agree with the raw data, for the CO emissions, CLEAR method is closer to the raw results for the dynamic compliant trip and EMROAD method is closer for the smooth trip. For

$CO_2$ emissions, the CLEAR method is in better agreement with the raw data, with the EMROAD method calculating 17-18% lower emissions than the raw data.

PN emissions calculation with CLEAR and EMROAD methods, for the compliant RDE trips, are illustrated in Figure 54. As in the case of CO emissions, CLEAR calculated PN emissions are closer to the raw results for the dynamic compliant trip while EMROAD performs better for the smooth trip.

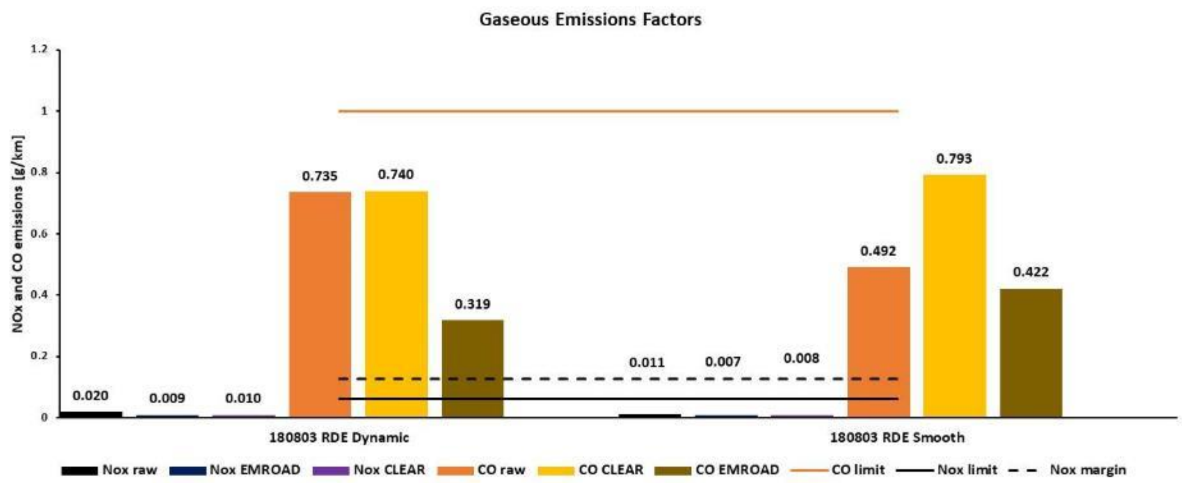



**Figure 52**: Total trip NOx and CO emissions calculated with CLEAR and EMROAD methods.

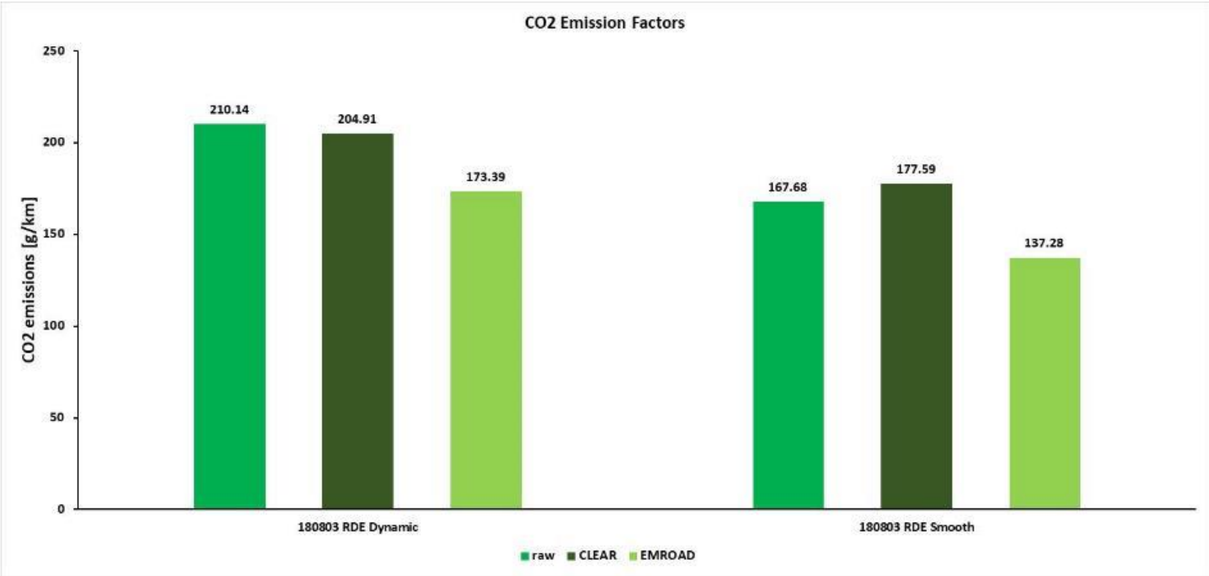



**Figure 53**: Total trip $CO_2$ emissions calculated with CLEAR and EMROAD methods.

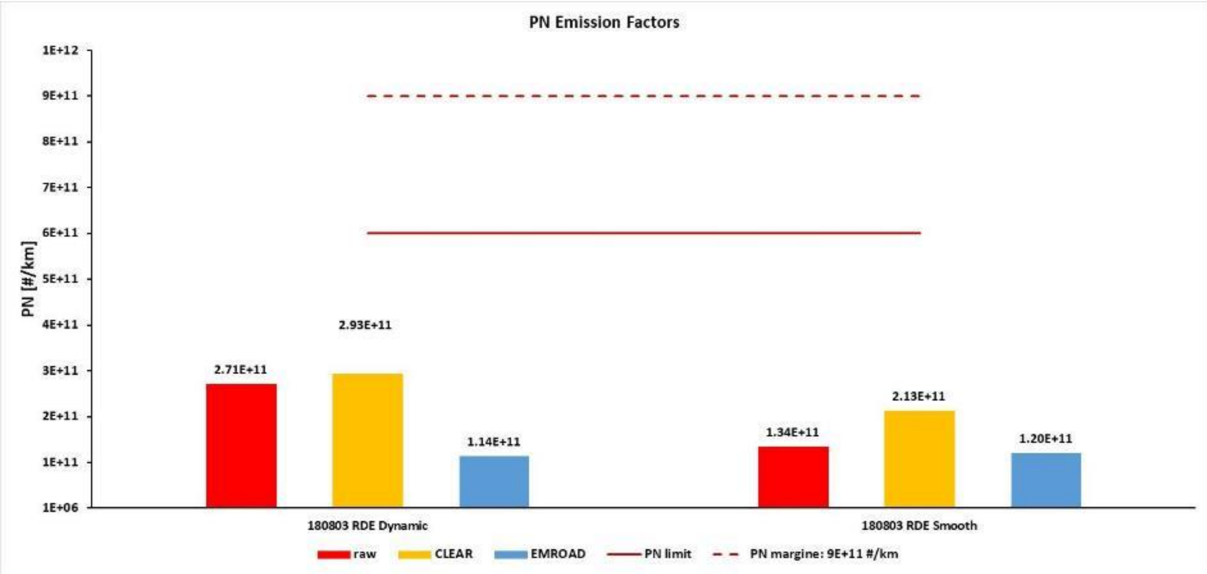



**Figure 54.** Total trip PN emissions calculated with CLEAR and EMROAD methods.

Figure 55 and Figure 56, depicts the NOx emissions per route segment. As for the total trip emissions, there are only insignificant differences between the two methods, CLEAR seems to be in better agreement with the raw results, for the urban part of the route, as this is the only route segment that comparison between these two methods can be conducted. EMROAD calculates approximately half the raw NOx emissions of the urban part of the routes, both for the case of the smooth and the dynamic trip. It should be mentioned that for all cases and route segments, NOx emissions stay far below the legislated limit.

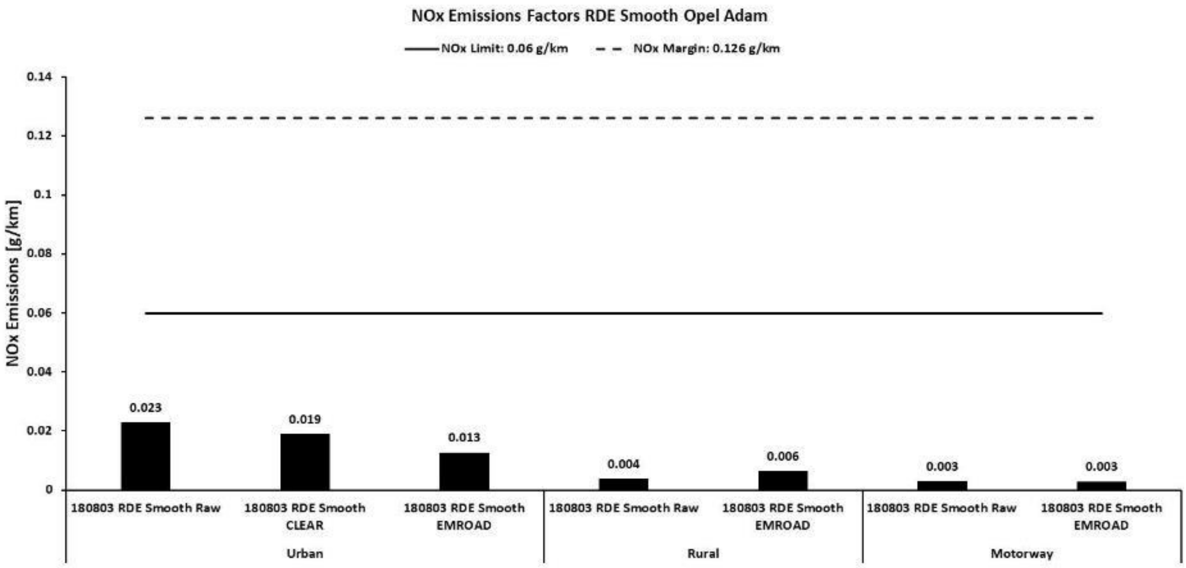



**Figure 55:** Compliant RDE smooth trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

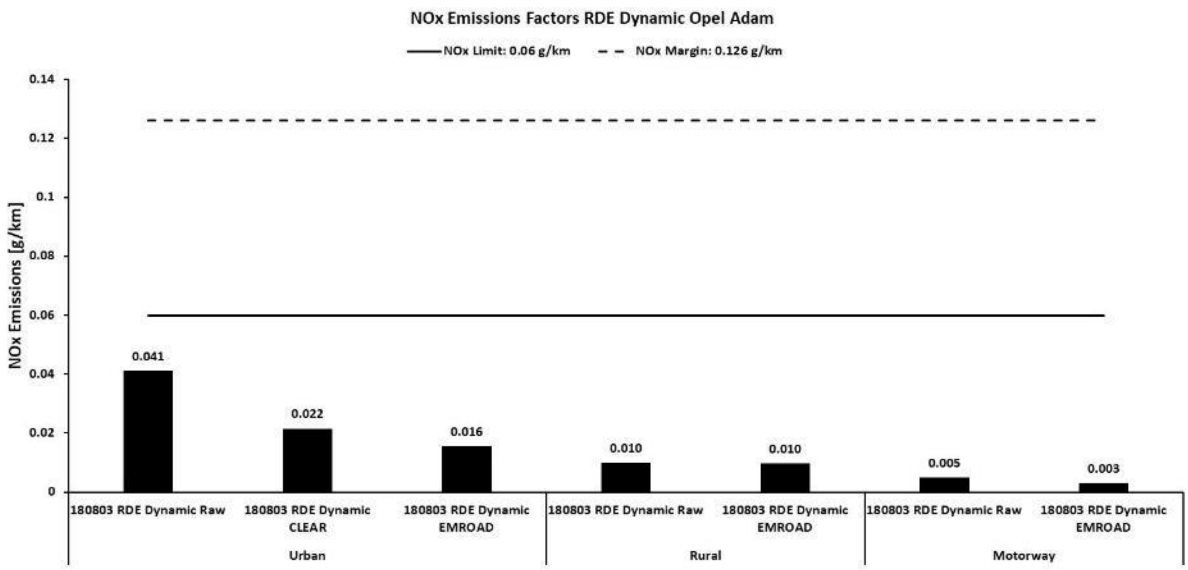



**Figure 56:** Compliant RDE dynamic trip, distributed NOx emissions calculated with CLEAR and EMROAD methods.

The comparison between the two methods in the urban part of the route, for $CO_2$ emissions (Figure 57 and Figure 58) is also showing that CLEAR method gives values closer to the raw results in both compliant routes, while EMROAD method gives 24-25% lower values. In addition, EMROAD calculated $CO_2$ emissions for the rural part are close to the raw values while for the motorway part EMROAD calculates 20-24% lower values than the raw results. Similar conclusions can be drawn for the CO emissions, presented in Figure 59 and Figure 60. Again, CLEAR method is in closer agreement with the raw results for the urban part of both RDE compliant trips.

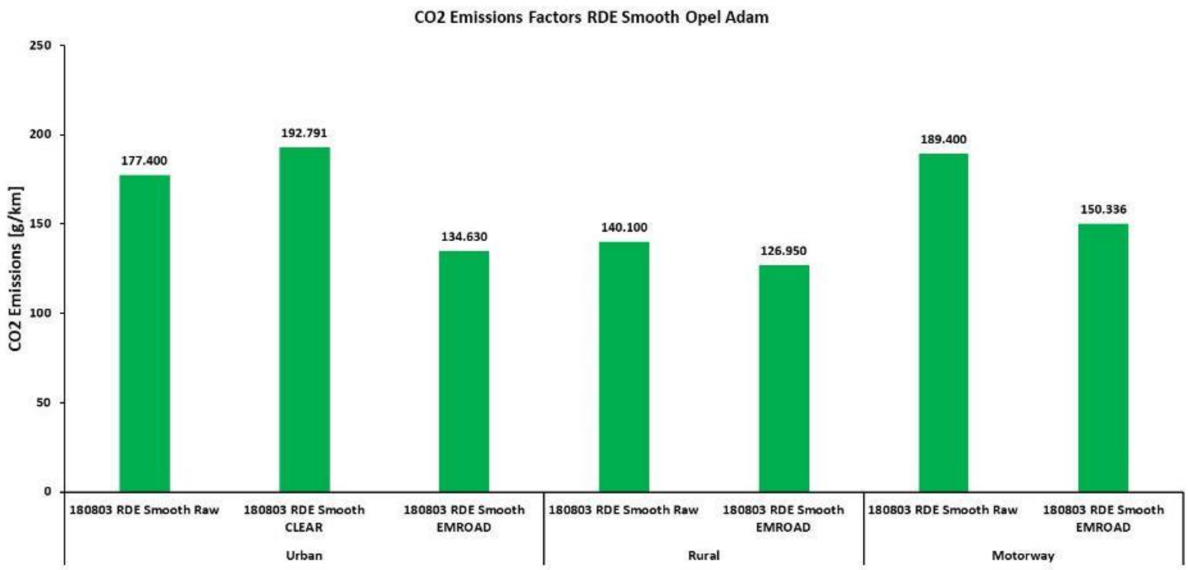



**Figure 57**: Compliant RDE smooth trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

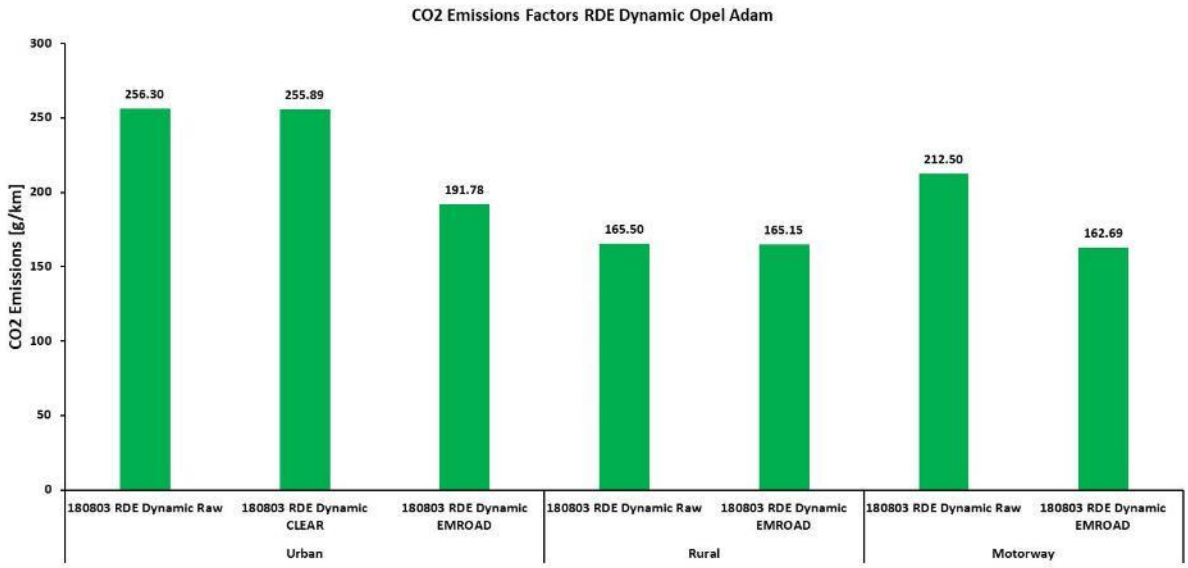



**Figure 58:** Compliant RDE dynamic trip, distributed $CO_2$ emissions calculated with CLEAR and EMROAD methods.

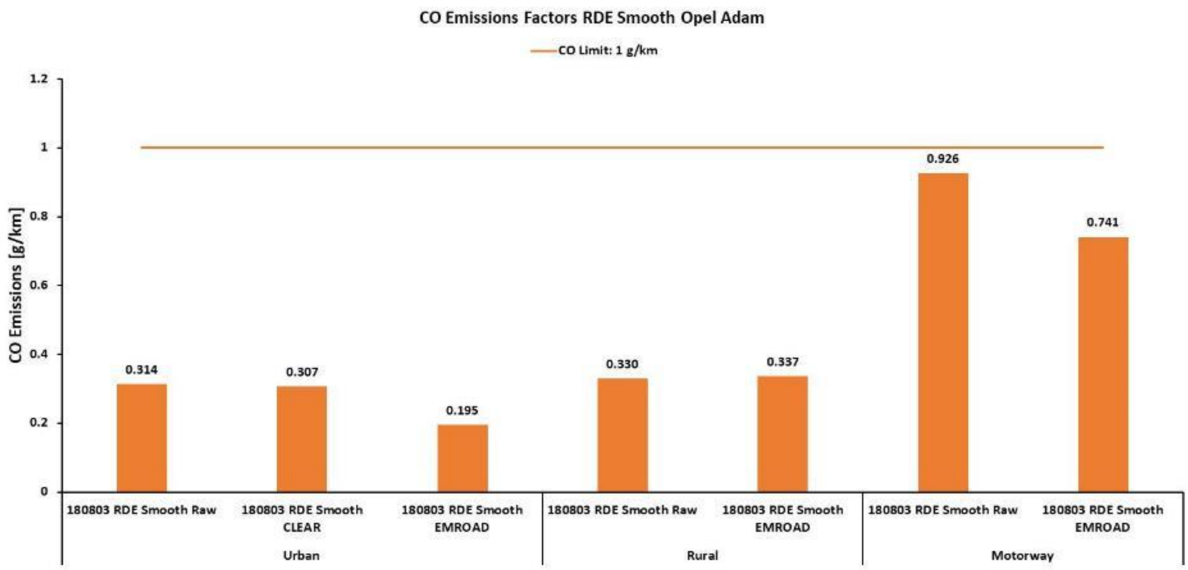



**Figure 59:** Compliant RDE smooth trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

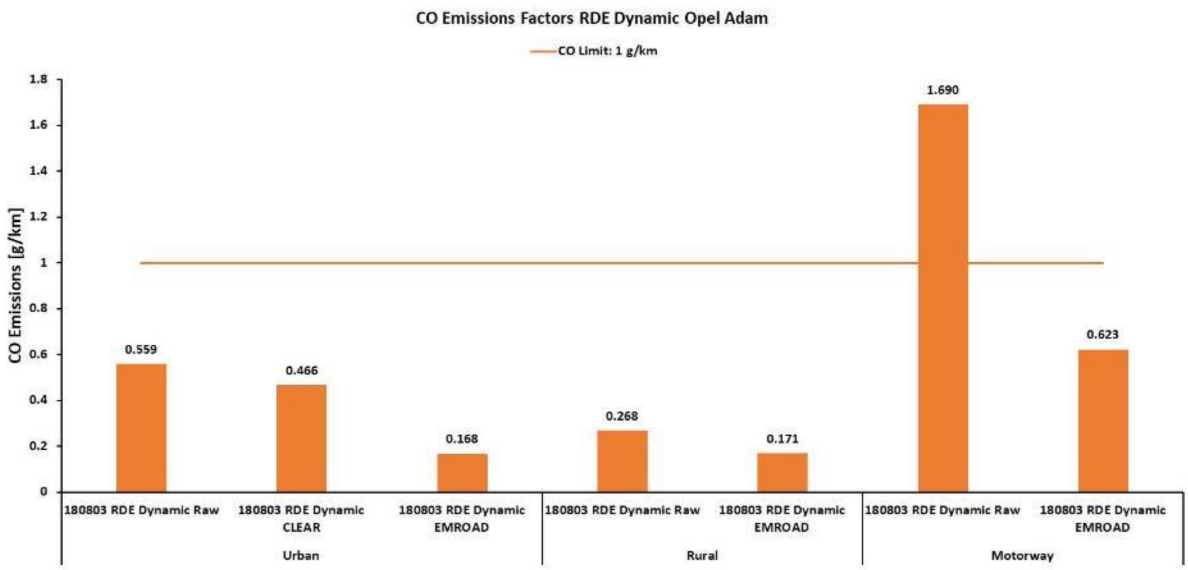



**Figure 60:** Compliant RDE dynamic trip, distributed CO emissions calculated with CLEAR and EMROAD methods.

Finally, the PN emissions presented in Figure 61 and in Figure 62, are higher with CLEAR in the urban part of both compliant routes, where EMROAD is in closer agreement with the raw results. It should be mentioned that for the urban part of the dynamic trip, CLEAR calculates PN emissions exceeding the legislated limit, while the raw value is approximately half. In the rural and the motorway part of both trips, PN emissions, which are lying below the legislated limit, EMROAD is in good agreement with the raw results.

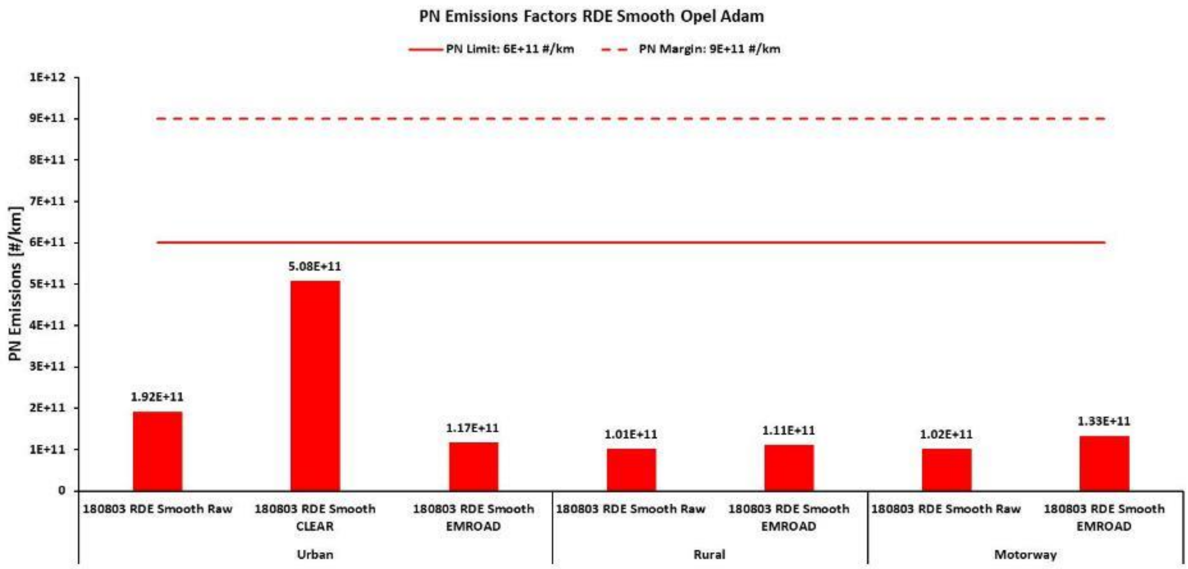



**Figure 61:** Compliant RDE smooth trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

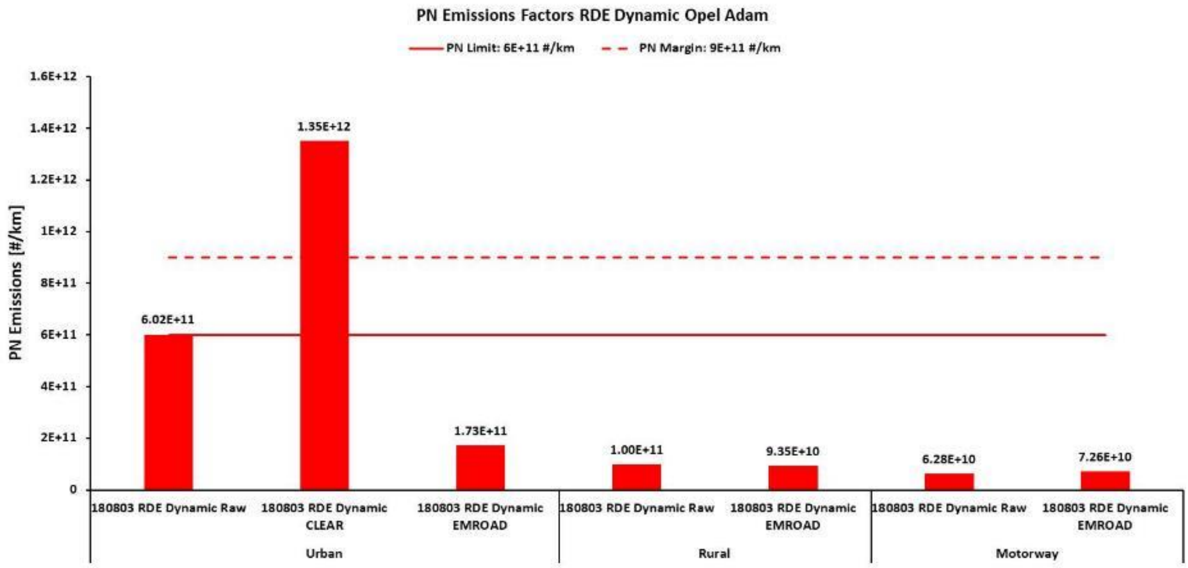



**Figure 62:** Compliant RDE dynamic trip, distributed PN emissions calculated with CLEAR and EMROAD methods.

Concluding the on road measurements of the segment A vehicle, it should be mentioned that for the smooth and the dynamic RDE compliant routes, the NOx emissions measured (20 mg/km) are much lower than the RDE value declared in the certificate of conformity of the vehicle (126 mg/km). In addition PN emissions are not legislated for gasoline MPI vehicles, so type approval data for PN are not provided.

### 3.3.2 Coast-down and Laboratory Testing

Before running the laboratory tests, a coast-down was conducted in order to determine the real world road load using the NEDC and WLTP-High test masses, as estimated by data declared in the certificate of conformity of the vehicle, and especially by assuming that the test mass declared is more likely to approach the WLTP-Low test mass. These loads were used on the chassis dyno measurements according to the relevant procedures. Figure 63 presents the result of this coast-down, together with the final deceleration times for NEDC and WLTP-High test masses. In addition Table 17 illustrates the test masses and the values of the coefficients of the second order polynomial function describing the total force exerted on the vehicle. It is observed that the final realistic coast-down time is very close between the two different test masses.

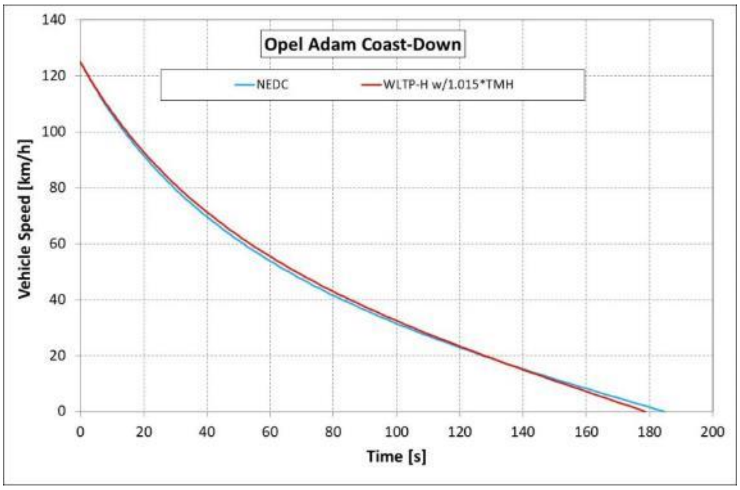



**Figure 63:** Coast down curves for the NEDC and the WLTP-High dynamometer settings

**Table 17:** Coast down test masses and coefficients.

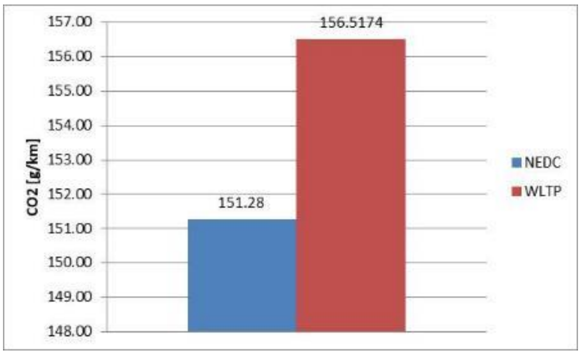
| | NEDC | WLTP-H | WLTP-TA |
|---|---|---|---|
| Test mass [kg] | 1130 | 1265 | 1242 |
| F0 [N] | 102.1 | 136.0 | 76.5 |
| F1 [N/(km/h)] | 0.2501 | -0.1421 | 0.903 |
| F2 [N/(km/h)^2] | 0.034 | 0.03840 | 0.029 |

For the faultless operation of the vehicle on the dyno, the dyno mode of the vehicle was applied, following a specific procedure. This was necessary, since the vehicle was tested on a 1-axis chassis dyno.

Figure 64 presents the comparison of $CO_2$ and CO emissions between the two procedures followed. It seems that WLTP-High $CO_2$ emissions are very near to the NEDC $CO_2$ emissions (less than 4% difference) with the WLTP value lying slightly higher. Comparing with the certificate of conformity of the vehicle WLTP $CO_2$ value (150 g/km), the measured value (156.5 g/km) is very close. It should be mentioned that the test mass declared in the certificate of conformity (1242 kg), is slightly lower than our test mass (1265 kg), as illustrated in Table 17. It is also worth noting that CO emissions on NEDC are higher than the Euro 6 limit, but it is below this limit on WLTP.

Figure 65 presents the comparison of $NO_x$ and NO emissions between the two procedures followed. WLTP-High NOx emissions (40 mg/km) are much higher than the NEDC NOx emissions (3 mg/km). Comparing with the certificate of conformity of the vehicle type approval NOx emissions (16.5 mg/km), the measured value is approximately double but still below the legislated limit.

Particle emissions of this vehicle have not been conducted as they are not legislated for gasoline MPI vehicles. Comparison of the fuel consumption between the two different procedures followed is illustrated in Figure 66. As expected due to the $CO_2$ emissions presented earlier, WLTP-High fuel consumption (6.65 l/100 km) is slightly higher than the NEDC fuel consumption (6.46 l/100 km). At the same time it is very close to the declared value in the vehicle certificate of conformity for the WLTP (6.6 l/100 km). The emissions results per cycle segment are summarized in Table 18 for NEDC procedure and in Table 19 for the WLTP.



