4 October 2010

Agreement

Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions*

(Revision 2, including the amendments which entered into force on 16 October 1995)

Addendum 100 Regulation No. 101

Revision 2 – Amendment 3

Supplement 9 to the original version of the Regulation: Date of entry into force: 19 August 2010

Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M_1 and N_1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range

UNITED NATIONS

* Former title of the Agreement: Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, don't at Geneva on 20 March 1958.

Annex 10, amend to read:

"Annex 10

Emissions test procedure for a vehicle equipped with a periodically regenerating system

1. Introduction

1.1. This annex defines the specific provisions regarding type approval of a vehicle equipped with a periodically regenerating system as defined in paragraph 2.16. of this Regulation.

2. Scope and extension of the type approval

2.1. Vehicle family groups equipped with periodically regenerating system

The procedure applies to vehicles equipped with a periodically regenerating system as defined in paragraph 2.16. of this Regulation. For the purpose of this annex vehicle family groups may be established. Accordingly, those vehicle types with regenerative systems, whose parameters described below are identical, or within the stated tolerances, shall be considered to belong to the same family with respect to measurements specific to the defined periodically regenerating systems.

2.1.1. Identical parameters are:

Engine:

(a) Number of cylinders,

(b) Engine capacity (±15 per cent),

(c) Number of valves,

(d) Fuel system,

(e) Combustion process (2 stroke, 4 stroke, rotary).

Periodically regenerating system (i.e. catalyst, particulate trap):

(a) Construction (i.e. type of enclosure, type of precious metal, type of substrate, cell density),

(b) Type and working principle,

(c) Dosage and additive system,

(d) Volume (±10 per cent),

(e) Location (temperature ±50 °C at 120 km/h or 5 per cent difference of maximum temperature / pressure).

2.2. Vehicle types of different reference masses

The K_i factor developed by the procedures in this annex for type approval of a vehicle type with a periodically regenerating system as defined in paragraph 2.16. of this Regulation, may be extended to other vehicles in the family group with a reference mass within the next two higher equivalent inertia classes or any lower equivalent inertia.

2.3. Instead of carrying out the test procedures defined in the following paragraph, a fixed K_i value of 1.05 may be used, if the technical service sees no reason that this value could be exceeded.

3. Test procedure

The vehicle may be equipped with a switch capable of preventing or permitting the regeneration process provided that this operation has no effect on original engine calibration. This switch shall be permitted only for the purpose of preventing regeneration during loading of the regeneration system and during the pre-conditioning cycles. However, it shall not be used during the measurement of emissions during the regeneration phase; rather the emission test shall be carried out with the unchanged Original Equipment Manufacturer's (OEM) control unit.

3.1. Measurement of carbon dioxide emission and fuel consumption between two cycles where regenerative phases occur

3.1.1. The average of carbon dioxide emission and fuel consumption between regeneration phases and during loading of the regenerative device shall be determined from the arithmetic mean of several approximately equidistant (if more than 2) Type I operating cycles or equivalent engine test bench cycles. As an alternative, the manufacturer may provide data to show that the carbon dioxide emission and fuel consumption remain constant ($\pm$4 per cent) between regeneration phases. In this case, the carbon dioxide emission and fuel consumption measured during the regular Type I test may be used. In any other case emissions measurement for at least two Type I operating cycles or equivalent engine test bench cycles must be completed: one immediately after regeneration (before new loading) and one as close as possible prior to a regeneration phase. All emissions measurements and calculations shall be carried out according to Annex 6. Determination of average emissions for a single regenerative system shall be according to paragraph 3.3. of this annex and for multiple regeneration systems according to paragraph 3.4. of this annex.

3.1.2. The loading process and K_i determination shall be made during the Type I operating cycle, on a chassis dynamometer or on an engine test bench using an equivalent test cycle. These cycles may be run continuously (i.e. without the need to switch the engine off between cycles). After any number of completed cycles, the vehicle may be removed from the chassis dynamometer, and the test continued at a later time.

