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COMMISSION IMPLEMENTING DECISION (EU) 2019/1119

of 28 June 2019

on the approval of efficient vehicle exterior lighting using light emitting diodes for use in internal combustion engine vehicles and non-externally chargeable hybrid electrified vehicles as an innovative technology for reducing CO_2 emissions from passenger cars pursuant to Regulation (EC) No 443/2009 of the European Parliament and of the Council

(Text with EEA relevance)

(OJ L 176, 1.7.2019, p. 67)

Amended by:

		Official Journal		
		No	page	date
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(Text with EEA relevance)

Article 1

Approval

The technology used in efficient light emitting diodes (LED) lighting is approved as an innovative technology within the meaning of Article 12 of Regulation (EC) No 443/2009, where that innovative technology is used for the purpose of external lighting in internal combustion engine passenger cars and non-externally chargeable hybrid electrified passenger cars.

Article 2

Definition

For the purpose of this Decision, efficient LED lighting means a technology consisting of a lighting module that is equipped with light emitting diode (LED) sources that are used for the exterior lighting of a vehicle and that has a lower power consumption than conventional halogen lighting.

Article 3

Application for certification of CO_2 savings

1. Any manufacturer may apply for the certification of CO_2 savings from one or several exterior efficient LED lightings where those are used for the external lighting of internal combustion engine M_1 vehicles and non-externally chargeable hybrid electrified M_1 vehicles. The efficient LED lighting shall include one or a combination of the following LED lights:

(a) low beam headlamp (including adaptative front lighting system);

(b) high beam headlamp;

(c) front position lamp;

(d) front fog lamp;

(e) rear fog lamp;

(f) front turn signal lamp;

(g) rear turn signal lamp;

(h) licence plate lamp;

(i) reversing lamp;

(j) cornering lamp;

(k) static bending lamp.

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The LED light or the combination of LED lights forming the efficient LED lighting shall as a minimum provide the CO_2 reduction specified in Article 9(1)(b) of Implementing Regulation (EU) No 725/2011 as demonstrated using the testing methodology set out in the Annex to this Decision.

2. An application for the certification of the savings from one or a combination of efficient LED lighting shall be accompanied by an independent verification report confirming that the conditions set out in paragraph 1 are met.

3. The type approval authority shall reject the application for certification if it finds that the conditions set out in paragraph 1 are not met.

Article 4

Certification of CO_2 savings

1. The reduction in CO_2 emissions from the use of an efficient LED lighting referred to in Article 3(1) shall be determined using the methodology set out in the Annex.

2. Where a manufacturer applies for the certification of the CO_2 savings from more than one efficient LED lighting referred to in Article 3(1) in relation to one vehicle version, the type approval authority shall determine which of the efficient LED lighting tested delivers the lowest CO_2 savings, and record the lowest value in the relevant type approval documentation. That value shall be indicated in the certificate of conformity in accordance with Article 11(2) of Implementing Regulation (EU) No 725/2011.

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2a. Where the innovative technology is fitted in a bi-fuel or flex-fuel vehicle, the approval authority shall record the CO_2 savings as follows:

(a) for a bi-fuel vehicle using petrol and gaseous fuels, the CO_2 savings with regard to LPG or CNG fuels;

(b) for a flex-fuel vehicle using petrol and E85, the CO_2 savings with regard to petrol.

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3. The type approval authority shall record the verification report and the test results on the basis of which the savings were determined and shall make that information available to the Commission on request.

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Article 5

Transitional period and eco-innovation codes

1. Until 24 March 2021, a manufacturer may apply for certification of the CO_2 savings by the type approval authority pursuant to this Decision in its version of 28 June 2019. Where that is the case, the eco-innovation code No 28 shall be entered into the type approval documentation.

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2. Where the manufacturer applies for certification of the CO_2 savings by the type approval authority pursuant to this Decision without making reference to its version of 28 June 2019, the eco-innovation code No 37 shall be entered into the type approval documentation.

3. CO_2 savings recorded by reference to the eco-innovation code No 28 or No 37 may be taken into account for the calculation of the average specific emissions of a manufacturer starting from calendar year 2021.

