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ANNEXES 5 to 10

ANNEXES

to the

Commission Regulation (EU) .../...

implementing Regulation (EU) No 595/2009 of the European Parliament and of the Council as regards the determination of the CO2 emissions and fuel consumption of heavy-duty vehicles and amending Directive 2007/46/EC of the European Parliament and of the Council and Commission Regulation (EU) No 582/2011

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ANNEX V

VERIFYING AXLE DATA

1. Introduction

This annex describes the certification provisions regarding the torque losses of propulsion axles for heavy duty vehicles. Alternatively to the certification of axles the calculation procedure for the standard torque loss as defined in Appendix 3 to this Annex can be applied for the purpose of the determination of vehicle specific CO_2 emissions.

2. Definitions

For the purposes of this Annex the following definitions shall apply:

(1) "Single reduction axle (SR)" means a driven axle with only one gear reduction, typically a bevel gear set with or without hypoid offset.

(2) "Single portal axle (SP)" means an axle, that has typically a vertical offset between the rotating axis of the crown gear and the rotating axis of the wheel due to the demand of a higher ground clearance or a lowered floor to allow a low floor concept for inner city buses. Typically, the first reduction is a bevel gear set, the second one a spur gear set with vertical offset close to the wheels.

(3) "Hub reduction axle (HR)" means a driven axle with two gear reductions. The first is typically a bevel gear set with or without hypoid offset. The other is a planetary gear set, what is typically placed in the area of the wheel hubs.

(4) "Single reduction tandem axle (SRT)" means a driven axle that is basically similar to a single driven axle, but has also the purpose to transfer torque from the input flange over an output flange to a further axle. The torque can be transferred with a spur gear set close at the input flange to generate a vertical offset for the output flange. Another possibility is to use a second pinion at the bevel gear set, what takes off torque at the crown wheel.

(5) "Hub reduction tandem axle (HRT)" means a hub reduction axle, what has the possibility to transfer torque to the rear as described under single reduction tandem axle (SRT).

(6) "Axle housing" means the housing parts that are needed for structural capability as well as for carrying the driveline parts, bearings and sealings of the axle.

(7) “Pinion” means a part of a bevel gear set which usually consists of two gears. The pinion is the driving gear which is connected with the input flange. In case of a SRT / HRT, a second pinion can be installed to take off torque from the crown wheel.

(8) “Crown wheel” means a part of a bevel gear set which usually consists of two gears. The crown wheel is the driven gear and is connected with the differential cage.

(9) “Hub reduction” means the planetary gear set that is installed commonly outside the planetary bearing at hub reduction axles. The gear set consists of three different gears. The sun, the planetary gears and the ring gear. The sun is in the centre, the planetary gears are rotating around the sun and are mounted to the planetary carrier that is fixed to the hub. Typically, the number of planetary gears is between three and five. The ring gear is not rotating and fixed to the axle beam.

(10) “Planetary gear wheels” means the gears that rotate around the sun within the ring gear of a planetary gear set. They are assembled with bearings on a planetary carrier, what is joined to a hub.

(11) “Oil type viscosity grade” means a viscosity grade as defined by SAE J306.

(12) “Factory fill oil” means the oil type viscosity grade that is used for the oil fill in the factory and which is intended to stay in the axle for the first service interval.

(13) “Axle line” means a group of axles that share the same basic axle-function as defined in the family concept.

(14) "Axle family" means a manufacturer’s grouping of axles which through their design, as defined in Appendix 4 of this Annex, have similar design characteristics and CO2 and fuel consumption properties.

(15) “Drag torque” means the required torque to overcome the inner friction of an axle when the wheel ends are rotating freely with 0 Nm output torque.

(16) “Mirror inverted axle casing” means the axle casing is mirrored regarding to the vertical plane.

(17) “Axle input” means the side of the axle on which the torque is delivered to the axle.

(18) “Axle output” means the side(s) of the axle where the torque is delivered to the wheels.

3. General requirements

The axle gears and all bearings, except wheel end bearings used for the measurements, shall be unused.

On request of the applicant different gear ratios can be tested in one axle housing using the same wheel ends.

Different axle ratios of hub reduction axles and single portal axles (HR, HRT, SP) may be measured by exchanging the hub reduction only. The provisions as specified in Appendix 4 to this Annex shall apply.

The total run-time for the optional run-in and the measurement of an individual axle (except for the axle housing and wheel-ends) shall not exceed 120 hours.

For testing the losses of an axle the torque loss map for each ratio of an individual axle shall be measured, however axles can be grouped in axle families following the provisions of Appendix 4 to this Annex.

3.1 Run-in

On request of the applicant a run-in procedure may be applied to the axle. The following provisions shall apply for a run-in procedure.

3.1.1 Only factory fill oil shall be used for the run-in procedure. The oil used for the run-in shall not be used for the testing described in paragraph 4.

3.1.2 The speed and torque profile for the run-in procedure shall be specified by the manufacturer.

3.1.3 The run-in procedure shall be documented by the manufacturer with regard to run-time, speed, torque and oil temperature and reported to the approval authority.

3.1.4 The requirements for the oil temperature (4.3.1), measurement accuracy (4.4.7) and test set-up (4.2) do not apply for the run-in procedure.

4. Testing procedure for axles

4.1 Test conditions

4.1.1 Ambient temperature

The temperature in the test cell shall be maintained to 25°C ± 10°C. The ambient temperature shall be measured within a distance of 1 m to the axle housing. Forced heating of the axle may only be applied by an external oil conditioning system as described in 4.1.5.

4.1.2 Oil temperature

The oil temperature shall be measured at the centre of the oil sump or at any other suitable point in accordance with good engineering practice. In case of external oil conditioning, alternatively the oil temperature can be measured in the outlet line from the axle housing to the conditioning system within 5 cm downstream the outlet. In both cases the oil temperature shall not exceed 70°C.

4.1.3 Oil quality

Only recommended factory fill oils as specified by the axle manufacturer shall be used for the measurement. In the case of testing different gear ratio variants with one axle housing, new oil shall be filled in for each single measurement.

4.1.4 Oil viscosity

If different oils with multiple viscosity grades are specified for the factory fill, the manufacturer shall choose the oil with the highest viscosity grade for performing the measurements on the parent axle.

If more than one oil within the same viscosity grade is specified within one axle family as factory fill oil, the applicant may choose one oil of these for the measurement related to certification.

4.1.5 Oil level and conditioning

The oil level or filling volume shall be set to the maximum level as defined in the manufacturer’s maintenance specifications.

An external oil conditioning and filtering system is permitted. The axle housing may be modified for the inclusion of the oil conditioning system.

4.2 Test set-up

For the purpose of the torque loss measurement different test set-ups are permitted as described in paragraph 4.2.3 and 4.2.4.

4.2.1 Axle installation

In case of a tandem axle, each axle shall be measured separately. The first axle with longitudinal differential shall be locked. Wheel ends and the output shaft of drive-through axles shall be installed freely rotatable.

4.2.2 Installation of torque meters

4.2.2.1 For a test setup with two electric machines, the torque meters shall be installed on the input flange and on one wheel end while the other one is locked.

4.2.2.2 For a test setup with three electric machines, the torque meters shall be installed on the input flange and on each wheel end.

4.2.2.3 Half shafts of different lengths are permitted in a two machine set-up in order to lock the differential and to ensure that both wheel ends are turning.