3.1.3. The number of cycles (D) between two cycles where regeneration phases occur, the number of cycles over which emissions measurements are made (n), and each emissions measurement (M'_{sij}) shall be reported in Annex 1, items 4.1.11.2.1.10.1. to 4.1.11.2.1.10.4. or 4.1.11.2.5.4.1. to 4.1.11.2.5.4.4. as applicable.

3.2. Measurement of carbon dioxide emission and fuel consumption during regeneration

3.2.1. Preparation of the vehicle, if required, for the emissions test during a regeneration phase, may be completed using the preparation cycles in paragraph 5.3. of Annex 4 of Regulation No. 83 or equivalent engine test bench cycles, depending on the loading procedure chosen in paragraph 3.1.2. above.

3.2.2. The test and vehicle conditions for the test described in Annex 6 apply before the first valid emission test is carried out.

3.2.3. Regeneration must not occur during the preparation of the vehicle. This may be ensured by one of the following methods:

3.2.3.1. A “dummy” regenerating system or partial system may be fitted for the pre-conditioning cycles.

3.2.3.2. Any other method agreed between the manufacturer and the type approval authority.

3.2.4. A cold-start exhaust emission test including a regeneration process shall be performed according to the Type I operating cycle, or equivalent engine test bench cycle. If the emissions tests between two cycles where regeneration phases occur are carried out on an engine test bench, the emissions test including a regeneration phase shall also be carried out on an engine test bench.

3.2.5. If the regeneration process requires more than one operating cycle, subsequent test cycle(s) shall be driven immediately, without switching the engine off, until complete regeneration has been achieved (each cycle shall be completed). The time necessary to set up a new test should be as short as possible (e.g. particular matter filter change). The engine must be switched off during this period.

3.2.6. The carbon dioxide emission and fuel consumption values during regeneration (M_{ri}) shall be calculated according to Annex 6. The number of operating cycles (d) measured for complete regeneration shall be recorded.

3.3. Calculation of the combined carbon dioxide emission and fuel consumption of a single regenerative system

(1) $$M_{si} = \frac{\sum_{j=1}^{n} M'_{sij}}{n} \qquad n \geq 2$$

(2) $$M_{ri} = \frac{\sum_{j=1}^{d} M'_{rij}}{d}$$

(3) $$M_{pi} = \left\{ \frac{M_{si} \cdot D + M_{ri} \cdot d}{D + d} \right\}$$

where for each carbon dioxide emission and fuel consumption considered:

M'_{sij} = mass emissions of CO_2 in g/km and fuel consumption in l/100 km over one part (i) of the operating cycle (or equivalent engine test bench cycle) without regeneration;

M'_{rij} = mass emissions of CO_2 in g/km and fuel consumption in l/100 km over one part (i) of the operating cycle (or equivalent engine test bench cycle) during regeneration. (when n > 1, the first Type I test is run cold, and subsequent cycles are hot);

M_{si} = mean mass emissions of CO_2 in g/km and fuel consumption in l/100 km over one part (i) of the operating cycle without regeneration;

M_{ri} = mean mass emissions of CO_2 in g/km and fuel consumption in l/100 km over one part (i) of the operating cycle during regeneration;

M_{pi} = mean mass emission of CO_2 in g/km and fuel consumption in l/100 km;

n = number of test points at which emissions measurements (Type I operating cycles or equivalent engine test bench cycles) are made between two cycles where regenerative phases occur, ≥ 2;

