COMMISSION IMPLEMENTING DECISION (EU) 2016/362

of 11 March 2016

on the approval of the MAHLE Behr GmbH & Co. KG enthalpy storage tank 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)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emissions performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles ([1]), and in particular Article 12(4) thereof,

Whereas:

(1) The supplier MAHLE Behr GmbH & Co. KG (the 'Applicant') submitted an application for the approval of an enthalpy storage tank as an innovative technology on 29 April 2015. The completeness of that application was assessed in accordance with Article 4 of Commission Implementing Regulation (EU) No 725/2011 ([2]). The Commission identified certain relevant information as missing in the original application and requested the Applicant to complete it. The Applicant provided the required information on 27 May 2015. The application was found to be complete and the period for the Commission's assessment of the application started on the day following the date of official receipt of the complete information, i.e. 28 May 2015.

(2) The application has been assessed in accordance with Article 12 of Regulation (EC) No 443/2009, Implementing Regulation (EU) No 725/2011 and the Technical Guidelines for the preparation of applications for the approval of innovative technologies pursuant to Regulation (EC) No 443/2009 (the Technical Guidelines, version February 2013) ([3]).

(3) The application refers to an enthalpy storage tank that reduces the CO_2 emissions and fuel consumption after a cold start of an internal combustion engine due to a faster engine warm-up.

(4) The Commission finds that the information provided in the application demonstrates that the conditions and criteria referred to in Article 12 of Regulation (EC) No 443/2009 and in Articles 2 and 4 of Implementing Regulation (EU) No 725/2011 have been met.

(5) The Applicant has demonstrated that enthalpy storage tanks were not fitted in 3 % or more of the new passenger cars registered in the reference year 2009 in accordance with Article 2(2)(a) of Implementing Regulation (EU) No 725/2011.

(6) The Applicant has used a comprehensive testing procedure in accordance with the Technical Guidelines, and defined the baseline vehicle as the vehicle fitted with a deactivated enthalpy storage tank.

(7) The Applicant has provided a methodology for testing the CO_2 reductions. The Commission considers that the testing methodology will provide testing results that are verifiable, repeatable and comparable and that it is capable of demonstrating in a realistic manner the CO_2 emissions benefits of the innovative technology with strong statistical significance in accordance with Article 6 of Implementing Regulation (EU) No 725/2011.

(8) Against that background the Applicant has demonstrated satisfactorily that the emission reduction achieved by the enthalpy storage tank is at least 1 g CO_2/km.

([1]) OJ L 140, 5.6.2009, p. 1.
([2]) Commission Implementing Regulation (EU) No 725/2011 of 25 July 2011 establishing a procedure for the approval and certification of innovative technologies for reducing CO_2 emissions from passenger cars pursuant to Regulation (EC) No 443/2009 of the European Parliament and of the Council (OJ L 194, 26.7.2011, p. 19).
([3]) https://circabc.europa.eu/w/browse/42c4a33e-6fd7-44aa-adac-f28620bd436f

(9) Since the enthalpy storage tank is not activated during the CO_2 emissions type approval test referred to in Regulation (EC) No 715/2007 of the European Parliament and of the Council [1] and Commission Regulation (EC) No 692/2008 [2], the Commission is satisfied that the technology in question is not covered by the standard test cycle.

(10) The activation of the enthalpy storage tank is not dependant on the choice of the driver. On that basis the Commission finds that the manufacturer should be considered accountable for the CO_2 emission reduction due to the use of the innovative technology.

(11) The Commission finds that the verification report has been prepared by TÜV SÜD Auto Service GmbH which is an independent and certified body and that the report supports the findings set out in the application.

(12) Against that background, the Commission finds that no objections should be raised as regards the approval of the innovative technology in question.

(13) 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 [3], the individual code to be used for the innovative technology approved through this Decision should be specified,

HAS ADOPTED THIS DECISION:

Article 1

1. The enthalpy storage tank described in the application of MAHLE Behr GmbH & Co. KG is approved as an innovative technology within the meaning of Article 12 of Regulation (EC) No 443/2009.