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Article 6

Entry into force

This Decision shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

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ANNEX

Methodology to determine the CO_2 savings of efficient LED lighting by reference to the Worldwide Harmonised Light Vehicle Test Procedure

1. INTRODUCTION

In order to determine the CO_2 emission reductions that can be attributed to efficient LED lighting consisting of an appropriate combination of external vehicle LED lights for the use in internal combustion engine M1 vehicles and non-externally chargeable hybrid electrified M1 vehicles, it is necessary to establish the following:

(1) the test conditions;

(2) the test equipment;

(3) the procedure to determine the power savings;

(4) the procedure to determine the CO_2 savings;

(5) the procedure to determine the uncertainty of the CO_2 savings.

2. SYMBOLS, PARAMETERS AND UNITS

Latin symbols

AFS — Adaptive Front lighting System

B — Baseline

CO_2 — Carbon dioxide

C_{CO_2} — CO_2 savings [g CO_2/km]

C — Number of classes of the adaptive front lighting system

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CF — Conversion factor as defined in Table 5

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EI — Eco-innovative

HEV — Hybrid Electrified Vehicle

K_{CO_2} — CO_2 correction factor, $\left[\left(\frac{gCO_2}{km}\right)/\left(\frac{Wh}{km}\right)\right]$ as defined in Regulation (EU) 2017/1151 Sub-Annex 8 Appendix 2

$\overline{K_{CO_2}}$ — Average of the T values of $K_{CO_{2_t}}$ $\left[\left(\frac{gCO_2}{km}\right)/\left(\frac{Wh}{km}\right)\right]$

m — Number of efficient exterior LED lights composing the package

MT — Minimum threshold [g CO_2/km]

n — Number of measurements of the sample

NOVC — Not Off-Vehicle Charging

P — Power consumption of the vehicle light [W]

P_{B_i} — Power consumption of the corresponding i light in a baseline vehicle [W]

P_{c_n} — Power consumption of the corresponding n sample for each class vehicle [W]

$\overline{P_c}$ — Power consumption for each class of vehicle (average of the n measurements) [W]

$P_{EI_{AFS}}$ — Power consumption of the Low beam AFS [W]

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$\overline{P_{EI_i}}$ — Average power consumption of the corresponding eco-innovative vehicle light [W]

ΔP_i — Power savings of each efficient exterior LED light [W]

$s_{C_{CO_2}}$ — Standard deviation of the total CO_2 savings [g CO_2/km]

$s_{K_{CO_2}}$ — Standard deviation of the K_{CO_2} $\left[\left(\frac{gCO_2}{km}\right)/\left(\frac{Wh}{km}\right)\right]$

$s_{\overline{K_{CO_2}}}$ — Standard deviation of average of the T values of $K_{CO_{2_t}}$ $\left[\left(\frac{gCO_2}{km}\right)/\left(\frac{Wh}{km}\right)\right]$

$s_{\overline{P_c}}$ — Standard deviation of average of power consumption for each class of vehicle [W]

$s_{P_{EI}}$ — Standard deviation of the LED light power consumption in eco-innovative vehicle [W]

$s_{\overline{P_{EI}}}$ — Standard deviation of the average LED light power consumption mean in eco-innovative vehicle [W]

$s_{\overline{P_{EI_{AFS}}}}$ — Uncertainty or Standard deviation of average of power of the Low beam AFS [W]

T — Number of measurements performed by the manufacturer for the extrapolation of the K_{CO_2}

t — Driving duration of the Worldwide Light vehicles Test Cycle (WLTC) [s], which is 1 800 s

UF — Usage factor for the vehicle light [-] as defined in Table 6

v — Mean driving speed of the Worldwide Light vehicles Test Cycle (WLTC) [km/h]

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V_{Pe} — Consumption of effective power as defined in Table 4

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$share_c$ — Time percentage per speed band in each vehicle class

$\frac{\partial C_{CO_2}}{\partial P_{EI}}$ — Sensitivity of calculated CO_2 savings related to the LED light power consumption

$\frac{\partial C_{CO_2}}{\partial K_{CO_2}}$ — Sensitivity of calculated CO_2 savings related to the CO_2 correction factor

η_A — Efficiency of the alternator [-]

η_{DCDC} — Efficiency of the DC-DC converter [-]

Subscripts

Index (c) refers to number of class of the adaptive front lighting system measurement of the sample

Index (i) refers to each vehicle lights

Index (j) refers to measurement of the sample

Index (t) refers to each number of measurements of T

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3. TESTING CONDITIONS

The testing conditions shall fulfil the requirements of UN/ECE Regulations Nos 4 ([1]), 6 ([2]), 7 ([3]), 19 ([4]), 23 ([5]), 38 ([6]), 48 ([7]), 100 ([8]), 112 ([9]), 119 ([10]) and 123 ([11]). The power consumption shall be determined in accordance with point 6.1.4 of UN/ECE Regulation No 112, and points 3.2.1 and 3.2.2 of Annex 10 to that Regulation.

