Second RDE LDV "Package" – Skeleton for the text (V3)

Informal EC working document

Introduction

This document is a skeleton of the intended "second RDE package". The document identifies which sections-appendices of the RDE regulation have to be ammended to introduce the following elements:

Item 1: Conformity factors for the various pollutants have to be indroduced in section 2.1. The factor "ext" to divide the emissions measured under extended ambient conditions shall be specified in section 9.5

Item 2: Additional boundary conditions for the absence/excess of driving dynamics have to be introduced in section 5.3 (for the application, ex-post, before the application of the data evaluation methods?) and Appendix 9 (Methodological aspects, e.g definition of indicators, limit curves).

Item 3: Additional boundary conditions for the urban trip requirements have to be introduced in Section 6.8 (the average urban speed range and the stop percentages).

Item 4: Additional boundary conditions for the road profile requirements have to be introduced in Section 6.11 (this shall be checked ex-ante [before the test] and the methodology to check this may be specified or not).

Item 5: Factor for the extended conditions in section 9.5

Appendices 1 to 8 are not mentionned in the present document and shall only be corrected for obvious errors.

Color codes

Current text to be ammended

Comments

Proposals for the ammendements

Editorial Technical Note

Save the document as Word 2010 (.docx) file to keep the possibility to edit the equations*

ANNEX

"ANNEX IIIA

VERIFYING REAL DRIVING EMISSIONS

1. INTRODUCTION, DEFINITIONS AND ABBREVIATIONS

Corrections or missing definitions, abbreviations shall be added here

2. GENERAL REQUIREMENTS

[Current Section 2.1] Throughout its normal life, the emissions of a vehicle type approved according to Regulation (EC) No 715/2007 as determined according to the requirements of this Annex and emitted at a RDE test performed in accordance to the requirements of this Annex, shall not be higher than the following not-to-exceed (NTE) values:

$NTE_{pollutant} = CF_{pollutant}$ *x* EURO-6,

where EURO-6 is the applicable Euro 6 emission limit in Table 2 of Annex I to Regulation (EC) No 715/2007 and $CF_{pollutant}$ the conformity factor for the respective pollutant specified as follows:

Pollutant	Mass of oxides of nitrogen (NOx)	Number of particles (PN)	Mass of carbon monoxide (CO)[1]	Mass of total hydrocarbons (THC)	Combined mass of total hydrocarbons and oxides of nitrogen (THC + NOx)
$CF_{pollutant}$	tbd	tbd	-	-	-

[1] CO emissions shall be measured and recorded at RDE tests..

Section 2.1 is ammended as follows:….

3. RDE TEST TO BE PERFORMED

Unchanged, a new text shall be developped for In-Service Conformity.

4. GENERAL REQUIRMENTS

Unchanged.

5. BOUNDARY CONDITIONS

[Current Section 5.3/5.4] The dynamic conditions encompass the effect of road grade, head wind and driving dynamics (accelerations, decelerations) and auxiliary systems upon energy consumption and emissions of the test vehicle. The verification of the normality of dynamic conditions shall be done after the test is completed, using the recorded PEMS data. The methods for verifying the normality of the dynamic conditions, are laid down in Appendices 5 and 6 of this Annex. Each method includes a reference for dynamic conditions, ranges around the reference and the minimum coverage requirements to achieve a valid test.

Adding additional trip dynamic verifications to section 5.x, referring to Appendix 9 for the methodology and boundaries.

Section 5.3 (or 5.4) is ammended as follows:

The dynamic conditions encompass the effect of road grade, head wind and driving dynamics (accelerations, decelerations) and auxiliary systems upon energy consumption and emissions of the test vehicle. The verification of the normality of dynamic conditions shall be done after the test is completed, using the recorded PEMS data. This verification shall be conducted in 2 steps:

5.3.1 The overall excess or insufficience of driving dynamics during the trip shall be checked using the methods described in Appendix 9 of this Annex.

5.3.2 If the trip results as valid following the verifications according to paragraph 5.3.1, the methods for verifying the normality of the dynamic conditions and laid down in Appendices 5 and 6 of this Annex must be applied. Each method includes a reference for dynamic conditions, ranges around the reference and the minimum coverage requirements to achieve a valid test.