4.2.3 Test set-up “Type A ”

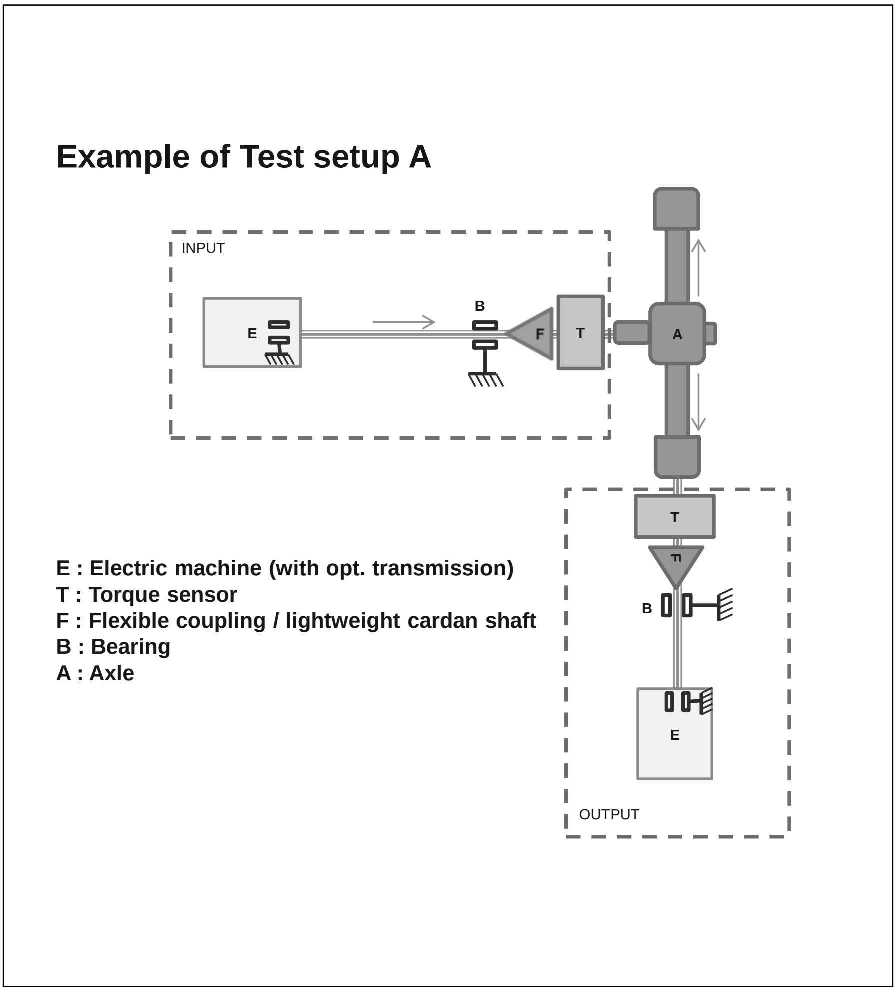
A test set-up considered “Type A” consists of a dynamometer on the axle input side and at least one dynamometer on the axle output side(s). Torque measuring devices shall be installed on the axle input- and output- side(s). For type A set-ups with only one dynamometer on the output side, the free rotating end of the axle shall be locked.

To avoid parasitic losses, the torque measuring devices shall be positioned as close as possible to the axle input- and output- side(s) being supported by appropriate bearings.

Additionally mechanical isolation of the torque sensors from parasitic loads of the shafts, for example by installation of additional bearings and a flexible coupling or lightweight cardan shaft between the sensors and one of these bearings can be applied. Figure 1 shows an example for a test test-up of Type A in a two dynamometer lay-out.

For Type A test set-up configurations the manufacturer shall provide an analysis of the parasitic loads. Based on this analysis the Technical Service or the Approval Authority shall decide about the maximum influence of parasitic loads. However the value i_{para} cannot be lower than 10%.

Figure 1 Example of Test set-up “Type A”



4.2.4 Test set-up “Type B”

Any other test set-up configuration is called test set-up Type B. The maximum influence of parasitic loads i_{para} for those configurations shall be set to 100%.

Lower values for i_{para} may be used in agreement with the Technical Service or Approval Authority.

4.3 Test procedure

To determine the torque loss map for an axle, the basic torque loss map data shall be measured and calculated as specified in paragraph 4.4. The torque loss results shall be complemented in accordance with 4.4.8 and formatted in accordance with Appendix 6 for the further processing by Vehicle Energy Consumption calculation Tool.

4.3.1 Measurement equipment

The calibration laboratory facilities shall comply with the requirements of either ISO/TS 16949, ISO 9000 series or ISO/IEC 17025. All laboratory reference measurement equipment, used for calibration and/or verification, shall be traceable to national (international) standards.

4.3.1.1 Torque measurement

The torque measurement uncertainty shall be calculated and included as described in paragraph 4.4.4.

The sample rate of the torque sensors shall be in accordance with 4.3.2.1.

4.3.1.2 Rotational speed

The uncertainty of the rotational speed sensors for the measurement of input and output speed shall not exceed ±2 rpm.

4.3.1.3 Temperatures

The uncertainty of the temperature sensors for the measurement of the ambient temperature shall not exceed ±1 °C.

The uncertainty of the temperature sensors for the measurement of the oil temperature shall not exceed ±0.5 °C.

4.3.2 Measurement signals and data recording

The following signals shall be recorded for the purpose of the calculation of the torque losses:

(i) Input and output torques [Nm]

(ii) Input and/or output rotational speeds [rpm]

(iii) Ambient temperature [°C]

(iv) Oil temperature [°C]

(v) Temperature at the torque sensor

4.3.2.1 The following minimum sampling frequencies of the sensors shall be applied:

Torque: 1 kHz

Rotational speed: 200 Hz

Temperatures: 10 Hz

4.3.2.2 The recording rate of the data used to determine the arithmetic mean values of each grid point shall be 10 Hz or higher. The raw data do not need to be reported.

Signal filtering may be applied in agreement with the approval authority. Any aliasing effect shall be avoided.

4.3.3 Torque range:

The extent of the torque loss map to be measured is limited to:

– either an output torque of 10 kNm[1, 2]

– or an input torque of 5 kNm

– or the maximum engine power tolerated by the manufacturer for a specific axle or in case of multiple driven axles according to the nominal power distribution.

4.3.3.1 The manufacturer may extend the measurement up to 20 kNm output torque by means of linear extrapolation of torque losses or by performing measurements up to 20 kNm output torque with steps of 2000 Nm. For this additional torque range another torque sensor at the output side with a maximum torque of 20 kNm (2-machine layout) or two 10 kNm sensors (3-machine layout) shall be used.

If the radius of the smallest tire is reduced (e.g. product development) after completing the measurement of an axle or when the physic boundaries of the test stand are reached (e.g. by product development changes), the missing points may be extrapolated by the manufacturer out of the existing map. The extrapolated points shall not exceed more than 10% of all points in the map and the penalty for these points is 5% torque loss to be added on the extrapolated points.

4.3.3.2 Output torque steps to be measured:

250 Nm < T_{out} < 1000 Nm:	250 Nm steps
1000 Nm ≤ T_{out} ≤ 2000 Nm:	500 Nm steps
2000 Nm ≤ T_{out} ≤ 10000 Nm:	1000 Nm steps
T_{out} > 10000 Nm:	2000 Nm steps

If the maximum input torque is limited by the manufacturer, the last torque step to be measured is the one below this maximum without consideration of any losses. In that case an extrapolation of the torque loss shall be applied up to the torque corresponding to the manufacturers limitation with the linear regression based on the torque steps of the corresponding speed step.

4.3.4 Speed range

The range of test speeds shall comprise from 50 rpm wheel speed to the maximum speed. The maximum test speed to be measured is defined by either the maximum axle input speed or the maximum wheel speed, whichever of the following conditions is reached first:

4.3.4.1 The maximum applicable axle input speed may be limited to design specification of the axle.

4.3.4.2 The maximum wheel speed under consideration of the smallest applicable tire diameter at a vehicle speed of 90 km/h for trucks and 110 km/h for coaches. If the smallest applicable tire diameter is not defined, paragraph 4.3.4.1 shall apply.

4.3.5 Wheel speed steps to be measured

The wheel speed step width for testing shall be 50 rpm.

4.4 Measurement of torque loss maps for axles

4.4.1 Testing sequence of the torque loss map

For each speed step the torque loss shall be measured for each output torque step starting from 250 Nm upward to the maximum and downward to the minimum. The speed steps can be run in any order.

The torque measurement sequence shall be performed and recorded twice. Interruptions of the sequence for cooling or heating purposes are permitted.

4.4.2 Measurement duration

The measurement duration for each single grid point shall be 20 seconds.

4.4.3 Averaging of grid points

The recorded values for each grid point within the 20 seconds interval according to point 4.4.2. shall be averaged to an arithmetic mean.

All four averaged intervals of corresponding speed and torque grid points from both sequences measured each upward and downward shall be averaged to an arithmetic mean and result into one torque loss value.

4.4.4 The torque loss (at input side) of the axle shall be calculated by

$$T_{loss} = T_{in} - \frac{T_{out}}{i_{gear}}$$

where:

$T_{loss,}$	=	Torque loss of the axle at the input side [Nm]
T_{in}	=	Input torque [Nm]
i_{gear}	=	Axle gear ratio [-]
T_{out}	=	Output torque [Nm]

4.4.5 Measurement validation

4.4.5.1 The averaged speed values per grid point (20 s interval) shall not deviate from the setting values by more than ± 5 rpm for the output speed.

4.4.5.2 The averaged output torque values as described under 4.4.3 for each grid point shall not deviate more than ± 20 Nm or ± 1% from the torque set point for the according grid point, whichever is the higher value.

4.4.5.3 If the above specified criteria are not met the measurement is void. In this case, the measurement for the entire affected speed step shall be repeated. After passing the repeated measurement, the data shall be consolidated.