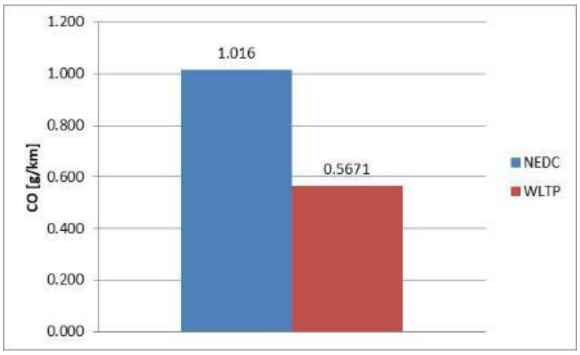
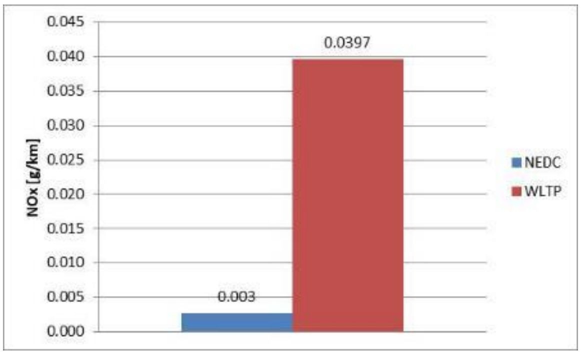




**Figure 64:** $CO_2$ emissions in NEDC and WLTP-High (left) and CO emissions in NEDC and WLTP-High (right)



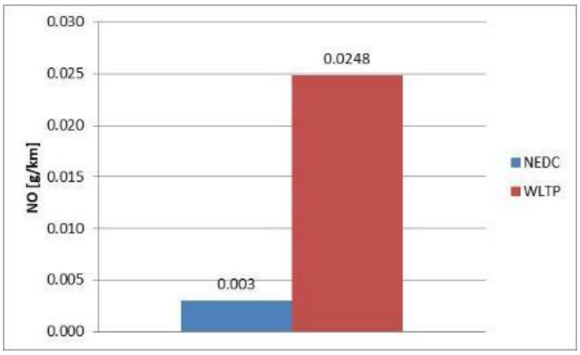




**Figure 65:** $NO_x$ emissions in NEDC and WLTP-High (left) and NO emissions in NEDC and WLTP-High (right)

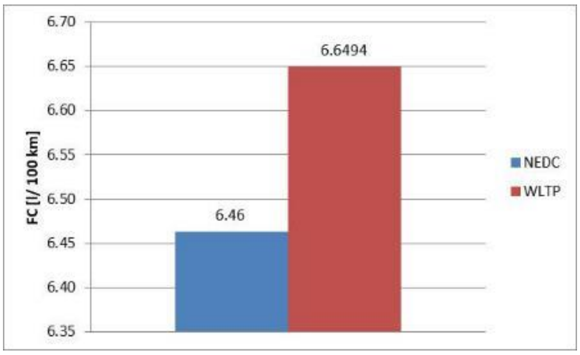



**Figure 66:** Fuel consumption in NEDC and WLTP-High

**Table 18:** Summary of NEDC emissions.

| | | | |
|---|---|---|---|
| **CO2 [g/km]** | 199.52 | 123.42 | 151.28 |
| **CO [g/km]** | 2.262 | 0.296 | 1.016 |
| **NOx [g/km]** | 0.008 | 0.000 | 0.003 |
| **NO [g/km]** | 0.008 | 0.000 | 0.003 |
| **FC [l/100 km]** | 8.60 | 5.23 | 6.46 |

**Table 19:** Summary of WLTP emissions.

| | WLTC Low | WLTC Medium | WLTC High | WLTC Extra High | WLTC |
|---|---|---|---|---|---|
| **CO2 [g/km]** | 221.10 | 142.06 | 131.27 | 162.75 | 156.5174 |
| **CO [g/km]** | 2.457 | 0.223 | 0.272 | 0.316 | 0.5671 |
| **NOx [g/km]** | 0.048 | 0.018 | 0.008 | 0.076 | 0.0397 |
| **NO [g/km]** | 0.032 | 0.012 | 0.005 | 0.046 | 0.0248 |
| **FC [l/100 km]** | 9.53 | 6.01 | 5.56 | 6.89 | 6.6494 |

The instantaneous WLTP measurements, along with the bag results presented above, were also used in the tool $CO_2$MPAS to check the accuracy of the prediction of the NEDC $CO_2$ emissions. The results are illustrated in Figure 67 and it can be seen that the NEDC $CO_2$ emissions are well predicted with only a 2.7% difference with the measured value.

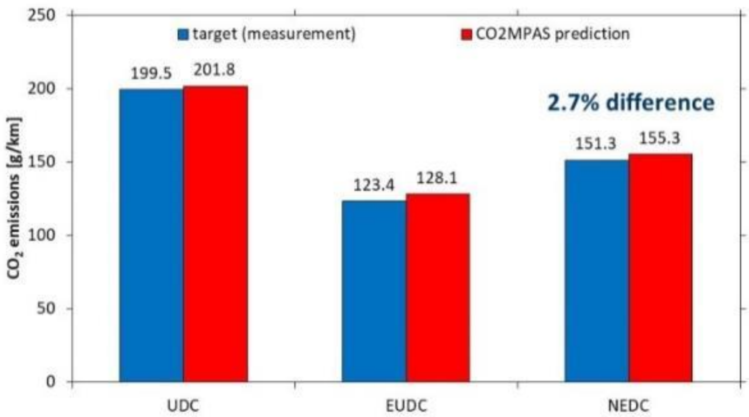



**Figure 67:** $CO_2$MPAS results for segment A vehicle.

# 4 Summary and Future Steps

This report summarized the work conducted by EMISIA SA and LAT in the context of a testing campaign and experimental study for Transport & Environment (T&E), supported by the European Commission Life+ Programme in the context of "Close the Gap" campaign. The work was related to the emissions testing on three vehicles of different technology, all of which Euro 6d-temp compliant, and under various driving conditions, both in laboratory and on-road using a Portable Emissions Measuring System (PEMS).

Three vehicles were tested, one diesel, one gasoline GDI and one gasoline MPI, all of them sourced by rental companies. The diesel vehicle had over 5000 km on the odometer while the gasoline vehicles were just bought by the rental companies at the time of testing. For that reason they have been driven for approximately 1000 km by EMISIA SA and LAT personnel before testing, on T&E's request, on open and public roads during week days with normal driving by following traffic flows in a mix of urban, rural, motorway. The diesel vehicle was equipped with NSC (LNT) and DPF, the gasoline GDI vehicle was equipped with a TWC and a GPF and the gasoline MPI vehicle was equipped only with a TWC. All vehicles were tested in the same 2 RDE-compliant routes (smooth and dynamic), while two additional extended conditions trips followed. In addition the compliant trips raw data were post processed with CLEAR and EMROAD methods. The testing campaign assisted the assessment of the real-world behavior of the tested vehicles and of different technologies. Further, all the vehicles were tested in the laboratory, under NEDC, WLTC using the real world road load determined by coast-down tests using the NEDC and WLTP-High test masses, as estimated by data declared in the certificates of conformity of the vehicles, and especially by assuming that the test mass declared is more likely to approach the WLTP-Low test mass. Moreover, the WLTP instantaneous data were used as input to the $CO_2$MPAS tool, to estimate the NEDC $CO_2$ emissions.

The activities in the context of this study provide a good basis for further testing and investigation on real-world emissions. It is interesting to expand the investigation in other vehicles with different engine technologies, such as a GDI lean-burn vehicle, focusing on $NO_x$ and PN emissions, as well as on $CO_2$ emissions and fuel consumption. It is also important also to include gasoline GDI vehicles with GPF, with mileage higher than 5000km to check if the high particle emissions observed in this study can be decreased after more intense operation of the particle filter.

# Appendix I : Detailed technical specifications of the Portable Emissions Measurement System (PEMS).

**Table 20:** Detailed specifications of the gas PEMS

| | Range | Display Resolution | Accuracy | Linearity |
|---|---|---|---|---|
| **CO** | Linearized range: 0 … 49999 ppm<br>Display range: 0 … 15 vol% | 1 ppm | 0 … 1499 ppm: ±30 ppm abs.<br>1500 ppm … 49999 ppm: ±2% rel. | Slope: 0.99 ≤ Slope ≤ 1.01<br>Intercept = 0.5%<br>SEE: ≤ 1% of range and $R^2$: ≥ 0.999 |
| **$CO_2$** | 0 … 20 vol% | 0.01 vol% | 0 … 9.99 vol%: ±0.1 vol% abs.<br>10 … 20 vol%: ±2% rel. | Slope: 0.99 ≤ Slope ≤ 1.01<br>Intercept = 0.5%<br>SEE: ≤ 1% of range and $R^2$: ≥ 0.999 |
| **NO** | 0 … 5000 ppm | 0.1 ppm | 0 … 5000 ppm: ±0.2% FS or ±2% rel. | Slope: 0.99 ≤ Slope ≤ 1.01<br>Intercept = 0.5%<br>SEE: ≤ 1% of range and $R^2$: ≥ 0.999 |
| **$NO_2$** | 0 … 2500 ppm | 0.1 ppm | 0 … 2500 ppm: ±0.2% FS or ±2% rel. | |
| **$O_2$** | 0 … 25% | 0.1 vol% | ±1 vol% of full scale at constant temperature and pressure | — |

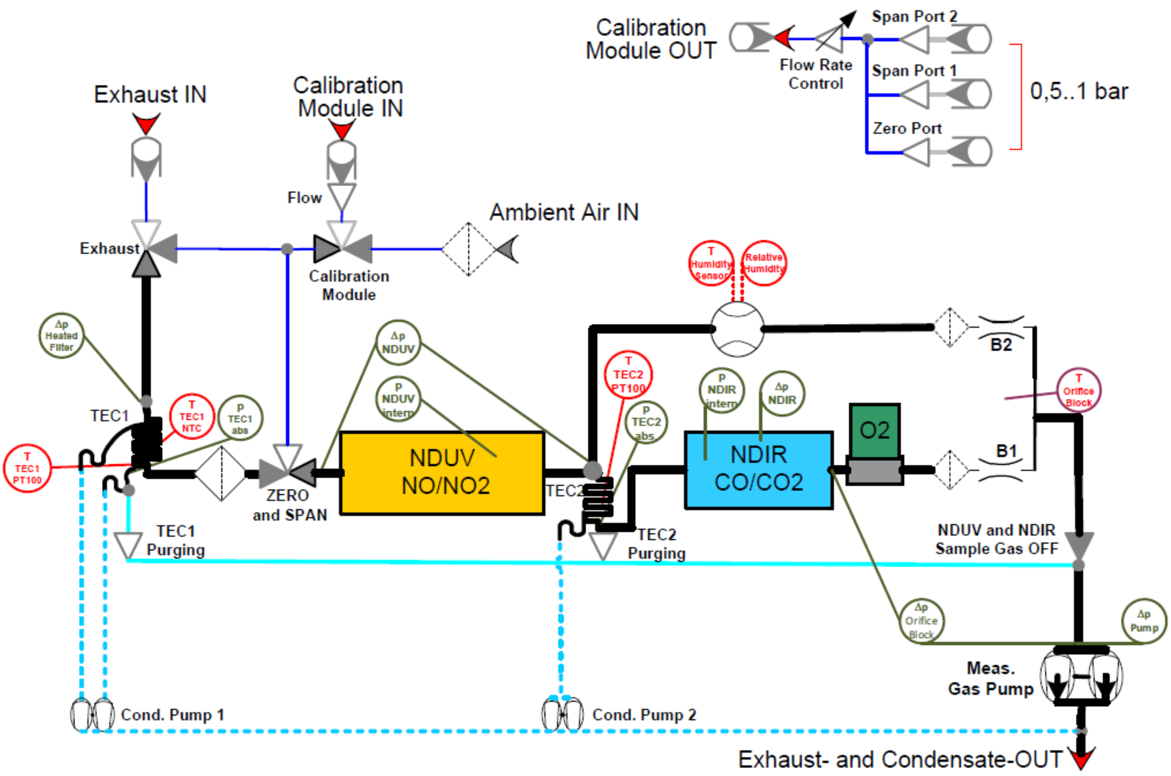
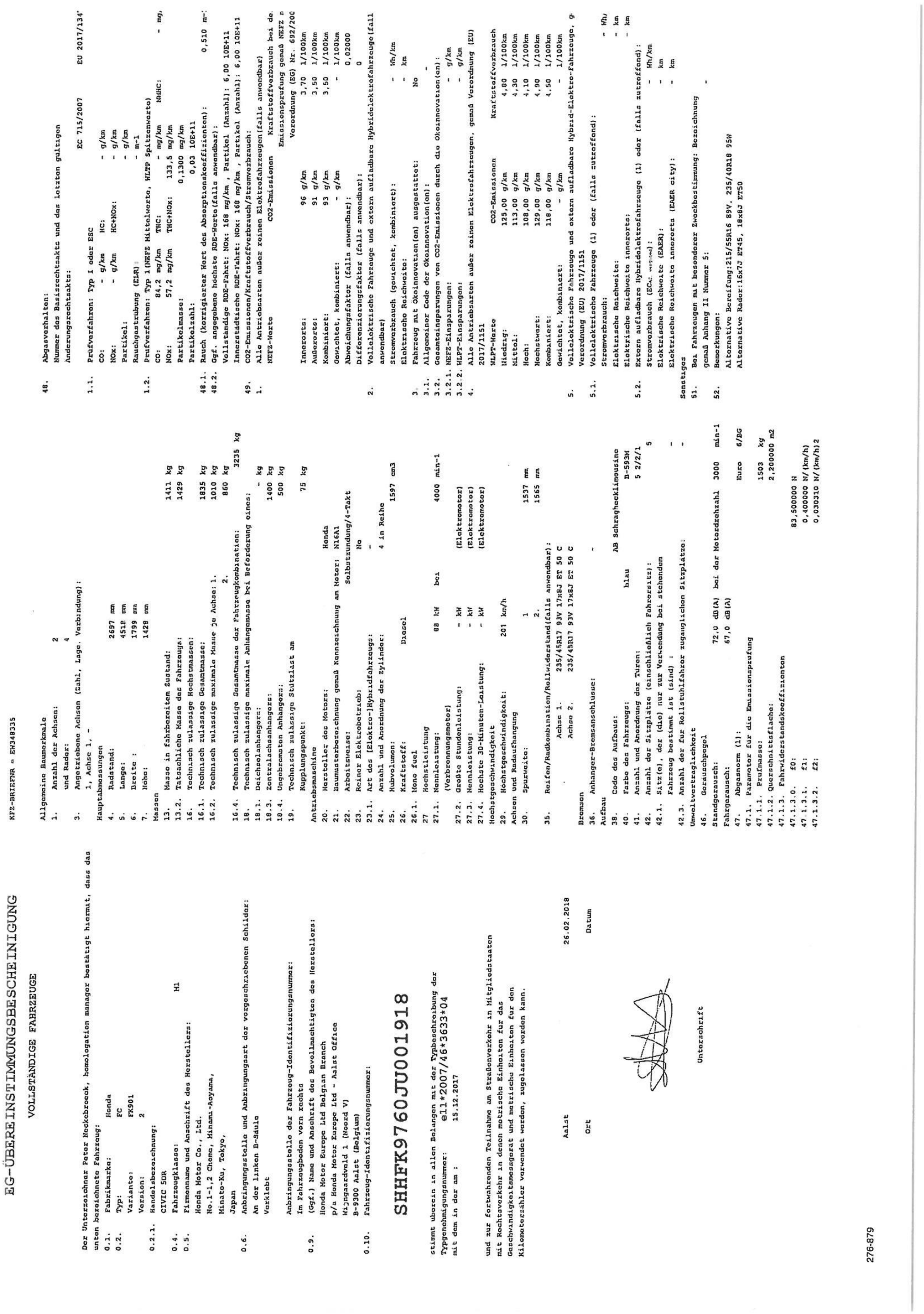



**Figure 68:** System description and measurement principles of the gas PEMS.

**Table 21:** Detailed specifications of the PN PEMS.

| Product name | AVL M.O.V.E PN PEMS iS | | |
|---|---|---|---|
| ▪ Heated line length: | 1.35 m | 1.05 m | 4.5 m |
| ▪ Material number: | GH1026 | GH1174 | GH1175 |
| **Power supply** | | | |
| ▪ Supply: | 21 … 28.8 V DC | | |
| ▪ Power consumption: | max. 550 W | max. 550 W | max. 730 W |
| **Warm-up time** | 25 … 60 min, depending on ambient temperature conditions | | |
| **Delay time** | < 3.5 s | | |
| **Rise time** | < 3 s | | |
| **Sample flow rate** | Approx. 0.5 $^{l}/_{min}$ | | |
| **Pneumatic inlets/outlets** | EXHAUST IN / Dilution Out, EXHAUST OUT, COND. OUT | | |
| **Max. exhaust temperature** | Max. 200 °C at sample point | | |
| **Max. exhaust pressure** | ±50 mbar rel. | | |
| **Update recording frequency** | Up to 10 Hz for measurement<br>Up to 1 Hz for service data | | |
| **Electrical inputs/outputs** | 1 × power supply<br>2 × heated sampling line | | |
| **Operating temperature** | -10 … +45 °C | | |
| **Storage temperature** | -30 … +70 °C | | |
| **Operation sea level** | Up to 3000 m | | |
| **Relative air humidity** | ≤ 95%, non-condensing at 25 °C ambient temperature | | |
| **Degree of protection** | IP 24 | | |
| **Dimensions** | | | |
| ▪ Measuring unit: | ~ 507 × 193 × 374 mm (W × H × D) | | |
| **Weights** | | | |
| ▪ Measuring unit: | ~16.0 kg | | |
| ▪ VPR assembly: | ~6.2 kg | ~6.2 kg | ~11.0 kg |
| **Communication interfaces** | 1 × Ethernet (TCP/IP), 2 × Serial | | |

## Appendix II : Vehicle’s certificates of conformity.



EG-ÜBEREINSTIMMUNGSBESCHEINIGUNG

VOLLSTÄNDIGE FAHRZEUGE

Der Unterzeichner Peter Neckebroeck, homologation manager bestätigt hiermit, dass das unten bezeichnete Fahrzeug:

0.1. Fabrikmarke: Honda
0.2. Typ: FC
Variante: FK901
Version: 2
0.2.1. Handelsbezeichnung: CIVIC 5DR
0.4. Fahrzeugklasse: M1
0.5. Firmenname und Anschrift des Herstellers: Honda Motor Co., Ltd. No.1-1,2 Chome, Minami-Aoyama, Minato-Ku, Tokyo, Japan
0.6. Anbringungsstelle und Anbringungsart der vorgeschriebenen Schilder: An der linken B-Säule Verklebt
Anbringungsstelle der Fahrzeug-Identifizierungsnummer: Im Fahrzeugboden vorn rechts
0.9. (Ggf.) Name und Anschrift des Bevollmächtigten des Herstellers: Honda Motor Europe Ltd Belgian Branch p/a Honda Motor Europe Ltd - Aalst Office Wijngaardveld 1 (Noord V) B-9300 Aalst (Belgium)
0.10. Fahrzeug-Identifizierungsnummer:

SHHFK9760JU001918

stimmt überein in allen Belangen mit der Typbeschreibung der Typgenehmigungsnummer: e11*2007/46*3633*04
mit dem in der am : 15.12.2017

und zur fortwährenden Teilnahme am Straßenverkehr in Mitgliedstaaten mit Rechtsverkehr in denen metrische Einheiten für das Geschwindigkeitsmessgerät und metrische Einheiten für den Kilometerzähler verwendet werden, zugelassen werden kann.

Aalst 26.02.2018
Ort Datum

Unterschrift

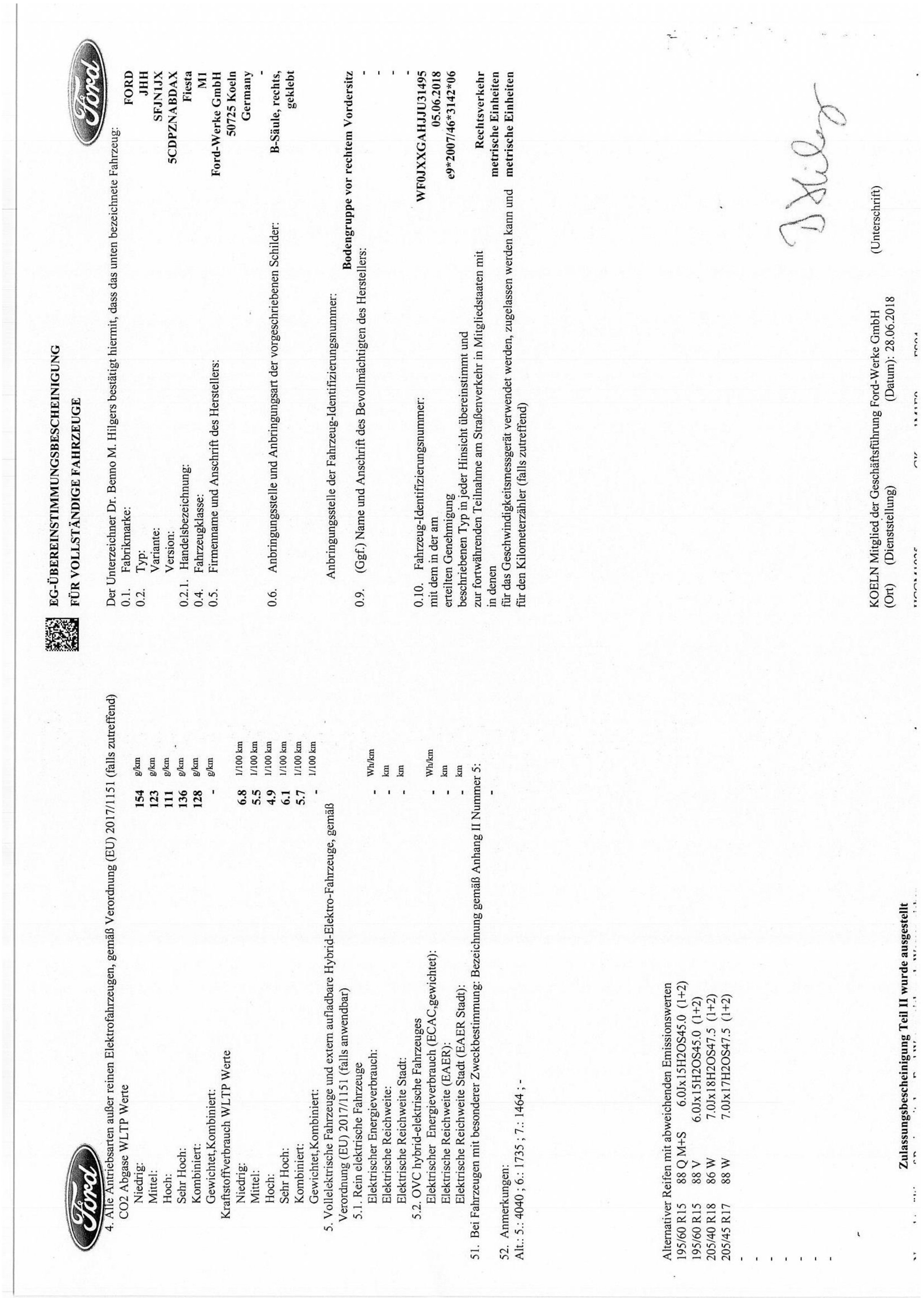
276-879

KFZ-BRIEFNR = EW348335

Allgemeine Baumerkmale
1. Anzahl der Achsen: 2
und Räder: 4
3. Angetriebene Achsen (Zahl, Lage, Verbindung): 1, Achse 1, -
Hauptabmessungen
4. Radstand: 2697 mm
5. Länge: 4518 mm
6. Breite : 1799 mm
7. Höhe: 1428 mm
Massen
13. Masse in fahrbereitem Zustand: 1411 kg
13.2. Tatsächliche Masse des Fahrzeugs: 1429 kg
16. Technisch zulässige Höchstmassen:
16.1. Technisch zulässige Gesamtmasse: 1835 kg
16.2. Technisch zulässige maximale Masse je Achse: 1. 1010 kg
2. 860 kg
16.4. Technisch zulässige Gesamtmasse der Fahrzeugkombination: 3235 kg
18. Technisch zulässige maximale Anhängemasse bei Beförderung eines:
18.1. Deichselanhängers: - kg
18.3. Zentralachsanhängers: 1400 kg
18.4. Ungebremsten Anhängers: 500 kg
19. Technisch zulässige Stützlast am Kupplungspunkt: 75 kg
Antriebsmaschine
20. Hersteller des Motors: Honda
21. Baumusterbezeichnung gemäß Kennzeichnung am Motor: N16A1
22. Arbeitsweise: Selbstzündung/4-Takt
23. Reiner Elektrobetrieb: No
23.1. Art des [Elektro-]Hybridfahrzeugs: -
24. Anzahl und Anordnung der Zylinder: 4 in Reihe
25. Hubvolumen: 1597 cm3
26. Kraftstoff: Diesel
26.1. Mono fuel
27 Höchstleistung
27.1. Nennleistung: 88 kW bei 4000 min-1 (Verbrennungsmotor)
27.2. Größte Stundenleistung: - kW (Elektromotor)
27.3. Nennleistung: - kW (Elektromotor)
27.4. Höchste 30-Minuten-Leistung: - kW (Elektromotor)
Höchstgeschwindigkeit
29. Höchstgeschwindigkeit: 201 km/h
Achsen und Radaufhängung
30. Spurweite: 1 1537 mm
2. 1565 mm
35. Reifen/Radkombination/Rollwiderstand(falls anwendbar):
Achse 1. 235/45R17 93V 17x8J ET 50 C
Achse 2. 235/45R17 93V 17x8J ET 50 C
Bremsen
36. Anhänger-Bremsanschlüsse: -
Aufbau
38. Code des Aufbaus: AB Schräghecklimousine
40. Farbe des Fahrzeugs: blau B-593M
41. Anzahl und Anordnung der Türen: 5 2/2/1
42. Anzahl der Sitzplätze (einschließlich Fahrersitz): 5
42.1. Sitz(e), der (die) nur zur Verwendung bei stehendem Fahrzeug bestimmt ist (sind) : -
42.3. Anzahl der für Rollstuhlfahrer zugänglichen Sitzplätze: -
Umweltverträglichkeit
46. Geräuschpegel
Standgeräusch: 72,0 dB(A) bei der Motordrehzahl 3000 min-1
Fahrgeräusch: 67,0 dB(A)
47. Abgasnorm (1): Euro 6/BG
47.1. Parameter für die Emissionsprüfung
47.1.1. Prüfmasse: 1503 kg
47.1.2. Querschnittsfläche: 2,200000 m2
47.1.3. Fahrwiderstandskoeffizienten
47.1.3.0. f0: 83,500000 N
47.1.3.1. f1: 0,400000 N/(km/h)
47.1.3.2. f2: 0,030310 N/(km/h)2

48. Abgasverhalten:
Nummer des Basisrechtsakts und des letzten gültigen Änderungsrechtsakts: EC 715/2007 EU 2017/134
1.1. Prüfverfahren: Typ I oder ESC
CO: - g/km HC: - g/km
NOx: - g/km HC+NOx: - g/km
Partikel: - g/km
Rauchgastrübung (ELR): - m-1
1.2. Prüfverfahren: Typ 1(NEFZ Mittelwerte, WLTP Spitzenwerte)
CO: 84,2 mg/km THC: - mg/km NMHC: - mg
NOx: 57,2 mg/km THC+NOx: 133,5 mg/km
Partikelmasse: 0,1300 mg/km
Partikelzahl: 0,03 10E+11
48.1. Rauch (korrigierter Wert des Absorptionskoeffizienten): 0,510 m-1
48.2. Ggf. angegebene höchste RDE-Werte(falls anwendbar):
Vollständige RDE-Fahrt: NOx: 168 mg/km , Partikel (Anzahl): 6,00 10E+11
Innerstädtische RDE-Fahrt: NOx: 168 mg/km , Partikel (Anzahl): 6,00 10E+11
49. CO2-Emissionen/Kraftstoffverbrauch/Stromverbrauch:
1. Alle Antriebsarten außer reinen Elektrofahrzeugen(falls anwendbar)
NEFZ-Werte CO2-Emissionen Kraftstoffverbrauch bei der Emissionsprüfung gemäß NEFZ n Verordnung (EG) Nr. 692/200
Innerorts: 96 g/km 3,70 1/100km
Außerorts: 91 g/km 3,50 1/100km
Kombiniert: 93 g/km 3,50 1/100km
Gewichtet, kombiniert: - g/km - 1/100km
Abweichungsfaktor (falls anwendbar): 0,02000
Differenzierungsfaktor (falls anwendbar): 0
2. Vollelektrische Fahrzeuge und extern aufladbare Hybridelektrofahrzeuge(falls anwendbar)
Stromverbrauch (gewichtet, kombiniert): - Wh/km
Elektrische Reichweite: - km
3. Fahrzeug mit Ökoinnovation(en) ausgestattet: No
3.1. Allgemeiner Code der Ökoinnovation(en): -
3.2. Gesamteinsparungen von CO2-Emissionen durch die Ökoinnovation(en):
3.2.1. NEFZ-Einsparungen: - g/km
3.2.2. WLPT-Einsparungen: - g/km
4. Alle Antriebsarten außer reinen Elektrofahrzeugen, gemäß Verordnung (EU) 2017/1151
WLPT-Werte CO2-Emissionen Kraftstoffverbrauch
Niedrig: 125,00 g/km 4,80 1/100km
Mittel: 113,00 g/km 4,30 1/100km
Hoch: 108,00 g/km 4,10 1/100km
Höchstwert: 129,00 g/km 4,90 1/100km
Kombiniert: 118,00 g/km 4,50 1/100km
Gewichtet, kombiniert: - g/km - 1/100km
5. Vollelektrische Fahrzeuge und extern aufladbare Hybrid-Elektro-Fahrzeuge, g Verordnung (EU) 2017/1151
5.1. Vollelektrische Fahrzeuge (1) oder (falls zutreffend):
Stromverbrauch: - Wh/
Elektrische Reichweite: - km
Elektrische Reichweite innerorts: - km
5.2. Extern aufladbare Hybridelektrofahrzeuge (1) oder (falls zutreffend):
Stromverbrauch (EC, gewichtet): - Wh/km
Elektrische Reichweite (EAER): - km
Elektrische Reichweite innerorts (EAER city): - km
Sonstiges
51. Bei Fahrzeugen mit besonderer Zweckbestimmung: Bezeichnung gemäß Anhang II Nummer 5: -
52. Bemerkungen:
Alternative Bereifung:215/55R16 89V, 235/40R18 95W
Alternative Räder:16x7J ET45, 18x8J ET50

**Figure 69:** Segment C vehicle certificate of conformity (scanned copy).



**EG-ÜBEREINSTIMMUNGSBESCHEINIGUNG**
**FÜR VOLLSTÄNDIGE FAHRZEUGE**

Der Unterzeichner Dr. Benno M. Hilgers bestätigt hiermit, dass das unten bezeichnete Fahrzeug:

| | | |
|---|---|---|
| 0.1. | Fabrikmarke: | **FORD** |
| 0.2. | Typ: | **JHH** |
| | Variante: | **SFJN1JX** |
| | Version: | **5CDPZNABDAX** |
| 0.2.1. | Handelsbezeichnung: | **Fiesta** |
| 0.4. | Fahrzeugklasse: | **M1** |
| 0.5. | Firmenname und Anschrift des Herstellers: | **Ford-Werke GmbH 50725 Koeln Germany** |
| | | - |
| 0.6. | Anbringungsstelle und Anbringungsart der vorgeschriebenen Schilder: | **B-Säule, rechts, geklebt** |
| | Anbringungsstelle der Fahrzeug-Identifizierungsnummer: | **Bodengruppe vor rechtem Vordersitz** |
| 0.9. | (Ggf.) Name und Anschrift des Bevollmächtigten des Herstellers: | - |
| | | - |
| | | - |
| | | - |
| 0.10. | Fahrzeug-Identifizierungsnummer: | **WF0JXXGAHJJU31495** |

mit dem in der am **05.06.2018**
erteilten Genehmigung **e9*2007/46*3142*06**
beschriebenen Typ in jeder Hinsicht übereinstimmt und
zur fortwährenden Teilnahme am Straßenverkehr in Mitgliedstaaten mit **Rechtsverkehr**
in denen **metrische Einheiten**
für das Geschwindigkeitsmessgerät verwendet werden, zugelassen werden kann und **metrische Einheiten**
für den Kilometerzähler (falls zutreffend)

KOELN Mitglied der Geschäftsführung Ford-Werke GmbH (Unterschrift)
(Ort) (Dienststellung) (Datum): 28.06.2018

4. Alle Antriebsarten außer reinen Elektrofahrzeugen, gemäß Verordnung (EU) 2017/1151 (falls zutreffend)

| | | |
|---|---|---|
| CO2 Abgase WLTP Werte | | |
| Niedrig: | **154** | g/km |
| Mittel: | **123** | g/km |
| Hoch: | **111** | g/km |
| Sehr Hoch: | **136** | g/km |
| Kombiniert: | **128** | g/km |
| Gewichtet,Kombiniert: | - | g/km |
| Kraftstoffverbrauch WLTP Werte | | |
| Niedrig: | **6.8** | l/100 km |
| Mittel: | **5.5** | l/100 km |
| Hoch: | **4.9** | l/100 km |
| Sehr Hoch: | **6.1** | l/100 km |
| Kombiniert: | **5.7** | l/100 km |
| Gewichtet,Kombiniert: | - | l/100 km |

5. Vollelektrische Fahrzeuge und extern aufladbare Hybrid-Elektro-Fahrzeuge, gemäß Verordnung (EU) 2017/1151 (falls anwendbar)

| | | |
|---|---|---|
| 5.1. Rein elektrische Fahrzeuge | | |
| Elektrischer Energieverbrauch: | - | Wh/km |
| Elektrische Reichweite: | - | km |
| Elektrische Reichweite Stadt: | - | km |
| 5.2. OVC hybrid-elektrische Fahrzeuges | | |
| Elektrischer Energieverbrauch (ECAC,gewichtet): | - | Wh/km |
| Elektrische Reichweite (EAER): | - | km |
| Elektrische Reichweite Stadt (EAER Stadt): | - | km |