2. The CO_2 emissions reduction from the use of the enthalpy storage tank shall be determined using the methodology set out in the Annex.

3. The individual eco-innovation code to be entered into type approval documentation to be used for the innovative technology approved through this Implementing Decision shall be '18'.

Article 2

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

Done at Brussels, 11 March 2016.

For the Commission
The President
Jean-Claude JUNCKER

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[1] Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information (OJ L 171, 29.6.2007, p. 1).

[2] Commission Regulation (EC) No 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information (OJ L 199, 28.7.2008, p. 1).

[3] Directive 2007/46/EC of the European Parliament ad 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).

ANNEX

METHODOLOGY TO DETERMINE THE CO_2 SAVINGS OF THE ENTHALPY STORAGE TANK TECHNOLOGY

1. INTRODUCTION

In order to determine the CO_2 reduction that can be attributed to the use of the enthalpy storage tank technology (EST system), it is necessary to establish the following:

(a) the testing procedure to be followed for determining the cool-down curves of the baseline vehicle (the vehicle fitted with a deactivated enthalpy storage tank) and the eco-innovation vehicle;

(b) the testing procedure to be followed for determining the CO_2 emission at different engine coolant start temperature;

(c) the testing procedure to be followed for determining the theoretical temperature of the engine after discharging the EST system;

(d) the testing procedure to be followed for determining the Hot start benefit;

(e) the formulae to be used for determining the CO_2 savings;

(f) the formulae to be used for determining the statistical error and significance of the results.

2. SYMBOLS AND ABBREVIATIONS

Latin symbols

B_{TA} — CO_2 emission of the vehicle under type approval conditions [g CO_2/km]

C_{CO_2} — CO_2 savings [g CO_2/km]

CO_2 — Carbon dioxide

CO_2 (T_k) — Arithmetic mean of the CO_2 emissions of the vehicle measured using NEDC cycle, ambient temperature of 14 °C and engine coolant start temperatures T_k [g CO_2/km]

d_{eng} — Temperature decay factor of the engine coolant cool down curve [1/h]

d_{EST} — Temperature decay factor of the EST cool down curve [1/h]

EST — Enthalpy Storage Tank

K — Effective ratio of thermal inertias [-]

m — Number of measurements of the sample

NEDC — New European Driving Cycle

$NP(T_{ti}^{eng})$ — Normalised fuel consumption potential at the engine coolant start temperature for the selected parking times ti [-]

pt — Parking time [h]

T^{eng} — Temperature of the engine coolant during parking time [°C]

T^{engmod} — Theoretical engine coolant temperature after discharging the EST system [°C]

T^{EST} — Temperature of the EST coolant during parking time [°C]

T_{cold} — Cold start temperature [°C] which is 14 °C

T_{hot} — Hot start temperature [°C] which is the coolant temperature reached at the end of the NEDC cycle

SOC — State of charge

SVS_{pt} — Share of parking time distribution [%] as defined in Table 6

WF_{ti} — Weighting factor for the parking time ti [%] as defined in Table 3

Subscripts

Index ti refers to the selected parking times as defined in Table 1

Index j refers to measurements of the sample

Index k refers to engine coolant start temperatures

3. DETERMINING THE COOL-DOWN CURVES AND TEMPERATURES

The cool-down curves shall be determined experimentally for the baseline vehicle engine coolant and the eco-innovation vehicle coolant. The same curves shall be applicable for vehicle variants with the same heat capacities, engine bay packaging, engine heat insulation and EST system. The experimental tests shall include continuous measurements of the representative coolant temperatures of the engine coolant and the coolant stored in the EST system by means of thermocouples at a constant ambient temperature of at least 14 °C for 24 h. The engine shall be heated up to the maximum coolant temperature before cut-off by a sufficient number of consecutive NEDC tests. After preconditioning, the ignition shall be switched off and the dash key pulled out. The car's bonnet shall be closed completely. Any artificial ventilation system inside the test cell shall be switched off.