6. TRIP REQUIREMENTS

[Current Section 6.8] The average speed (including stops) of the urban driving part of the trip should be between 15 and 30 km/h. Stop periods, defined as vehicle speed of less than 1 km/h, shall account for at least 10% of the time duration of urban operation. Urban operation shall contain several stop periods of 10s or longer. The inclusion of one excessively long stop period that individually comprises >80% of the total stop time of urban operation shall be avoided.

Contents of the ammended section 6.8 shall be discussed. The following points must be agreed upon:

- Average urban speed range
- Maximum stop duration and/or stop percentage over the entire test

Section 6.8 is ammended as follows…

[Current Section 6.11] The start and the end point shall not differ in their elevation above sea level by more than 100 m.

For the new road profile requirements: should we like to specify the methods and the tools (partial or complete map based approach, algorithm), we will need a new Appendix as well (Number 10).

Section 6.11 is ammended as follows:

The start and the end point shall not differ in their elevation above sea level by more than 100 m. In addition, the proportional cumulative positive altitude gain shall be less than 1000m(/100km).

7. OPERATIONAL REQUIREMENTS

Do we want to add here additional vehicle operational requirements. For instance: gearshifting, rules for vehicle mode selection shall be added here. The rules for verifying the correct usage of the gearshift shall be described in detail in a separate (new) appendix.

8. LUBRICATING OIL, FUEL AND REAGENT

Unchanged.

9. EMISSIONS AND TRIP EVALUATION

[Current Section 9.5] If during a particular time interval the ambient conditions are extended according to point 5.2, the emissions during this particular time interval calculated according to Appendix 4 of this Annex shall be divided by a value ext before being evaluated for compliance with the requirements of this Annex.

Section 9.5 is ammended as follows:

If during a particular time interval the ambient conditions are extended according to point 5.2, the emissions during this particular time interval calculated according to Appendix 4 of this Annex shall be divided by a value [TO BE DECIDED] before being evaluated for compliance with the requirements of this Annex.

[UNDER Development by the data evaluation Task Force] Procedures indicating how to calculate separately the urban, rural and motorway values of the indicators, the corresponding average speeds and the permissible values. The text is provided as first draft and has not been checked by the experts group as off 26 June 2015.

Appendix 9

Verification of overall trip dynamics

1. INTRODUCTION

This Appendix describes the calculation procedures to verify the overall trip dynamics, to determine the overall excess or absence of dynamics during urban, rural and motorway driving.

2. SYMBOLS

RPA Relative Positive Acceleration

"acceleration resolution a_{res}" minimum acceleration >0 measured in m/s^2

T4253H compound data smoother

"positive acceleration a_{pos}" acceleration [m/s^2] greater than 0.1 m/s^2

Index (i) refers to the time step

Index (j) refers to the time step of positive acceleration datasets

Index (k) refers to the category (t=total, u=urban, r=rural, m=motorway)

Δ	-	difference
$>$	-	larger
$\geq$	-	larger or equal
%	-	per cent
$<$	-	smaller
$\leq$	-	smaller or equal
a	-	acceleration [m/s^2]
a_i	-	acceleration in time step i [m/s^2]
a_{pos}	-	positive acceleration greater than 0.1 m/s^2 [m/s^2]
$a_{pos,i,k}$	-	positive acceleration greater than 0.1 m/s^2 in time step i considering the urban, rural and motorway shares [m/s^2]
a_{res}	-	acceleration resolution [m/s^2]
d_i	-	distance covered in time step i [m]
$d_{i,k}$	-	distance covered in time step i considering the urban, rural and motorway shares [m]
$\mathbf{M_k}$	-	number of samples for urban, rural and motorway shares with positive acceleration greater than 0.1 m/s^2
N_k	-	total number of samples for the urban, rural and motorway shares and the complete trip
r_{max}	-	acceleration resolution threshold for vehicle speed data quality
RPA_k	-	relative positive acceleration for urban, rural and motorway shares [m/s^2 or kWs/(kg*km)]
t_k	-	duration of the urban, rural and motorway shares and the complete trip [s]
v	-	vehicle speed [km/h]
v_i	-	actual vehicle speed in time step i [km/h]
$v_{i,k}$	-	actual vehicle speed in time step i considering the urban, rural and motorway shares [km/h]
$(v \cdot \mathbf{a})_i$	-	actual vehicle speed per acceleration in time step i [m^2/s^3 or W/kg]
$(v \cdot \mathbf{a}_{pos})_{j,k}$	-	actual vehicle speed per positive acceleration greater than 0.1 m/s^2 in time step j considering the urban, rural and motorway shares [m^2/s^3 or W/kg].