51. Bei Fahrzeugen mit besonderer Zweckbestimmung: Bezeichnung gemäß Anhang II Nummer 5:
-

52. Anmerkungen:
Alt.: 5.: 4040 ; 6.: 1735 ; 7.: 1464 ; -

Alternativer Reifen mit abweichenden Emissionswerten

| | | |
|---|---|---|
| 195/60 R15 | 88 Q M+S | 6.0Jx15H2OS45.0 (1+2) |
| 195/60 R15 | 88 V | 6.0Jx15H2OS45.0 (1+2) |
| 205/40 R18 | 86 W | 7.0Jx18H2OS47.5 (1+2) |
| 205/45 R17 | 88 W | 7.0Jx17H2OS47.5 (1+2) |

-
-
-
-
-
-
-

**Zulassungsbescheinigung Teil II wurde ausgestellt**

**Figure 70:** Segment B vehicle certificate of conformity (scanned copy of page 1).

| | | | |
|---|---|---|---|
| 1. | Anzahl der Achsen und Räder: | 2/4 | |
| 3. | Antriebsachsen (Anzahl, Lage, gegenseitige Verbindung): | 1, Achse 1, - | |
| 4. | Radstand: | 2493 | mm |
| | 4.1. Achsabstände:1-2/2-3/3-4: | 2493 | mm |
| 5. | Länge: | 4068 | mm |
| 6. | Breite: | 1756 | mm |
| 7. | Höhe: | 1498 | mm |
| 13. | Masse in fahrbereitem Zustand: | 1190 | kg |
| | 13.2. Tatsächliche Masse des Fahrzeugs: | 1235 | kg |
| 16. | Technisch zulässige Höchstmassen | | |
| | 16.1. Technisch zulässige Gesamtmasse in beladenem Zustand: | 1675 | kg |
| | 16.2. Technisch zulässige maximale Masse je Achse 1/2/3: | 880 /835 | kg |
| | 16.4. Technisch zulässige Gesamtmasse der Fahrzeugkombination: | 2675 | kg |
| 18. | Technisch zulässige maximale Anhängemasse bei Beförderung eines | | |
| | 18.1. Deichselanhängers: | - | kg |
| | 18.3. Zentralachsanhängers: | 1000 | kg |
| | 18.4. ungebremsten Anhängers: | 595 | kg |
| 19. | Technisch zulässige Stützlast am Kupplungspunkt: | 65 | kg |
| 20. | Hersteller der Antriebsmaschine: | FORD | |
| 21. | Baumusterbezeichnung gemäß Kennzeichnung am Motor: | SFJN | |
| 22. | Arbeitsverfahren: | Fremdzündung | |
| 23. | Reiner Elektroantrieb: | Nein | |
| | 23.1. Klasse des Hybrid (Elektro) Fahrzeugs: | - | |
| 24. | Anzahl und Anordnung der Zylinder: | 3, in Reihe | |
| 25. | Hubraum: | 998 | $cm^3$ |
| 26. | Kraftstoff: | Benzin | |
| | 26.1. | Einstoffbetrieb | |
| | 26.2. (nur Zweistoffmotor) | - | |
| 27. | Maximale Leistung | | |
| | 27.1. Höchste Nennleistung (Verbrennungsmotor): | 73.5/4500 | kW at $min^{-1}$ |
| | 27.2. Höchste Stundenleistung (Elektromotor): | - | kW |
| | 27.3. Höchste Nennleistung (Elektromotor): | - | kW |
| | 27.4. Höchste 30-Minuten-Leistung (Elektromotor): | - | kW |
| 29. | Höchstgeschwindigkeit: | 183 | km/h |
| 30. | Spurweite 1/2/3 : | 1503/1466 | mm |
| 35. | Reifen-/Radkombination/Rollwiderstandsklasse (falls zutreffend) | | |
| | - Achse 1 195/55 R16 87 V | 6.5Jx16H2OS47.5 C | |
| | - Achse 2 195/55 R16 87 V | 6.5Jx16H2OS47.5 C | |
| 36. | Anhänger-Bremsanschlüsse: | - | |
| 38. | Code des Aufbaus: | AB Schrägheckllimousine | |
| 40. | Farbe des Fahrzeugs: | Schwarz | |
| 41. | Anzahl und Anordnung der Türen: | 4; 2; 2 | |
| 42. | Anzahl der Sitzplätze (einschließlich Fahrersitz): | 5; | |
| | 42.1. Sitze, die nur zur Verwendung bei stehendem Fahrzeug bestimmt sind: | - | |
| | 42.3. Anzahl der für Rollstuhlfahrer zugänglichen Sitzplätze: | - | |
| 46. | Geräuschpegel - Standgeräusch bei der Motordrehzahl/Fahrgeräusch: | 75 bei 3750 / 68 | $dB(A)min^{-1}$/dB(A) $dB(A)min^{-1}$/dB(A) |
| 47. | Abgasnorm: Euro | 6 AG | |
| 47.1. | Einflußgrößen für die Abgasteste | | |
| | 47.1.1 Testmasse: | 1311 | kg |
| | 47.1.2 Frontfläche: | 0.000 | $m^2$ |
| | 47.1.3 Lastkurven-Koeffizienten | | |
| | 47.1.3 .0. f0: | 119.69647 | N |
| | 47.1.3 .1. f1: | 0.60100 | N / (km/h) |
| | 47.1.3 .2. f2: | 0.02935 | N / $(km/h)^2$ |

2

| | | | | |
|---|---|---|---|---|
| 48. Abgasverhalten: | | | | |
| Nummer des Basisrechtsakts und des letzten gültigen Änderungsrechtsakts: | | | 715/2007; 2017/1347AG | |
| 1.1. Prüfverfahren: Typ 1 or ESC | | | - | |
| | see 26. | see 26. | Petrol/Diesel | |
| CO:- HC:- NOx:- HC + NOx:- Partikel:- Rauchgastrübung (ELR):- | | | | |
| 1.2. Prüfverfahren: Typ I (Euro) | | | 6 | |
| CO: | - | - | 137.6 | mg/km |
| THC: | - | - | 20.9 | mg/km |
| NMHC: | - | - | 16.9 | mg/km |
| NOx: | - | - | 22.2 | mg/km |
| THC + NOx: | - | - | - | mg/km |
| NH3: | - | - | - | ppm |
| Partikelmasse: | - | - | 0.18 | mg/km |
| Partikelanzahl: | - | - | 1.96 | $10^{11}$/km |
| 2.1. Prüfverfahren: ETC (falls zutreffend) | | | | |
| CO: | - | - | - | g/kWh |
| NOx: | - | - | - | g/kWh |
| NMHC: | - | - | - | g/kWh |
| THC: | - | - | - | g/kWh |
| CH4: | - | - | - | g/kWh |
| Partikel: | - | - | - | g/kWh |
| 2.2. Prüfverfahren: WHTC (EURO VI) | | | | |
| CO: | - | - | - | mg/kWh |
| NOx: | - | - | - | mg/kWh |
| NMHC: | - | - | - | mg/kWh |
| THC: | - | - | - | mg/kWh |
| CH4: | - | - | - | mg/kWh |
| NH3: | - | - | - | ppm |
| Partikelmasse: | - | - | - | mg/kWh |
| Partikelanzahl: | - | - | - | $10^{11}$/kWh |
| 48.1 Rauch (korrigierter Wert des Absorptionskoeffizienten): | | | - | $m^{-1}$ |
| 48.2. Deklarierte maximale RDE Werte (falls zutreffend) | | | | |
| Komplette RDE Strecke: NOx: | - | - | 126.0 | mg/km |
| Partikel (Anzahl) : | - | - | 9.0 | $10^{11}$/km |
| Städtische RDE Strecke: NOx: | - | - | 126.0 | mg/km |
| Partikel (Anzahl) : | - | - | 9.0 | $10^{11}$/km |
| 49. CO2 -Emissionen/Kraftstoffverbrauch/Stromverbrauch: | | | | |
| 1. Alle Antriebsarten außer reinen Elektrofahrzeugen (falls zutreffend) | | | | |
| CO2 -Emissionen NEDC Werte | | | | |
| Innerorts: | - | - | 133 | g/km |
| Außerorts: | - | - | 95 | g/km |
| Kombiniert: | - | - | 110 | g/km |
| Gewichtet, kombiniert: | - | - | - | g/km |
| Kraftstoffverbrauch bei Emissionsprüfungen nach Verordnung (EG) Nr. 692/2008 NEDC-Werte | | | | |
| Innerorts: | - | - | 5.8 | l/100 km |
| Außerorts: | - | - | 4.2 | l/100 km |
| Kombiniert: | - | - | 4.8 | l/100 km |
| Gewichtet, kombiniert: | - | - | - | l/100 km |
| Abweichungsfaktor (falls zutreffend) | | - | | |
| Bestätigungsfaktor (falls zutreffend) | | 0 | | |
| 2. Reine Elektrofahrzeuge und extern aufladbare Hybridelektrofahrzeuge | | | | |
| Stromverbrauch (Gewichtet,kombiniert) | | | - | Wh/km |
| Elektrische Reichweite | | | - | km |
| 3. Fahrzeug ausgerüstet mit Eco-Innovation(en): | | | Nein | |
| 3.1. Generelle Kodierung(en) der Eco-Innovation(en): | | | - | |
| 3.2. Gesamt-CO2-Emissionseinsparungen durch Eco-Innovation(en): | | | - | |
| 3.2.1. NEDC Einsparungen (falls zutreffend) | | | - | g/km |
| 3.2.2. WLTP Einsparungen (falls zutreffend) | | | - | g/km |

3

**Figure 71:** Segment B vehicle certificate of conformity (scanned copy of page 2).

Andere (siehe 26.)

| NEFZ-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] | Kraftstoffverbrauch [m³/100km] |
|---|---|---|---|
| Innerorts | - | - | - |
| Außerorts | - | - | - |
| Kombiniert | - | - | - |
| Abweichungsfaktor | - | - | - |
| Differenzierungsfaktor | - | - | - |

2. Reine Elektrofahrzeuge und extern aufladbare Hybridelektrofahrzeuge

| | | |
|---|---|---|
| Stromverbrauch (gewichtet, kombiniert): | - | Wh/km |
| Elektrische Reichweite: | - | km |

3. Fahrzeug mit Ökoinnovation(en) ausgestattet: **nein**
3.1. Allgemeiner Code der Ökoinnovation(en): -
3.2. Gesamteinsparung von CO2-Emissionen durch Öko-Innovation(en):
3.2.1. Einsparungen durch NEFZ

| | | |
|---|---|---|
| Benzin / Diesel | - | g/km |
| Gas | - | g/km |
| Andere (siehe 26.) | - | g/km |

3.2.2. Einsparungen durch WLTP

| | | |
|---|---|---|
| Benzin / Diesel | - | g/km |
| Gas | - | g/km |
| Andere (siehe 26.) | - | g/km |

4. Alle Antriebsarten außer reinen Elektrofahrzeugen, gemäß Verordnung (EU) 2017/1151

Benzin / Diesel

| WLTP-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] |
|---|---|---|
| Niedrig | 199 | 8.8 |
| Mittel | 137 | 6.1 |
| Hoch | 128 | 5.7 |
| Höchstwert | 157 | 7.0 |
| Kombiniert | 150 | 6.6 |
| Gewichtet, kombiniert | - | - |

Gas

| WLTP-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] | Kraftstoffverbrauch [m³/100km] |
|---|---|---|---|
| Niedrig | - | - | - |
| Mittel | - | - | - |
| Hoch | - | - | - |
| Höchstwert | - | - | - |
| Kombiniert | - | - | - |
| Gewichtet, kombiniert | - | - | - |

Andere (siehe 26.)

| WLTP-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] | Kraftstoffverbrauch [m³/100km] |
|---|---|---|---|
| Niedrig | - | - | - |
| Mittel | - | - | - |
| Hoch | - | - | - |
| Höchstwert | - | - | - |
| Kombiniert | - | - | - |
| Gewichtet, kombiniert | - | - | - |

5. Vollelektrische Fahrzeuge und extern aufladbare Hybrid-Elektro-Fahrzeuge, gemäß Verordnung (EU) 2017/1151
5.1 Vollelektrische Fahrzeuge

| | | |
|---|---|---|
| Stromverbrauch | - | Wh/km |
| Elektrische Reichweite | - | km |
| Elektrische Reichweite innerorts | - | km |

5.2 Extern aufladbare Hybrid-Elektro-Fahrzeuge

| | | |
|---|---|---|
| Stromverbrauch (ECAC, weighted) | - | Wh/km |
| Elektrische Reichweite (EAER) | - | km |
| Elektrische Reichweite innerorts (EAER city) | - | km |

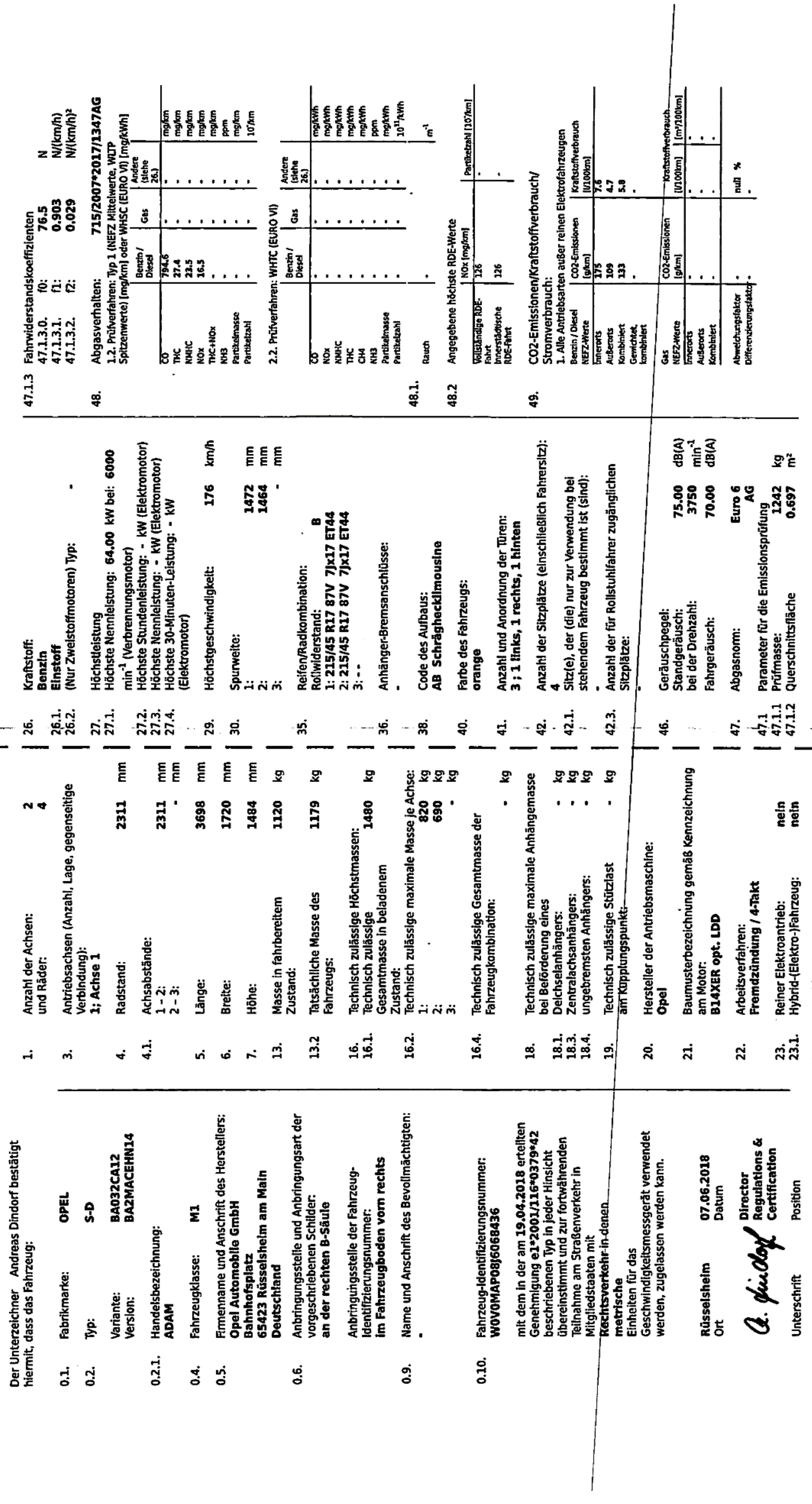
51. Bei Fahrzeugen mit besonderer Zweckbestimmung:
Bezeichnung gemäß Anhang II Nummer 5:
-

52. Zusätzliche Reifen-Felgenkombinationen:
technische Parameter (keine Bezugnahme auf RR)
**zu Nr. 5: ww. 3747;**
**zu Nr. 7: ww. 1475 - 1508;**
**zu Nr. 35:**
**175/70 R14 84T auf 5.5JX14 ET39;**
**185/70 R14 88T auf 5.5JX14 ET39;**
**185/60 R15 84H auf 6.0JX15 ET39;**
**185/65 R15 88T auf 6.0JX15 ET39;**
**195/55 R16 87H auf 6.0JX16 ET40;**
**195/55 R16 87H auf 6.5JX16 ET40;**
**215/45 R17 87V auf 7.0JX17 ET44;**
**225/35 R18 87W auf 7.5JX18 ET47;**
**Die Verwendung der optionalen Reifen kann zu Abweichungen von den offiziellen Werten für Kraftstoffverbrauch und CO2-Ausstoß führen**
**Vermerke des Herstellers:**
weitere Angaben siehe Bedienungsanleitung
Job- PA-Nummer 0042VNNV
Haendler Code DE1303
B/E
Motorkennzeichnung B14XER -
Motorseriennummer 19TK4444
KFZ-Brief wurde erstellt

**EC CERTIFICATE OF CONFORMITY**

**CERTIFICADO DE CONFORMIDAD CE**
**CERTIFICADO DE CONFORMIDADE CE**
**CERTIFICAT DE CONFORMITÉ CE**
**CERTIFICATO DI CONFORMITÀ CE**
**EG CERTIFICAAT VAN OVEREENSTEMMING**
**EG INTYG OM ÖVERENSSTÄMMELSE**
**EG ÜBEREINSTIMMUNGSBESCHEINIGUNG**
**EY VAATIMUSTENMUKAISUUSTODISTUS**
**OVERENSSTEMMELSES ERKLÆRING EF**
**ΠΙΣΤΟΠΟΙΗΤΙΚΟ ΣΥΜΜΟΡΦΩΣΗΣ ΕΚ**
für vollständige Fahrzeuge
W0V0MAP08J6068436

**Figure 72:** Segment A vehicle certificate of conformity (scanned copy of page 1).


Der Unterzeichner Andreas Dindorf bestätigt hiermit, dass das Fahrzeug:

0.1. Fabrikmarke: **OPEL**
0.2. Typ: **S-D**
Variante: **BA032CA12**
Version: **BA2MACEHN14**
0.2.1. Handelsbezeichnung: **ADAM**
0.4. Fahrzeugklasse: **M1**
0.5. Firmenname und Anschrift des Herstellers: **Opel Automobile GmbH Bahnhofsplatz 65423 Rüsselsheim am Main Deutschland**
0.6. Anbringungsstelle und Anbringungsart der vorgeschriebenen Schilder: **an der rechten B-Säule**
Anbringungsstelle der Fahrzeug-Identifizierungsnummer: **im Fahrzeugboden vorn rechts**
0.9. Name und Anschrift des Bevollmächtigten: -
0.10. Fahrzeug-Identifizierungsnummer: **W0V0MAP08J6068436**

mit dem in der am **19.04.2018** erteilten Genehmigung **e1*2001/116*0379*42** beschriebenen Typ in jeder Hinsicht übereinstimmt und zur fortwährenden Teilnahme am Straßenverkehr in Mitgliedstaaten mit ~~Rechtsverkehr in denen~~ **metrische** Einheiten für das Geschwindigkeitsmessgerät verwendet werden, zugelassen werden kann.

**Rüsselsheim** **07.06.2018**
Ort Datum

Unterschrift **Director Regulations & Certification**
Position

1. Anzahl der Achsen: **2** und Räder: **4**
3. Antriebsachsen (Anzahl, Lage, gegenseitige Verbindung): **1; Achse 1**
4. Radstand: **2311** mm
4.1. Achsabstände: 1 - 2: **2311** mm; 2 - 3: **-** mm
5. Länge: **3698** mm
6. Breite: **1720** mm
7. Höhe: **1484** mm
13. Masse in fahrbereitem Zustand: **1120** kg
13.2 Tatsächliche Masse des Fahrzeugs: **1179** kg
16. Technisch zulässige Höchstmassen:
16.1. Technisch zulässige Gesamtmasse in beladenem Zustand: **1480** kg
16.2. Technisch zulässige maximale Masse je Achse: 1: **820** kg; 2: **690** kg; 3: **-** kg
16.4. Technisch zulässige Gesamtmasse der Fahrzeugkombination: **-** kg
18. Technisch zulässige maximale Anhängemasse bei Beförderung eines
18.1. Deichselanhängers: **-** kg
18.3. Zentralachsanhängers: **-** kg
18.4. ungebremsten Anhängers: **-** kg
19. Technisch zulässige Stützlast am Kupplungspunkt: **-** kg
20. Hersteller der Antriebsmaschine: **Opel**
21. Baumusterbezeichnung gemäß Kennzeichnung am Motor: **B14XER opt. LDD**
22. Arbeitsverfahren: **Fremdzündung / 4-Takt**
23. Reiner Elektroantrieb: **nein**
23.1. Hybrid-(Elektro-)Fahrzeug: **nein**
24. Anzahl und Anordnung der Zylinder: **4 ; in Reihe**
25. Hubraum: **1398** $cm^3$

26. Kraftstoff: **Benzin**
26.1. **Einstoff**
26.2. (Nur Zweistoffmotoren) Typ: **-**
27. Höchstleistung
27.1. Höchste Nennleistung: **64.00** kW bei: **6000** $min^{-1}$ (Verbrennungsmotor)
27.2. Höchste Stundenleistung: **-** kW (Elektromotor)
27.3. Höchste Nennleistung: **-** kW (Elektromotor)
27.4. Höchste 30-Minuten-Leistung: **-** kW (Elektromotor)
29. Höchstgeschwindigkeit: **176** km/h
30. Spurweite: 1: **1472** mm; 2: **1464** mm; 3: **-** mm
35. Reifen/Radkombination: Rollwiderstand: **B**
**1: 215/45 R17 87V 7Jx17 ET44**
**2: 215/45 R17 87V 7Jx17 ET44**
**3: - -**
36. Anhänger-Bremsanschlüsse: **-**
38. Code des Aufbaus: **AB Schräghecklimousine**
40. Farbe des Fahrzeugs: **orange**
41. Anzahl und Anordnung der Türen: **3 ; 1 links, 1 rechts, 1 hinten**
42. Anzahl der Sitzplätze (einschließlich Fahrersitz): **4**
42.1. Sitz(e), der (die) nur zur Verwendung bei stehendem Fahrzeug bestimmt ist (sind): **-**
42.3. Anzahl der für Rollstuhlfahrer zugänglichen Sitzplätze: **-**
46. Geräuschpegel: Standgeräusch: **75.00** dB(A) bei der Drehzahl: **3750** $min^{-1}$; Fahrgeräusch: **70.00** dB(A)
47. Abgasnorm: **Euro 6 AG**
47.1 Parameter für die Emissionsprüfung
47.1.1 Prüfmasse: **1242** kg
47.1.2 Querschnittsfläche **0.697** $m^2$

47.1.3 Fahrwiderstandskoeffizienten
47.1.3.0. f0: **76.5** N
47.1.3.1. f1: **0.903** N/(km/h)
47.1.3.2. f2: **0.029** $N/(km/h)^2$

48. Abgasverhalten: **715/2007*2017/1347AG**
1.2. Prüfverfahren: Typ 1 (NEFZ Mittelwerte, WLTP Spitzenwerte) [mg/km] oder WHSC (EURO VI) [mg/kWh]

| | Benzin / Diesel | Gas | Andere (siehe 26.) | |
|---|---|---|---|---|
| CO | 794.6 | - | - | mg/km |
| THC | 27.4 | - | - | mg/km |
| NMHC | 23.5 | - | - | mg/km |
| NOx | 16.5 | - | - | mg/km |
| THC+NOx | - | - | - | mg/km |
| NH3 | - | - | - | ppm |
| Partikelmasse | - | - | - | mg/km |
| Partikelzahl | - | - | - | [illegible]/km |

2.2. Prüfverfahren: WHTC (EURO VI)

| | Benzin / Diesel | Gas | Andere (siehe 26.) | |
|---|---|---|---|---|
| CO | - | - | - | mg/kWh |
| NOx | - | - | - | mg/kWh |
| NMHC | - | - | - | mg/kWh |
| THC | - | - | - | mg/kWh |
| CH4 | - | - | - | mg/kWh |
| NH3 | - | - | - | ppm |
| Partikelmasse | - | - | - | mg/kWh |
| Partikelzahl | - | - | - | $10^{11}$/kWh |

48.1. Rauch - $m^{-1}$

48.2 Angegebene höchste RDE-Werte

| | NOx [mg/km] | Partikelzahl [10^?/km] |
|---|---|---|
| Vollständige RDE-Fahrt | 126 | - |
| Innerstädtische RDE-Fahrt | 126 | - |

49. CO2-Emissionen/Kraftstoffverbrauch/Stromverbrauch:
1. Alle Antriebsarten außer reinen Elektrofahrzeugen

| Benzin / Diesel NEFZ-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] |
|---|---|---|
| Innerorts | 175 | 7.6 |
| Außerorts | 109 | 4.7 |
| Kombiniert | 133 | 5.8 |
| Gewichtet, kombiniert | - | - |

| Gas NEFZ-Werte | CO2-Emissionen [g/km] | Kraftstoffverbrauch [l/100km] | [m³/100km] |
|---|---|---|---|
| Innerorts | - | - | - |
| Außerorts | - | - | - |
| Kombiniert | - | - | - |

| | | |
|---|---|---|
| Abweichungsfaktor | - | null % |
| Differenzierungsfaktor | - | - |

**Figure 73:** Segment A vehicle certificate of conformity (scanned copy of page 2).

## Appendix III : Driving dynamics and instantaneous on-road measurements of segment C vehicle.

**Measurement conducted in 18/07/2018 (non-compliant, extended conditions, hot, experimental purposes)**

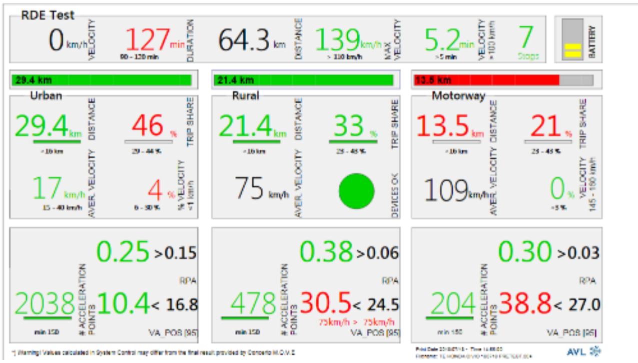



**Figure 74:** Driving dynamics of segment C vehicle (18/07/2018, non-compliant, extended conditions, hot, experimental purposes)

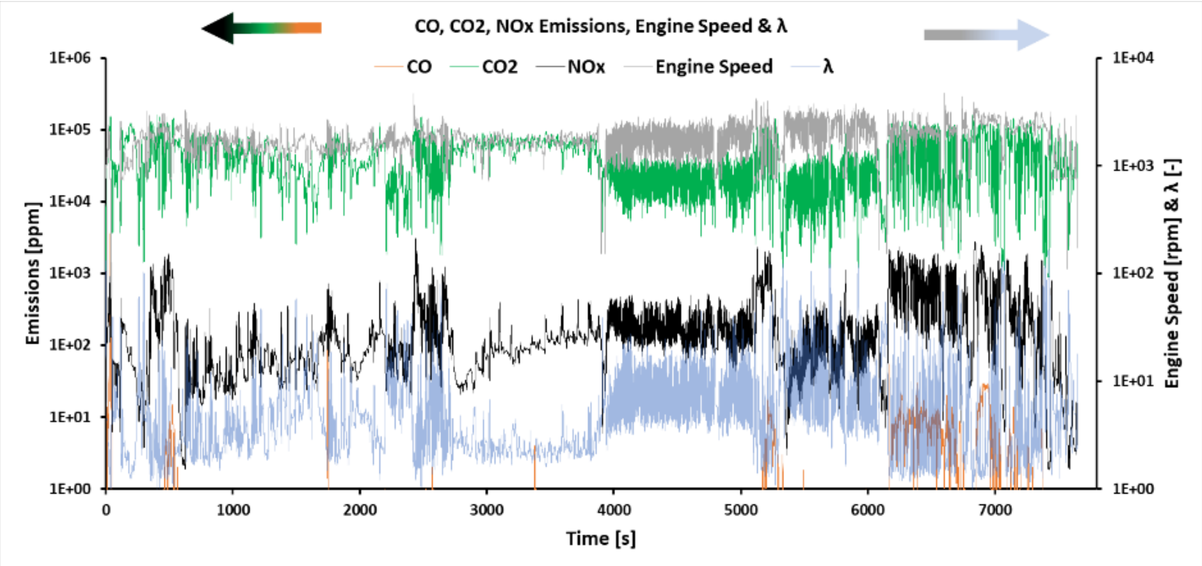



**Figure 75:** Instantaneous gaseous emissions measurements, engine speed & λ of segment C vehicle (18/07/2018, non-compliant, extended conditions, hot, experimental purposes).

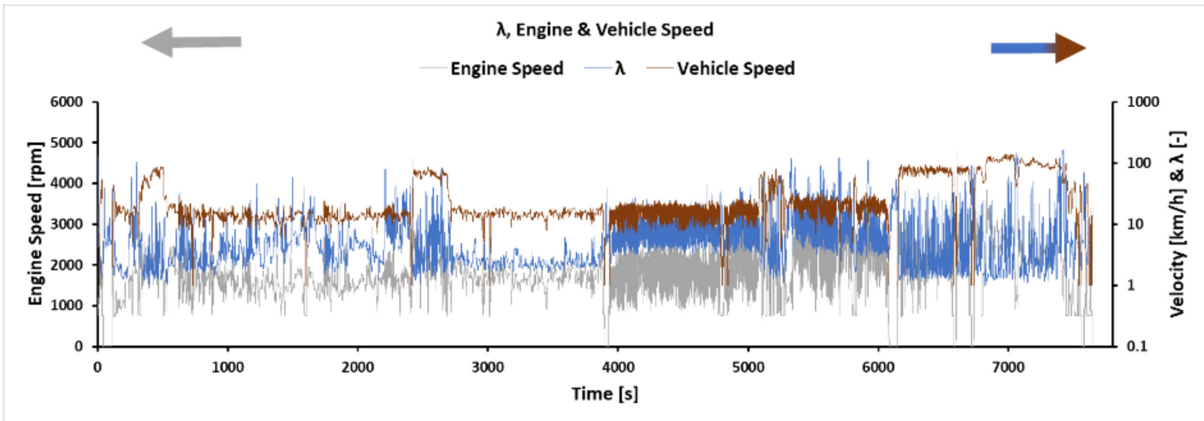



**Figure 76:** Second by second, engine speed, λ and vehicle speed of segment C vehicle (18/07/2018, non-compliant, extended conditions, hot, experimental purposes).

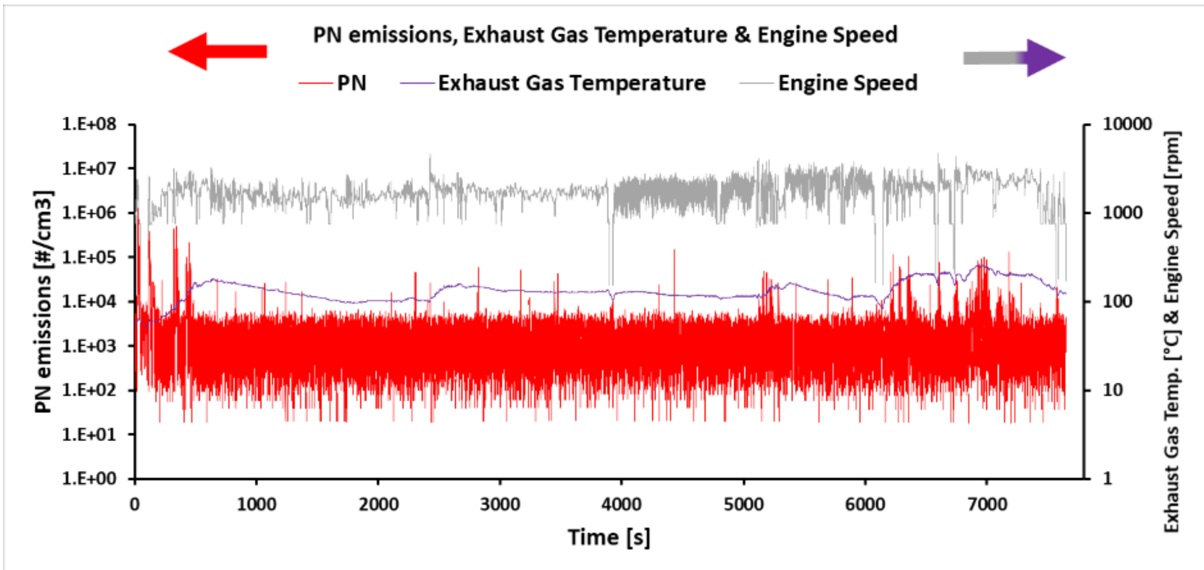



**Figure 77:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment C vehicle (18/07/2018, non-compliant, extended conditions, hot, experimental purposes).