4.4.6 Uncertainty calculation

The total uncertainty $U_{T,loss}$ of the torque loss shall be calculated based on the following parameters:

i. Temperature effect

ii. Parasitic loads

iii. Uncertainty (incl. sensitivity tolerance, linearity, hysteresis and repeatability)

The total uncertainty of the torque loss ($U_{T,loss}$) is based on the uncertainties of the sensors at 95% confidence level. The calculation shall be done for each applied sensor (e.g. three machine lay out: $U_{T,in}$, $U_{T,out,1}$, $U_{Tout,2}$) as the square root of the sum of squares ("Gaussian law of error propagation").

$$U_{T,loss} = \sqrt{U_{T_{out}}^2 + (U_{T_{in}} * i_{gear})^2}$$

$$U_{T\,in/out} = 2 * \sqrt{U_{TKC}^2 + U_{TK0}^2 + U_{cal}^2 + U_{para}^2}$$

$$U_{TKC} = \frac{1}{\sqrt{3}} * \frac{w_{tkc}}{K_{ref}} * \Delta K * T_c$$

$$U_{TK0} = \frac{1}{\sqrt{3}} * \frac{w_{tk0}}{K_{ref}} * \Delta K * T_n$$

$$U_{cal} = 1 * \frac{w_{cal}}{k_{cal}} * T_n$$

$$U_{para} = \frac{1}{\sqrt{3}} * w_{para} * T_n$$

$$w_{para} = sens_{para} * i_{para}$$

where:

$U_{T,loss}$=		Total uncertainty of torque loss measurement at 95% confidence level; [Nm]
$U_{T,in/out}$	=	Uncertainty of input / output torque loss measurement separately for input and output torque; [Nm]
i_{gear}	=	Axle gear ratio [-]
U_{TKC}	=	Uncertainty by temperature influence on current torque signal; [Nm]
w_{tkc}	=	Temperature influence on current torque signal per K_{ref}, declared by sensor manufacturer; [%]
U_{TK0}	=	Uncertainty by temperature influence on zero torque signal (related to nominal torque) [Nm]
w_{tk0}	=	Temperature influence on zero torque signal per K_{ref} (related to nominal torque), declared by sensor manufacturer; [%]
K_{ref}	=	Reference temperature span for tkc and tk0, declared by sensor manufacturer; [°C]
ΔK	=	Absolute difference in sensor temperature measured at torque sensor between calibration and measurement; [°C]
T_c	=	Current / measured torque value at torque sensor; [Nm]
T_n	=	Nominal torque value of torque sensor; [Nm]
U_{cal}	=	Uncertainty by torque sensor calibration; [Nm]
w_{cal}	=	Relative calibration uncertainty (related to nominal torque); [%]
k_{cal}	=	calibration advancement factor (if declared by sensor manufacturer, otherwise = 1)
U_{para}	=	Uncertainty by parasitic loads; [Nm]
w_{para}	=	$sens_{para} * i_{para}$ Relative influence of forces and bending torques caused by misalignment
$sens_{para}$	=	Maximum influence of parasitic loads for specific torque sensor declared by sensor manufacturer [%]; if no specific value for

parasitic loads is declared by the sensor manufacturer, the value shall be set to 1.0%

i_{para} = Maximum influence of parasitic loads for specific torque sensor depending on test set-up as indicated in section 4.2.3 and 4.2.4 of this annex.
i_{para} is set to10% for test set-up A and to 100% for test set-up in accordance with B. Lower values can be used if proof can be furnished by the manufacturer (calculation, tests).

4.4.7 Assessment of total uncertainty of the torque loss

In the case the calculated uncertainties $U_{T,in/out}$ are below the following limits, the reported torque loss $T_{loss,rep}$ shall be regarded as equal to the measured torque loss T_{loss}.

$U_{T,in}$: 7.5 Nm or 0.25 % of the measured torque, whichever allowed uncertainty value is higher

$U_{T,out}$: 15 Nm or 0.25% of the measured torque, whichever allowed uncertainty value is higher

In the case of higher calculated uncertainties, the part of the calculated uncertainty exceeding the above specified limits shall be added to T_{loss} for the reported torque loss $T_{loss,rep}$ as follows:

If the limits of $U_{T,in}$ are exceeded:

$$T_{loss,rep} = T_{loss} + \Delta UT_{in}$$

$$\Delta U_{T,in} = MIN((U_{T,in} - 0.25\% * T_c) \text{ or } (U_{T,in} - 7.5 \text{ Nm}))$$

If limits of $U_{T,out}$ out are exceeded:

$$T_{loss,rep} = T_{loss} + \Delta U_{T,out} / i_{gear}$$

$$\Delta U_{T,out} = MIN((U_{T,out} - 0.25\% * T_c) \text{ or } (U_{T,out} - 15Nm))$$

where:

$U_{T,loss}$= Total uncertainty of torque loss measurement at 95% confidence level; [Nm]

$U_{T,in/out}$ = Uncertainty of input / output torque loss measurement separately for input and output torque; [Nm]

i_{gear} = Axle gear ratio [-]

ΔU_T = The part of the calculated uncertainty exceeding the specified limits

4.4.8 Complement of torque loss map data

4.4.8.1 If the torque values exceed the upper range limit linear extrapolation shall be applied. For the extrapolation the slope of linear regression based on all measured torque points for the corresponding speed step shall be applied.

4.4.8.2 For the output torque range values below 250 Nm the torque loss values of the 250 Nm point shall be applied.

4.4.8.3 For 0 rpm wheel speed rpm the torque loss values of the 50 rpm speed step shall be applied.

4.4.8.4 For negative input torques (e.g. overrun, free rolling), the torque loss value measured for the related positive input torque shall be applied.

4.4.8.5 In case of a tandem axle, the combined torque loss map for both axles shall be calculated out of the test results for the single axles.

$$T_{loss,rep,tdm} = T_{loss,rep,1} + T_{loss,rep,2}$$

5. Conformity of production

5.1. Every axle type approved in accordance with this Annex shall be so manufactured as to conform, with regard to the description as given in the certification form and its annexes, to the approved type. The conformity of production procedures shall comply with those set out in Article 12 of Directive 2007/46/EC.

5.2. Conformity of production shall be checked on the basis of the description in the certificate set out in Appendix 1 to this Annex and the specific conditions laid down in this paragraph.

5.3. The manufacturer shall test annually at least the number of axles indicated in Table 1 based on the annual production numbers. For the purpose of establishing the production numbers, only axles which fall under the requirements of this Regulation shall be considered.

5.4. Each axle which is tested by the manufacturer shall be representative for a specific family.

5.5. The number of families of single reduction (SR) axles and other axles for which the tests shall be conducted is shown in Table 1.

Table 1: Sample Size for conformity testing

Production number	Number of test for SR axles	Number of tests for other axles then SR axles
0 – 40.000	2	1
40.001 – 50.000	2	2
50.001 – 60.000	3	2
60.001 – 70.000	4	2
70.001 – 80.000	5	2
80.001 and more	5	3

5.6. The two axle families with the highest production volumes shall always be tested. The manufacturer shall justify (e.g. by showing sales numbers) to the approval authority the number of tests which has been performed and the choice of the families. The remaining families for which the tests are to be performed shall be agreed between the manufacturer and the approval authority.

5.7. For the purpose of the conformity of production testing the Technical Service shall identify together with the manufacturer the axle type(s) to be tested. The selected axle type(s) shall be manufactured under the supervision of the Technical Service in order to ensure that the same standards as for serial production apply.

5.8. If the result of a test performed in accordance with point 6 is higher than the one specified in point 6.4, three additional axles from the same family shall be tested. If at least one of them fails, provisions of Article 22 shall apply.

6. Production conformity testing

6.1 For conformity of production testing, one of the following methods shall apply upon prior agreement between the approval authority and the applicant for a certificatel:

a) Torque loss measurement according to this Annex by following the full procedure limited to the grid points described in 6.2.