$(v \cdot a_{pos})_{k[95]}$ - 95th percentile of the product of vehicle speed per positive acceleration greater than 0.1 m/s² for urban, rural and motorway shares [m²/s³ or W/kg]

$\bar{v}_k$ - average vehicle speed for urban, rural and motorway shares [km/h]

3. TRIP INDICATORS

3.1. Calculations

3.1.1. Data pre-processing

Before dynamic parameters like acceleration $v \cdot a_{pos}$ or RPA can be calculated, the vehicle speed trace needs to be checked for faulty or implausible sections. The vehicle speed trace of such sections is characterised by steps, jumps, terraced speed traces or missing values.

In order to make the detection of such sections easier the acceleration shall be calculated as described in paragraph 3.1.2 and the speed trace shall be scanned for excessive high values (e.g. above 4 m/s² or below – 4 m/s²).

If such sections are found, the trip is invalid.

In a second step the acceleration values shall be ranked in ascending order, in order to determine the acceleration resolution (minimum acceleration value > 0).

- If $a_{res} \leq 0.01 \frac{m}{s^2}$, the vehicle speed measurement is accurate enough.
- If $0.01 < a_{res} \leq \frac{r_{max}[m}{s^2}$, smoothing by using a T4253H Hanning filter.
- If $a_{res} > \frac{r_{max}[m}{s^2}$, the trip is invalid.

The T4235 Hanning filter performs the following calculations: The smoother starts with a running median of 4, which is centered by a running median of 2. It then resmoothes these values by applying a running median of 5, a running median of 3, and hanning (running weighted averages). Residuals are computed by subtracting the smoothed series from the original series. This whole process is then repeated on the computed residuals. Finally, the smoothed residuals are computed by subtracting the smoothed values obtained the first time through the process.

If smoothing was applied, the smoothed speed trace builds the basis for further calculations and binning and the acceleration values need to be recalculated on the basis of the smoothed speed trace as described in paragraph 3.1.2.

3.1.2. Calculation of distance, acceleration and $v \cdot a$

The following calculations shall be performed over the whole time based speed trace (1 Hz resolution) from second 1 to second t_z (last second).

The distance increment per data sample shall be calculated as follows:

$$d_t = \frac{v_t}{3.6}, \quad t = 1 \text{ to } N_t$$

Comment [PB1]: Remark of the author (Heinz Steven): Paragraph 7 of annex IIIa does not allow any modification of data for a trip. It should be discussed, whether small corrections like replacement of single missing values should be allowed.

Comment [PB2]: Remark of the author (Heinz Steven):
I will make a proposal for rmax, but some further checks are necessary to do this.
The required acceleration resolution results in a speed resolution of 0.072 km/h or better. That means, the vehicle speed trace needs to be provided with at least two digits behind the decimal point.

Comment [PB3]: Remark of the author (Heinz Steven): This description is copied from the SPSS software and may be deleted.

Where:

d_i is the distance covered in time step i [m]

v_i is the actual vehicle speed in time step i [km/h]

N_t is the total number of samples

The acceleration shall be calculated as follows:

$$a_i = \frac{v_{i+1} - v_{i-1}}{2 \cdot 3.6}, \qquad i = 1 \text{ to } N_t$$

Where:

a_i is the acceleration in time step i [m/s^2]. For $i = 1$: $v_{i-1} = 0$, for $i = N_t$: $v_{i+1} = 0$.

The product of vehicle speed per acceleration shall be calculated as follows:

$$(v \cdot a)_i = v_i \cdot \frac{a_i}{3.6}, \qquad i = 1 \text{ to } N_t$$

Where:

$(v \cdot a)_i$ is the product of the actual vehicle speed per acceleration in time step i [m^2/s^3 or W/kg].

3.1.3. Binning of the results

After the calculation of a_i and $(v \cdot a)_i$, the values v_i, d_i, a_i and $(v \cdot a)_i$ shall be ranked in ascending order of the vehicle speed.