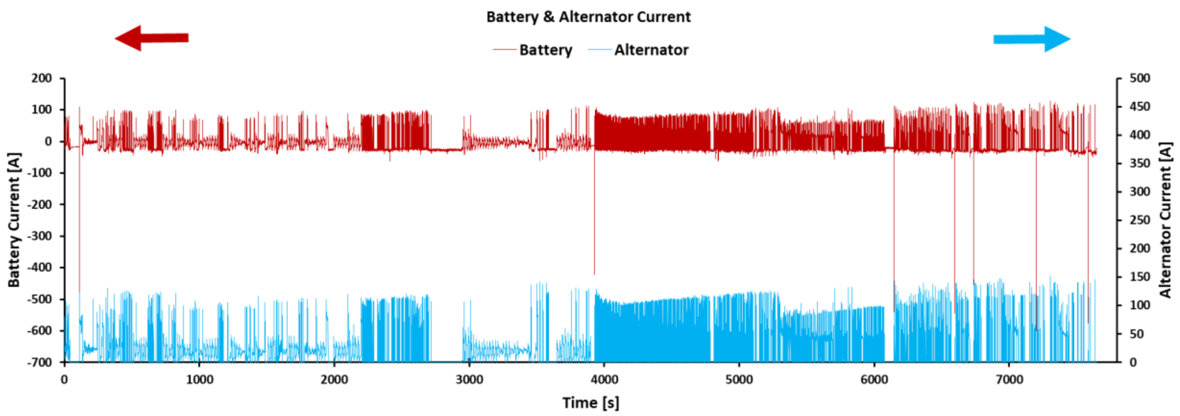



**Figure 78:** Instantaneous battery and alternator current of segment C vehicle (18/07/2018, non-compliant, extended conditions, hot, experimental purposes).

## Measurement conducted in 19/07/2018 (non-compliant, extended conditions, cold)

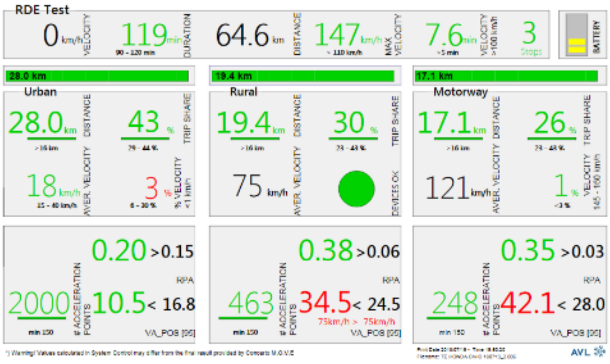



**Figure 79:** Driving dynamics of segment C vehicle (19/07/2018, non-compliant, extended conditions, cold)

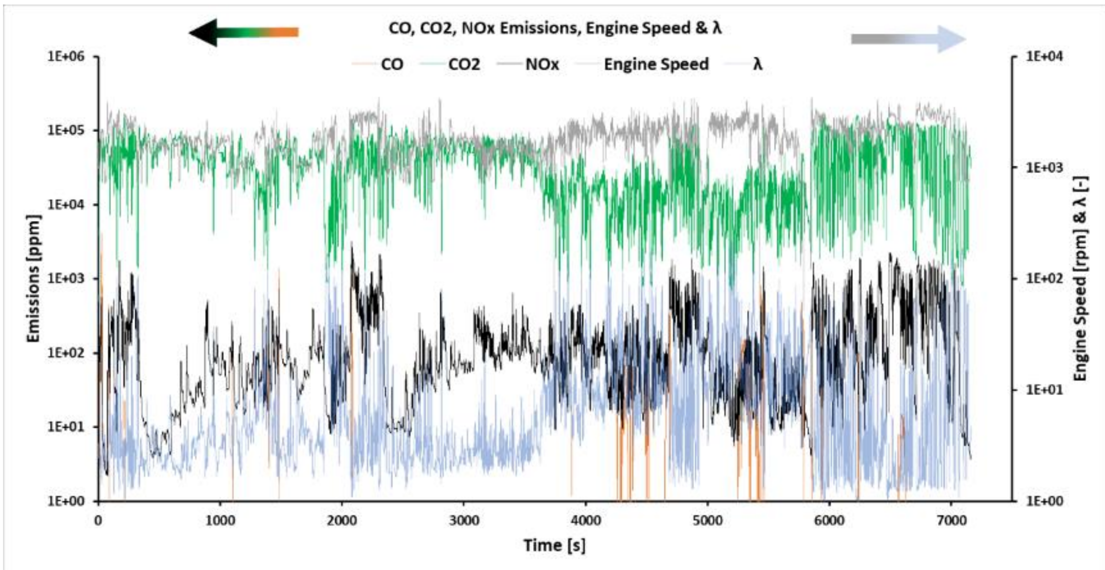



**Figure 80:** Instantaneous gaseous emissions measurements, engine speed & λ of segment C vehicle (19/07/2018, non-compliant, extended conditions, cold).

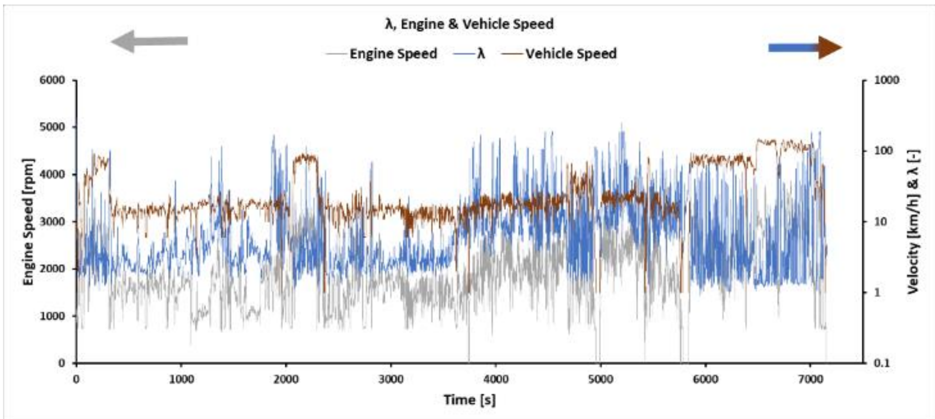



**Figure 81:** Second by second, engine speed, λ and vehicle speed of segment C vehicle (19/07/2018, non-compliant, extended conditions, cold).

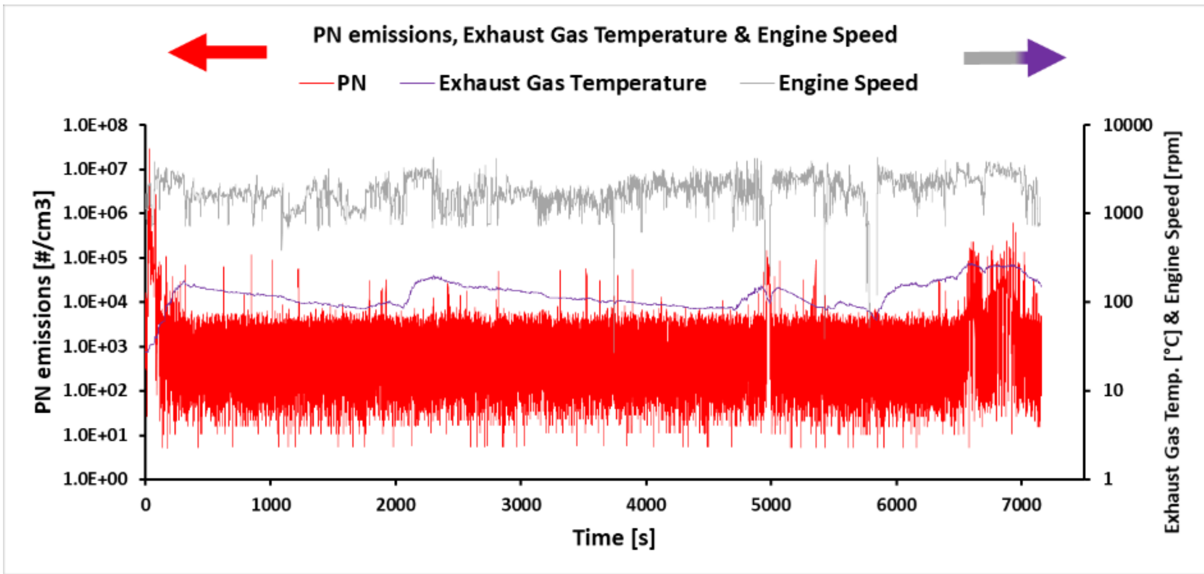



**Figure 82:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment C vehicle (19/07/2018, non-compliant, extended conditions, cold).

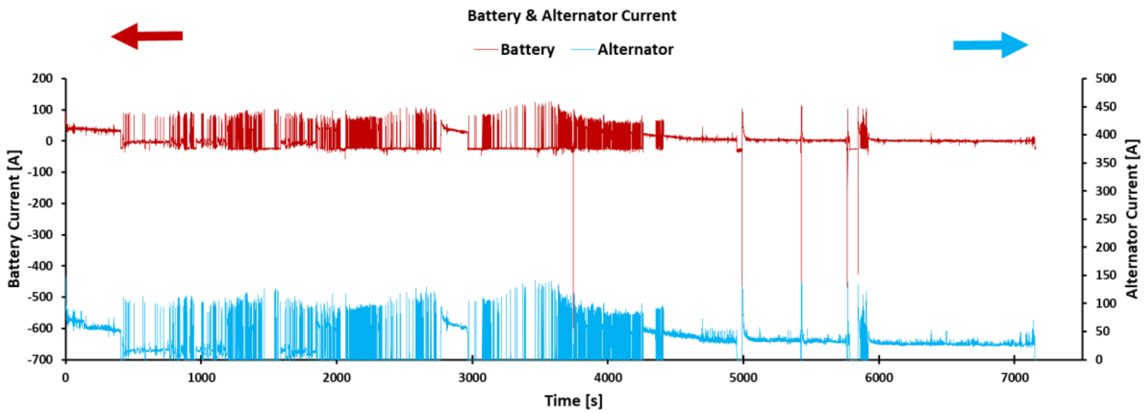



**Figure 83:** Instantaneous battery and alternator current of segment C vehicle (19/07/2018, non-compliant, extended conditions, cold).

## Measurement conducted in 21/07/2018 (compliant, smooth, cold)

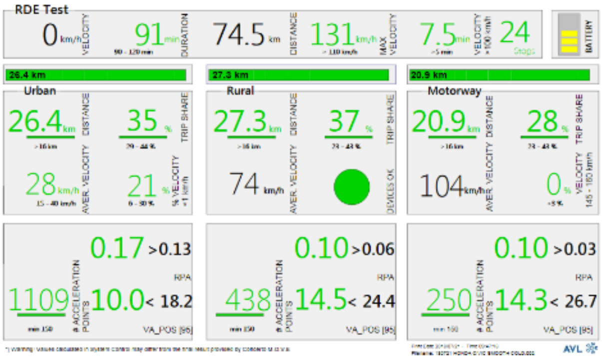


**Figure 84:** Driving dynamics of segment C vehicle (21/07/2018, compliant, smooth, cold)

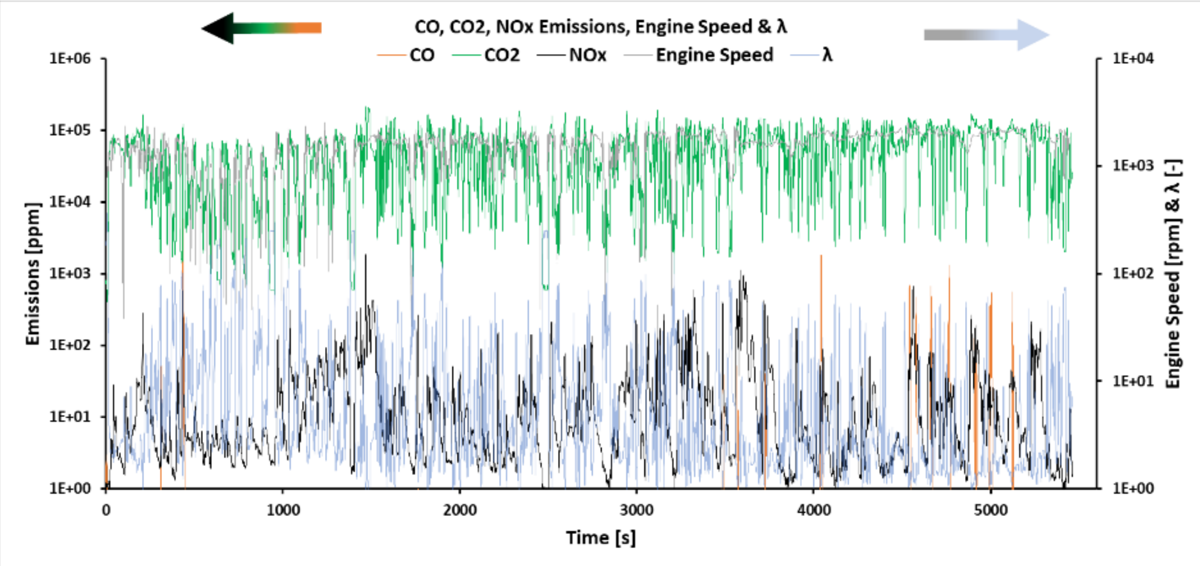



**Figure 85:** Instantaneous gaseous emissions measurements, engine speed & λ of segment C vehicle (21/07/2018, compliant, smooth, cold).

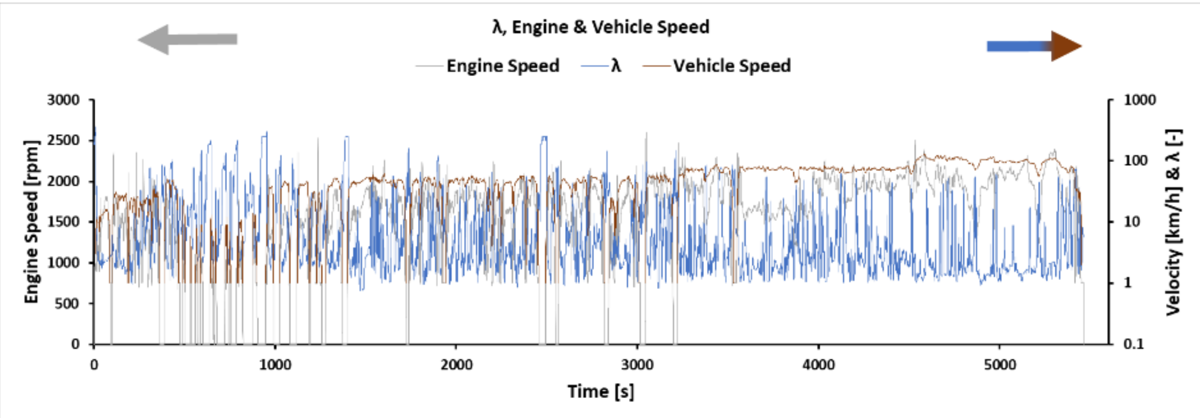



**Figure 86:** Second by second, engine speed, λ and vehicle speed of segment C vehicle (21/07/2018, compliant, smooth, cold).

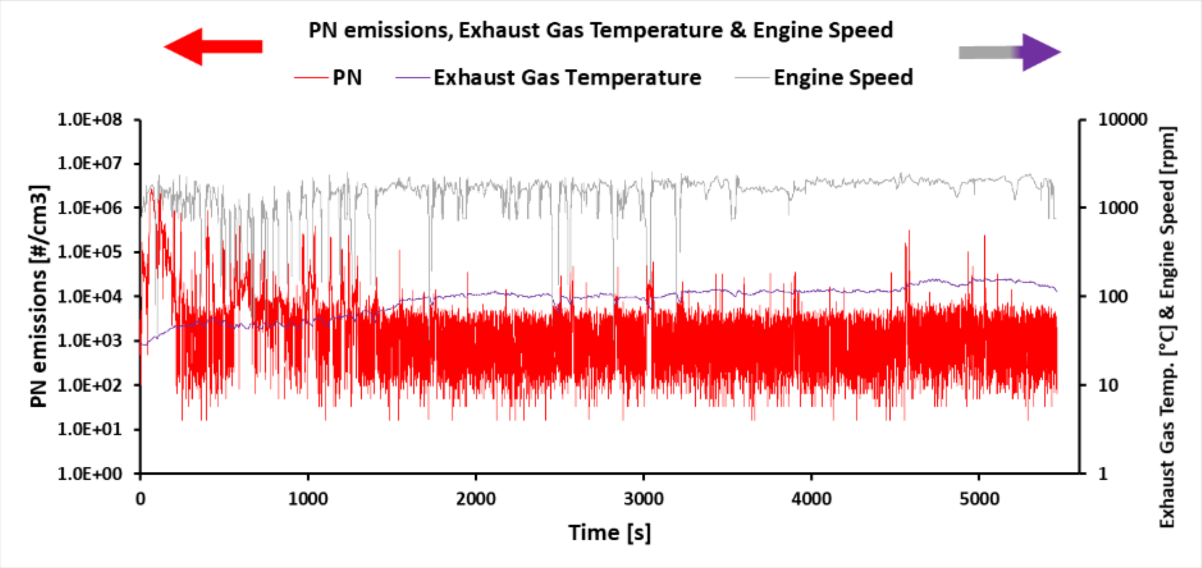



**Figure 87:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment C vehicle (21/07/2018, compliant, smooth, cold).

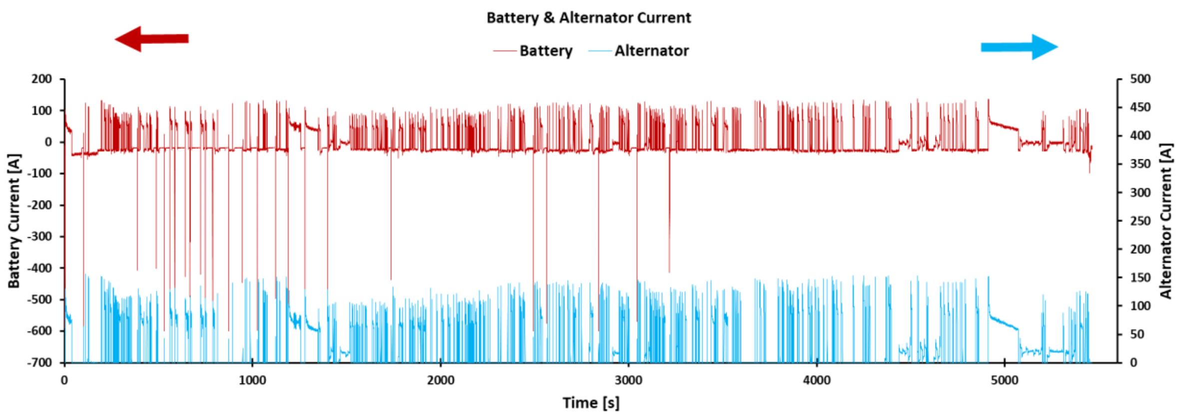



**Figure 88:** Instantaneous battery and alternator current of segment C vehicle (21/07/2018, compliant, smooth, cold).

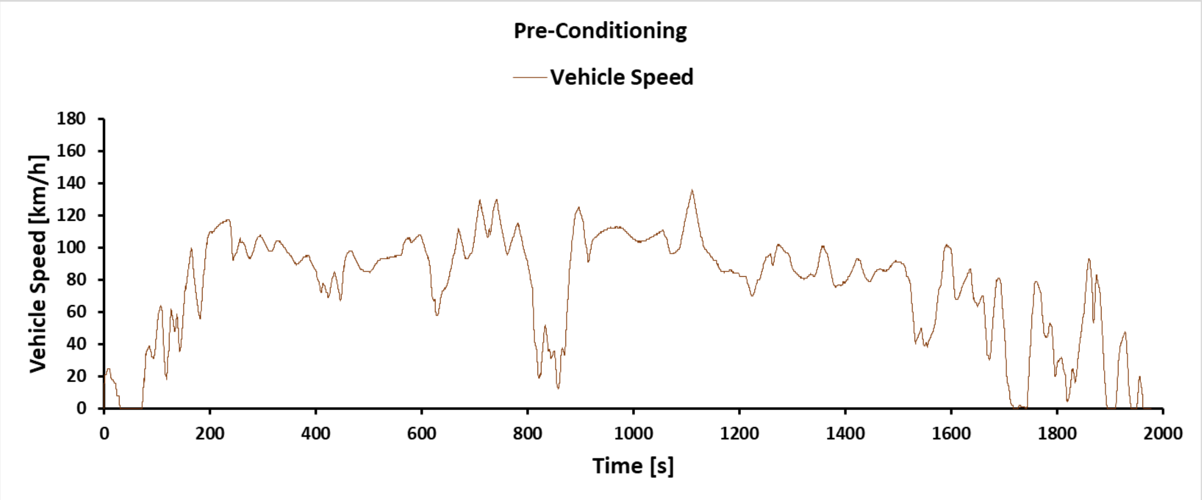



**Figure 89:** Vehicle speed during measurement pre-conditioning of segment C vehicle (21/07/2018, compliant, smooth, cold).

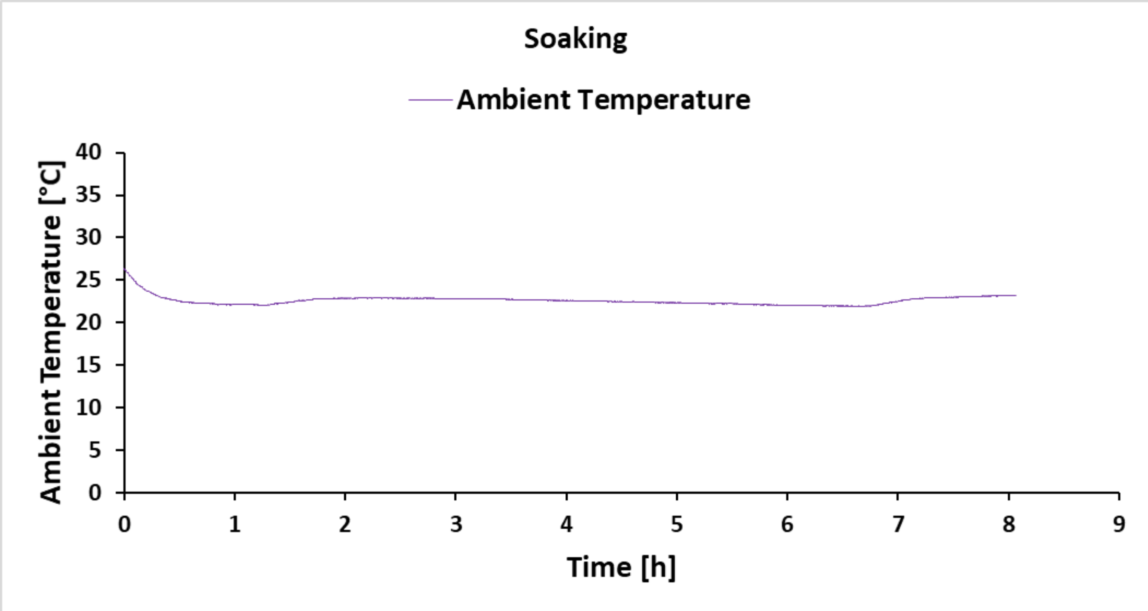



**Figure 90:** Pre-measurement soaking of segment C vehicle (21/07/2018, compliant, smooth, cold).

## Measurement conducted in 21/07/2018 (non-compliant, extended conditions, cold, regeneration occured)

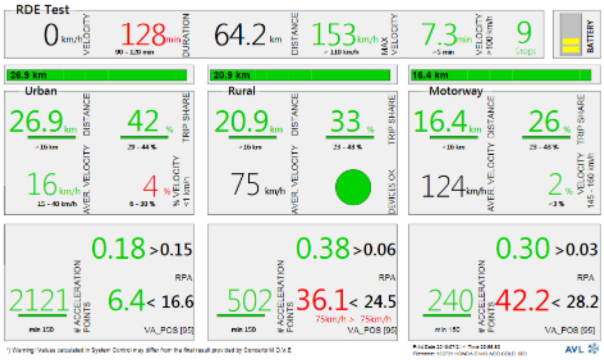



**Figure 91:** Driving dynamics of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred)

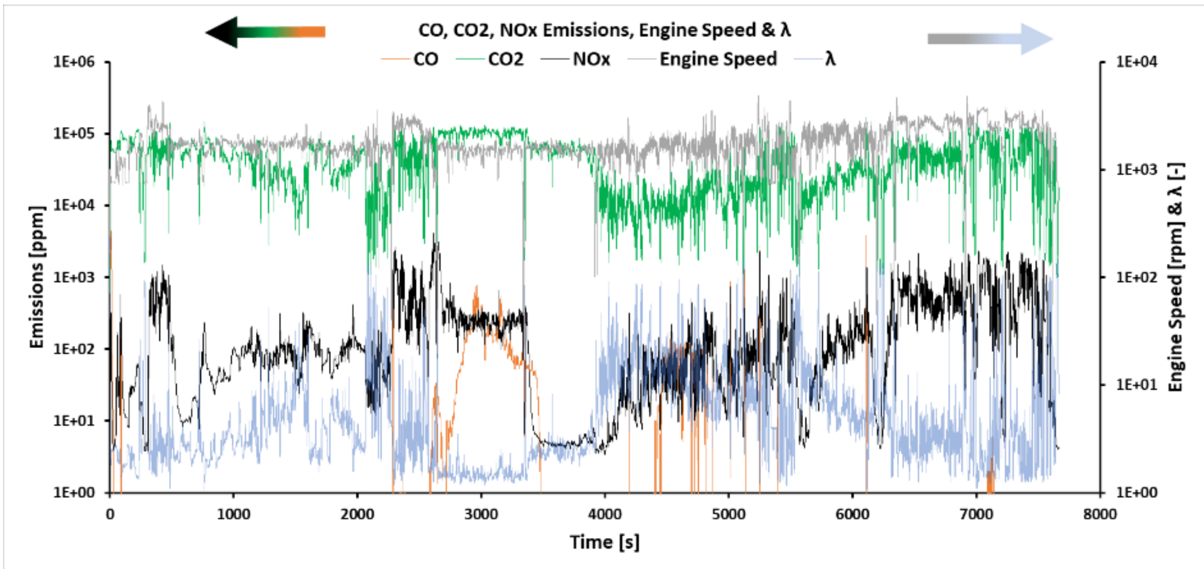



**Figure 92:** Instantaneous gaseous emissions measurements, engine speed & λ of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

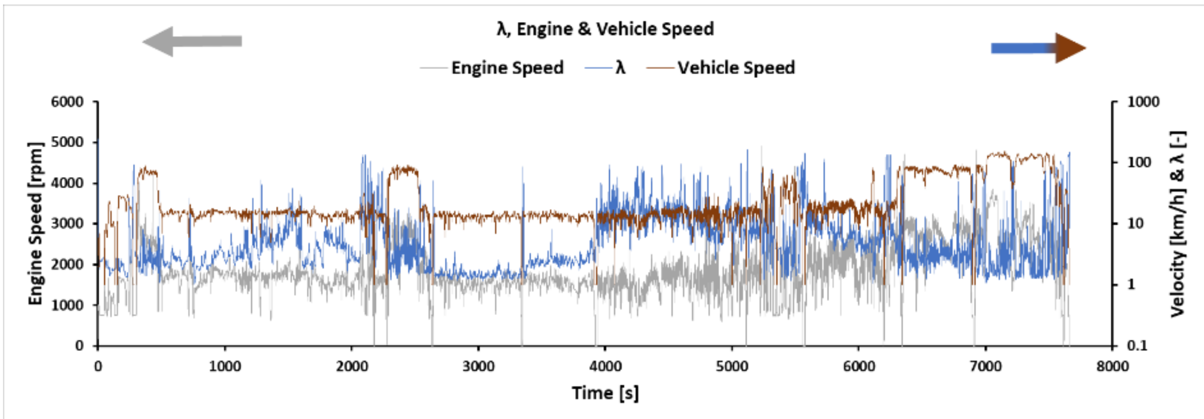



**Figure 93:** Second by second, engine speed, λ and vehicle speed of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

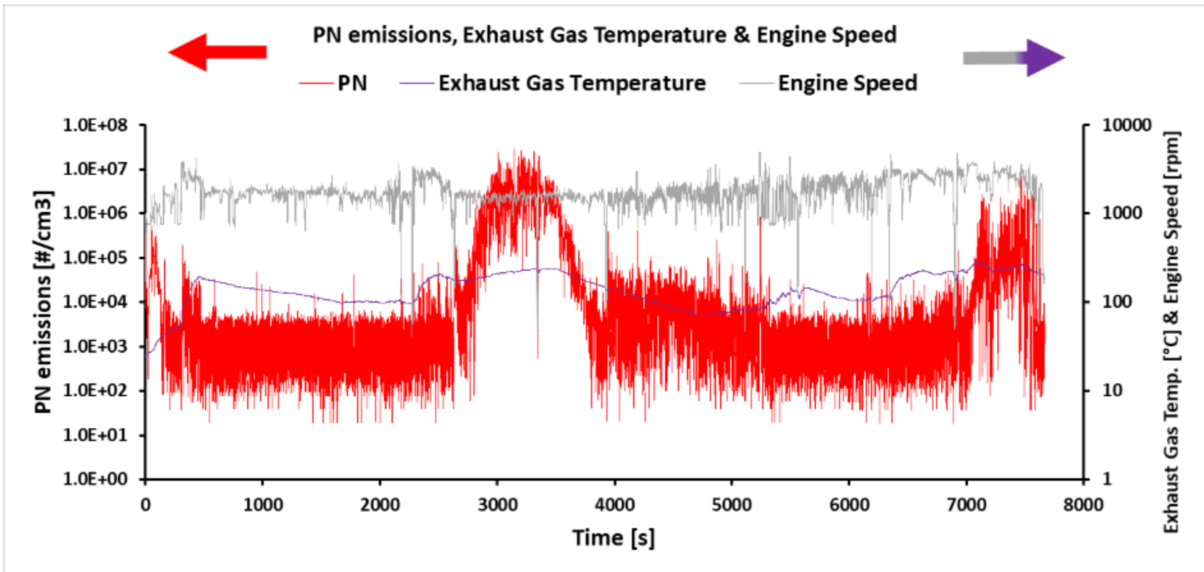



**Figure 94:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

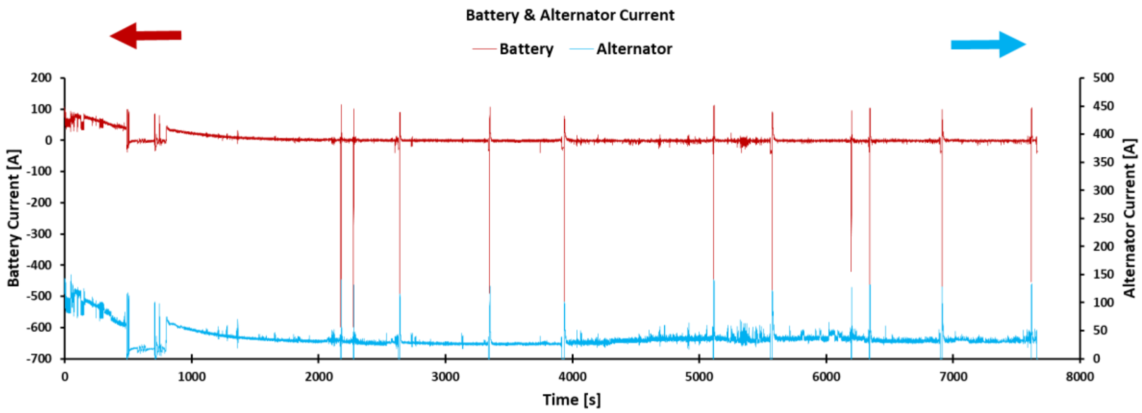



**Figure 95:** Instantaneous battery and alternator current of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

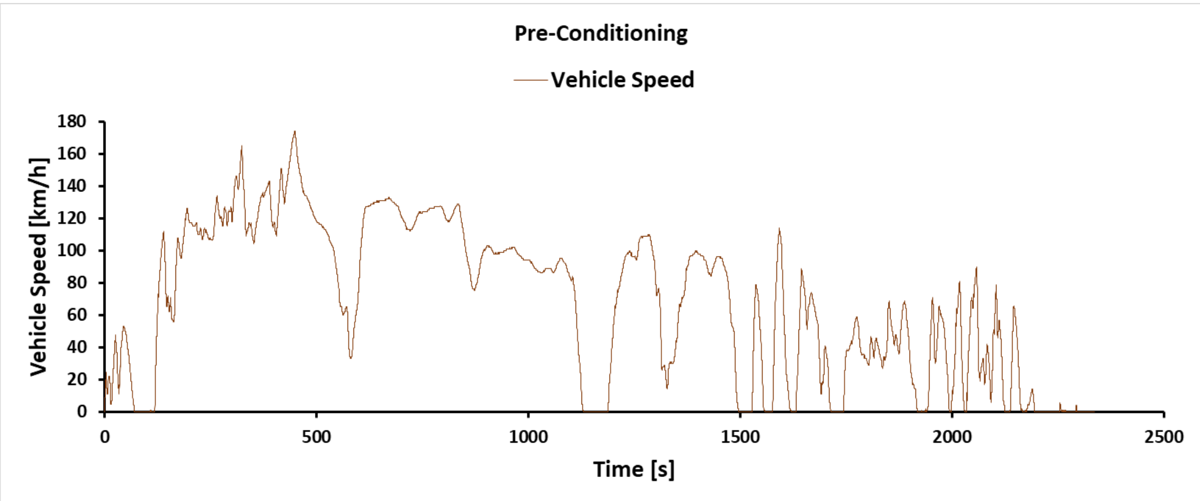



**Figure 96:** Vehicle speed during measurement pre-conditioning of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

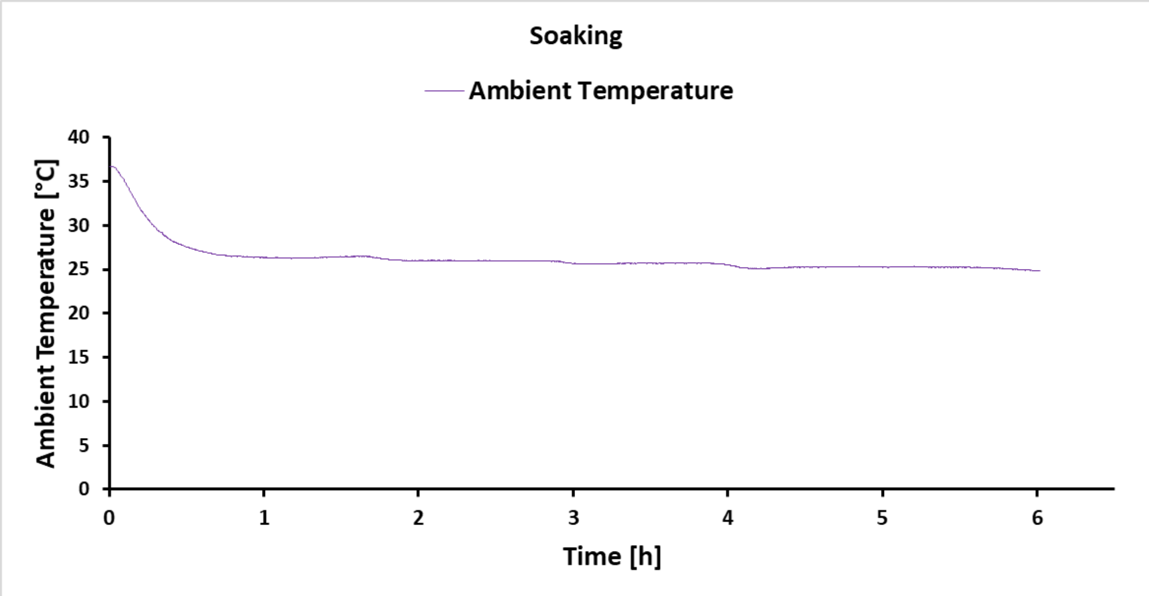



**Figure 97:** Pre-measurement soaking of segment C vehicle (21/07/2018, non-compliant, extended conditions, cold, regeneration occurred).