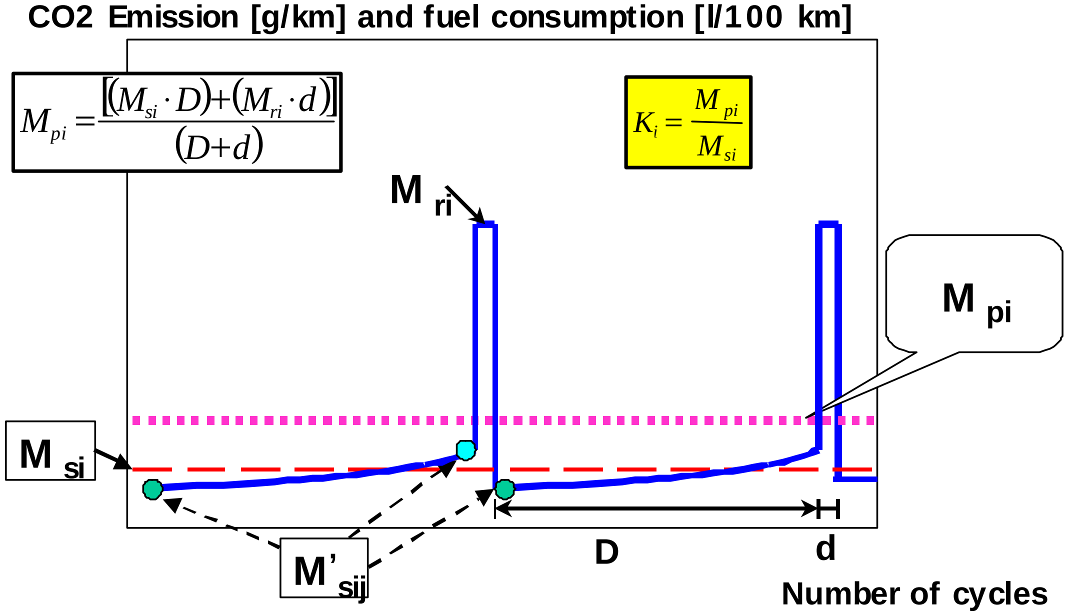
d = number of operating cycles required for regeneration;

D = number of operating cycles between two cycles where regenerative phases occur.

For an illustration of measurement parameters see figure 10/1.

Figure 10/1

Parameters measured during carbon dioxide emission and fuel consumption test during and between cycles where regeneration occurs (schematic example, the emissions during 'D' may increase or decrease)



3.3.1. Calculation of the regeneration factor K for carbon dioxide emission and fuel consumption (i) considered

$$K_i = M_{pi} / M_{si}$$

M_{si}, M_{pi} and K_i results shall be recorded in the test report delivered by the Technical Service.

K_i may be determined following the completion of a single sequence.

3.4. Calculation of combined CO_2-emission and fuel consumption of multiple periodic regenerating systems

(1) $$M_{sik} = \frac{\sum_{k=1}^{n_k} M'_{sik,j}}{n_k} \qquad n_k \geq 2$$

(2) $$M_{rik} = \frac{\sum_{k=1}^{d_k} M'_{rik,j}}{d_k}$$

(3) $$M_{si} = \frac{\sum_{k=1}^{x} M_{sik} \cdot D_k}{\sum_{k=1}^{x} D_k}$$

(4) $$M_{ri} = \frac{\sum_{k=1}^{x} M_{rik} \cdot d_k}{\sum_{k=1}^{x} d_k}$$

(5) $$M_{pi} = \frac{M_{si} \cdot \sum_{k=1}^{x} D_k + M_{ri} \cdot \sum_{k=1}^{x} d_k}{\sum_{k=1}^{x} (D_k + d_k)}$$

(6) $$M_{pi} = \frac{\sum_{k=1}^{x} (M_{sik} \cdot D_k + M_{rik} \cdot d_k)}{\sum_{k=1}^{x} (D_k + d_k)}$$

(7) $$K_i = \frac{M_{pi}}{M_{si}}$$

where:

M_{si} = mass emission of all events k of CO2 in g/km and fuel consumption in l/100 km (i) without regeneration;

M_{ri} = mass emission of all events k of CO2 in g/km and fuel consumption in l/100 km (i) during regeneration;

M_{pi} = mass emission of all events k of CO2 in g/km and fuel consumption in l/100 km (i);

M_{sik} = mass emission of event k of CO2 in g/km and fuel consumption in l/100 km (i) without regeneration;

M_{rik} = mass emission of event k of CO2 in g/km and fuel consumption in l/100 km (i) during regeneration;

$M'_{sik,j}$ = mass emission of event k of CO2 in g/km and fuel consumption in l/100 km (i) over one Type I operating cycle (or equivalent engine test bench cycle) without regeneration measured at point j; $1 \leq j \leq n$;