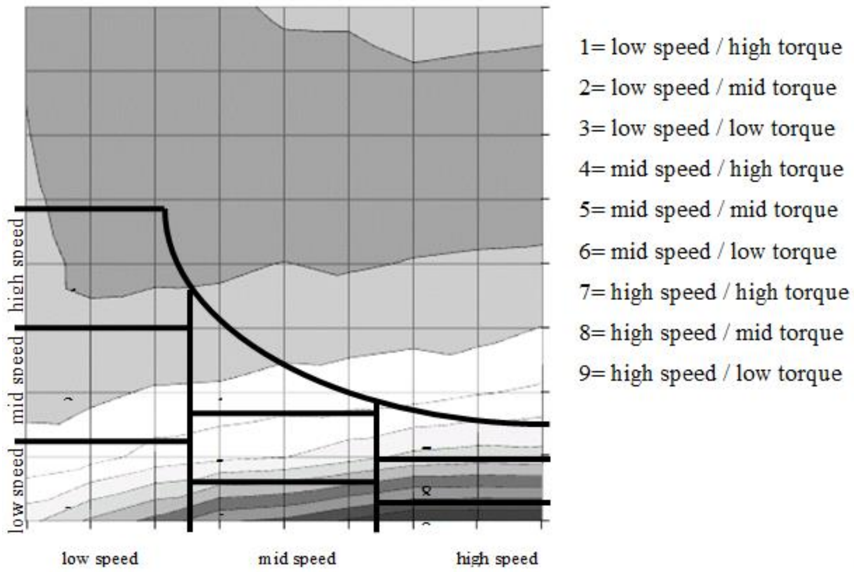
b) Torque loss measurement according to this Annex by following the full procedure limited to the grid points described in 6.2, with exception of the run-in procedure. In order to consider the run-in characteristic of an axle, a corrective factor may be applied. This factor shall be determined according to good engineering judgement and with agreement of the approval authority.

c) Measurement of drag torque according to paragraph 6.3. The manufacturer may choose a run-in procedure according to good engineering judgement up to 100 h.

6.2 If the conformity of production assessment is performed according to 6.1. a) or b) the grid points for this measurement are limited to 4 grid points from the approved torque loss map.

6.2.1 For that purpose the full torque loss map of the axle to be tested for conformity of production shall be segmented into three equidistant speed ranges and three torque ranges in order to define nine control areas as shown in figure 2.

Figure 2: Speed and torque range for conformity of production testing



6.2.2 For four control areas one point shall be selected, measured and evaluated according to the full procedure as described in section 4.4. Each control point shall be selected in the following manner:

(i) The control areas shall be selected depending on the axle line:

- SR axles including tandem combinations: Control areas 5, 6, 8 and 9

- HR axles including tandem combinations: Control areas 2, 3, 4 and 5

(ii) The selected point shall be located in the centre of the area referring to the speed range and the applicable torque range for the according speed.

(iii) In order to have a corresponding point for comparison with the loss map measured for certification, the selected point shall be moved to the closest measured point from the approved map.

6.2.3 For each measured point of the conformity of production test and its corresponding point of the type approved map, the efficiency shall be calculated with:

$$\eta_i = \frac{T_{out}}{\mathrm{i}_{\mathrm{axle}} * T_{in}}$$

where:

η_i	=	Efficiency of the grid point from each single control area 1 to 9
T_{out}	=	Output torque [Nm]
T_{in}	=	Input torque [Nm]
$\mathrm{i}_{\mathrm{axle}}$	=	axle ratio [-]

6.2.4 The average efficiency of the control area shall be calculated as follows:

For SR axles:

$$\eta_{avr,mid\ speed} = \frac{\eta_5 + \eta_6}{2}$$

$$\eta_{avr,high\ speed} = \frac{\eta_8 + \eta_9}{2}$$

$$\eta_{avr,total} = \frac{\eta_{avr,mid\ speed} + \eta_{avr,high\ speed}}{2}$$

For HR axles:

$$\eta_{avr,low\ speed} = \frac{\eta_2 + \eta_3}{2}$$

$$\eta_{avr,mid\ speed} = \frac{\eta_4 + \eta_5}{2}$$

$$\eta_{avr,total} = \frac{\eta_{avr,low\ speed} + \eta_{avr,mid\ speed}}{2}$$

where:

$\eta_{avr,low\ speed}$	=	average efficiency for low speed
$\eta_{avr,mid\ speed}$	=	average efficiency for mid speed
$\eta_{avr,high\ speed}$	=	average efficiency for high speed
$\eta_{avr,total}$	=	simplified averaged efficiency for axle

6.2.5 If the conformity of production assessment is performed in accordance with 6.1. c), the drag torque of the parent axle of the family to which the tested axle belongs shall be determined during the certification. This can be done prior to the run-in procedure or after the run-in procedure according to paragraph 3.1 or by linear extrapolation of all the torque map values for each speed step downwards to 0 Nm.

6.3 Determination of drag torque

6.3.1 For determination of the drag torque of an axle a simplified test set-up with one electric machine and one torque sensor on the input side is required.

6.3.2 The test conditions according to paragraph 4.1 shall apply. The uncertainty calculation regarding torque may be omitted.

6.3.3 The drag torque shall be measured in the speed range of the approved type according to paragraph 4.3.4 under consideration of the speed steps according to 4.3.5.

6.4. Conformity of production test assessment

6.4.1 A conformity of production test is passed when one of the following conditions apply:

a) If a torque loss measurement according to 6.1. a) or b) is conducted, the average efficiency of the tested axle during conformity of production procedure shall not deviate more than 1,5 % SR axles and 2,0 % for all other axles lines from corresponding average efficiency the type approved axle.

b) If a measurement of drag torque according to 6.1 c) is conducted, the deviation of the drag torque of the tested axle during conformity of production procedure shall not be higher than indicated in table 2

Table 2

Axle line	**Tolerances for axles measured in CoP after run-in Comparison to Td0**				**Tolerances for axles measured in CoP without run in Comparison to Td0**			
	for i	**tolerance Td0_input [Nm]**	**for i**	**tolerance Td0_input [Nm]**	**for i**	**tolerance Td0_input Nm]**	**for i**	**tolerance Td0_input [Nm]**
SR	≤ 3	15	> 3	12	≤ 3	25	> 3	20
SRT	≤ 3	16	> 3	13	≤ 3	27	> 3	21
SP	≤ 6	11	> 6	10	≤ 6	18	> 6	16
HR	≤ 7	10	> 7	9	≤ 7	16	> 7	15
HRT	≤ 7	11	> 7	10	≤ 7	18	> 7	16

i = gear ratio

Appendix 1

MODEL OF A CERTIFICATE OF A COMPONENT, SEPARATE TECHNICAL UNIT AND SYSTEM

Maximum format: A4 (210 x 297 mm)

CERTIFICATE

Stamp administration

Communication concerning:

– granting[(1)]

– extension [(1)]

– refusal [(1)]

– withdrawal[(1)]

of a certificate for a component, separate technical unit, system[(1)] with regard to Regulation (EC) No 595/2009 as implemented by Regulation No … [this Regulation].

Regulation (EC) No XXXXX and Regulation No … [this Regulation] as last amended by ……………..

certification number:

Hash:

Reason for extension:

(1) Delete where not applicable (there are cases where nothing needs to be deleted when more than one entry is applicable)

SECTION I

0.1 Make (trade name of manufacturer):

0.2 Type:

0.3 Means of identification of type, ~~if~~ marked on the axle

0.3.1 Location of the marking:

0.4 Name and address of manufacturer:

0.5 In the case of components and separate technical units, location and method of affixing of the EC certification mark:

0.6 Name(s) and address(es) of assembly plant(s):

0.7 Name and address of the manufacturer's representative (if any)

SECTION II

1. Additional information (where applicable): see Addendum
2. Technical service responsible for carrying out the tests:
3. Date of test report
4. Number of test report
5. Remarks (if any): see Addendum
6. Place
7. Date
8. Signature

Attachments:

1. Information document
2. Test report

Appendix 2

Axle information document

Information document no.:

Issue:

Date of issue:

Date of Amendment:

pursuant to …

Axle type:

…

0. GENERAL

0.1 Name and address of manufacturer

0.2 Make (trade name of manufacturer):

0.3 Axle type:

0.4 Axle family (if applicable):

0.5 Axle type as separate technical unit / Axle family as separate technical unit

0.6 Commercial name(s) (if available):

0.7 Means of identification of type, if marked on the axle:

0.8 In the case of components and separate technical units, location and method of affixing of the certification mark:

0.9 Name(s) and address(es) of assembly plant(s):

0.10 Name and address of the manufacturer's representative:

PART 1

ESSENTIAL CHARACTERISTICS OF THE (PARENT) AXLE AND THE AXLE TYPES WITHIN AN AXLE FAMILY

|Parent axle |Family member |

|or axle type| #1 | #2 | #3 |

0.0 GENERAL

0.1 Make (trade name of manufacturer)

0.2 Type

0.3 Commercial name(s) (if available)

0.4 Means of identification of type

0.5 Location of that marking

0.6 Name and address of manufacturer

0.7 Location and method of affixing of the certification mark

0.8. Name(s) and address (es) of assembly plant(s)

0.9. Name and address of the manufacturer's representative (if any)

1.0 SPECIFIC AXLE INFORMATION

1.1 Axle line (SR, HR, SP, SRT, HRT) … … … …

1.2 Axle gear ratio … … … …

1.3 Axle housing (number / ID / drawing) … … … …

1.4 Gear specifications … … …

1.4.1 Crown wheel diameter; [mm] … …

1.4.2 Vertical offset pinion / crown wheel; [mm] …

1.4.3 Pinion angle with respect to horizontal plane; [°]

1.4.4 for portal axles only:

Angle between pinion axle and crown wheel axle; [°]

1.4.5 Teeth number of pinion

1.4.6 Teeth number of crown gear

1.4.7 Horizontal offset of pinion; [mm]

1.4.8 Horizontal offset of crown wheel; [mm]

1.5 Oil volume; [cm³]

1.6 Oil level; [mm]

1.7 Oil specification

1.8 Bearing type (number / ID / drawing)

1.9 Seal type (main diameter, lip number); [mm]

1.10. Wheel ends (number / ID / drawing)

1.10.1 Bearing type (number / ID / drawing)

1.10.2 Seal type (main diameter, lip number); [mm]

1.10.3 Grease type

1.11. Number of planetary / spur gears

1.12 Smallest width of planetary/ spur gears; [mm]

1.13 Gear ratio of hub reduction

LIST OF ATTACHMENTS

No.:	Description:	Date of issue:
1	…	…
2	…	

Appendix 3

Calculation of the standard torque loss

The standard torque losses for axles are shown in Table 1. The standard table values consist of the sum of a generic constant efficiency value covering the load dependent losses and a generic basic drag torque loss to cover the drag losses at low loads.

Tandem axles shall be calculated using a combined efficiency for an axle including drive-thru (SRT, HRT) plus the matching single axle (SR, HR).

Basic function	Generic efficiency η	Drag torque (wheel side) $T_{d0} = T_0 + T_1 * i_{gear}$
Single reduction axle (SR)	0.98	T_0 = 70 Nm T_1 = 20 Nm
Single reduction tandem axle (SRT) / single portal axle (SP)	0.96	T_0 = 80 Nm T_1 = 20 Nm
Hub reduction axle (HR)	0.97	T_0 = 70 Nm T_1 = 20 Nm
Hub reduction tandem axle (HRT)	0.95	T_0 = 90 Nm T_1 = 20 Nm

Table 1: Generic efficiency and drag loss

The basic drag torque (wheel side) T_{d0} is calculated by

$$T_{d0} = T_0 + T_1 * i_{gear}$$

using the values from Table 1.

The standard torque loss $T_{loss,std}$ on the wheel side of the axle is calculated by

$$T_{loss,std} = T_{d0} + \frac{T_{out}}{\eta} - T_{out}$$

where:

$T_{loss,std}$	=	Standard torque loss at the wheel side [Nm]
T_{d0}	=	Basis drag torque over the complete speed range [Nm]
i_{gear}	=	Axle gear ratio [-]
η	=	Generic efficiency for load dependent losses [-]
T_{out}	=	Output torque [Nm]

Appendix 4

Family Concept

1. The applicant for a certificate shall submit to the approval authority an application for a certificate for an axle family based on the family criteria as indicated in paragraph 6.

An axle family is characterized by design and performance parameters. These shall be common to all axles within the family. The axle manufacturer may decide which axle belongs to an axle family, as long as the family criteria of paragraph 4 are respected. In addition to the parameters listed in paragraph 4, the axle manufacturer may introduce additional criteria allowing the definition of families of more restricted size. These parameters are not necessarily parameters that have an influence on the level of performance. The axle family shall be approved by the approval authority. The manufacturer shall provide to the approval authority the appropriate information relating to the performance of the members of the axle family.

2. Special cases

In some cases there may be interaction between parameters. This shall be taken into consideration to ensure that only axles with similar characteristics are included within the same axle family. These cases shall be identified by the manufacturer and notified to the approval authority. It shall then be taken into account as a criterion for creating a new axle family.

In case of parameters, which are not listed in paragraph 3 and which have a strong influence on the level of performance, this parameters shall be identified by the manufacturer on the basis of good engineering practice, and shall be notified to the approval authority.

3. Parameters defining an axle family:

3.1 Axle category

(a) Single reduction axle (SR)

(b) Hub reduction axle (HR)

(c) Single portal axle (SP)

(d) Single reduction tandem axle (SRT)

(e) Hub reduction tandem axle (HRT)

(f) Same inner axle housing geometry between differential bearings and horizontal plane of centre of pinion shaft according to drawing specification (Exception for single portal axles (SP)). Geometry changes due to an optional integration of a differential lock are permitted within the same axle family. In case of mirror inverted axle casings of axles, the mirror inverted axles can be combined in the same axle family as the origin axles, under the premise, that the bevel gear sets are adapted to the other running direction (change of spiral direction).

(g) Crown wheel diameter (+1.5 / -8% ref. to the largest drawing diameter)

(h) Vertical hypoid offset pinion/crown wheel within ±2 mm

(i) In case of single portal axles (SP): Pinion angle with respect to horizontal plane within ±5°

(j) In case of single portal axles (SP): Angle between pinion axle and crown wheel axle within ±3.5°

(k) In case of hub reduction and single portal axles (HR, HRT, FHR, SP): Same number of planetary gear and spur wheels

(l) Gear ratio of every gear step within an axle in a range of 1, as long as only one gear set is changed

(m) Oil level within ±10mm or oil volume ±0.5 litre referring to drawing specification and the installation position in the vehicle

(n) Same oil type viscosity grade (recommended factory fill)

(o) For all bearings: same bearing rolling/sliding circle diameter (inner/outer) and width within ±2 mm ref. to drawing

(p) Same seal type (main diameters, oil lip number) within ±0,5 mm ref. to drawing

4. Choice of the parent axle:

4.1 The parent axle within an axle family is determined as the axle with the highest axle ratio. In case of more than two axles having the same axle ratio, the manufacturer shall provide an analysis in order to determine the worst-case axle as parent axle.

4.2. The approval authority may conclude that the worst-case torque loss of the family can best be characterized by testing additional axles. In this case, the axle manufacturer shall submit the appropriate information to determine the axle within the family likely to have the highest torque loss level.

4.3. If axles within the family incorporate other features which may be considered to affect the torque losses, these features shall also be identified and taken into account in the selection of the parent axle.

Appendix 5

Markings and numbering

1. Markings

In the case of an axle being type approved accordant to this Annex, the axle shall bear:

1.1 The manufacturer’s name and trade mark

1.2 The make and identifying type indication as recorded in the information referred to in paragraph 0.2 and 0.3 of Appendix 2 to this Annex

1.3 The certification mark as a rectangle surrounding the lower-case letter ‘e’ followed by the distinguishing number of the Member State which has granted the certificate:

1 for Germany;

2 for France;

3 for Italy;

4 for the Netherlands;

5 for Sweden;

6 for Belgium;

7 for Hungary;

8 for the Czech Republic;

9 for Spain;

11 for the United Kingdom;

12 for Austria;

13 for Luxembourg;

17 for Finland;

18 for Denmark;

19 for Romania;

20 for Poland;

21 for Portugal;

23 for Greece;

24 for Ireland;

25 for Croatia;

26 for Slovenia;

27 for Slovakia;

29 for Estonia;

32 for Latvia;

34 for Bulgaria;

36 for Lithuania;

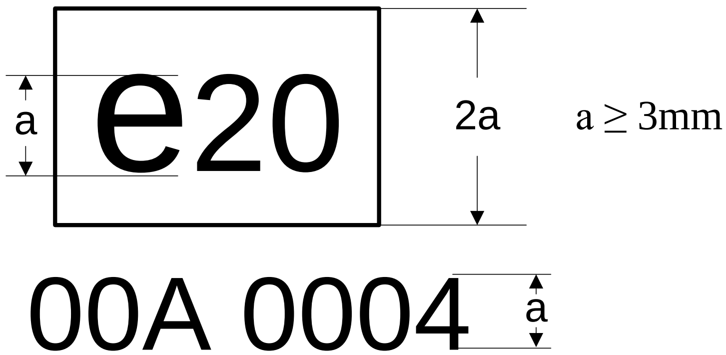
49 for Cyprus;

50 for Malta

1.4 The certification mark shall also include in the vicinity of the rectangle the ‘base certification number’ as specified for Section 4 of the type-approval number set out in Annex VII to Directive 2007/46/EC, preceded by the two figures indicating the sequence number assigned to the latest technical amendment to this Regulation and by a character 'A' indicating that the certificate has been granted for an axle.

For this Regulation, the sequence number shall be 00.