## Measurement conducted in 23/07/2018 (compliant, dynamic, cold)

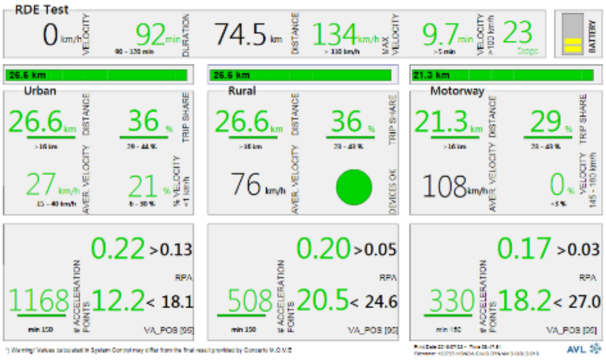



**Figure 98:** Driving dynamics of segment C vehicle (23/07/2018, compliant, dynamic, cold)

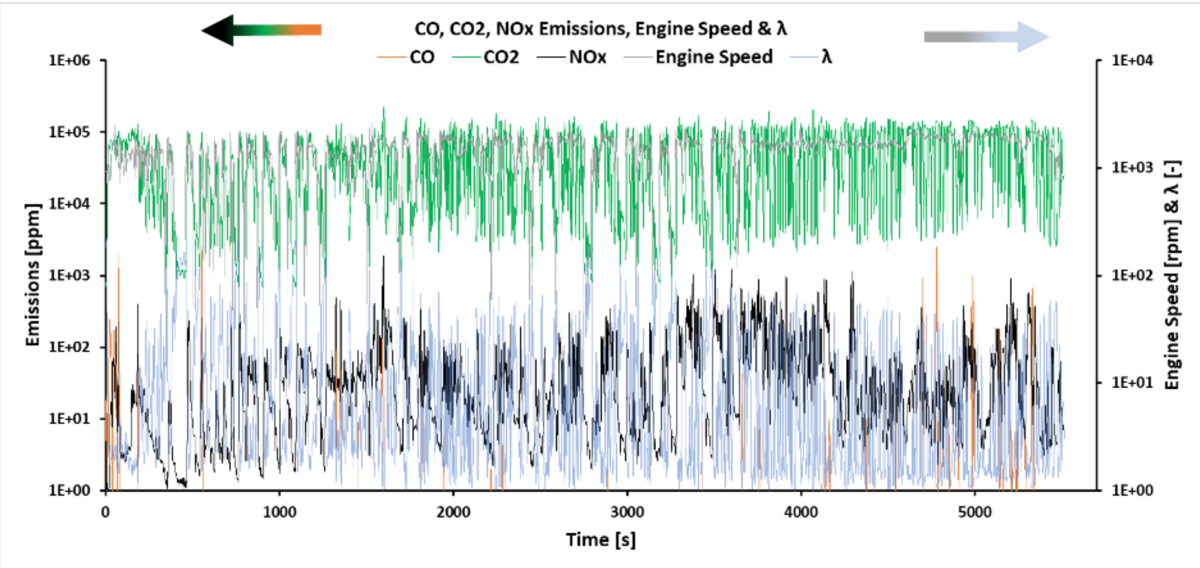



**Figure 99:** Instantaneous gaseous emissions measurements, engine speed & λ of segment C vehicle (23/07/2018, compliant, dynamic, cold).

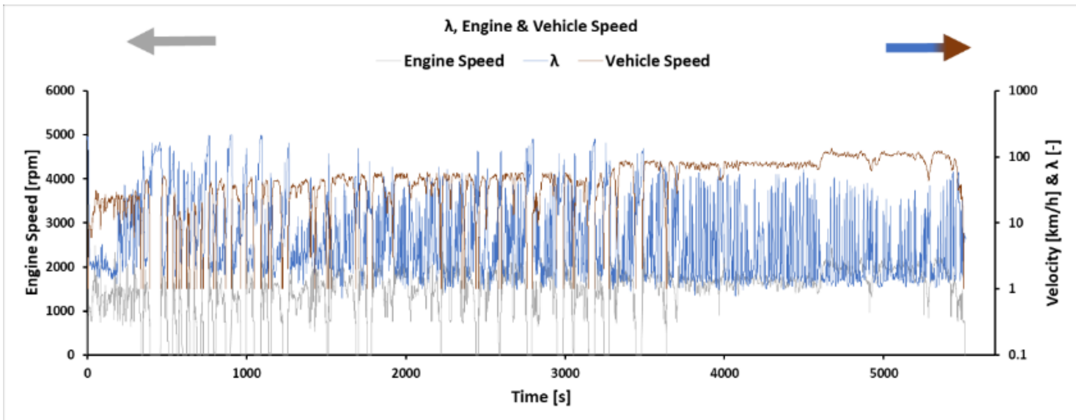



**Figure 100:** Second by second, engine speed, λ and vehicle speed of segment C vehicle (23/07/2018, compliant, dynamic, cold).

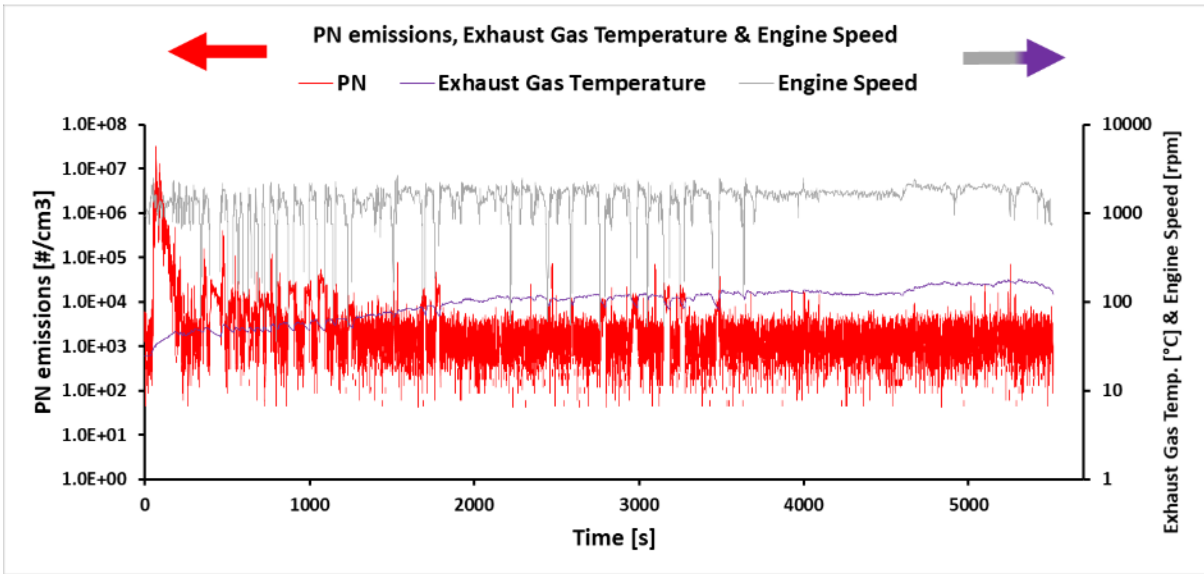



**Figure 101:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment C vehicle (23/07/2018, compliant, dynamic, cold).

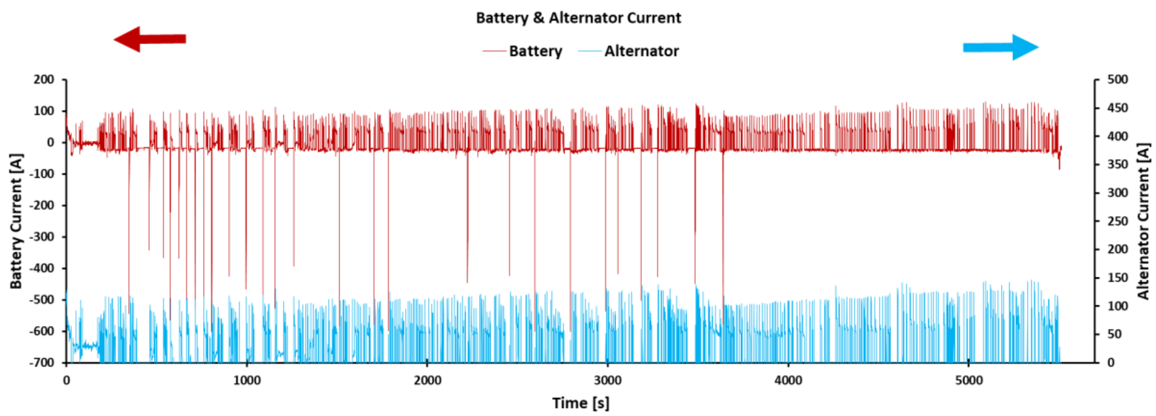



**Figure 102:** Instantaneous battery and alternator current of segment C vehicle (23/07/2018, compliant, dynamic, cold).

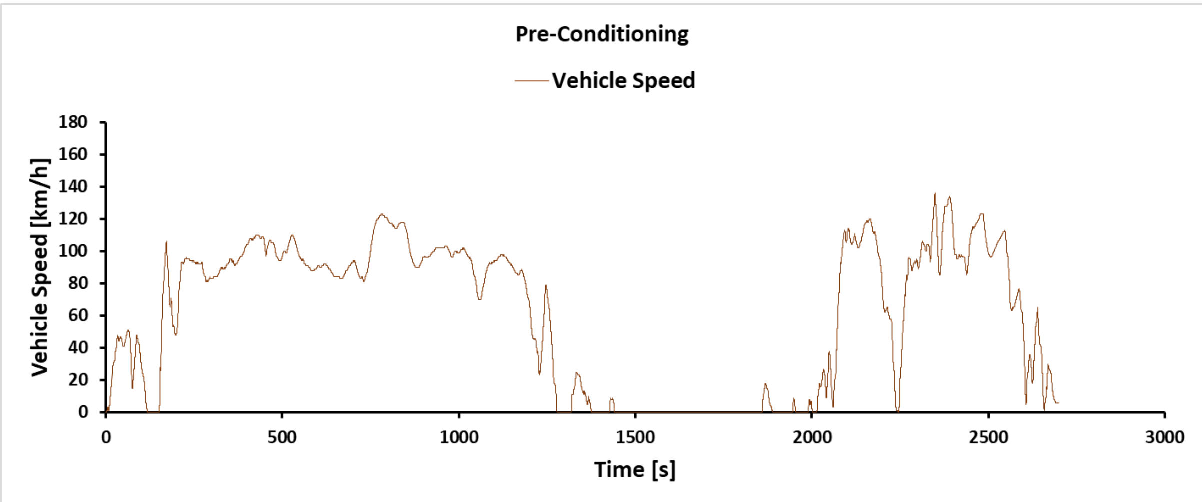



**Figure 103:** Vehicle speed during measurement pre-conditioning of segment C vehicle (23/07/2018, compliant, dynamic, cold).

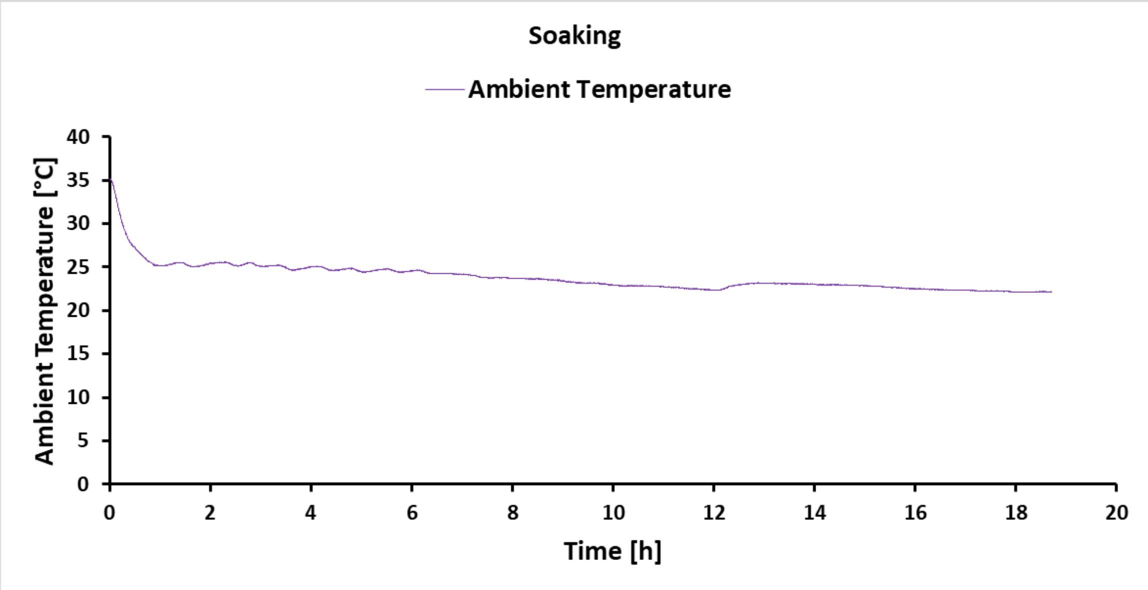



**Figure 104:** Pre-measurement soaking of segment C vehicle (23/07/2018, compliant, dynamic, cold).

# Appendix IV : Driving dynamics and instantaneous on-road measurements of segment B vehicle.

### Measurement conducted in 31/07/2018 (non-compliant, extended conditions, cold)

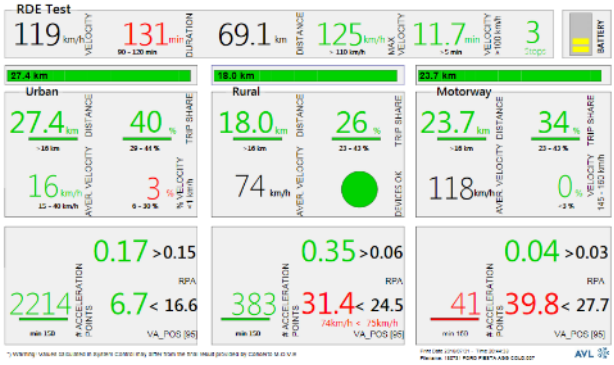



**Figure 105:** Driving dynamics of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold)

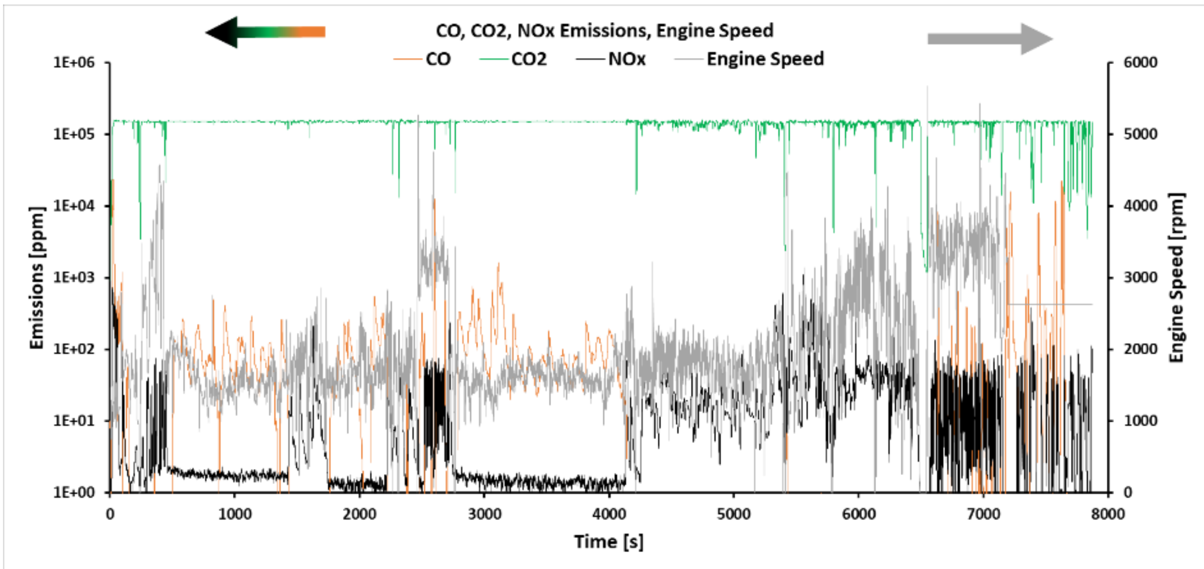



**Figure 106:** Instantaneous gaseous emissions measurements, engine speed & λ of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

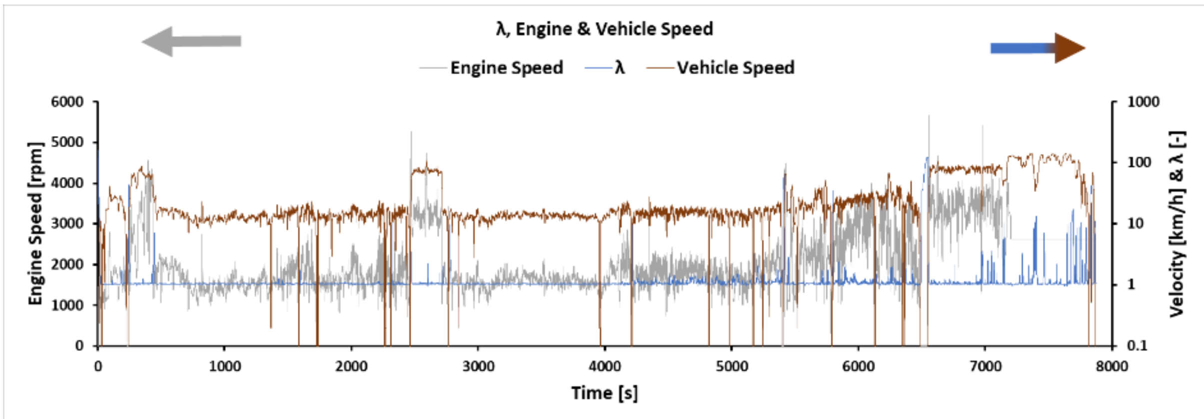



**Figure 107:** Second by second, engine speed, λ and vehicle speed of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

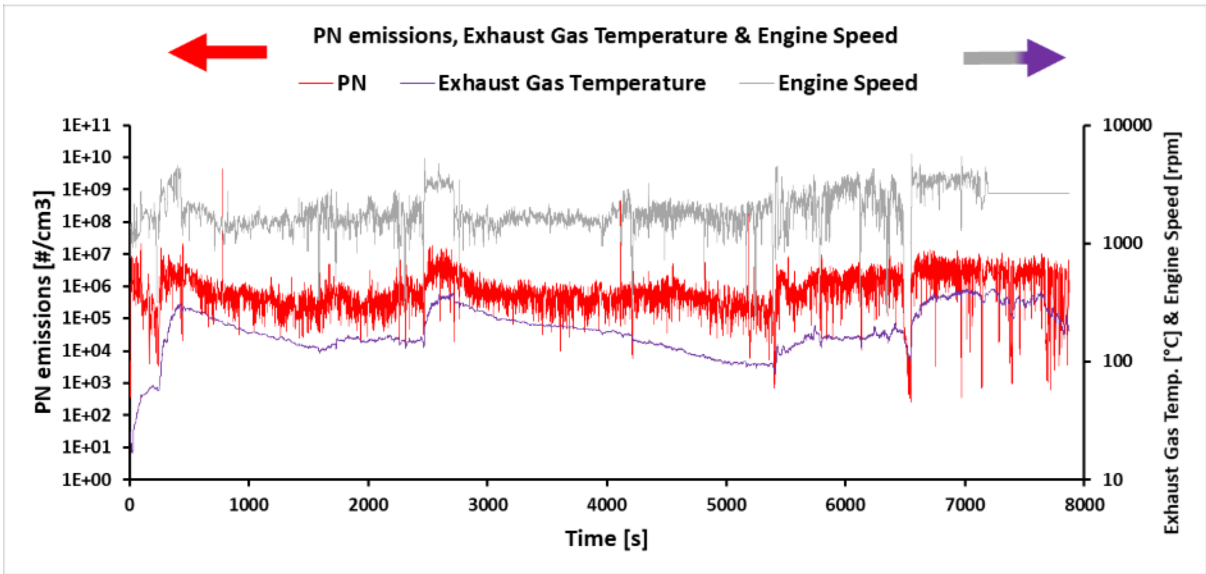



**Figure 108:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

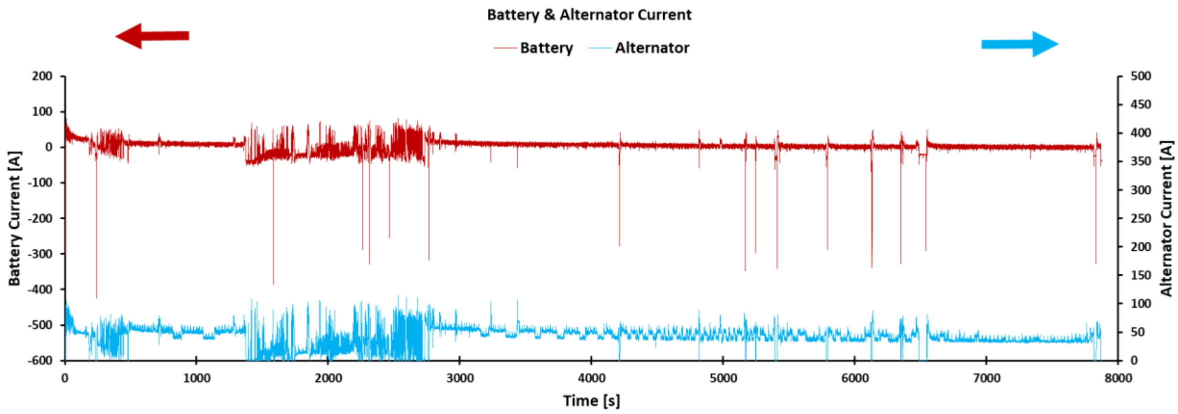



**Figure 109:** Instantaneous battery and alternator current of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

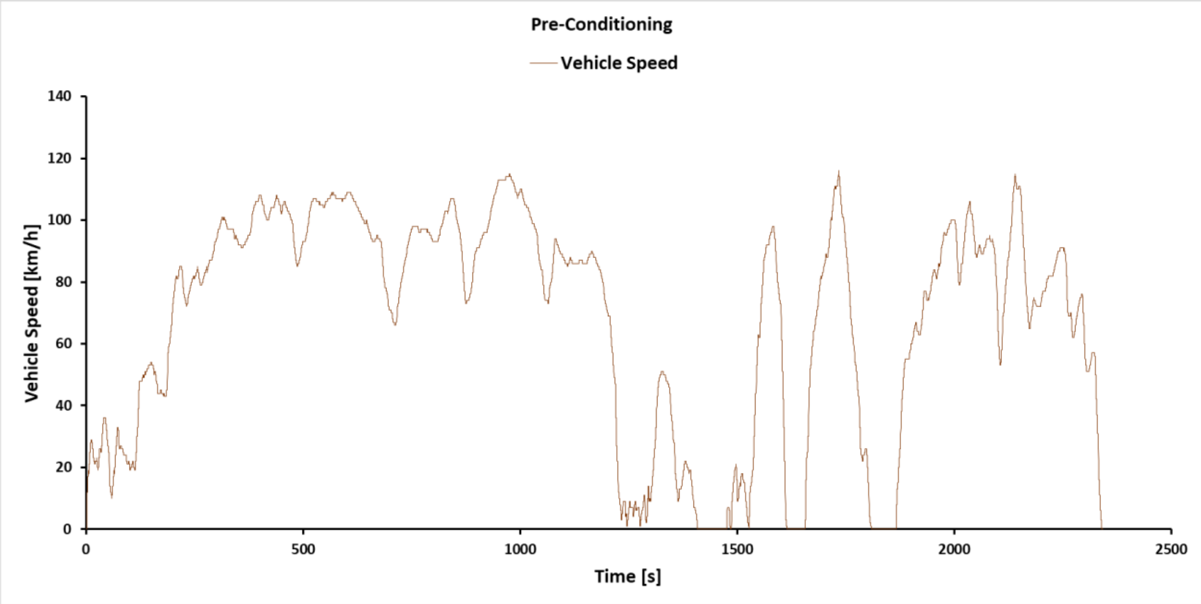



**Figure 110:** Vehicle speed during measurement pre-conditioning of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

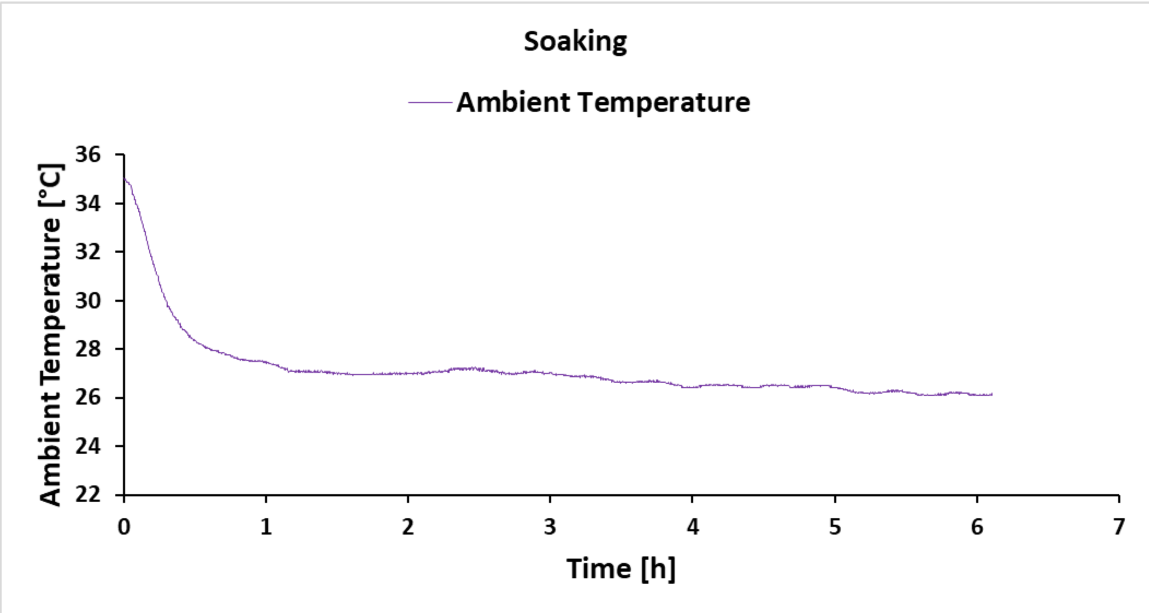



**Figure 111:** Pre-measurement soaking of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

## Measurement conducted in 01/08/2018 (compliant, smooth, cold)

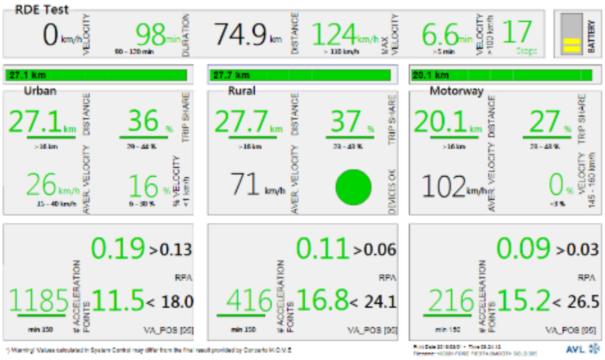



**Figure 112:** Driving dynamics of segment B vehicle (01/08/2018, compliant, smooth, cold)

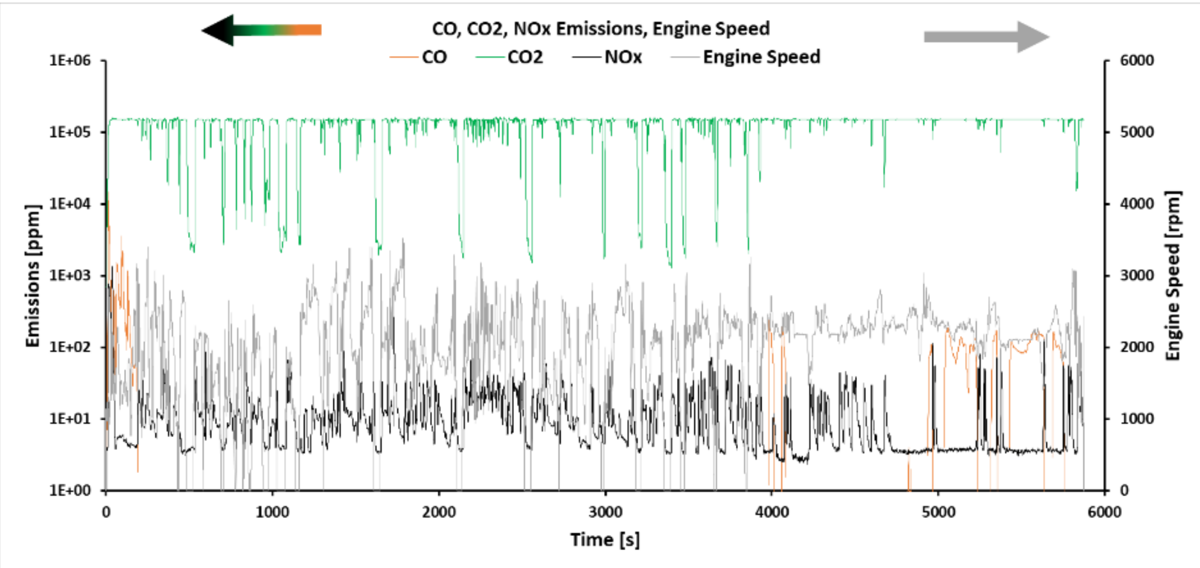



**Figure 113:** Instantaneous gaseous emissions measurements, engine speed & λ of segment B vehicle (31/07/2018, non-compliant, extended conditions, cold).