All datasets with $v_i \leq \frac{60km}{h}$ belong to the "urban" speed bin, all datasets with $\frac{60km}{h} < v_i \leq \frac{90km}{h}$ belong to the "rural" speed bin and all datasets with $v_i > \frac{90km}{h}$ km/h belong to the "motorway" speed bin.

The number of datasets with acceleration values $a_i > \frac{0.1m}{s^2}$ shall be bigger or equal to 150 in each speed bin.

For each speed bin the average vehicle speed $\overline{v}_k$ shall be calculated as follows:

$$\overline{v}_k = \frac{\sum_i v_{i,k}}{N_k}, \; i = 1 \text{ to } N_k, k = u, r, m$$

Where:

N_k is the total number of samples of the urban, rural, and motorway shares.

3.1.4. Calculation of $v \cdot a_{pos_{95}}$ per speed bin

The 95th percentile of the $v \cdot a_{pos}$ values shall be calculated as follows:

Comment [PB4]: The definition of u/r/m speed bins is in accordance with annex IIIa

Comment [PB5]: Remark of the author (Heiz Steven): [150] needs to be discussed. >= 100 is necessary in order to be able to calculate a reasonable v*apos_[95] value.

Comment [PB6]: If not what happens?

The $(v \cdot a)_{i,k}$ values in each speed bin shall be ranked in ascending order for all datasets with $a_{i,k} \geq \frac{0.1m}{s^2}$ and the total number of these samples M_k shall be determined.

Percentile values are then assigned to the $(v \cdot a_{pos})_{j,k}$ values as follows:

The lowest $v \cdot a_{pos}$ value gets the percentile $1/M_k$, the second lowest $2/M_k$, the third lowest $3/M_k$ and the highest value $M_k/M_k = 100\%$.

Comment [TGV7]: A multiplication by 100 is missing?

$(v \cdot a_{pos})_{k_{[95]}}$ is the $(v \cdot a_{pos})_{j,k}$ value, with $\frac{j}{M_k} = 95\%$. If $\frac{j}{M_k} = 95\%$ cannot be met, $(v \cdot a_{pos})_{k_{[95]}}$ shall be calculated by linear interpolation between consecutive samples j and j+1 with $\frac{j}{M_k} < 95\%$ and $\frac{j+1}{M_k} > 95\%$.

Comment [TGV8]: …for each of urban, rural and motorway shares…

The relative positive acceleration per speed bin shall be calculated as follows:

$$RPA_k = \sum_j^{\frac{[(\Delta t \cdot](v \cdot a_{pos})_{j,k}\right)}{\sum_i d_{i,k}}}, \quad j = 1 \text{ to } M_k, i = 1 \text{ to } N_k, k = u,r,m$$

Where:

$\mathbf{RPA_k}$ is the relative positive acceleration for urban, rural and motorway shares in [m/s^2 or kWs/(kg*km)]

$\mathbf{\Delta t}$ time difference equal to 1 second

$\mathbf{M_k}$ the sample number for urban, rural and motorway shares with positive acceleration

$\mathbf{N_k}$ the total sample number for urban, rural and motorway shares

4. VERIFICATION OF TRIP VALIDITY

*4.1.1. Verification of v*a$_{pos_[95]}$ per speed bin*

If $\bar{v}_k \leq \frac{74.6km}{h}$ and $(v \cdot a_{pos})_{k_{[95]}} > (0.1961 \cdot \bar{v}_k + 9.8725)$ is fulfilled for the urban or the rural speed bin, the trip is invalid.

If $\bar{v}_k > \frac{74.6km}{h}$ and $(v \cdot a_{pos})_{k_{[95]}} > (0.0742 \cdot \bar{v}_k + 18.966)$ is fulfilled for the rural or motorway speed bin, the trip is invalid.

4.1.2. Verification of RPA per speed bin

If $\bar{v}_k \leq \frac{94.05km}{h}$ and $RPA_k < (-0.0016 \cdot \bar{v}_k + 0.1755)$ is fulfilled for any speed bin, the trip is invalid.

If $\bar{v}_k > \frac{54.05km}{h}$ and $PPA_k < 0.025$ is fulfilled for the motorway speed bin, the trip is invalid.

5. NUMERICAL EXAMPLES