1.4.1 Example and dimensions of the certification mark



The above certification mark affixed to an axle shows that the type concerned has been approved in Poland (e20), pursuant to this Regulation. The first two digits (00) are indicating the sequence number assigned to the latest technical amendment to this Regulation. The following digit indicates that the certificate was granted for an axle (A). The last four digits (0004) are those allocated by the type-approval authority to the axle as the base certification number.

1.5 Upon request of the applicant for a certificate and after prior agreement with the type-approval authority other type sizes than indicated in 1.4.1 may be used. Those other type sizes shall remain clearly legible.

1.6 The markings, labels, plates or stickers must be durable for the useful life of the axle and must be clearly legible and indelible. The manufacturer shall ensure that the markings, labels, plates or sticker cannot be removed without destroying or defacing them.

1.7 The certification number shall be visible when the axle is installed on the vehicle and shall be affixed to a part necessary for normal operation and not normally requiring replacement during component life.

2. Numbering:

2.1. Certification number for axles shall comprise the following:

eX*YYY/YYYY*ZZZZ/ZZA*0000*00

section 1	section 2	section 3	Additional character to section 3	section 4	section 5

Indication of country issuing the certificate	Basic act (595/2009)	Latest version of the implementing act (2017/xx)	A= Axles	Base certification number 0000	Extension 00

Appendix 6

Input parameters for the simulation tool

Introduction

This Appendix describes the list of parameters to be provided by the component manufacturer as input to the simulation tool. The applicable XML schema as well as example data are available at the dedicated electronic distribution platform.

Definitions

(1) "Parameter ID": Unique identifier as used in "Vehicle Energy Consumption calculation Tool" for a specific input parameter or set of input data

(2) "Type": Data type of the parameter

string …….. sequence of characters in ISO8859-1 encoding

date ……… date and time in UTC time in the format: YYYY-MM-DD***T***HH:MM:SS***Z*** with italic letters denoting fixed characters e.g. "2002-05-30T09:30:10Z"

integer …… value with an integral data type, no leading zeros, e.g. "1800"

double, X .... fractional number with exactly X digits after the decimal sign (".") and no leading zeros e.g. for "double, 2": "2345.67"; for "double, 4": "45.6780"

(3) "Unit" … physical unit of the parameter

Set of input parameters

Table 1: Input parameters “Axlegear/General”

Parameter name	Param ID	Type	Unit	Description/Reference
Manufacturer	P215	string		
Make	P216	string		Trade name of manufacturer
TypeID	P217	string		Identifier of the component as used in the certification process
Date	P218	date		Date and Time when the component file is created.
AppVersion	P219	string		Version number identifying the evaluation tool
Ratio	P150	double, 3	[-]	

Table 2: Input parameters “Axlegear/LossMap” for each grid point in the loss map

Parameter name	Param ID	Type	Unit	Description/Reference
InputSpeed	P151	double, 2	[1/min]	
InputTorque	P152	double, 2	[Nm]	
TorqueLoss	P153	double, 2	[Nm]	

ANNEX VI

VERIFYING AIR DRAG DATA

1. Introduction

This Annex sets out the test procedure for verifying air drag data.

2. Defintions

For the purposes of this Annex the following definitions shall apply:

(1) "Active aero device" means measures which are activated by a control unit to reduce the air drag of the total vehicle.

(2) "Aero accessories" mean optional devices which have the purpose to influence the air flow around the total vehicle.

(3) "A-pillar" means the connection by a supporting structure between the cabin roof and the front bulkhead.

(4) "Body in white geometry" means the supporting structure incl. the windshield of the cabin.

(5) "B-pillar" means the connection by a supporting structure between the cabin floor and the cabin roof in the middle of the cabin.

(6) "Cab bottom" means the supporting structure of the cabin floor.

(7) "Cabin over frame" means distance from frame to cabin reference point in vertical Z. Distance is measured from top of horizontal frame to cabin reference point in vertical Z.

(8) "Cabin reference point" means the reference point (X/Y/Z = 0/0/0) from the CAD coordinate system of the cabin or a clearly defined point of the cabin package e.g. heel point.

(9) "Cabin width" means the horizontal distance of the left and right B-pillar of the cabin.

(10) "Constant speed test" means measurement procedure to be carried out on a test track in order to determine the air drag.

(11) "Dataset" means the data recorded during a single passing of a measurement section.

(12) "EMS" means the European Modular System (EMS) in accordance with Council Directive 96/53/EC.

(13) "Frame height" means distance of wheel center to top of horizontal frame in Z.

(14) "Heel point" means the point which is representing the heel of shoe location on the depressed floor covering, when the bottom of shoe is in contact with the undepressed accelerator pedal and the ankle angle is at 87°. (ISO 20176:2011)

(15) "Measurement area(s)" means designated part(s) of the test track consisting of at least one measurement section and a preceded stabilisation section.

(16) "Measurement section" means a designated part of the test track which is relevant for data recording and data evaluation.

(17) "Roof height" means distance in vertical Z from cabin reference point to highest point of roof w/o sunroof

3. Determination of air drag

The constant speed test procedure shall be applied to determine the air drag characteristics. During the constant speed test the main measurement signals driving torque, vehicle speed, air flow velocity and yaw angle shall be measured at two different constant vehicle speeds (low and high speed) under defined conditions on a test track. The measurement data recorded during the constant speed test shall be entered into the Vehicle Energy Consumption calculation Tool Air drag tool which determines product of drag coefficient by cross sectional area for zero crosswind conditions $C_d\ A_{cr}\ (0)$ as input for Vehicle Energy Consumption calculation Tool. The applicant for a certificate shall declare a value $C_d{\cdot}A_{declared}$ in a range from equal to a maximum of +0.2 m² higher than $C_d{\cdot}A_{cr}\ (0)$. The value $C_d{\cdot}A_{declared}$ shall be the input for the Vehicle Energy Consumption calculation Tool CO_2 simulation tool and the reference value for conformity of production testing.

Vehicles which are not measured by the constant speed test shall use the standard values for $C_d{\cdot}A_{declared}$ as described in Appendix 8 to this Annex.

3.1. Test track requirements

3.1.1. The geometry of test track shall be either a:

i. Circuit track (drivable in one direction*):

with two measurement areas, one on each straight part, with maximum deviation of less than 20 degrees);

* at least for the misalignment correction of the mobile anemometer (see 3.6) the test track has to be driven in both directions

or

ii. Circuit or straight line track (drivable in both directions):

with one measurement area (or two with the above named maximum deviation); two options: alternating driving direction after each test section; or after a selectable set of test sections e.g. ten times driving direction 1 followed by ten times driving direction 2.

3.1.2. Measurement sections

On the test track measurement section(s) of a length of 250 m with a tolerance of ± 3 m shall be defined.

3.1.3. Measurement areas

A measurement area shall consist of at least one measurement section and a stabilisation section. The first measurement section of a measurement area shall be preceded by a stabilisation section to stabilise the speed and torque. The stabilisation section shall have a length of minimum 25 m. The test track layout shall enable that the vehicle enters the stabilisation section already with the intended maximum vehicle speed during the test.

Latitude and longitude of start and end point of each measurement section shall be determined with an accuracy of better or equal 0.15 m 95% Circular Error Probable (DGPS accuracy).

3.1.4. Shape of the measurement sections

The measurement section and the stabilization section have to be a straight line.

3.1.5. Longitudinal slope of the measurement sections

The average longitudinal slope of each measurement and the stabilisation section shall not exceed ± 1 per cent. Slope variations on the measurement section shall not lead to velocity and torque variations above the thresholds specified in 3.10.1.1 item 0 of this Annex.

3.1.6. Track surface

The test track shall consist of asphalt or concrete. The measurement sections shall have one surface. Different measurement sections are allowed to have different surfaces.

3.1.7. Standstill area

There shall be a standstill area on the test track where the vehicle can be stopped to perform the zeroing and the drift check of the torque measurement system.

3.1.8. Distance to roadside obstacles and vertical clearance

There shall be no obstacles within 5 m distance to both sides of the vehicle. Safety barriers up to a height of 1 m with more than 2.5 m distance to the vehicle are permitted. Any bridges or similar constructions over the measurement sections are not allowed. The test track shall have enough vertical clearance to allow the anemometer installation on the vehicle as specified in 3.4.7 of this Annex.