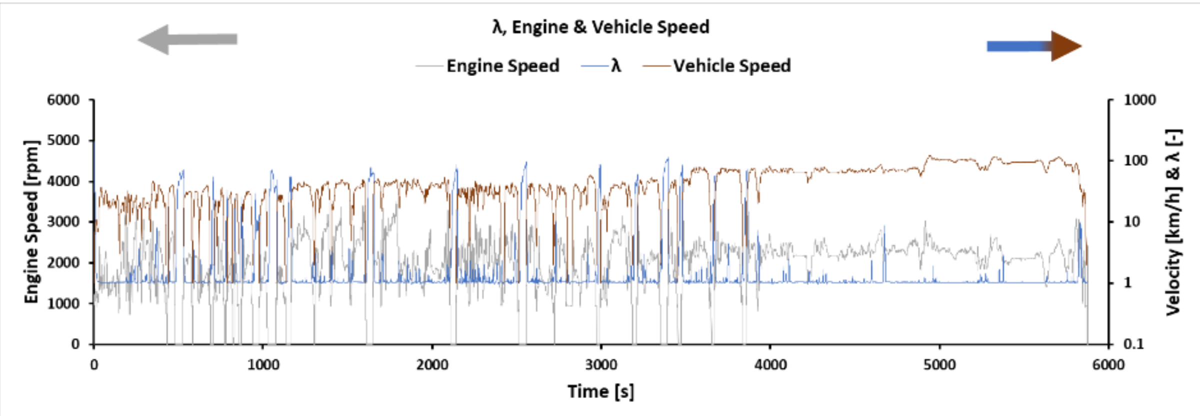



**Figure 114:** Second by second, engine speed, λ and vehicle speed of segment B vehicle (01/08/2018, compliant, smooth, cold).

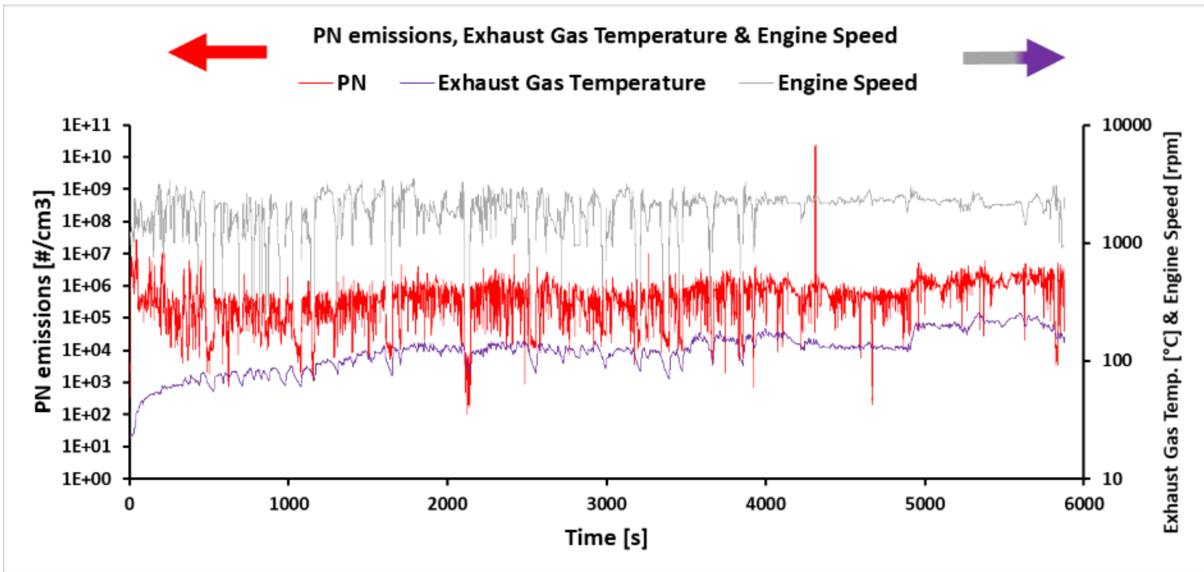



**Figure 115:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment B vehicle (01/08/2018, compliant, smooth, cold).

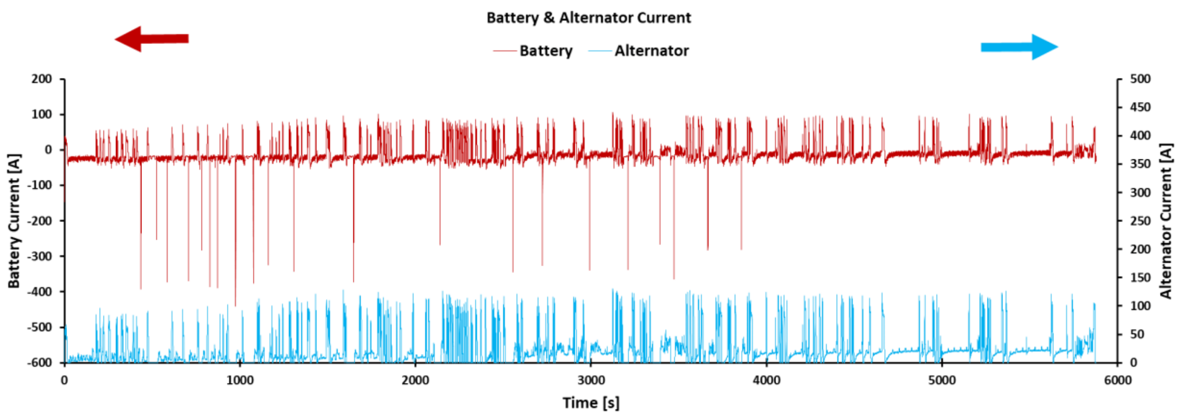



**Figure 116:** Instantaneous battery and alternator current of segment B vehicle (01/08/2018, compliant, smooth, cold).

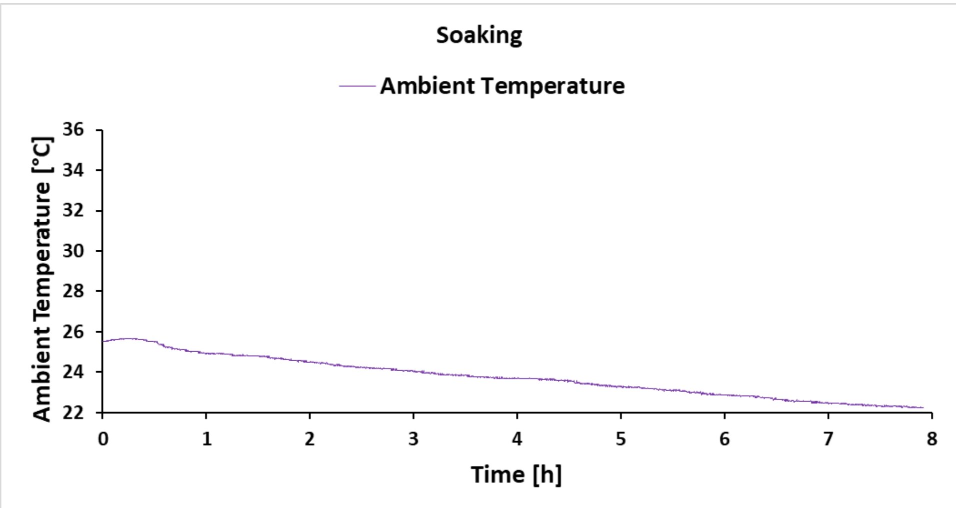



**Figure 117:** Pre-measurement soaking of segment B vehicle (01/08/2018, compliant, smooth, cold).

## Measurement conducted in 01/08/2018 (non-compliant, extended conditions, cold)

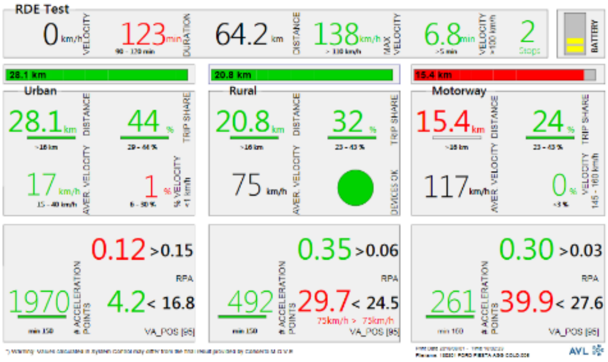



**Figure 118:** Driving dynamics of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold)

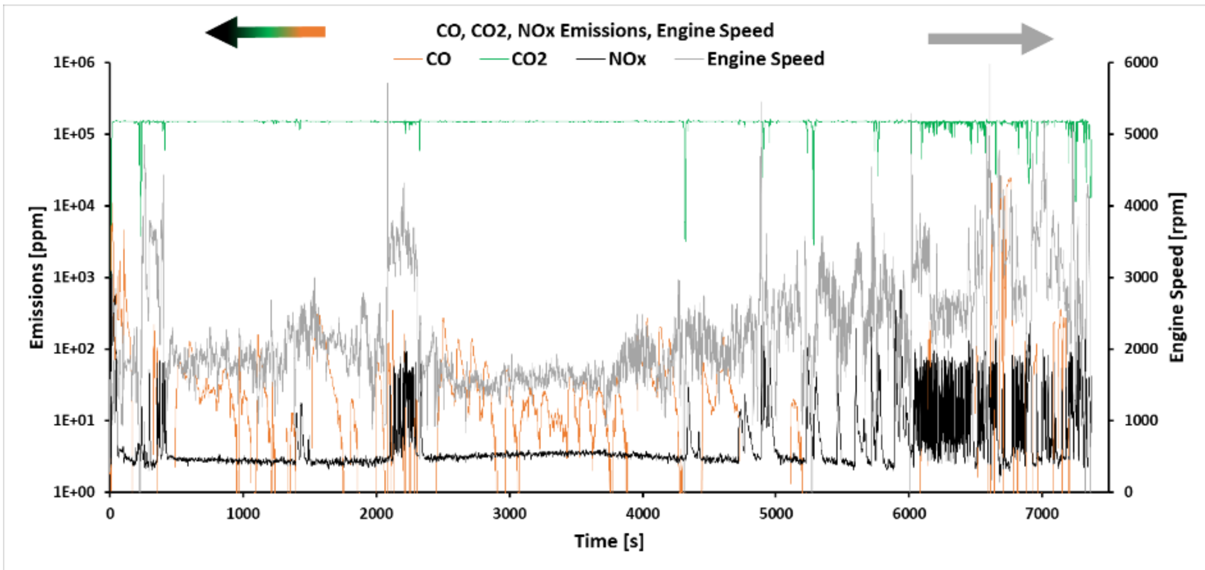



**Figure 119:** Instantaneous gaseous emissions measurements, engine speed & λ of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold).

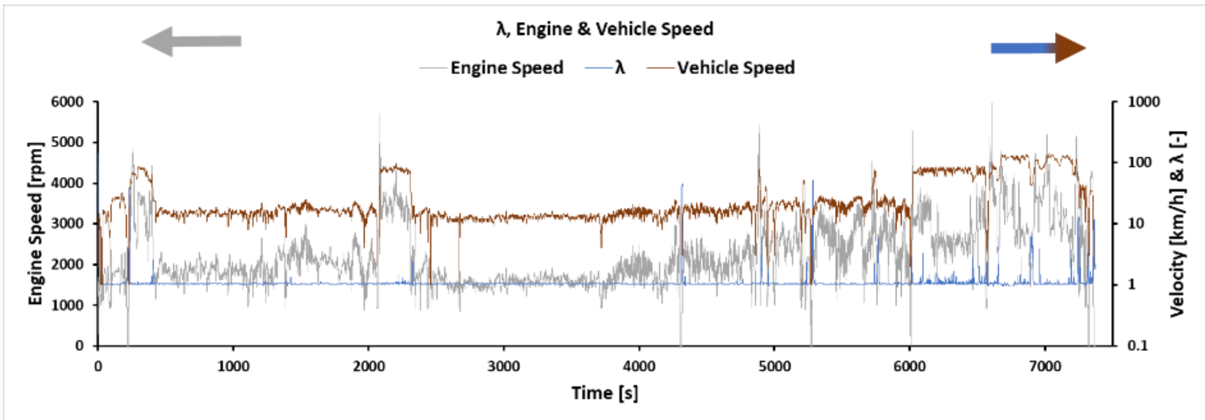



**Figure 120:** Second by second, engine speed, λ and vehicle speed of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold).

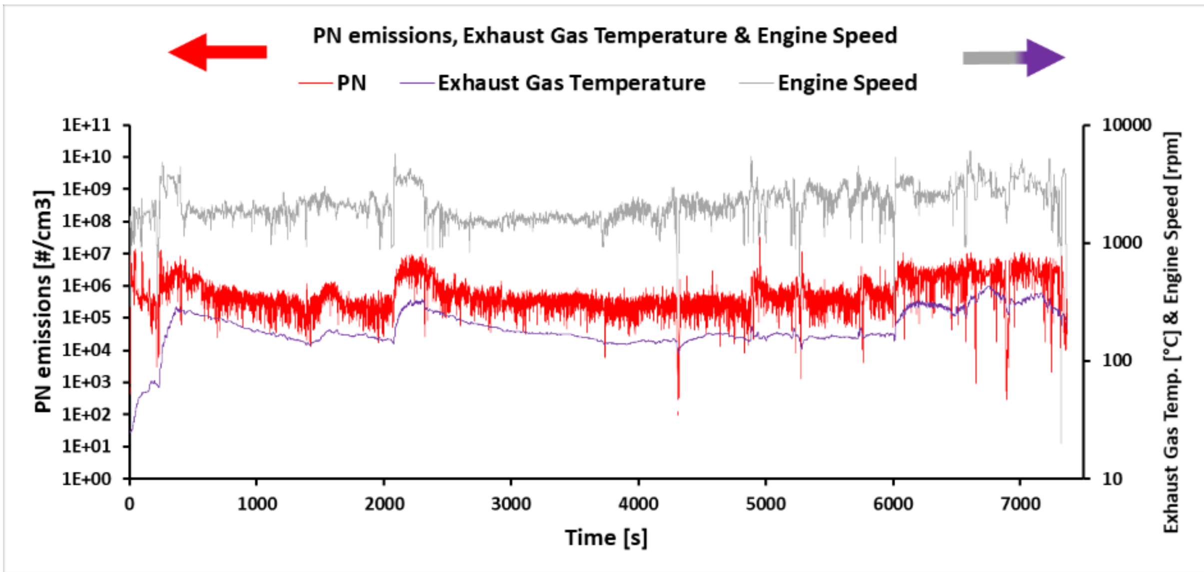



**Figure 121:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold).

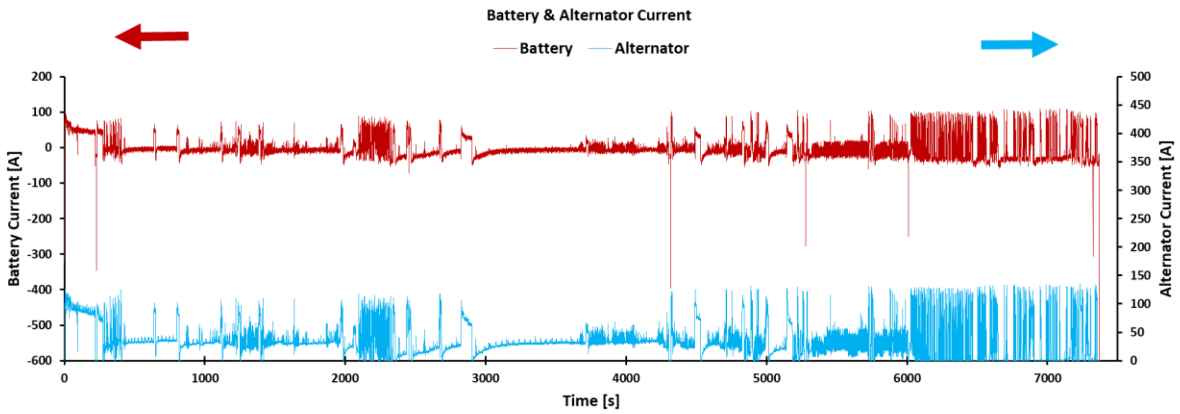



**Figure 122:** Instantaneous battery and alternator current of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold).

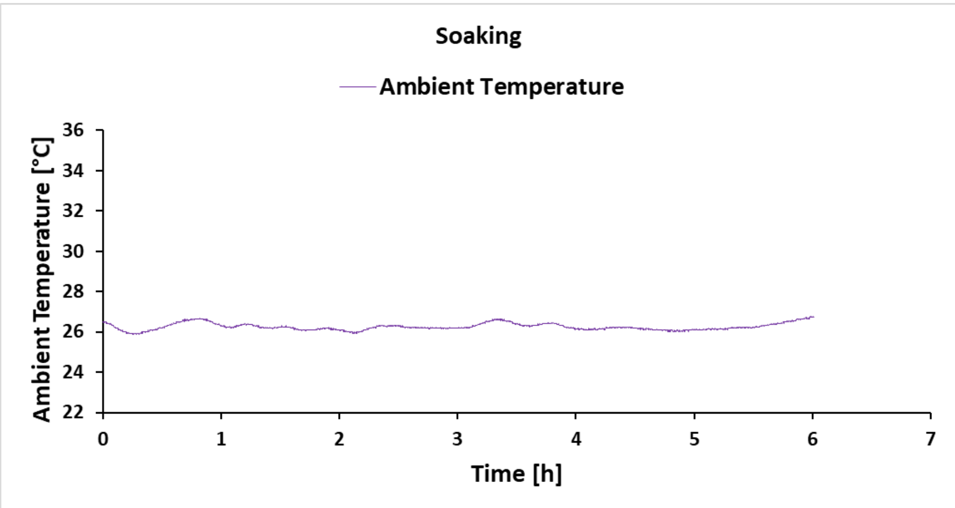



**Figure 123:** Pre-measurement soaking of segment B vehicle (01/08/2018, non-compliant, extended conditions, cold).

## Measurement conducted in 02/08/2018 (dynamic, cold, over-extended conditions)

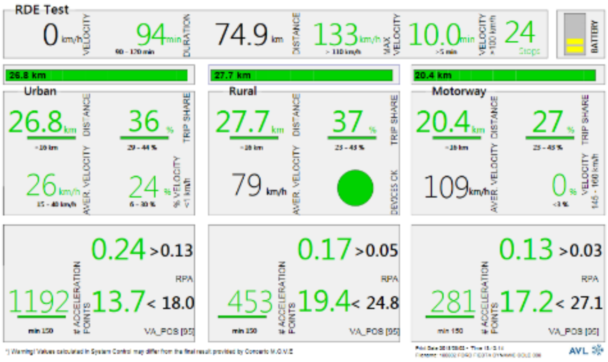



**Figure 124:** Driving dynamics of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions)

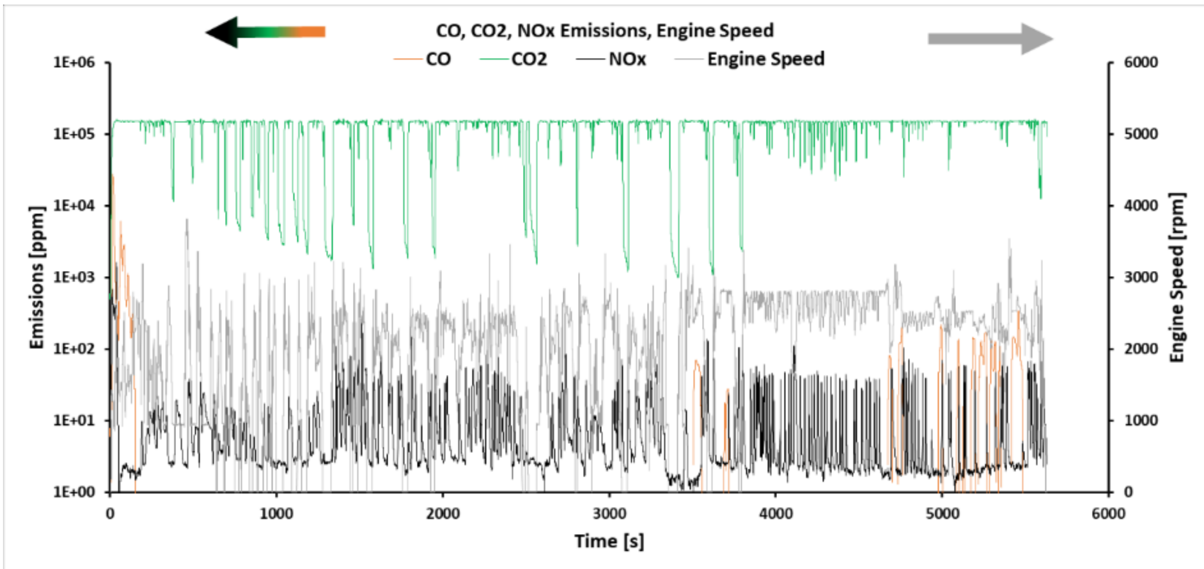



**Figure 125:** Instantaneous gaseous emissions measurements, engine speed & λ of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions).

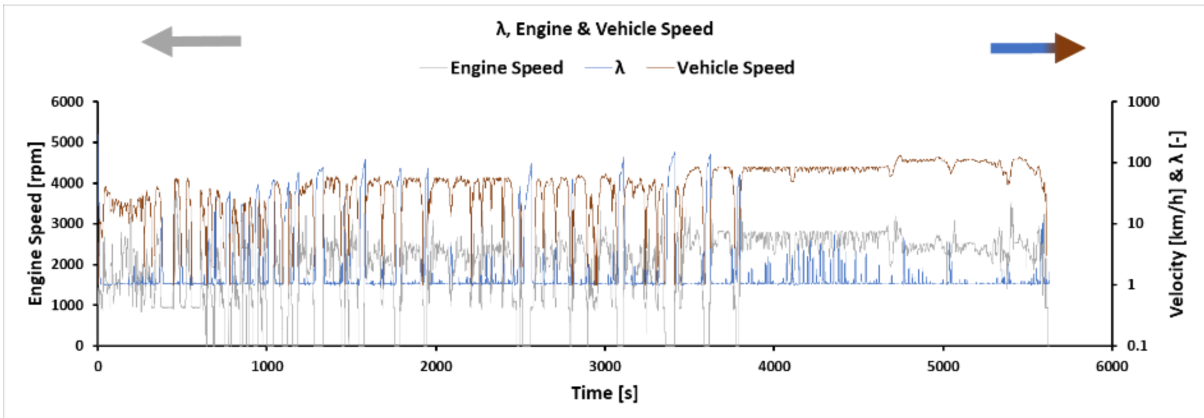



**Figure 126:** Second by second, engine speed, λ and vehicle speed of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions).

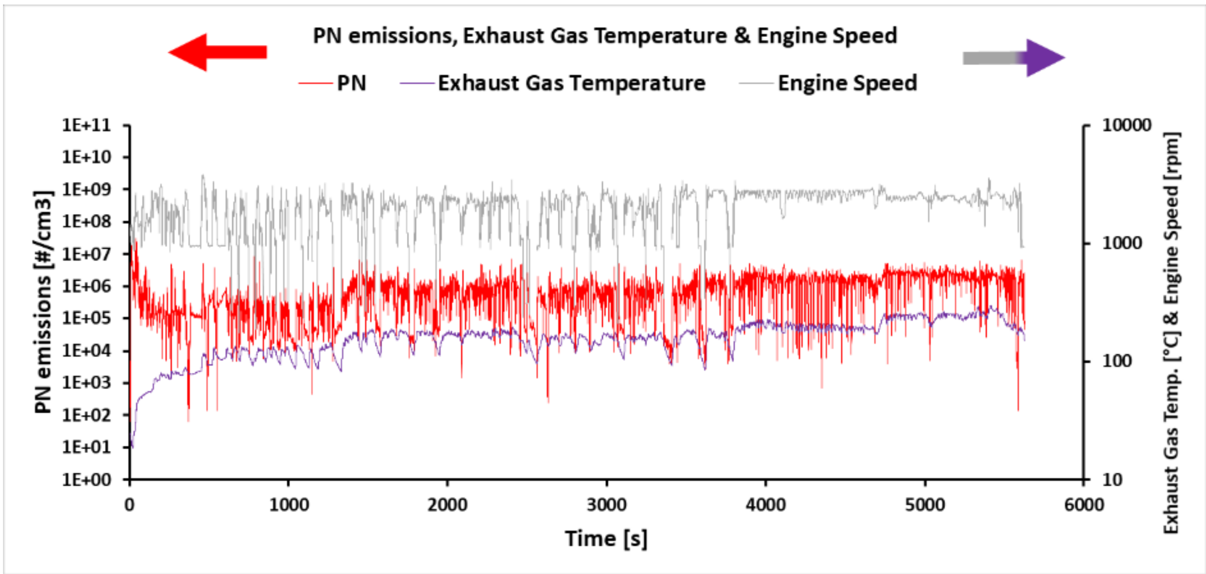



**Figure 127:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions).

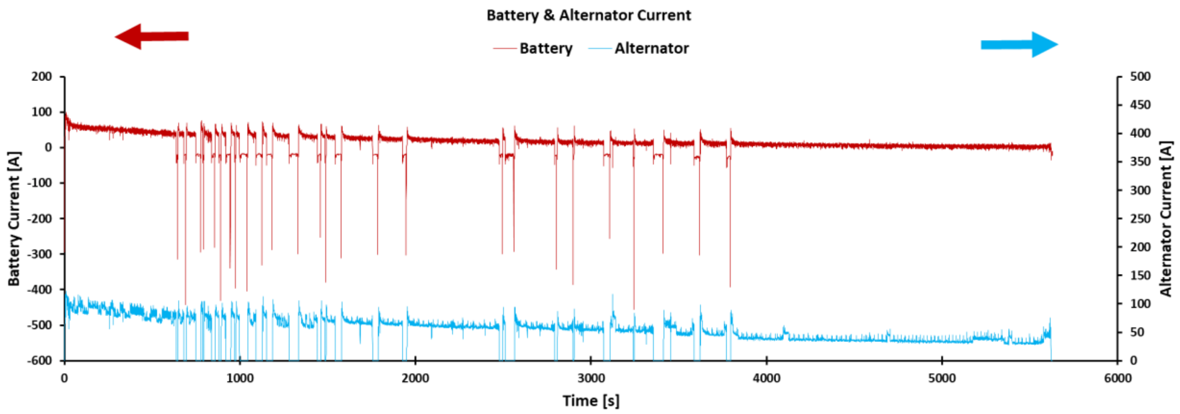



**Figure 128:** Instantaneous battery and alternator current of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions).

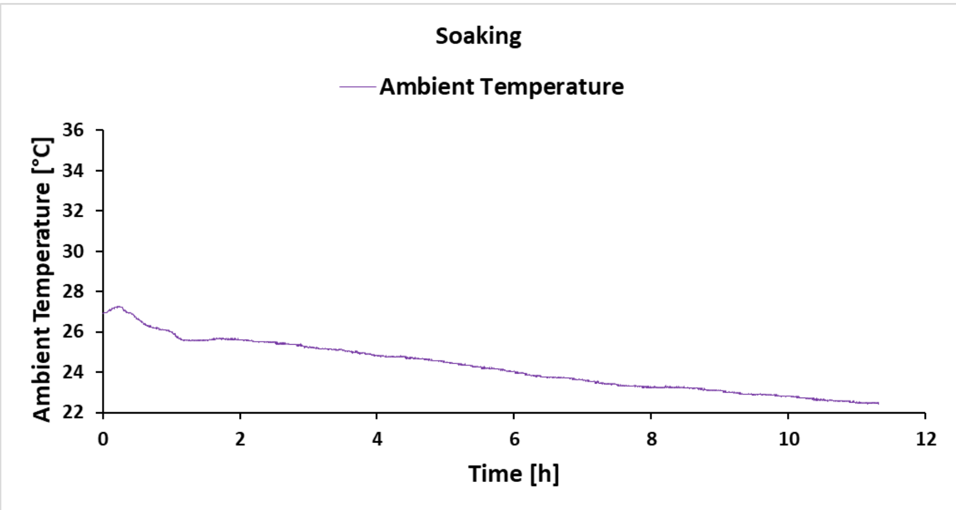



**Figure 129:** Pre-measurement soaking of segment B vehicle (02/08/2018, dynamic, cold, over-extended conditions).

## Measurement conducted in 02/08/2018 (compliant, dynamic, cold)

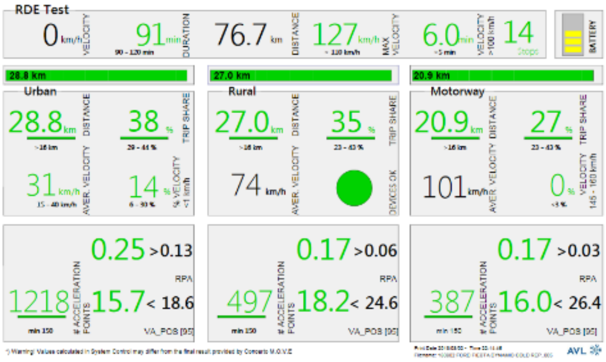



**Figure 130:** Driving dynamics of segment B vehicle (02/08/2018, compliant, dynamic, cold)

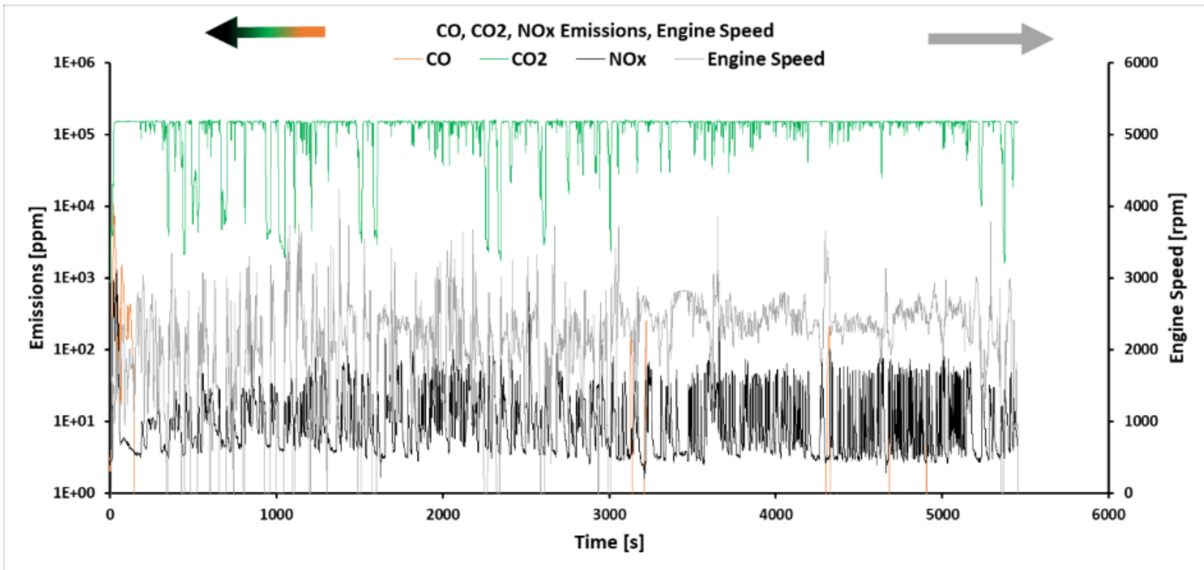



**Figure 131:** Instantaneous gaseous emissions measurements, engine speed & λ of segment B vehicle (02/08/2018, compliant, dynamic, cold).

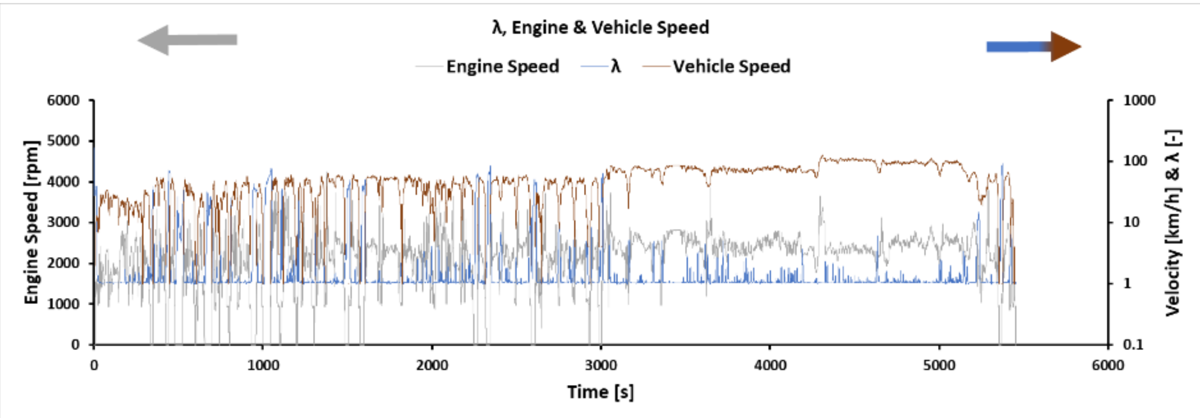



**Figure 132:** Second by second, engine speed, λ and vehicle speed of segment B vehicle (02/08/2018, compliant, dynamic, cold).