For the low beam adaptive front lighting system (AFS) falling within at least two of the Classes C, E, V or W as defined in Regulation UN/ECE No 123, unless it is agreed with the technical service that Class C is the representative/average LED intensity for the vehicle application, power measurements shall be done at the LED intensity of each class (Pc) as defined in Regulation UN/ECE 123. If Class C is the representative/average LED intensity for the vehicle application, power measurements shall be done in the same way as for any other exterior LED light included in the combination.

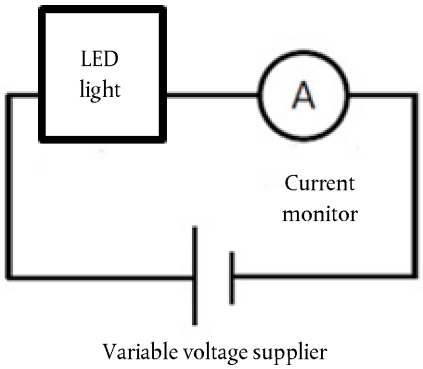
Test equipment

The following equipment shall be used, as shown in the Figure below:

— a power supply unit (i.e. variable voltage supplier);

— two digital multimeters, one for measuring the DC-current, and the other for measuring the DC-voltage. In the Figure, a possible test set-up is shown, when the DC-voltage meter is integrated in the power supply unit.

Test set-up



Measurements and determination of the power savings

For each efficient exterior LED light included in the combination the measurement of the current shall be performed as shown in the Figure at a voltage of 13,2 V. LED module(s) operated by an electronic light source control gear, shall be measured as specified by the applicant.

The manufacturer may request that other measurements of the current shall be done at other additional voltages. In that case, the manufacturer shall hand over verified documentation on the necessity to perform those other measurements to the type-approval authority. The measurements of the currents at each of those additional voltages shall be performed consecutively at least five times. The exact installed voltages and the measured current shall be recorded in four decimals.

([1]) OJ L 4, 7.1.2012, p. 17.
([2]) OJ L 213, 18.7.2014, p. 1.
([3]) OJ L 285, 30.9.2014, p. 1.
([4]) OJ L 250, 22.8.2014, p. 1.
([5]) OJ L 237, 8.8.2014, p. 1.
([6]) OJ L 148, 12.6.2010, p. 55.
([7]) OJ L 323, 6.12.2011, p. 46.
([8]) OJ L 302, 28.11.2018, p. 114.
([9]) OJ L 250, 22.8.2014, p. 67.
([10]) OJ L 89, 25.3.2014, p. 101.
([11]) OJ L 222, 24.8.2010, p. 1.

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The power consumption shall be determined by multiplying the installed voltage with the measured current. The average of the power consumption for each efficient exterior LED light ($\overline{P_{EL_i}}$) shall be calculated. Each value shall be expressed in four decimals. When a stepper motor or electronic controller is used for the supply of the electricity to the LED lights, the electric load of that component part shall be excluded from the measurement.

Additional measurements for Low beam Adaptive Front Lighting System (AFS)

Table 1

Classes of Low beam AFS

Class	See point 1.3 and footnote 2 of UN/ECE Regulation 123	% LED Intensity	Activation Mode [1]
C	Base Passing Beam (Country)	100 %	50 km/h < speed < 100 km/h Or when no mode of another passing beam class is activated (V, W, E)
V	Town	85 %	Speed < 50 km/h
E	Motorway	110 %	Speed > 100 km/h
W	Adverse Conditions	90 %	Windshield wiper active > 2 min

[1] Activation speeds to be checked for each vehicle application in accordance with UN/ECE Regulation No 48 section 6, chapter 6.22, paragraphs 6.22.7.4.1 (class C), 6.22.7.4.2 (class V), 6.22.7.4.3 (class E), 6.22.7.4.4 (class W).