$M'_{rik,j}$ = mass emission of event k of CO2 in g/km and fuel consumption in l/100 km (i) over one Type I operating cycle (or equivalent engine test bench cycle) during regeneration (when $j > 1$, the first Type I test is run cold, and subsequent cycles are hot) measured at operating cycle j; $1 \leq j \leq d$;

nk = number of test points of event k at which emissions measurements (Type I operating cycles or equivalent engine test bench cycles) are made between two cycles where regenerative phases occur, ≥;

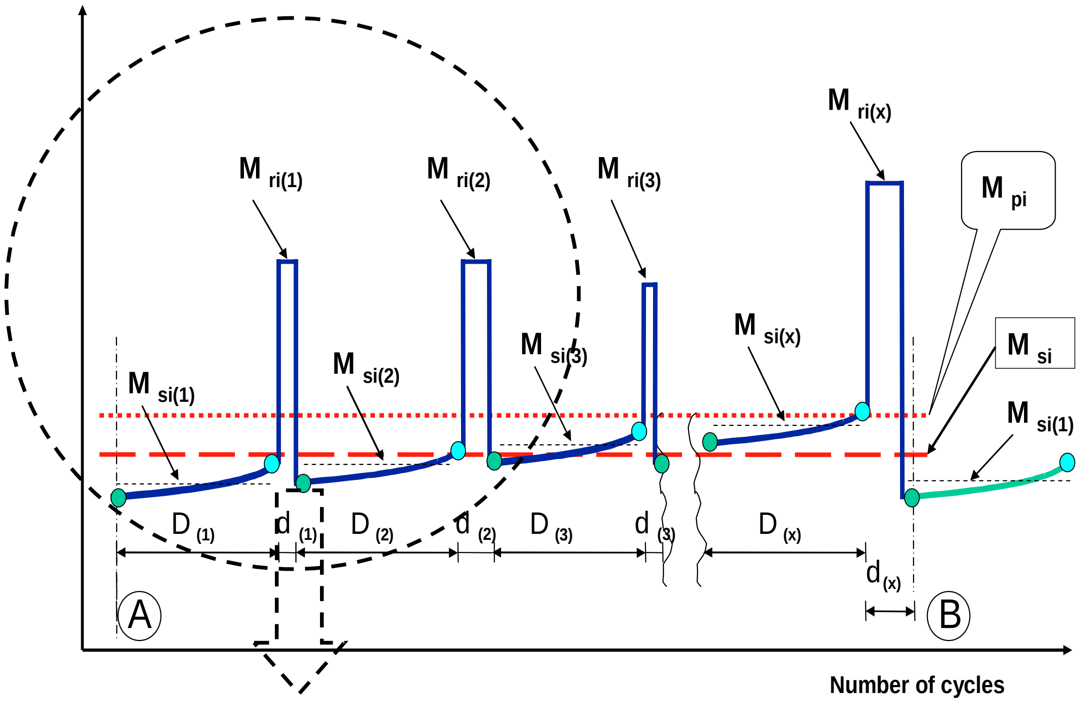
dk = number of operating cycles of event k required for regeneration;

Dk = number of operating cycles of event k between two cycles where regenerative phases occur.