3.1.9. Altitude profile

The manufacturer shall define whether the altitude correction as described in Appendix 1 shall be applied in the test evaluation. In case an altitude correction is applied, for each measurement section the altitude profile shall be made available. The data shall meet the following requirements:

i. The altitude profile shall be measured at a grid distance of lower or equal than 50 m in driving direction.

ii. For each grid point the longitude, the latitude and the altitude shall be measured at least one point (“altitude measurement point”) on each side of the centre line of the lane and then be processed to an average value for the grid point on the centre line.

iii. The positioning of the altitude measurement points to the centre line of the lane (perpendicular distance, number of points) shall be chosen in a way that the resulting altitude profile is representative for the gradient driven by the test vehicle.

iv. The altitude profile shall have an accuracy of ± 1cm or better.

v. The measurement data shall not be older than 10 years. A renewal of the surface in the measurement area requires a new altitude profile measurement.

3.2. Requirements for ambient conditions

3.2.1. The ambient conditions shall be measured with the equipment specified in 3.4.

3.2.2. The ambient temperature shall be in the range of 0°C to 25°C. This criterion is checked by Vehicle Energy Consumption calculation Tool Air Drag based on the signal for ambient temperature measured on the vehicle. This criterion only applies to the datasets recorded in the low speed - high speed – low speed sequence and not to the misalignment test and the warm-up phases.

3.2.3. The ground temperature shall not exceed 40°C. This criterion is checked by Vehicle Energy Consumption calculation Tool Air Drag based on the signal for ground temperature measured on the vehicle by an IR Sensor. This criterion only applies to the datasets recorded in the low speed - high speed – low speed sequence and not to the misalignment test and the warm-up phases.

3.2.4. The road surface shall be dry during the low speed – high speed - low speed sequence to provide comparable rolling resistance coefficients.

3.2.5. The wind conditions shall be within the following range:

i. Average wind speed: ≤ 5 m/s

ii. Gust wind speed (1s central moving average): ≤ 8 m/s

Items i. and ii. are applicable for the datasets recorded in the high speed test and the misalignment calibration test but not for the low speed tests.

iii. Average yaw angle (β):

≤ 3 degrees for datasets recorded in the high speed test

≤ 5 degrees for datasets recorded during misalignment calibration test

The validity of wind conditions is checked by Vehicle Energy Consumption calculation Tool Air Drag based on the signals recorded at the vehicle after application of the boundary layer correction. Measurement data collected under conditions exceeding the above named limits are automatically excluded from the calculation.

3.3. Installation of the vehicle

3.3.1. The vehicle chassis shall fit to the dimensions of the standard body or semi-trailer as defined in Appendix 5 of this Annex.

3.3.2. The vehicle height determined according to 3.5.3.1. item 0. shall be within the limits as specified in Appendix 4 to this Annex.

3.3.3. The minimal distance between cabin and the box or semi-trailer shall be in accordance with manufacturer requirements and body builder instructions of the manufacturer.

3.3.4. The cabin and the aero accessories (e.g. spoilers) shall be adapted to best fit to the defined standard body or semi-trailer.

3.3.5. The vehicle shall fulfil the legal requirements for a whole vehicle type approval. Equipment which is necessary to execute the constant speed test (e.g. overall vehicle height including anemometer) is excluded from this provision.

3.3.6. The setup of the semi-trailer shall be as defined in Appendix 5 to this Annex.

3.3.7. The vehicle shall be equipped with tyres meeting the following demands:

i. Best or second best label for rolling resistance which is available at the moment the test is performed

ii. Maximum tread depth of 10 mm on the complete vehicle including trailer

iii. Tyres inflated to the highest allowable pressure of the tire manufacturer

3.3.8. The axle alignment shall be within the manufacturer specifications.

3.3.9. No active tyre pressure control systems are allowed to be used during the measurements of the low speed - high speed - low speed tests.

3.3.10. If the vehicle is equipped with an active aero device it has to be demonstrated to the approval authority that

i. The device is always activated and effective to reduce the air drag at vehicle speed over 60 km/h

ii. The device is installed and effective in a similar manner on all vehicles of the family.

If i. and ii. are not applicable the active aero device has to be fully deactivated during the constant speed test.

3.3.11. The vehicle shall not have any provisional features, modifications or devices that are aimed only to reduce the air drag value, e.g. sealed gaps. Modifications which aim to align the aerodynamic characteristics of the tested vehicle to the defined conditions for the parent vehicle (e.g. sealing of mounting-holes for sun-roofs) are allowed.

3.3.12. All different removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars are not considered in the air drag for the CO_2 regulation. Any such removable add on parts shall be removed from the vehicle before the air drag measurement

3.3.13. The vehicle shall be measured without payload.

3.4. Measurement equipment

The calibration laboratory shall comply with the requirements of either ISO/TS 16949, ISO 9000 series or ISO/IEC 17025. All laboratory reference measurement equipment, used for calibration and/or verification, shall be traceable to national (international) standards.

3.4.1. Torque

3.4.1.1. The direct torque at all driven axles shall be measured with one of the following measurement systems:

a. Hub torque meter

b. Rim torque meter

c. Half shaft torque meter

3.4.1.2. The following system requirements shall be met by a single torque meter by calibration:

i. Non linearity: < ± 6 Nm

ii. Repeatability: < ± 6 Nm

iii. Crosstalk: < ± 1 % FSO (only applicable for rim torque meters)

iv. Measurement rate: ≥ 20 Hz

where:

"Non linearity" means the maximum deviation between ideal and actual output signal characteristics in relation to the measurand in a specific measuring range.

"Repeatability" means closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement.

"Crosstalk" means signal at the main output of a sensor (M_y), produced by a measurand (F_z) acting on the sensor, which is different from the measurand assigned to this output. Coordinate system assignment is defined according to ISO 4130.

"FSO" means full scale output of calibrated range.

The recorded torque data shall be corrected for the instrument error determined by the supplier.

3.4.2. Vehicle speed

The vehicle speed is determined by the Vehicle Energy Consumption calculation Tool Air Drag tool based on the CAN-bus front axle signal which is calibrated based on either:

Option a) a reference speed calculated by a delta-time from two fixed opto-electronic barriers (see 3.4.4 of this Annex) and the known length(s) of the measurement section(s) or

Option b) a delta-time determined speed signal from the position signal of a DGPS and the known length(s) of the measurement section(s), derived by the DGPS coordinates

For the vehicle speed calibration the data recorded during the high speed test are used.

3.4.3. Reference signal for calculation of rotational speed of the wheels at the driven axle

For the calculation of rotational speed of the wheels at the driven axle the CAN engine speed signal together with the transmission ratios (gears for low speed test and high speed test, axle ratio) shall be made available. For the CAN engine speed signal it shall be demonstrated that the signal provided to Vehicle Energy Consumption calculation Tool Air Drag is identical to the signal to be used for in-service testing as set out in Annex I of 582/2011.

For vehicles with torque converter which are not able to drive the low speed test with closed lockup clutch additionally the cardan shaft speed signal and the axle ratio or the average wheel speed signal for the driven axle shall be provided to Vehicle Energy Consumption calculation Tool Air Drag. It shall be demonstrated that the engine speed calculated from this additional signal is within 1% range compared to the CAN engine speed. This shall be demonstrated for the average value over a measurement section driven at the lowest possible vehicle speed in the torque converter locked mode and at the applicable vehicle speed for the high speed test.

3.4.4. Opto-electronic barriers

The signal of the barriers shall be made available to Vehicle Energy Consumption calculation Tool Air Drag for triggering begin and end of the measurement section and the calibration of the vehicle speed signal. The measurement rate of the trigger signal shall be greater or equal to 100 Hz. Alternatively a DGPS system can be used.

3.4.5. (D)GPS system

Option a) for position measurement only: GPS

Required accuracy:

i. Position: < 3 m 95% Circular Error Probable

ii. Update rate: ≥ 4 Hz

Option b) for vehicle speed calibration and position measurement: Differential GPS system (DGPS)

Required accuracy:

i. Position: 0.15 m 95% Circular Error Probable

ii. Update rate: ≥ 100 Hz

3.4.6. Stationary weather station

Ambient pressure and humidity of the ambient air are determined from a stationary weather station. This meteorological instrumentation shall be positioned in a distance less than 2000 m to one of the measurement areas, and shall be positioned at an altitude exceeding or equal that of the measurement areas.

Required accuracy:

i. Temperature: ± 1°C

ii. Humidity: ± 5 %RH

iii. Pressure: ± 1 mbar

iv. Update rate: ≤ 5 minutes

3.4.7. Mobile anemometer

A mobile anemometer shall be used to measure air flow conditions, i.e. air flow velocity and yaw angle (β) between total air flow and vehicle longitudinal axis.