Where the power measurements at the LED intensity of each class are needed, after conducting the measurements of each P_c, the power of the Low beam AFS ($P_{EI_{AFS}}$) shall be calculated as a weighted average of the LED Power during the WLTC speed bands, with the following Formula 1.

Formula 1

$$P_{EI_{AFS}} = \sum_{c=1}^{C} WLTC_share_c \cdot \overline{P_c}$$

Where:

$\overline{P_c}$ is the power consumption (mean of the n measurements) for each class;

$WLTC_share_c$ is the WLTC time percentage per speed band in each class (WLTC last 1 800 s in total):

Table 2

Speed band	Time	$WLTC_share_c$ (%)
< 50 km/h:	1 058 s	0,588 (58,8 %)
50 – 100 km/h	560 s	0,311 (31,1 %)
> 100 km/h	182 s	0,101 (10,1 %)

When the Low beam AFS only has 2 classes not covering all WLTC speeds (e.g. C & V), the weighting of Class C power shall also include the WLTC time not covered by the 2nd class (e.g. Class C time 't' = 0,588 + 0,101)

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The resulting power savings of each efficient exterior LED light (ΔP_i) shall be calculated with the following Formula 2:

Formula 2

$$\Delta P_i = P_{B_i} - \overline{P_{EI_i}}$$

where the power consumption of the corresponding baseline vehicle light is as specified in Table 3:

Table 3

Power consumptions for different baseline vehicle lights

Vehicle light	Total electric power (P_B) [W]
Low beam headlamp	137
High beam headlamp	150
Front position	12
License plate	12
Front fog lamp	124
Rear fog lamp	26
Front turn signal lamp	13
Rear turn signal lamp	13
Reversing lamp	52
Cornering lamp	44
Static Bending lamp	44

4. CALCULATION OF THE CO_2 SAVINGS AND STATISTICAL MARGIN

4.1. **Calculation of the CO_2 savings**

The total CO_2 savings of the lighting package shall be calculated in accordance with the specific powertrain of the vehicle (i.e. Conventional, NOVC-HEV).

▼M1

4.1.1. *Internal combustion engine powered passenger cars and NOVC-HEVs of category M_1 for which uncorrected measured fuel consumption and CO_2 emission values may be used in accordance with paragraph 1.1.4 of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151*

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The CO_2 savings shall be calculated in accordance with the following Formula 3:

Formula 3

$$C_{CO_2} = \left(\sum_{i=1}^{m} \Delta P_i \cdot UF_i \right) \cdot \frac{V_{Pe}}{\eta_A} \cdot \frac{CF}{v}$$

Where:

v: Mean driving speed of the WLTC [km/h], which is 46,60 km/h

η_A: Efficiency of the alternator, which is 0,67

V_{Pe}: Consumption of effective power as specified in Table 4

▼M1

Table 4

Consumption of effective power

Type of Engine	Consumption of effective power (V_{Pe}) [l/kWh]
Petrol/E85	0,264
Petrol/E85 Turbo	0,280
Diesel	0,220
LPG	0,342
LPG Turbo	0,363
	Consumption of effective power (V_{Pe}) [m^3/kWh]
CNG (G20)	0,259
CNG (G20) Turbo	0,275

CF: CF: Conversion factor as defined in Table 5.

Table 5

Fuel conversion factor

Type of fuel	Conversion factor (CF) [gCO_2/l]
Petrol/E85	2 330
Diesel	2 640
LPG	1 629
	Conversion factor (CF) [gCO_2/m^3]
CNG (G20)	1 795

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UF_i: Usage factor for the vehicle light [-] as defined in Table 6.

