
Changes to legislation: There are currently no known outstanding effects for the Commission Implementing Decision of 10 September 2013 on the approval of the Daimler engine compartment encapsulation system as an innovative technology for reducing CO2 emissions from new passenger cars pursuant to Regulation (EC) No 443/2009 of the European Parliament and of the Council (Text with EEA relevance) (2013/451/EU), ANNEX. (See end of Document for details)

Commission Implementing Decision of 10 September 2013 on the approval of the Daimler engine compartment encapsulation system as an innovative technology for reducing CO2 emissions from new passenger cars pursuant to Regulation (EC) No 443/2009 of the European Parliament and of the Council (Text with EEA relevance) (2013/451/EU)

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ANNEX

Methodology for determining the reduction in CO₂ emissions due to the use of the Daimler engine compartment encapsulation system in an M₁ vehicle

1. INTRODUCTION

In order to determine the CO₂ reductions that can be attributed to the use of the Daimler engine compartment encapsulation system in an M₁ vehicle, it is necessary to establish the following:

- (a) the testing procedure to be followed for determining the cool-down curves of the eco-innovation vehicle with and without an engine compartment encapsulation;
- (b) the testing procedure to be followed to determine the Hot Start Benefit (HSB) of the eco-innovation vehicle;
- (c) the formulae for calculating the variation coefficients;
- (d) the formulae for calculating the CO₂ savings;
- (e) the determination of the CO₂ savings for the certification by type-approval authorities.

2. DETERMINING THE COOL-DOWN CURVES

The cool-down curves shall be determined experimentally for the baseline and the eco-innovation vehicle. The curves shall be applicable for vehicle variants with the same heat capacities, engine bay packaging and engine heat insulation as those available in the baseline and EI vehicle. The experimental test shall include continuous measurements of representative coolant temperatures by means of a thermocouple at a constant ambient temperature of at least 14 °C over 24 hours. The engine shall be heated up to the maximum coolant temperature before cut-off by a sufficient number of consecutive New European Driving Cycles (NEDC) as specified in point 3.

After preconditioning, for deactivation of all pumps and fans, the ignition shall be switched off and the dash key pulled out. The car's bonnet shall be closed completely. Any artificial ventilation systems inside the test cell shall be switched off. The resulting measurement curves shall be converged by the mathematical approach described by formula 1.

Formula 1:

$$T(t) = (T_0 - T_A) \times e^{-d \times t} + T_A$$

with:

T(t)	:	temperature over time [°C]
T _O	:	temperature of the operating engine [°C]
T _A	:	ambient temperature [°C]
d	:	decay constant [1/h]

The least squares method shall be used for the fitting of the two curves. To do that, the temperature measurement data of the first 20 minutes after engine cut-off is not to be considered because of the untypical behaviour of the coolant temperature after switching off the coolant system.

3. DETERMINING THE HOT START BENEFIT (HSB)

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The HSB of the EI vehicle shall be determined experimentally. This value describes the difference of CO₂ emissions between a cold start and a hot start NEDC test in relation to the cold start result:

Formula 2:

$$\text{HSB} = 1 - \frac{\text{CO}_2(\text{hot})}{\text{CO}_2(14\text{ °C})}$$

with:

HSB : Hot Start Benefit
 CO₂ (hot) : CO₂ emissions of hot start NEDC test [g CO₂/km]
 CO₂ (14 °C) : CO₂ emissions of cold start NEDC test [g CO₂/km]

The coolant temperature at the beginning of the cold start test and the ambient temperature in the test cell shall not be below 14 °C. The hot start NEDC test shall be conducted following the cold start NEDC test. It is possible to perform one or two preconditioning NEDC tests between the cold start and the hot start NEDC test. It shall be ensured and documented that the state of charge (SOC) variation (for example, using his Controller Area Network signal) of the starter battery after each test is within 5 %. The complete test procedure shall be repeated at least two times. Arithmetic means of the cold start and of the hot start CO₂ results and the respective variation coefficients of the means shall be calculated. The complete test procedure shall be repeated as long as the variation coefficients of both arithmetic means are below 1 % (see point 4).

4. CALCULATING THE VARIATION COEFFICIENTS OF THE ARITHMETIC MEANS

The variation coefficients of the arithmetic means shall be calculated using the following formulae:

Formula 3:

$$c_v = s_{x'} / \bar{x}$$

c_v : variation coefficient;
 $s_{x'}$: standard deviation of arithmetic mean [g CO₂/km];
 \bar{x} : arithmetic mean [g CO₂/km];

and

Formula 4:

$$s_{x'} = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n(n-1)}}$$

$s_{x'}$: standard deviation of arithmetic mean [g CO₂/km];
 x_i : measurement value [g CO₂/km];
 \bar{x} : arithmetic mean [g CO₂/km];
 n : number of measurements.