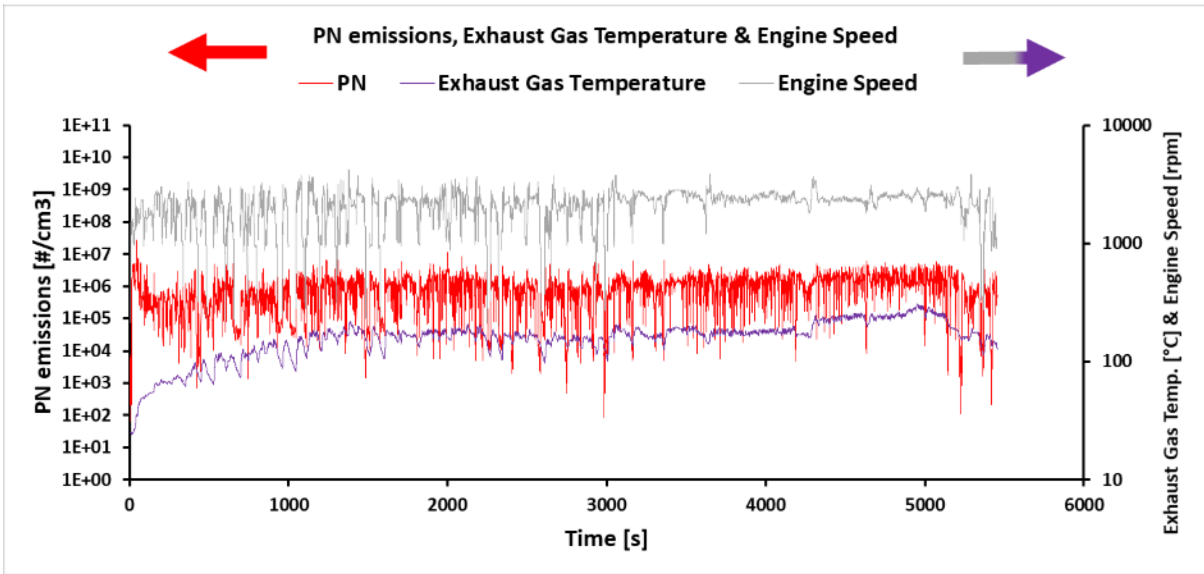



**Figure 133:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment B vehicle (02/08/2018, compliant, dynamic, cold).

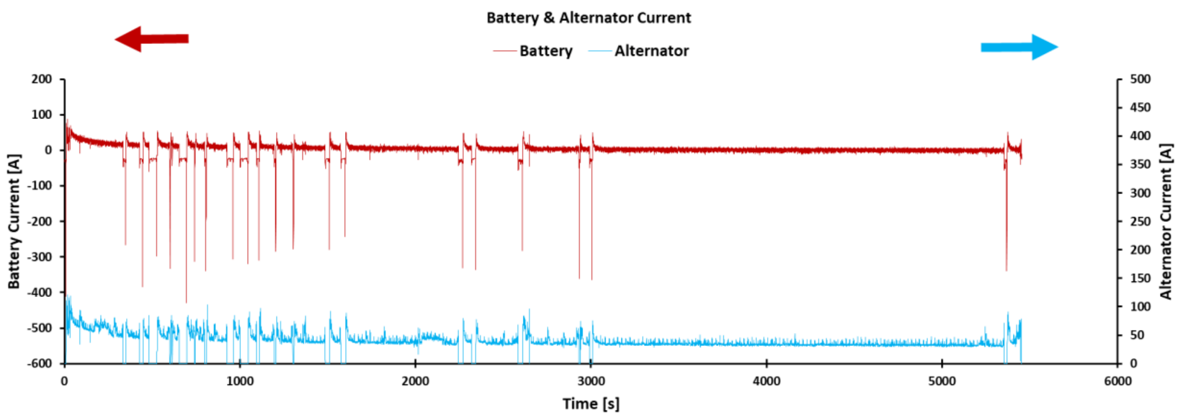



**Figure 134:** Instantaneous battery and alternator current of segment B vehicle (02/08/2018, compliant, dynamic, cold).

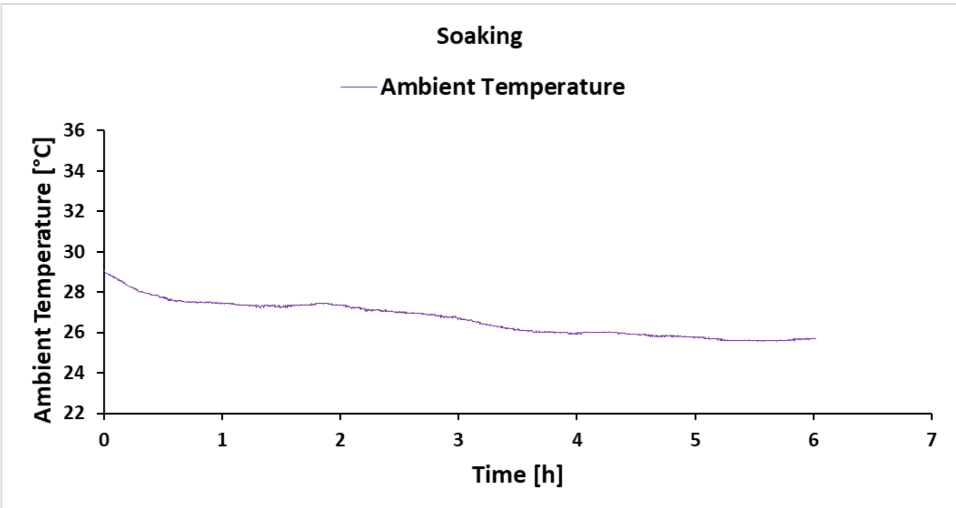



**Figure 135:** Pre-measurement soaking of segment B vehicle (02/08/2018, compliant, dynamic, cold).

# Appendix V : Driving dynamics and instantaneous on-road measurements of segment A vehicle.

**Measurement conducted in 03/08/2018 (compliant, dynamic, cold)**

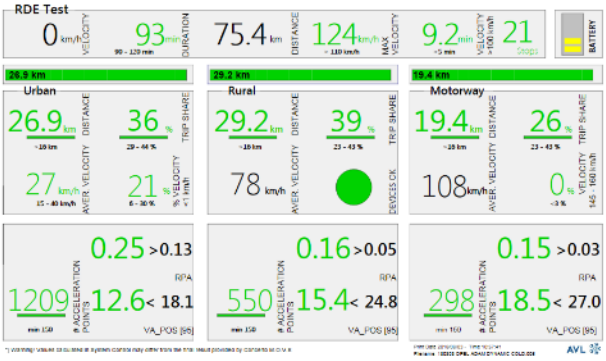



**Figure 136:** Driving dynamics of segment A vehicle (03/08/2018, compliant, dynamic, cold)

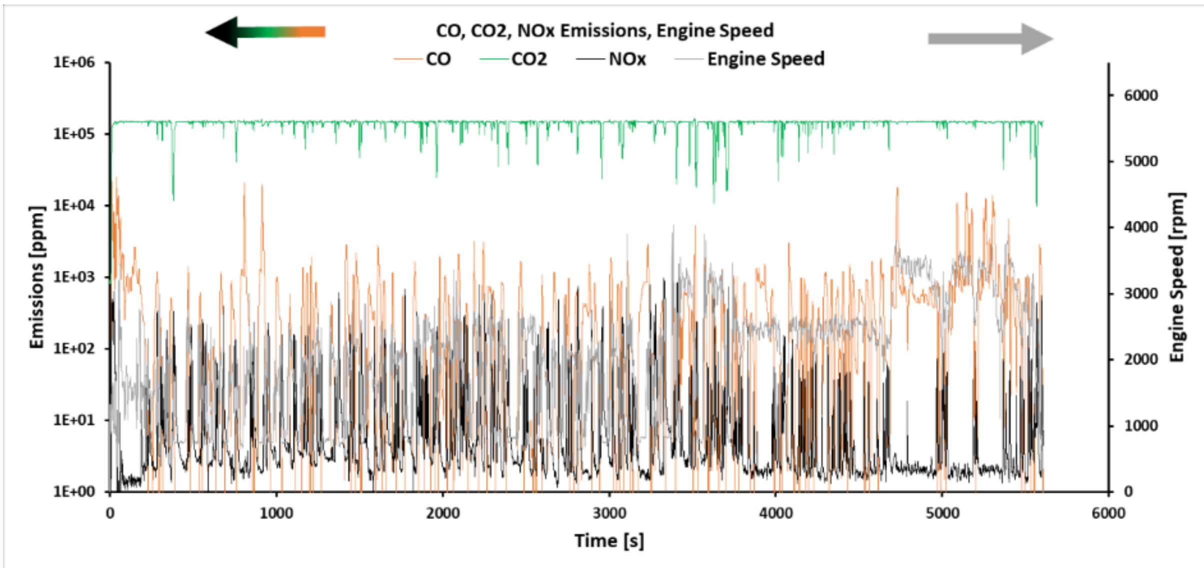



**Figure 137:** Instantaneous gaseous emissions measurements, engine speed & λ of segment A vehicle (03/08/2018, compliant, dynamic, cold).

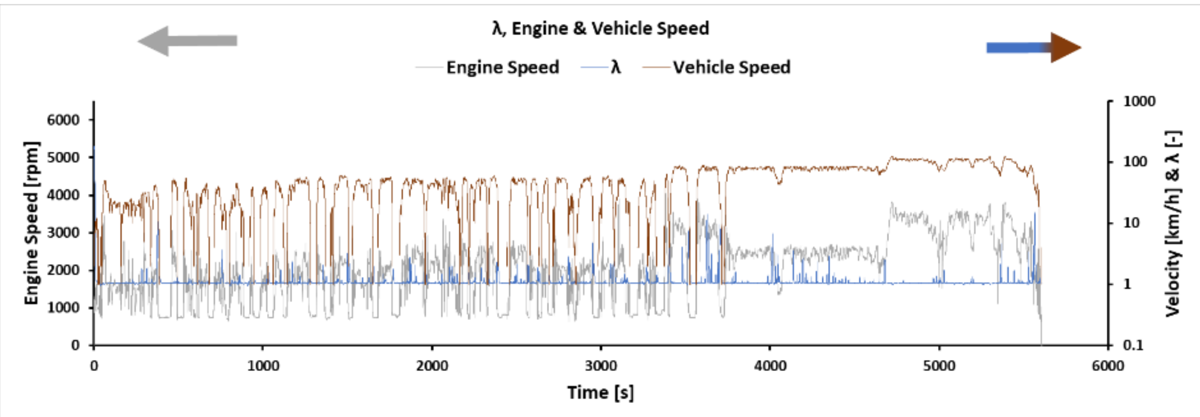



**Figure 138:** Second by second, engine speed, λ and vehicle speed of segment A vehicle (03/08/2018, compliant, dynamic, cold).

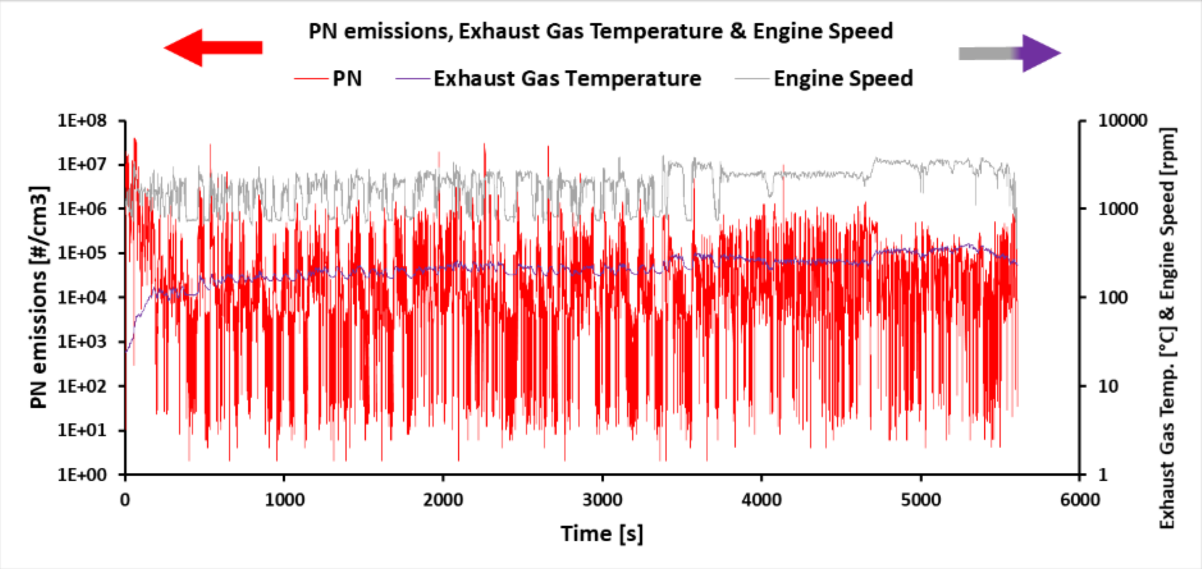



**Figure 139:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment A vehicle (03/08/2018, compliant, dynamic, cold).

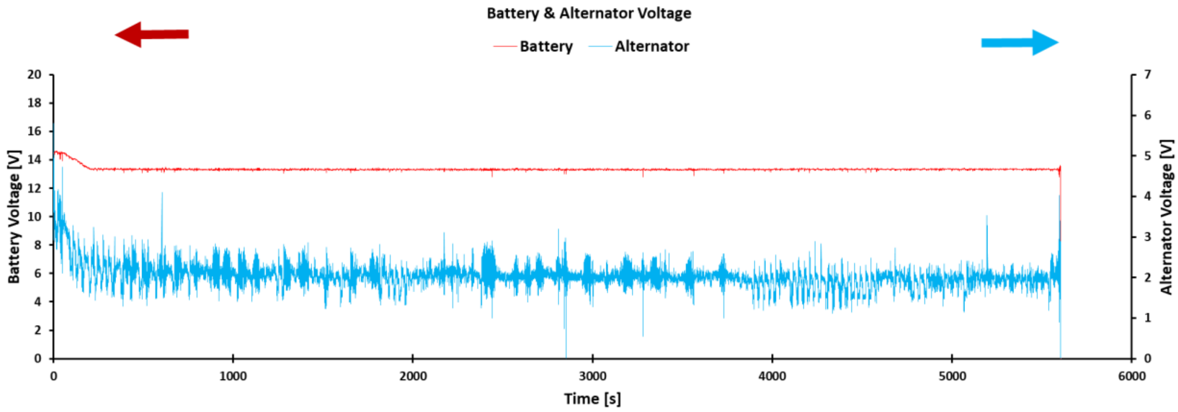



**Figure 140:** Instantaneous battery and alternator voltage of segment A vehicle (03/08/2018, compliant, dynamic, cold).

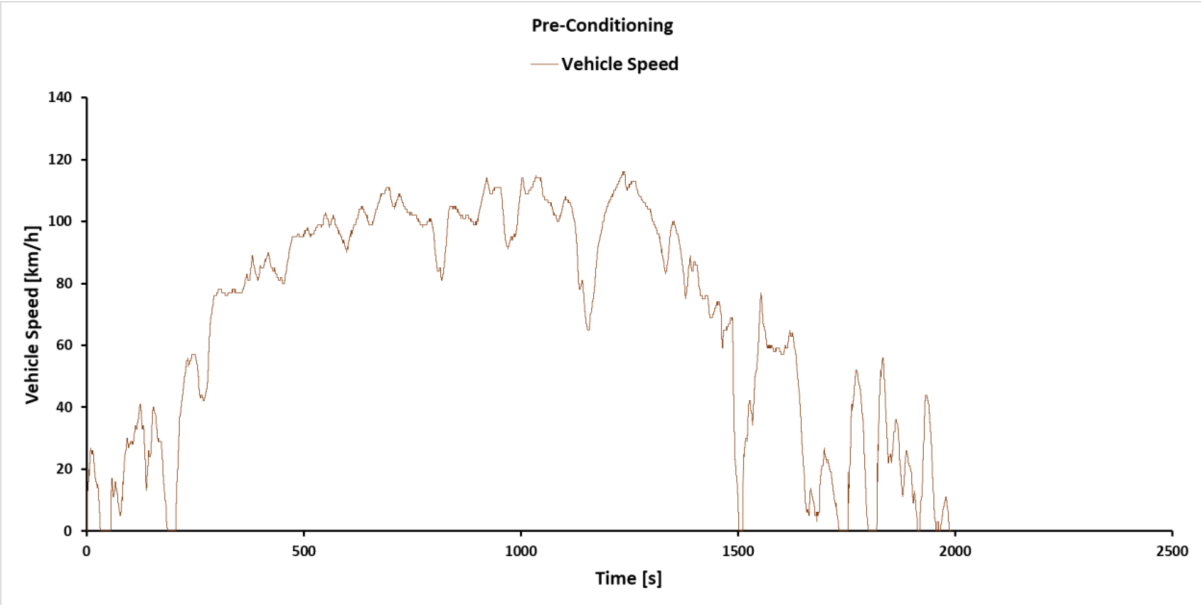



**Figure 141:** Vehicle speed during measurement pre-conditioning of segment A vehicle (03/08/2018, compliant, dynamic, cold).

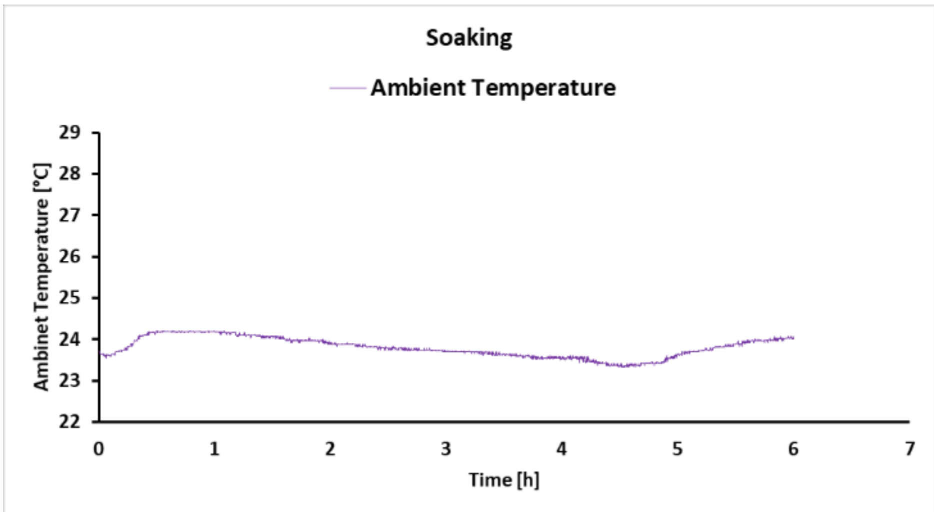



**Figure 142:** Pre-measurement soaking of segment A vehicle (03/08/2018, compliant, dynamic, cold).

## Measurement conducted in 04/08/2018 (non-compliant, extended conditions, cold)

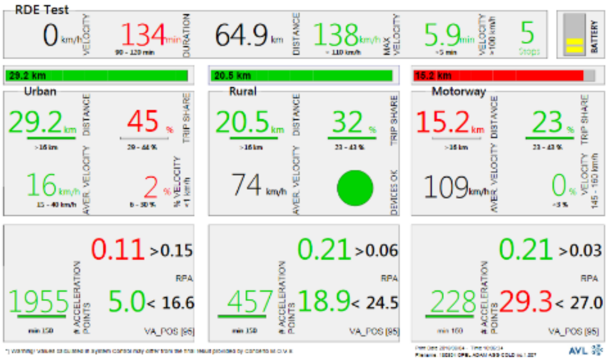



**Figure 143:** Driving dynamics of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold)

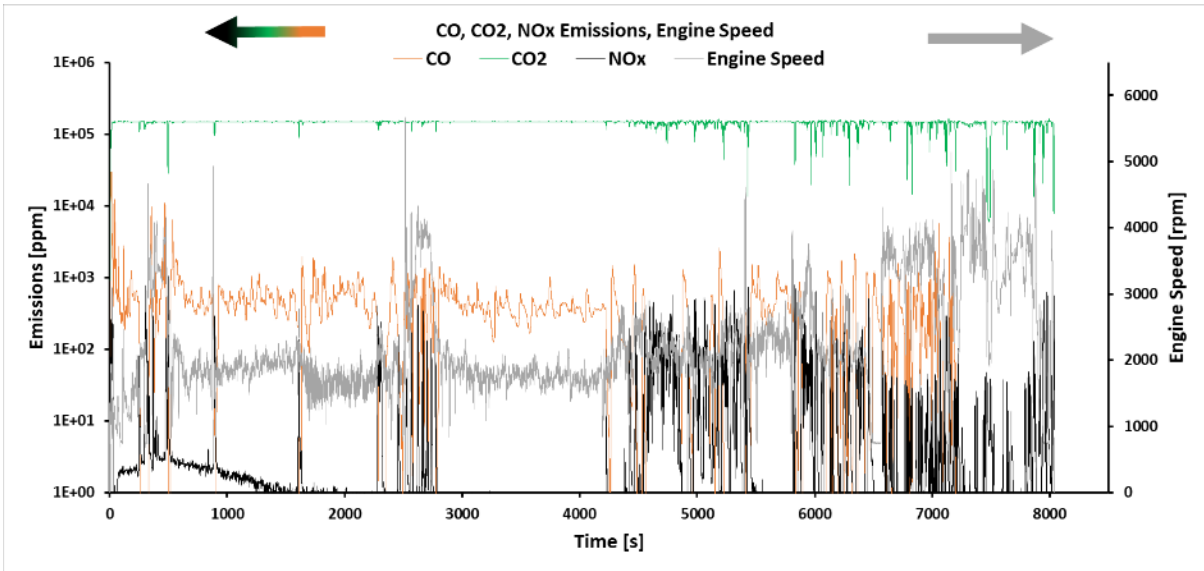



**Figure 144:** Instantaneous gaseous emissions measurements, engine speed & λ of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

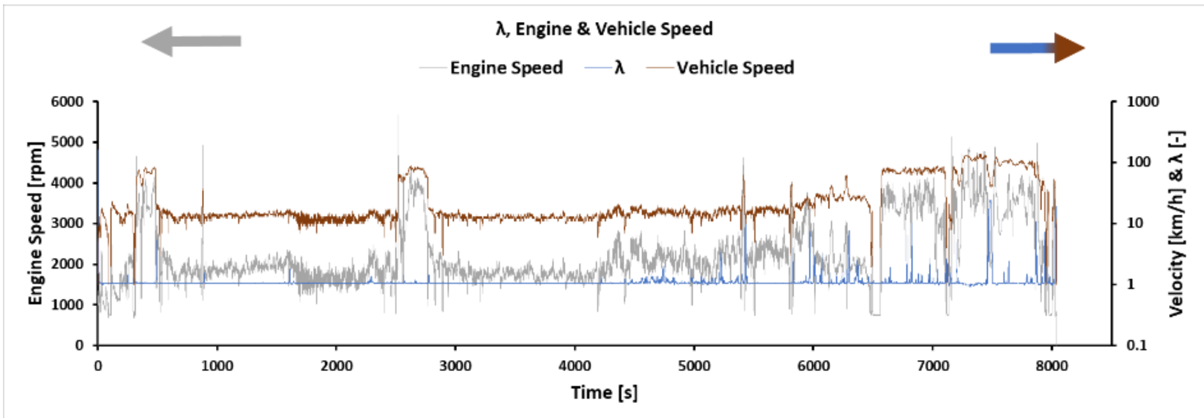



**Figure 145:** Second by second, engine speed, λ and vehicle speed of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

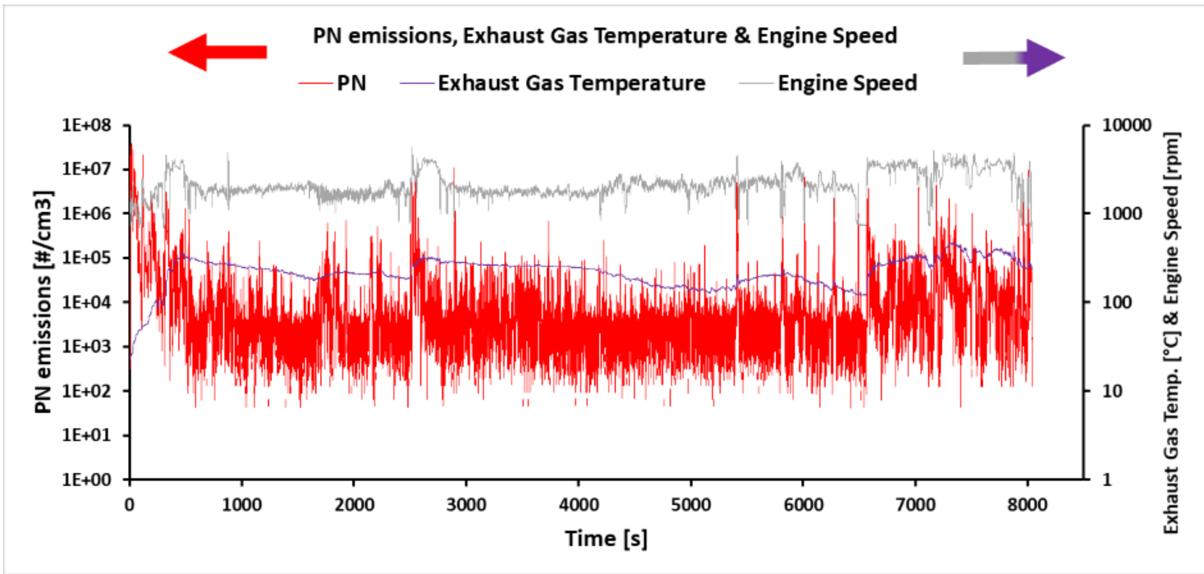



**Figure 146:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

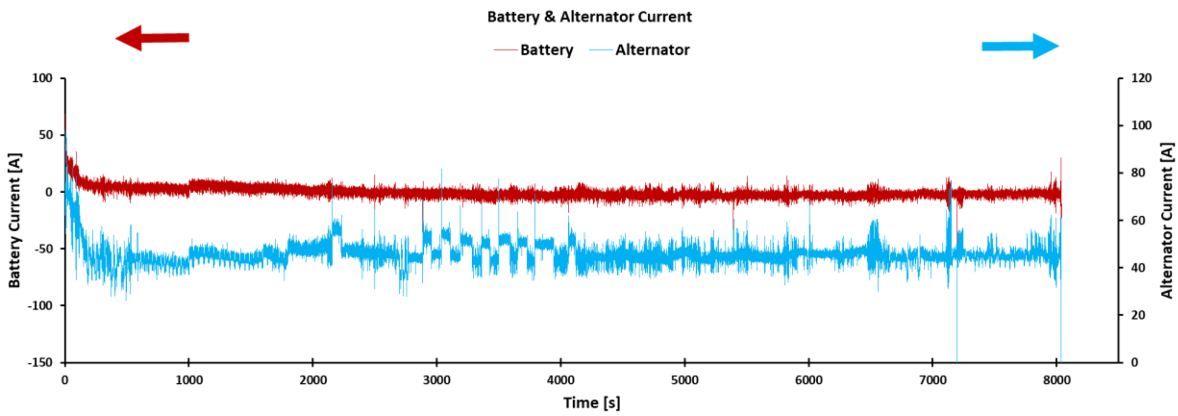



**Figure 147:** Instantaneous battery and alternator current of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

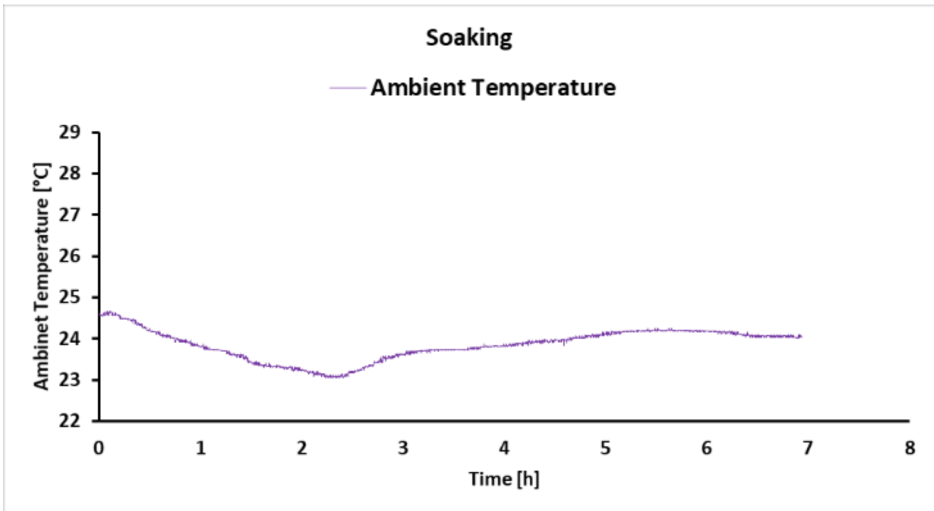



**Figure 148:** Pre-measurement soaking of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

## Measurement conducted in 04/08/2018 (non-compliant, extended conditions, cold)

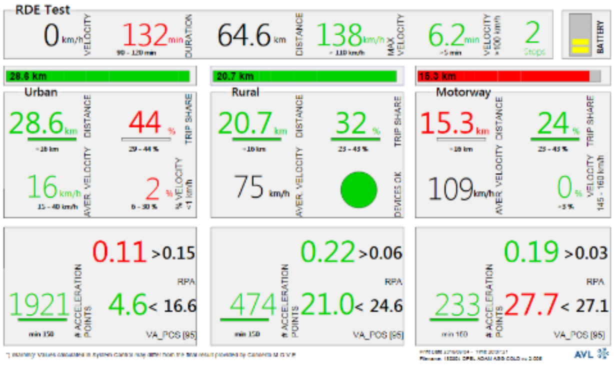



**Figure 149:** Driving dynamics of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold)

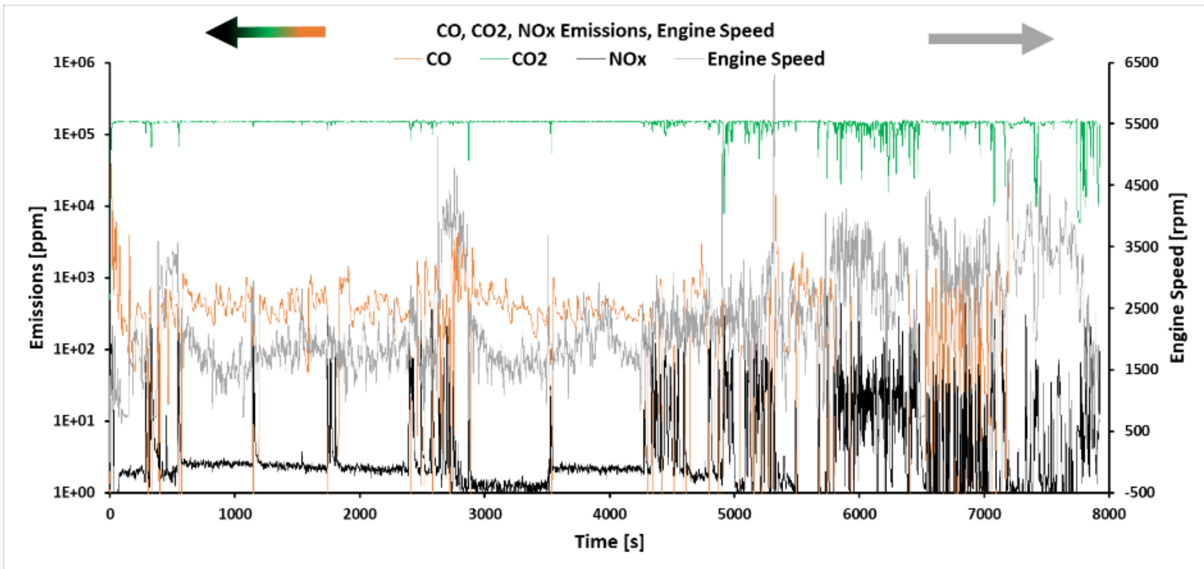



**Figure 150:** Instantaneous gaseous emissions measurements, engine speed & λ of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