Table 6

Usage factor for different vehicle lights

Vehicle light	Usage factor (UF) [-]
Low beam headlamp	0,33
High beam headlamp	0,03
Front position	0,36
License plate	0,36

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Vehicle light	Usage factor (UF) [-]
Front fog lamp	0,01
Rear fog lamp	0,01
Front turn signal lamp	0,15
Rear turn signal lamp	0,15
Reversing lamp	0,01

▼M1

Cornering lamp	0,019
Static Bending lamp	0,039

4.1.2. *NOVC-HEVs not falling within the scope of point 4.1.1*

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The CO_2 savings shall be calculated in accordance with the following Formula 4:

Formula 4

$$C_{CO_2} = \frac{\sum_{i=1}^{m} \Delta P_i \cdot UF_i}{v \cdot \eta_{DCDC}} \cdot K_{CO_2}$$

Where:

η_{DCDC}: Efficiency of the DC-DC converter

K_{CO_2}: CO_2 correction factor $\left[\left(\frac{gCO_2}{km}\right)/\left(\frac{Wh}{km}\right)\right]$, as defined in paragraph 2.2 of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151.

The efficiency of the DC-DC converter (η_{DCDC}) shall be evaluated in accordance with the appropriate vehicle architecture, as specified in Table 7:

Table 7

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Efficiency of the DC-DC converter for different vehicle light architectures

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#	Architecture	η_{DCDC}
1	Lights connected in parallel to the low voltage battery (lights fed directly from the high voltage battery via DCDC converter)	0,xx
2	Lights connected in series after the low voltage battery, and the low voltage battery connected in series to the High voltage battery	1
3	High Voltage and low voltage batteries have exactly the same voltage (12 V, 48 V,…) as the lights	1

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For architecture #1, the efficiency of the DC-DC converter (η_{DCDC}) shall be the highest value resulting from the efficiency tests performed in the operative electric current range. The measuring interval shall be equal or lower than 10 % of the operative electric current range.

4.2. **Calculation of the statistical margin**

The statistical margin of the lighting package shall be calculated in accordance with the specific powertrain of the vehicle (i.e. Conventional, NOVC-HEV).

▼M1

4.2.1. *Internal combustion engine powered passenger cars and NOVC-HEVs of category M_1 for which uncorrected measured fuel consumption and CO_2 emission values may be used in accordance with paragraph 1.1.4of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151*

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The statistical margin of the results of the testing methodology caused by the measurements shall be quantified. For each efficient exterior LED light included in the package the standard deviation shall be calculated in accordance with Formula 5:

Formula 5

$$s_{\overline{P_{EI_i}}} = \frac{s_{P_{EI_i}}}{\sqrt{n}} = \sqrt{\frac{\sum_{j=1}^{n}(P_{EI_j} - \overline{P_{EI_i}})^2}{n(n-1)}}$$

Where:

n: Number of measurements of the sample, which is at least 5

Where the standard deviation of the power consumption of each efficient exterior LED light ($s_{\overline{P_{EI_i}}}$) leads to an error in the CO_2 savings ($s_{C_{CO_2}}$) that error shall be calculated by means of Formula 6:

Formula 6

$$s_{C_{CO_2}} = \sqrt{\sum_{i=1}^{m}\left(\frac{\partial C_{CO_2}}{\partial P_{EI_i}} \cdot s_{\overline{P_{EI_i}}}\right)^2} = \frac{V_{Pe} \cdot CF}{\eta_A \cdot v} \cdot \sqrt{\sum_{i=1}^{m}\left(UF_i \cdot s_{\overline{P_{EI_i}}}\right)^2}$$

▼M1

4.2.2. *NOVC-HEVs not falling within the scope of point 4.2.1*

▼B

The statistical margin of the results of the testing methodology caused by the measurements shall be quantified. For each efficient exterior LED light included in the package the standard deviation shall be calculated in accordance with Formula 7:

Formula 7

$$s_{\overline{P_{EI_i}}} = \frac{s_{P_{EI_i}}}{\sqrt{n}} = \sqrt{\frac{\sum_{j=1}^{n}(P_{EI_j} - \overline{P_{EI_i}})^2}{n(n-1)}}$$

Where:

n: Number of measurements of the sample, which is at least 5

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The CO_2-emission correction factor K_{CO_2} shall be determined from a set of T measurements performed by the manufacturer, in accordance with paragraph 2.2 of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151. For each measurement, electric balance during the test and the measured CO_2-emissions shall be recorded.

In order to evaluate the statistical error of K_{CO_2}, all T combinations without repetitions of T-1 measurements shall be used to extrapolate T different values of K_{CO_2} (i.e. $K_{CO_{2_t}}$). The extrapolation shall be performed in accordance with the method defined in paragraph 2.2 of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151.