5. FORMULAE FOR CALCULATING THE CO₂ SAVINGS

The relative CO₂ reduction potential $\Delta\text{CO}_2(t)$ for different parking times shall be calculated using formula 5 with the following input data:

- decay constant of the eco-innovation vehicle without an engine compartment encapsulation (baseline vehicle): d_B [1/h]. This value shall be calculated with formula 1;

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- decay constant of eco-innovation vehicle with an engine compartment encapsulation: d_E [1/h]. This value shall be calculated with formula 1;
- Hot Start Benefit: **HSB**. This value shall be calculated with formula 2;
- parking time distribution (share of vehicle stops): **SVS**. Table 2 (below) shall be used;
- CO₂ type-approval value: **TA_{CO₂}** [g CO₂/km], i.e. CO₂ mass emissions combined.

Formula 5:

$$\Delta CO_2 = 1,443 \times \ln \left(\frac{e^{(-d_E \times t)} + 1}{e^{(-d_B \times t)} + 1} \right) \times HSB$$

The calculation results shall be given in the following Table 1:

TABLE 1

Relative CO₂ reduction potential $\Delta CO_2(t)$ for different parking times

Parking time [h]	0,5	1,5	2,5	3,5	4,5	5,5	6,5	7,5	8,5	9,5	10,5	11,5
$\Delta CO_2(t)$ [%]												
Parking time [h]	12,5	13,5	14,5	15,5	16,5	17,5	18,5	19,5	20,5	21,5	22,5	23,5
$\Delta CO_2(t)$ [%]												

The total CO₂ savings, weighted by the parking times (pt) shall be calculated using formula 6⁽¹⁾.

Formula 6:

$$C_{CO_2} = TA_{CO_2} \times \sum_{pt=1}^{24} \Delta CO_2(t)_{pt} \times SVS_{pt}$$

Where the values for parking time [h] and SVS [%] shall be those in Table 2:

TABLE 2

Parking time distribution (share of vehicle stops)

Parking time [h]	0,5	1,5	2,5	3,5	4,5	5,5	6,5	7,5	8,5	9,5	10,5	11,5
SVS [%]	36	13	6	4	2	2	1	1	3	4	3	1
Parking time [h]	12,5	13,5	14,5	15,5	16,5	17,5	18,5	19,5	20,5	21,5	22,5	23,5
SVS [%]	1	3	3	2	1	1	1	1	1	1	1	1

The CO₂ savings shall be the type-approval value (CO₂ mass emissions combined) multiplied by a factor of $x^{(2)}$. The value of x is equal to the term

$$\sum \Delta CO_2(t)_{pt} \times SVS_{pt}$$

of formula 6.

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Where an existing vehicle type is equipped with the innovative technology the following formula shall be used:

Formula 7:

$$C_{CO_2} = x * TA_{CO_2 \text{ baseline vehicle}}$$

with:

C_{CO_2} : CO₂ savings [g CO₂/km]
 $TA_{CO_2 \text{ baseline vehicle}}$: type-approval value of the eco-innovation vehicle without an engine compartment encapsulation [g CO₂/km]

Where the innovative technology is installed on a new vehicle type and the type-approval CO₂ value has been determined with the innovative technology installed, the following formula for calculating the CO₂ savings shall be used:

Formula 8:

$$C_{CO_2} = x / (1 - x) * TA_{CO_2 \text{ new vehicle type}}$$

with:

C_{CO_2} : CO₂ savings [g CO₂/km]
 $TA_{CO_2 \text{ new vehicle type}}$: type-approval value of the new vehicle type equipped with the innovative technology [g CO₂/km]

6. ECO-INNOVATION CODE TO BE ENTERED INTO TYPE-APPROVAL DOCUMENTATION

For the purposes of determining the general eco-innovation code to be used in the relevant type-approval documents in accordance with Annexes I, VIII and IX to Directive 2007/46/EC of the European Parliament and of the Council⁽⁹⁾, the individual code to be used for the innovative technology approved through this Decision shall be '3'.

F1
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Textual Amendments

F1 Words in [Annex para. 6](#) omitted (31.12.2020) by virtue of [The Road Vehicle Carbon Dioxide Emission Performance Standards \(Cars and Vans\) \(Amendment\) \(EU Exit\) Regulations 2019 \(S.I. 2019/550\)](#), regs. 1, **8(3)**; 2020 c. 1, Sch. 5 para. 1(1)

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- (1) In this formula 6, TA_{CO₂} is the type-approval value for the baseline vehicle.
- (2) In accordance with point 8.5 of the Technical Guidelines.
- (3) Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (Framework Directive) ([OJ L 263, 9.10.2007, p. 1](#)).

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