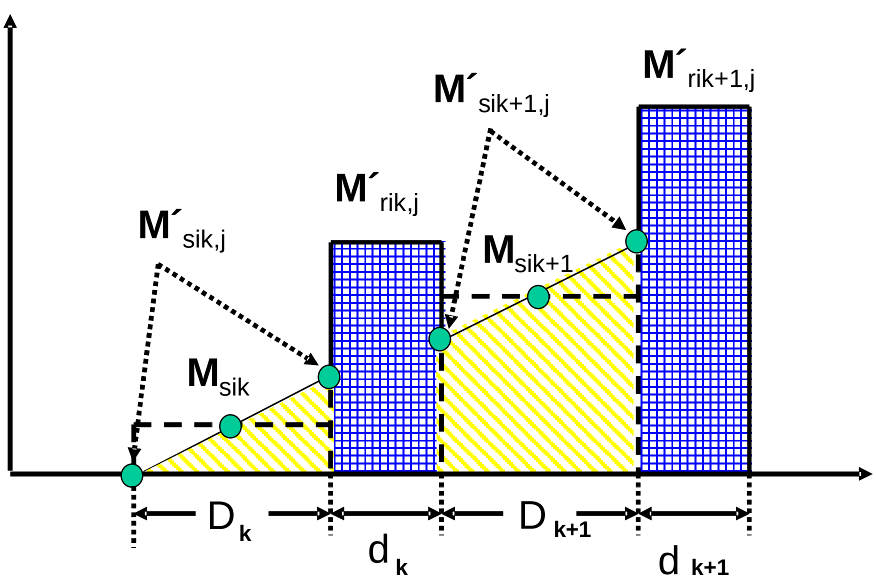
For an illustration of measurement parameters see Figure 10/2 (below)

Figures 10/2 and 10/3

Parameters measured during emissions test during and between cycles where regeneration occurs (schematic example)



For more details of the schematic process see Figure 10/3



For application of a simple and realistic case, the following description gives a detailed explanation of the schematic example shown in Figure 10/3 above):

1. DPF: regenerative, equidistant events, similar emissions (±15 per cent) from event to event

$D_k = D_{k+1} = D_1$

$d_k = d_{k+1} = d_1$

$M_{rik} - M_{sik} = M_{rik+1} - M_{sik+1}$

$n_k = n$

2. DeNOx: the desulphurisation (SO_2 removal) event is initiated before an influence of sulphur on emissions is detectable (±15 per cent of measured emissions) and in this example for exothermic reason together with the last DPF regeneration event performed.

$M'_{sik,j=1} = \text{constant} \rightarrow M_{sik} = M_{sik+1} = M_{si2}$
$M_{rik} = M_{rik+1} = M_{ri2}$

For SO2 removal event:

M_{ri2}, M_{si2}, d_2, D_2, $n_2 = 1$

3. Complete system (DPF + DeNOx):

$$M_{si} = \frac{n \cdot M_{si1} \cdot D_1 + M_{si2} \cdot D_2}{n \cdot D_1 + D_2}$$

$$M_{ri} = \frac{n \cdot M_{ri1} \cdot d_1 + M_{ri2} \cdot d_2}{n \cdot d_1 + d_2}$$

$$M_{pi} = \frac{M_{si} + M_{ri}}{n \cdot (D_1 + d_1) + D_2 + d_2} = \frac{n \cdot (M_{si1} \cdot D_1 + M_{ri1} \cdot d_1) + M_{si2} \cdot D_2 + M_{ri2} \cdot d_2}{n \cdot (D_1 + d_1) + D_2 + d_2}$$

The calculation of the factor (K_i) for multiple periodic regenerating systems is only possible after a certain number of regeneration phases for each system. After performing the complete procedure (A to B, see Figure 10/2), the original starting conditions A should be reached again.

3.4.1. Extension of approval for a multiple periodic regeneration system

3.4.1.1. If the technical parameter(s) and or the regeneration strategy of a multiple regeneration system for all events within this combined system are changed, the complete procedure including all regenerative devices should be performed by measurements to update the multiple K_i factor.

3.4.1.2. If a single device of the multiple regeneration system changed only in strategy parameters (i.e. such as "D" and/or "d" for DPF) and the manufacturer could present technical feasible data and information to the Technical Service that:

(a) There is no detectable interaction with the other device(s) of the system, and

(b) The important parameters (i.e. construction, working principle, volume, location etc.) are identical,

the necessary update procedure for K_i could be simplified.

As agreed between the manufacturer and the Technical Service in such a case only a single event of sampling/storage and regeneration should be performed and the test results ("M_{si}", "M_{ri}") in combination with the changed parameters ("D" and/or "d") could be introduced in the relevant formula(s) to update the multiple K_i factor in a mathematical way under substitution of the existing basis K_i factor formula(s)."