The standard deviation of K_{CO_2} ($s_{\overline{K_{CO_2}}}$) shall be calculated in accordance with Formula 8.

Formula 8

$$s_{\overline{K_{CO_2}}} = \frac{s_{K_{CO_2}}}{\sqrt{T}} = \sqrt{\frac{\sum_{t=1}^{T}(K_{CO_{2_t}} - \overline{K_{CO_2}})^2}{T(T-1)}}$$

Where:

T: Number of measurements performed by the manufacturer for the extrapolation of the K_{CO_2} as defined in paragraph 2.2 of Appendix 2 to Sub-Annex 8 to Annex XXI to Regulation (EU) 2017/1151.

$\overline{K_{CO_2}}$: mean of the T values of $K_{CO_{2_t}}$

Where the standard deviation of the power consumption of each efficient exterior LED light ($s_{\overline{P_{EL_i}}}$) and the standard deviation of the k_{CO_2} ($s_{\overline{k_{CO_2}}}$) lead to an error in the CO_2 savings ($s_{C_{CO_2}}$), that error shall be calculated by means of Formula 9.

Formula 9

$$s_{C_{CO_2}} = \sqrt{\sum_{i=1}^{m}\left(\frac{\partial C_{CO_2}}{\partial P_{EI_i}} \cdot s_{\overline{P_{EI_i}}}\right)^2 + \left(\frac{\partial C_{CO_2}}{\partial K_{CO_2}} \cdot s_{\overline{K_{CO_2}}}\right)^2}$$

$$= \sqrt{\left(\frac{K_{CO_2}}{v \cdot \eta_{DCDC}}\right)^2 \cdot \sum_{i=1}^{m}\left(UF_i \cdot s_{\overline{P_{EI_i}}}\right)^2 + \left(\sum_{i=1}^{m} s_{\overline{P_{EI_i}}} \cdot UF_i\right)^2 \cdot \left(\frac{K_{CO_2}}{v \cdot \eta_{DCDC}}\right)}$$

4.3. **Statistical margin for Low beam AFS**

Where the Low beam AFS is present, formulae 9 shall be adapted to take into account the additional measurements required.

The value of the uncertainty ($s_{\overline{P_{EI_{AFS}}}}$) that is to be used for the Low beam AFS shall be calculated with the following formulae 10 and 11:

Formula 10

$$s_{\overline{P_c}} = \frac{s_{P_c}}{\sqrt{n}} = \sqrt{\frac{\sum_{n=1}^{N}(P_{c_n} - \overline{P_c})^2}{n(n-1)}}$$

Formula 11

$$s_{\overline{P_{EI_{AFS}}}} = \sqrt{\sum_{c=1}^{C}(WLTC_{s}hare_c \cdot s_{\overline{P_c}})^2}$$

Where:

n: Number of measurements of the sample, which is at least 5

$\overline{P_c}$: mean of the n values of P_c

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5. ROUNDING

The calculated CO_2 savings value (C_{CO_2}) and the statistical margin of the CO_2 saving ($s_{C_{CO_2}}$) shall be rounded to a maximum of two decimal places.

Each value used in the calculation of the CO_2 savings may be applied unrounded or rounded to the minimum number of decimal places which allows the combined impact of all rounded values on the savings to be lower than 0,25 gCO_2/km.

6. STATISTICAL SIGNIFICANCE

It shall be demonstrated for each type, variant and version of a vehicle fitted with the efficient LED lightings that the uncertainty of the CO_2 savings calculated in accordance with Formula 6 or Formula 9 is not greater than the difference between the total CO_2 savings and the minimum savings threshold specified in Article 9(1) of Implementing Regulation (EU) No 725/2011 (see Formula 12).

Formula 12

$$MT < C_{CO_2} - s_{C_{CO_2}}$$

Where:

MT: minimum threshold [g CO_2/km]

C_{CO_2}: total CO_2 saving [g CO_2/km]

$s_{C_{CO_2}}$: standard deviation of the total CO_2 saving [gCO_2/km]

Where the total CO_2 emission savings of the efficient LED lighting as determined in accordance with the testing methodology set out in this Annex are below the threshold specified in Article 9(1)(b) of Implementing Regulation (EU) No 725/2011 the second subparagraph of Article 11(2) of that Regulation shall apply.