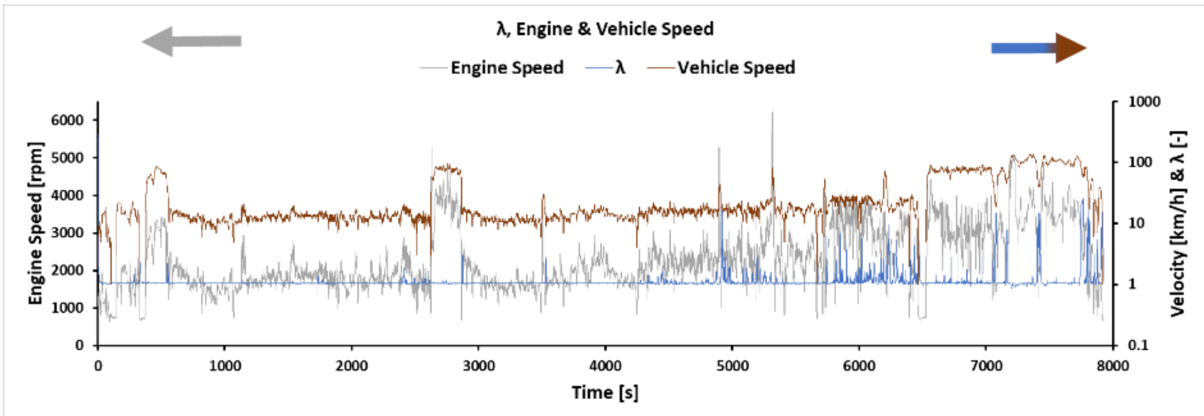



**Figure 151:** Second by second, engine speed, λ and vehicle speed of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

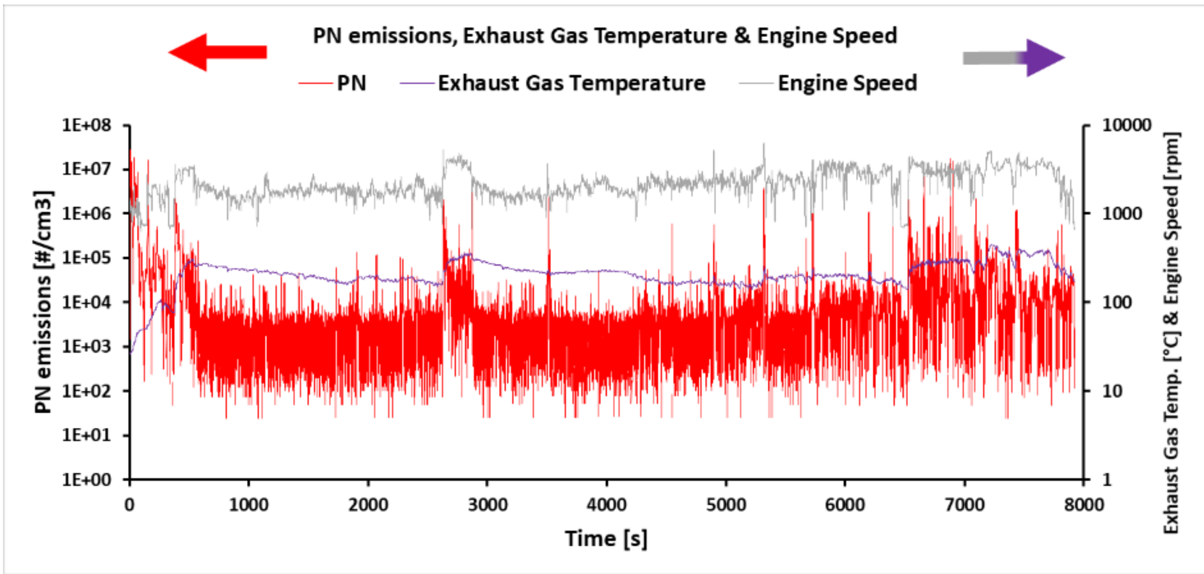



**Figure 152:** Instantaneous PN emissions measurements, engine speed & exhaust gas temperature of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

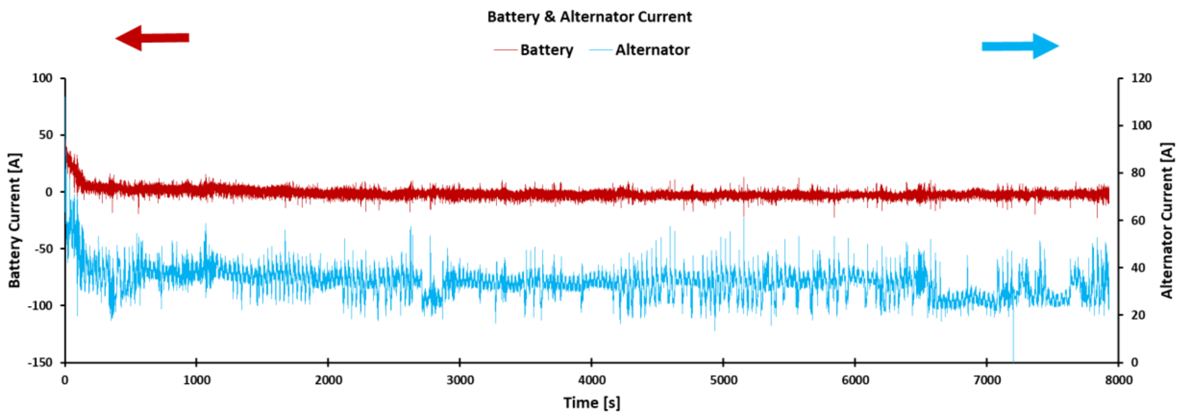



**Figure 153:** Instantaneous battery and alternator current of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

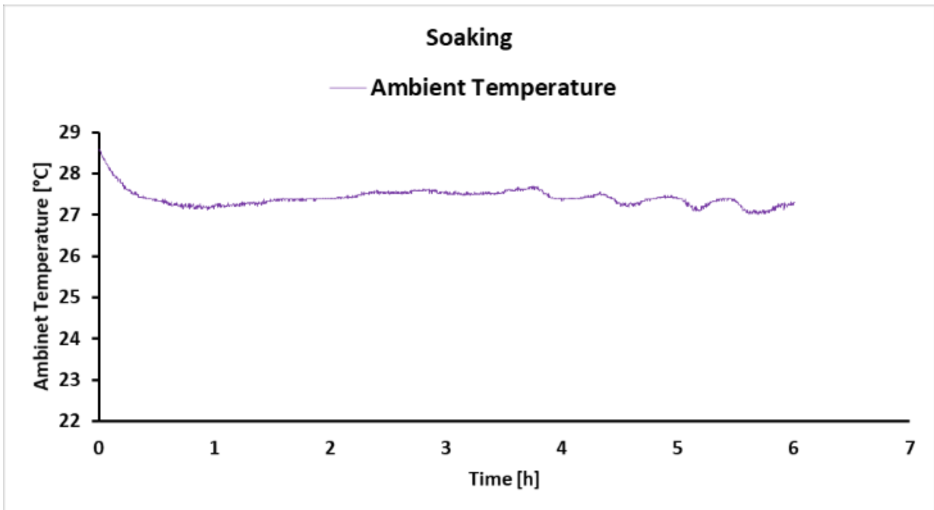



**Figure 154:** Pre-measurement soaking of segment A vehicle (04/08/2018, non-compliant, extended conditions, cold).

# Appendix VI : Aggregated emissions (raw) per route segment.

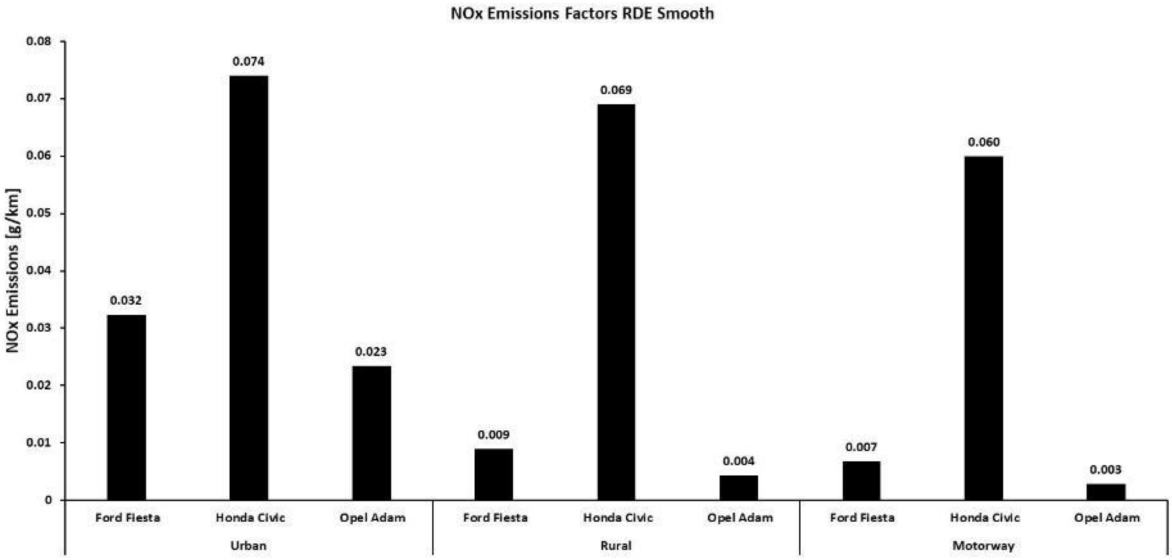



**Figure 155:** NOx aggregated emissions (raw) per route segment, for compliant RDE smooth trips.

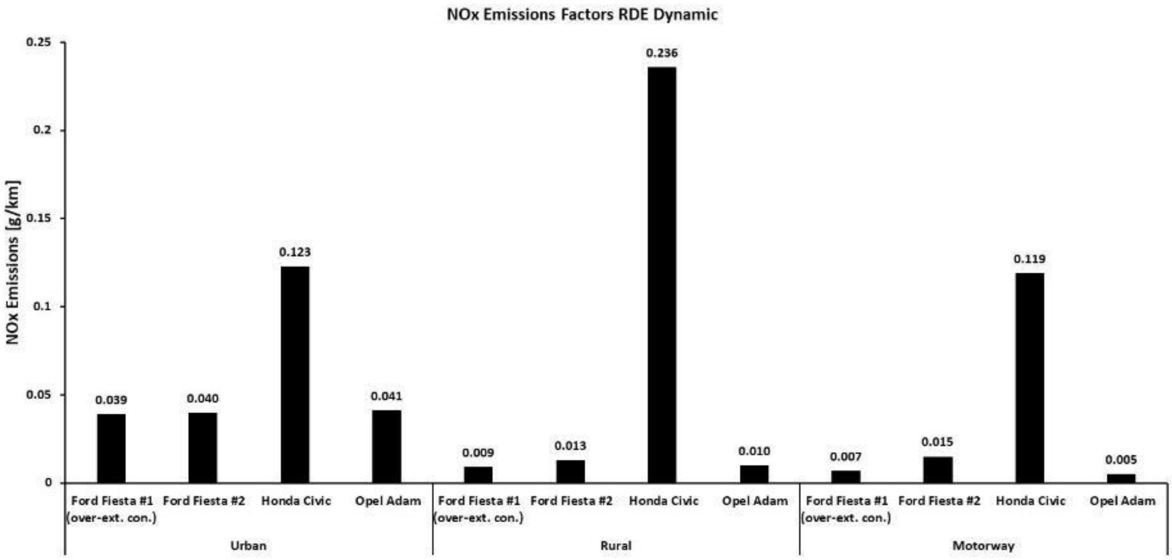



**Figure 156:** NOx aggregated emissions (raw) per route segment, for compliant RDE dynamic trips.

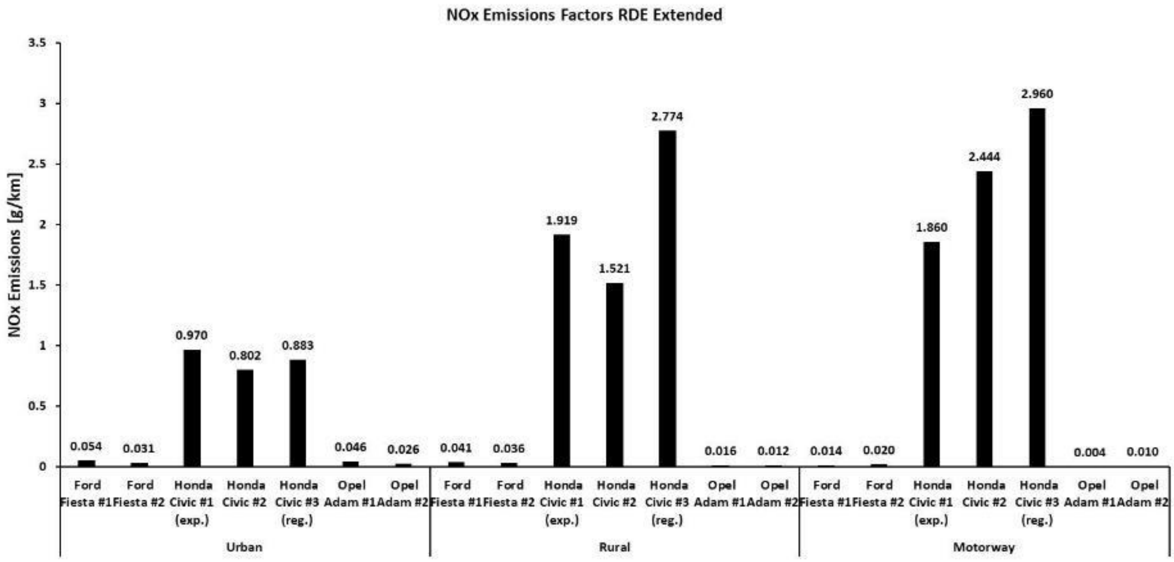



**Figure 157:** NOx aggregated emissions (raw) per route segment, for non-compliant RDE extended conditions trips.

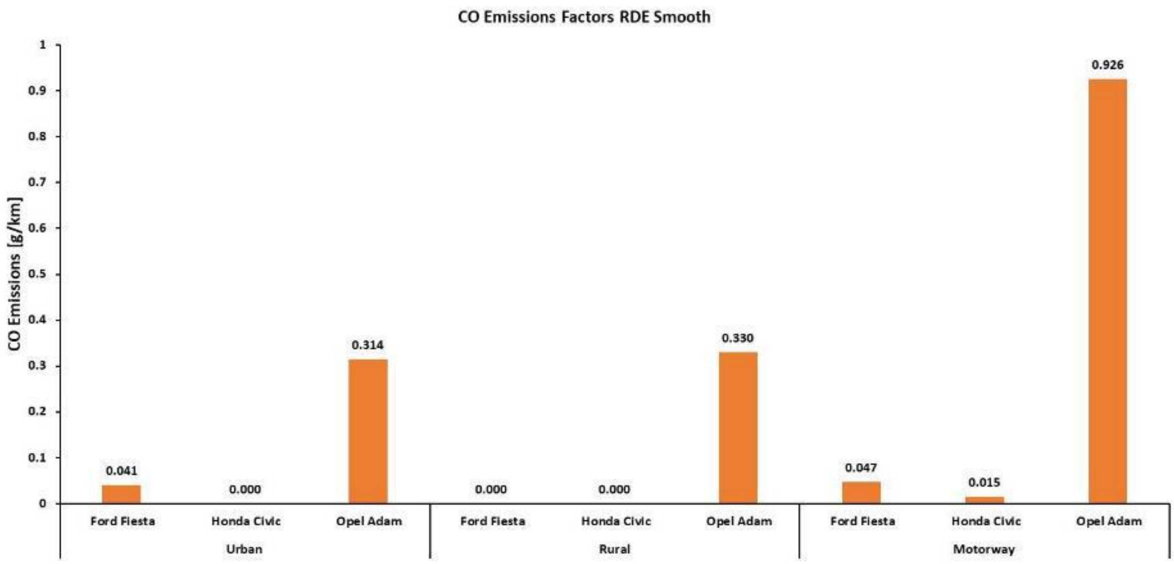



**Figure 158:** CO aggregated emissions (raw) per route segment, for compliant RDE smooth trips.

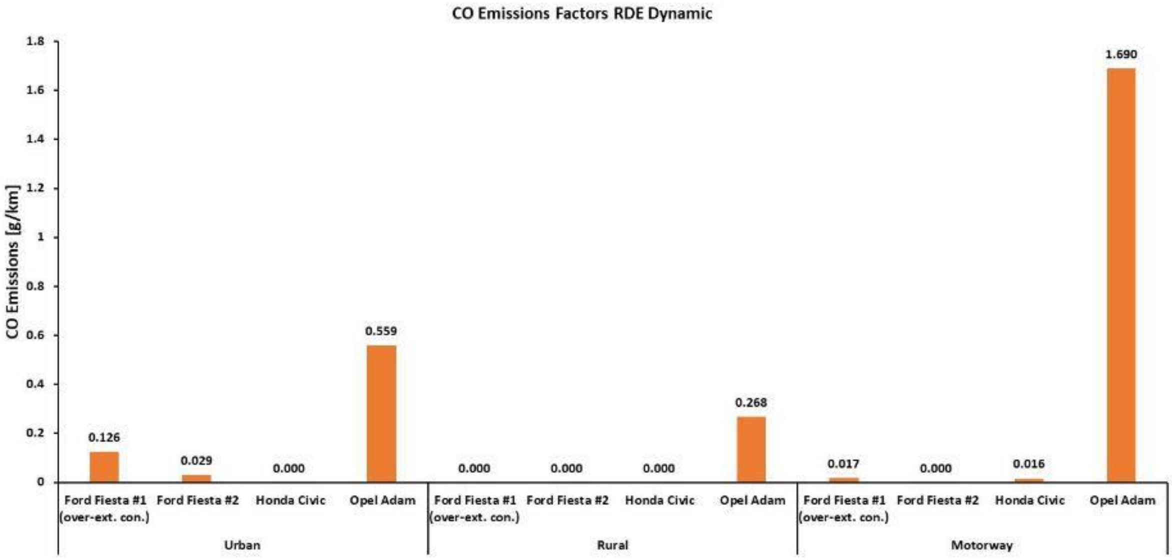



**Figure 159:** CO aggregated emissions (raw) per route segment, for compliant RDE dynamic trips.

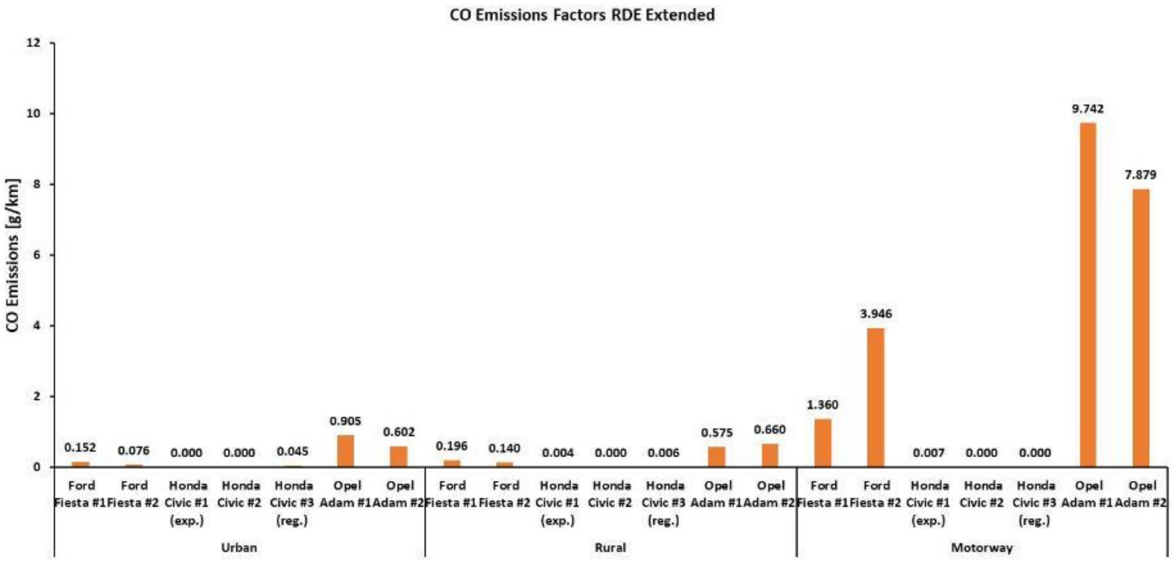



**Figure 160:** CO aggregated emissions (raw) per route segment, for non-compliant RDE extended conditions trips.

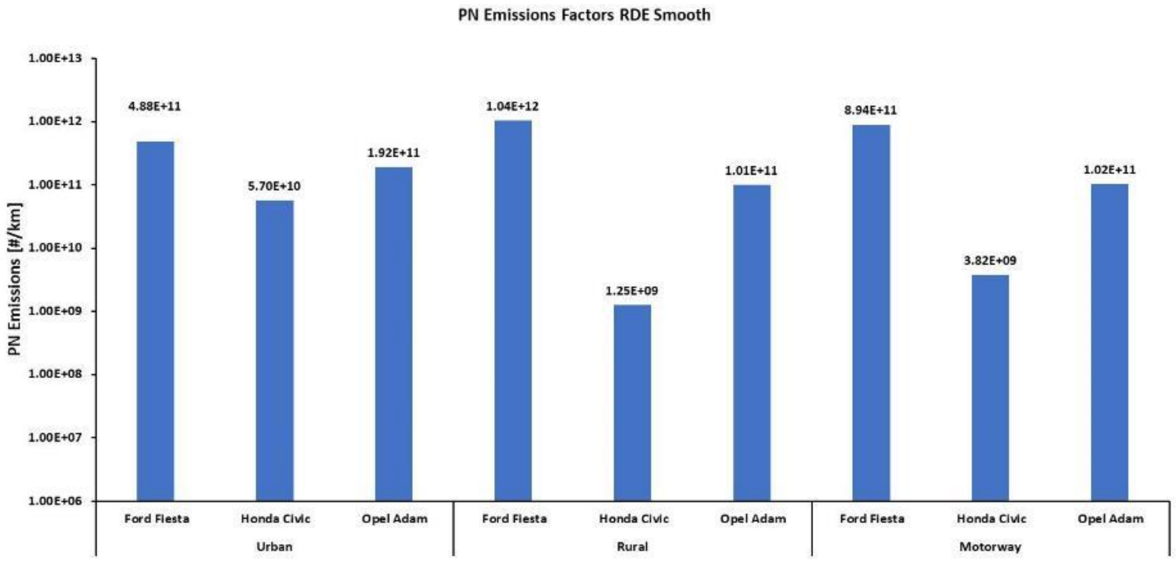



**Figure 161:** PN aggregated emissions (raw) per route segment, for compliant RDE smooth trips.

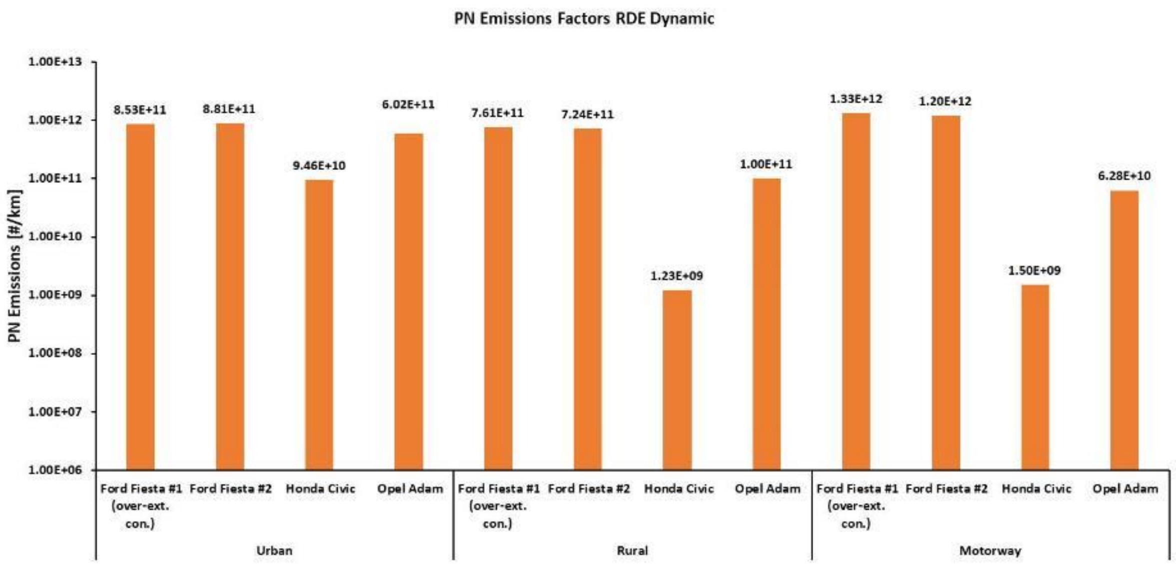



**Figure 162:** PN aggregated emissions (raw) per route segment, for compliant RDE dynamic trips.

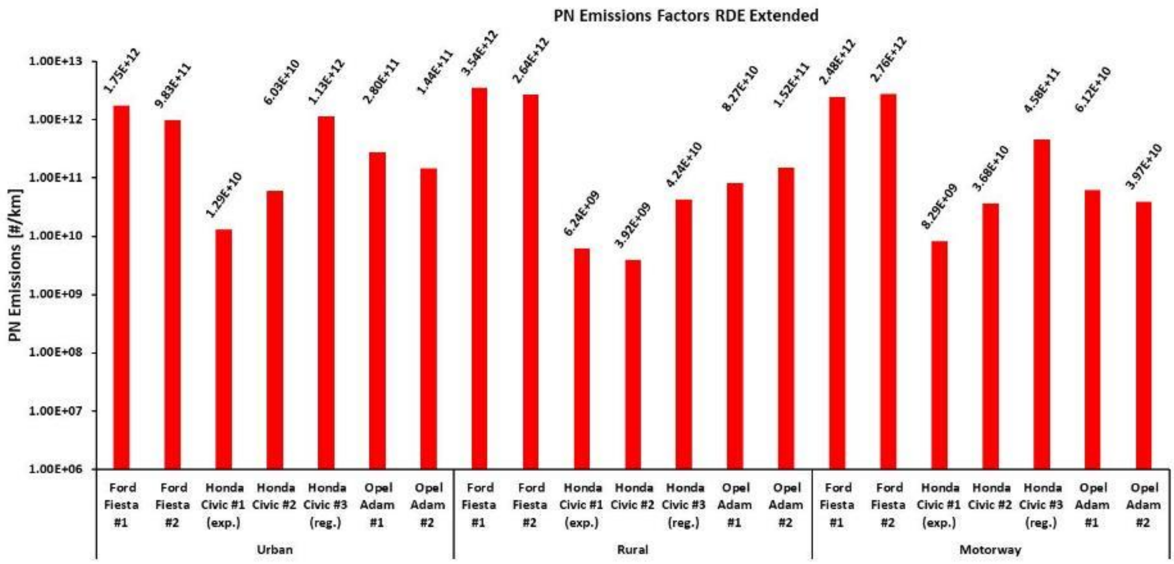



**Figure 163:** PN aggregated emissions (raw) per route segment, for non-compliant RDE extended conditions trips.

## Appendix VII : Dry to wet correction for $CO_2$ and CO emissions according to RDE 3 regulation.

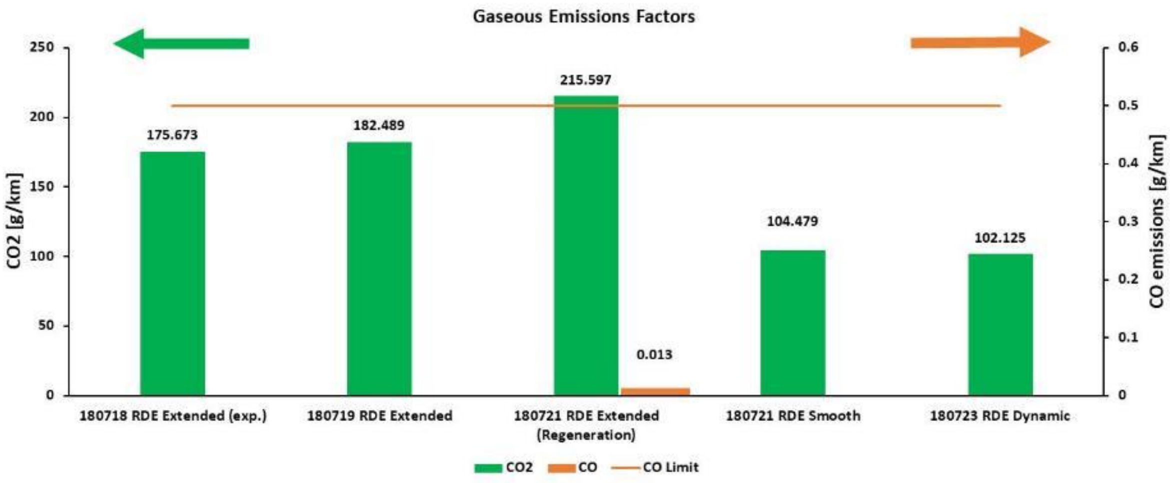



**Figure 164:** Dry to wet correction of $CO_2$ and CO emissions for Segment C vehicle.

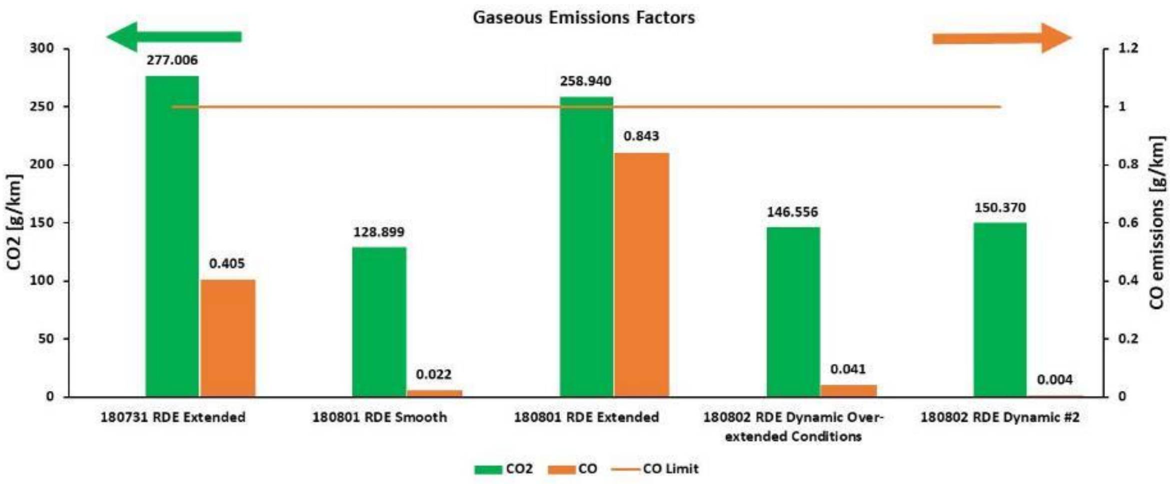



**Figure 165:** Dry to wet correction of $CO_2$ and CO emissions for Segment B vehicle.

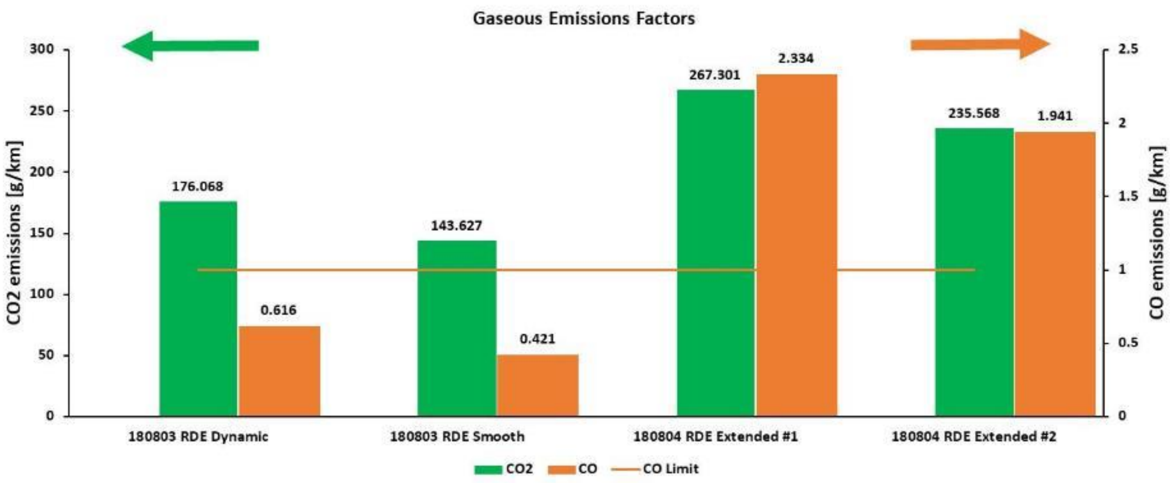



**Figure 166:** Dry to wet correction of $CO_2$ and CO emissions for Segment A vehicle.