The resulting measured cool-down curves shall be converged by the mathematical approach described by Formula 1 and Formula 2 for the engine and the EST system respectively.

Formula 1

$$T_{pt}^{eng} = T_{cold} + (T_{hot} - T_{cold})e^{-d_{eng} \cdot pt}$$

Formula 2

$$T_{pt}^{EST} = T_{cold} + (T_{hot} - T_{cold})e^{-d_{EST} \cdot pt}$$

The least squares method shall be used for the fitting of the curves. To do that, at least the temperature measurement data of the first 30 minutes after engine cut-off are not to be considered because of the untypical behaviour of the coolant temperature after switching off the coolant system.

Using Formula 1, the engine temperature at specific parking time conditions (T_{ti}^{eng}) should be calculated and given in Table 1.

Table 1

Engine temperature at selected parking time conditions

Selected parking time (ti)	t1	t2	t3
pt [h]	2,5	4,5	16,5
T_{ti}^{eng} [°C]			

4. DETERMINING THE CO_2 EMISSION AT DIFFERENT COOLANT START TEMPERATURES

The emission of CO_2 and fuel consumptions of the vehicle have to be measured in accordance with Annex 6 to UN/ECE Regulation No 101 (Method of measuring emission of carbon dioxide and fuel consumption of vehicles powered by an internal combustion engine only). The procedure should be modified accordingly to the following:

1. the ambient temperature in the test cell shall be below 14 °C;

2. the 5 engine coolant start temperatures shall be the followings: T_{cold}, T_{hot}, T_{t1}^{eng}, T_{t2}^{eng} and T_{t3}^{eng}.

The tests can be performed at any order. It is possible to perform one or two preconditioning NEDC tests between the tests. It shall be ensured and documented that the state of charge (SOC) of the starter battery (for example, using its Controller Area Network signal) after each test is within 5 %.

The complete tests procedure shall be repeated at least three times (i.e. m ≥ 3). Arithmetic means of the CO_2 results at each engine coolant start temperatures (T_k) shall be calculated using Formula 3 and given in Table 2.

Formula 3

$$CO_2(T_k) = \frac{\sum_{j=1}^{m} CO_2(T_k)_j}{m}$$

where k = 1, 2, …, 5

$T_1 = T_{cold}$ $T_2 = T_{hot}$ $T_3 = T_{t1}^{eng}$ $T_4 = T_{t2}^{eng}$ $T_5 = T_{t3}^{eng}$

Table 2

CO_2 emission at different engine coolant start temperatures

Engine coolant starting temperature T_k	T_{cold}	T_{hot}	T_{t1}^{eng}	T_{t2}^{eng}	T_{t3}^{eng}
$CO_2(T_k)$ [g CO_2/km]					

5. DETERMINING THE THEORETICAL TEMPERATURE OF THE ENGINE AFTER DISCHARGING THE EST SYSTEM

Using the test results defined in paragraph 4 and reported in Table 2, the Normalised fuel consumption potential $NP(T_{ti}^{eng})$ at the selected parking time conditions reported in Table 1, shall be calculated using Formula 4.

Formula 4

$$NP(T_{ti}^{eng}) = \frac{CO_2(T_{cold}) - CO_2(T_{ti}^{eng})}{CO_2(T_{cold}) - CO_2(T_{hot})}$$

Then, the theoretical engine coolant temperature after discharging the EST system for the selected parking time conditions T_{ti}^{engmod}, shall be calculated using Formula 5.

Formula 5

$$T_{ti}^{engmod} = (2^{NP(T_{ti}^{eng})} - 1) \cdot (T_{hot} - T_{cold}) + T_{cold}$$

The relative ratio of thermal inertias K_{ti} at the selected parking time conditions shall be defined using Formula 6.

Formula 6

$$K_{ti} = \frac{T_{ti}^{engmod} - T_{ti}^{eng}}{T_{ti}^{EST} - T_{ti}^{eng}}$$

The resulting effective ratio of thermal inertias K is calculated weighting the three results K_{ti} by the share of vehicle stops, as defined by Formula 7.

Formula 7

$$K = \sum_{i=1}^{3} K_{ti} \cdot WF_{ti}$$

where

WF_{ti} — Weighting factor for the parking time ti [-] as defined in Table 3

Table 3

Weighting parameter for K factor calculation

WF_{t1} [%]	63,4
WF_{t2} [%]	14,0
WF_{t3} [%]	22,6

The theoretical temperature of the engine after discharging the EST system for the parking time condition pt T_{pt}^{engmod} shall be calculated using Formula 8.

Formula 8

$$T_{pt}^{engmod} = T_{pt}^{eng} + K \cdot (T_{pt}^{EST} - T_{pt}^{eng})$$

The calculation results shall be given in Table 4

Table 4

Theoretical temperature of the engine after discharging the EST system for different parking times

pt [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
T_{pt}^{engmod} [°C]												
pt [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
T_{pt}^{engmod} [°C]												

6. DETERMINING THE HOT START BENEFIT

The hot start benefit (HSB) of the vehicle fitted with the technology shall be determined experimentally with Formula 9. This value describes the difference of CO_2 emissions between a cold start and a hot start NEDC test in relation to the cold start result.

Formula 9

$$HSB = 1 - \frac{CO_2(T_{hot})}{CO_2(T_{cold})}$$

7. DETERMINING THE CO_2 SAVINGS

Prior to the launch of the official Type I test to be performed in accordance with Regulation (EC) No 692/2008, the type approval authority shall verify that the coolant temperature, including inside the enthalpy storage tank, is within ± 2 K of the temperature of the room. Where this temperature is not achieved, the methodology for determining the CO_2 savings for the EST may not be applied.

The verification may be performed either by a measurement inside the Enthalpy Storage Tank (e.g. by means of a thermocouple), or by turning off the EST system before the conditioning procedure in order not to store heated coolant inside the tank. The temperature inside the enthalpy storage tank shall be recorded in the test report.

The relative CO_2 reduction potential $\Delta CO_{2_{pt}}$ at different parking times shall be calculated using Formula 10.

Formula 10

$$\Delta CO_{2_{pt}} = 1{,}443 \cdot \ln\left(\frac{T_{pt}^{engmod} + T_{hot} - 2 \cdot T_{cold}}{T_{pt}^{eng} + T_{hot} - 2 \cdot T_{cold}}\right) \cdot HSB$$

The calculation results shall be given in Table 5

Table 5

Relative CO_2 reduction potential $\Delta CO_{2_{pt}}$ for different parking times

pt [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
ΔCO_2(pt) [%]												
pt [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
ΔCO_2(pt) [%]												

The CO_2 savings weighted by the parking times (pt) shall be calculated using Formula 11.

Formula 11

$$C_{CO_2} = B_{TA} \cdot \sum_{pt=1}^{24} \Delta CO_{2_{pt}} \cdot SVS_{pt}$$

where:

SVS_{pt} — Share of parking time distribution [%] as defined in Table 6

Table 6

Parking time distribution (share of vehicle stops)

pt [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_{pt} [%]	36	13	6	4	2	2	1	1	3	4	3	1
pt [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_{pt} [%]	1	3	3	2	1	1	1	1	1	1	1	1

8. CALCULATION OF THE STATISTICAL ERROR

The statistical errors in the outcomes of the testing methodology caused by the measurements are to be quantified. For each test performed at the different engine coolant start temperatures, the standard deviation of the arithmetic mean is calculated as defined by Formula 12.

Formula 12

$$S_{CO_2(T_k)} = \sqrt{\frac{\sum_{j=1}^{m} (CO_2(T_k)_j - CO_2(T_k))^2}{m(m-1)}}$$

where k = 1, 2, …, 5

$$T_1 = T_{cold} \qquad T_2 = T_{hot} \qquad T_3 = T_{t1}^{eng} \qquad T_4 = T_{t2}^{eng} \qquad T_5 = T_{t3}^{eng}$$

The standard deviation of the CO_2 savings $S_{C_{CO_2}}$ is to be calculated by means of Formula 13.

Formula 13

$$s_{C_{co_2}} = \sqrt{\sum_{k=1}^{5} \left(\frac{\partial C_{CO_2}}{\partial CO_2(T_k)} \cdot s_{CO_2(T_k)} \right)^2}$$

where

$$\frac{\partial C_{CO_2}}{\partial CO_2(T_k)} = B_{TA} \cdot \ln(2) \cdot SVS_{pt} \cdot \sum_{pt=1}^{24} \left[\ln(2) \cdot HSB \cdot \frac{1}{T_{pt}^{engmod} + T_{hot} - 2 \cdot T_{cold}} \cdot (T_{hot} - T_{cold}) \cdot \sum_{i=1}^{3} \left(2^{NP(T_{ti}^{eng})} - 1 \right) \cdot \frac{1}{T_{ti}^{EST} - T_{ti}^{eng}} \cdot WF_{ti} \cdot \frac{\partial NP(T_{ti}^{eng})}{\partial CO_2(T_k)} \right] +$$

$$+ \ln \left(\frac{T_{pt}^{engmod} + T_{hot} - 2 \cdot T_{cold}}{T_{pt}^{eng} + T_{hot} - 2 \cdot T_{cold}} \right) \cdot \frac{\partial HSB}{\partial CO_2(T_k)}$$

$$\frac{\partial HSB}{\partial CO_2(T_{hot})} = -\frac{1}{CO_2(T_{cold})}$$

$$\frac{\partial HSB}{\partial CO_2(T_{cold})} = \frac{CO_2(T_{hot})}{CO_2(T_{cold})^2}$$

$$\frac{\partial HSB}{\partial CO_2(T_{ti}^{eng})} = 0$$

$$\frac{\partial NP(T_{ti}^{eng})}{\partial CO_2(T_{hot})} = \frac{NP(T_{ti}^{eng})}{CO_2(T_{cold}) - CO_2(T_{hot})}$$

$$\frac{\partial NP(T_{ti}^{eng})}{\partial CO_2(T_{hot})} = \frac{CO_2(T_{cold}) - CO_2(T_{hot})}{[CO_2(T_{cold}) - CO_2(T_{hot})]^2}$$

$$\frac{\partial NP(T_{ti}^{eng})}{\partial CO_2(T_{ti}^{eng})} = -\frac{1}{CO_2(T_{cold}) - CO_2(T_{hot})}$$

9. STATISTICAL SIGNIFICANCE

It has to be demonstrated for each type, variant and version of a vehicle fitted with the EST system that the error in the CO_2 savings calculated with Formula 13 is not greater than the difference between the total CO_2 savings and the minimum savings threshold specified in Article 9(1) of Regulation (EU) No 725/2011 (see Formula 14).

Formula 14

$$MT \leq C_{CO_2} - S_{C_{CO_2}} - \Delta CO_{2m}$$

where:

MT: Minimum threshold [gCO_2/km], which is 1 gCO_2/km

ΔCO_{2m}: CO_2 correction coefficient due to the mass increase due to the installation of the EST system. For ΔCO_{2m} the data in Table 7 is to be used.

Table 7

CO_2 correction coefficient due to the extra mass

Type of fuel	CO_2 correction coefficient due to the extra mass (ΔCO_{2m}) [g CO_2/km]
Petrol	$0{,}0277 \cdot \Delta m$
Diesel	$0{,}0383 \cdot \Delta m$

In Table 7 Δm is the extra mass due to the installation of the EST system. It is the mass of the EST system fully charged with the coolant.

10. THE EST SYSTEM TO BE FITTED IN VEHICLES

The type approval authority is to certify the CO_2 savings based on measurements of the EST system using the test methodology set out in this Annex. Where the CO_2 emission savings are below the threshold specified in Article 9(1), the second subparagraph of Article 11(2) of Regulation (EU) No 725/2011 shall apply.