3.4.7.1. Accuracy requirements

The anemometer shall be calibrated in facility according to ISO 16622. The accuracy requirements according to Table 1 have to be fulfilled:

Table 1: Anemometer accuracy requirements

air speed range [m/s]	**accuracy air speed** [m/s]	**accuracy yaw angle** in yaw angle range of 180 ±7 degrees [degrees]
20 ± 1	± 0.7	± 1.0
27 ± 1	± 0.9	± 1.0
35 ± 1	± 1.2	± 1.0

3.4.7.2. Installation position

The mobile anemometer shall be installed on the vehicle in the prescribed position:

i. X position:

truck: front face ± 0.3 m of the semi-trailer or box-body

bus/coach: in the 1st fourth to the 3rd fourth of vehicle length

ii. Y position: plane of symmetry within a tolerance ± 0.1 m

iii. Z position:

The installation height above the vehicle shall be one third of total vehicle height with in a tolerance of 0.0 m to +0.2 m.

The instrumentation shall be done as exact as possible using geometrical/optical aids. Any remaining misalignment is subject to the misalignment calibration to be performed in accordance with 3.6 of this Annex.

3.4.7.3. The update rate of the anemometer shall be 4 Hz or higher.

3.4.8. Temperature transducer for ambient temperature on vehicle

The ambient air temperature shall be measured on the pole of the mobile anemometer. The installation height shall be maximum 600 mm below the mobile anemometer. The sensor shall be shielded to the sun.

Required accuracy: ± 1° C

Update rate: ≥ 1 Hz

3.4.9. Proving ground temperature

The temperature of the proving ground shall be recorded on vehicle by means of a contactless IR sensor by wideband (8 to 14 µm). For tarmac and concrete an emissivity factor of 0.90 shall be used. The IR sensor shall be calibrated according to ASTM E2847.

Required accuracy at calibration: Temperature: ± 2.5° C

Update rate: ≥ 1 Hz

3.5. Constant speed test procedure

On each applicable combination of measurement section and driving direction the constant speed test procedure consisting of the low speed, high speed and low speed test sequence as specified below shall be performed in the same direction.

3.5.1. The average speed within a measurement section in the low speed test shall be a in the range of 10 to 15 km/h.

3.5.2. The average speed within a measurement section in the high speed test shall be in the following range:

maximum speed: 95 km/h:

minimum speed: 85 km/h or 3 km/h less than the maximum vehicle speed the vehicle can be operated at the test track, which ever value is lower.

3.5.3. The testing shall be performed strictly according to the sequence as specified in 3.5.3.1 to 3.5.3.9 of this Annex.

3.5.3.1. Preparation of vehicle and measurement systems

i. Installation of torque meters on the driven axles of the test vehicle and check of installation and signal data according to the manufacturer specification.

ii. Documentation of relevant general vehicle data for the official testing template in accordance with 3.7 of this Annex.

iii. For the calculation of the acceleration correction by the Vehicle Energy Consumption calculation Tool Air Drag tool the actual vehicle weight shall be determined before the test within a range of ± 500 kg.

iv. Check of tyres for the maximum allowable inflation pressure and documentation of tyre pressure values.

v. Preparation of opto-electronic barriers at the measurement section(s) or check of proper function of the DGPS system.

vi. Installation of mobile anemometer on the vehicle and/or control of the installation, position and orientation. A misalignment calibration test has to be performed every time the anemometer has been mounted newly on the vehicle.

vii. Check of vehicle setup regarding the maximum height and geometry, with running engine. The maximum height of the vehicle shall be determined by measuring at the four corners of the box/semi-trailer.

viii. Adjustment the height of the semi-trailer to the target value and redo determination of maximum vehicle height if necessary.

ix. Mirrors or optical systems, roof fairing or other aerodynamic devices shall be in their regular driving condition.

3.5.3.2. Warm-up phase

Drive the vehicle minimum 90 minutes at the target speed of the high speed test to warm-up the system. A repeated warm up (e.g. after a configuration change, an invalid test etc.) shall be at least as long as the standstill time. The warm-up phase can be used to perform the misalignment calibration test as specified in 3.6 of this Annex.

3.5.3.3. Zeroing of torque meters

The zeroing of the torque meters shall be performed as follows:

i. Bring the vehicle to a standstill

ii. Lift the instrumented wheels off the ground

ii. Perform the zeroing of the amplifier reading of the torque meters

The standstill phase shall not exceed 10 minutes.

3.5.3.4. Drive another warm-up phase of minimum 10 minutes at the target speed of the high speed test.

3.5.3.5. First low speed test

Perform the first measurement at low speed. It shall be ensured that:

i. the vehicle is driven through the measurement section along a straight line as straight as possible

ii. the average driving speed is in accordance with 3.5.1 of this Annex for the measurement section and the preceding stabilisation section

iii. the stability of the driving speed inside the measurement sections and the stabilisation sections is in accordance with 3.10.1.1 item 0. of this Annex

iv. the stability of the measured torque inside the measurement sections and the stabilisation sections is in accordance with 3.10.1.1 item 0. of this Annex

v. the begin and end of the measurement sections is clearly recognizable in the measurement data via a recorded trigger signal (opto-electronic barriers plus recorded GPS data) or via use of a DGPS system

vi. driving at the parts of the test track outside the measurement sections and the preceding stabilisation sections shall be performed without any delay. Any unnecessary manoeuvres shall be avoided during these phases (e.g. driving in sinuous lines)

vii. the maximum time for the low speed test shall not exceed 20 minutes in order to prevent cool down of the tires.

3.5.3.6. Drive another warm-up phase of minimum 5 minutes at the target speed of the high speed test.

3.5.3.7. High speed test

Perform the measurement at the high speed. It shall be ensured that:

i. the vehicle is driven through the measurement section along a straight line as straight as possible

ii. the average driving speed is in accordance with 3.5.2 of this Annex for the measurement section and the preceding stabilisation section

iii. the stability of the driving speed inside the measurement sections and the stabilisation sections is in accordance with 3.10.1.1 item 0. of this Annex

iv. the stability of the measured torque inside the measurement sections and the stabilisation sections is in accordance with 3.10.1.1 item 0. of this Annex

v. the begin and end of the measurement sections is clearly recognizable in the measurement data via a recorded trigger signal (opto-electronic barriers plus recorded GPS data) or via use of a DGPS system

vi. in the driving phases outside the measurement sections and the preceding stabilization sections any unnecessary manoeuvres shall be avoided (e.g. driving in sinuous lines, unnecessary accelerations or decelerations)

vii. the distance between the measured vehicle to another driven vehicle on the test track shall be at least 500 m.

viii. at least 10 valid passings per heading are recorded

The high speed test can be used to determine the misalignment of the anemometer if the provisions stated in 3.6 are fulfilled.

3.5.3.8. Second low speed test

Perform the second measurement at the low speed directly after the high speed test. Similar provisions as for the first low speed test shall be fulfilled.

3.5.3.9. Drift check of torque meters

Directly after the finalisation of the second low speed test the drift check of the torque meters shall be performed in accordance to the following procedure:

1. Bring the vehicle to standstill

2. Lift the instrumented wheels off the ground

3. The drift of each torque meter calculated from the average of the minimum sequence of 10 seconds shall be less than 25 Nm.

Exceeding this limit leads to an invalid test.

3.6. Misalignment calibration test

The misalignment of the anemometer shall be determined by a misalignment calibration test on the test track.

3.6.1. At least 5 valid passings of a 250 ± 3 m straight section driven in each direction at high vehicle speed shall be performed.

3.6.2. The validity criteria for wind conditions as specified in section 3.2.5 of this Annex and the test track criteria as specified in section 3.1 of this Annex are applicable.

3.6.3. The data recorded during the misalignment calibration test shall be used by the Vehicle Energy Consumption calculation Tool Air Drag tool to calculate the misalignment error and perform the according correction. The signals for wheel torques and engine speed are not used in the evaluation.

3.6.4. The misalignment calibration test can be performed independently from the constant speed test procedure. If the misalignment calibration test is performed separately it shall be executed as follows:

i. Prepare the opto-electronic barriers at the 250 m ± 3 m section, or check the proper function of the DGPS System.

ii. Check the vehicle setup regarding the height and geometry in accordance with 3.5.3.1 of this Annex. Adjust the height of the semi-trailer to the requirements as specified in Annex 4 to this Annex if necessary

iii. No prescriptions for warm-up are applicable

iv Perform the misalignment calibration test by at least 5 valid passings as described above.

3.6.5. A new misalignment test shall be performed in the following cases:

a. the anemometer has been dismounted from the vehicle

b. the anemometer has been moved

c. a different tractor or truck is used

d. the cab family has been changed

3.7. Testing Template

In addition to the recording of the modal measurement data, the testing shall be documented in a template which contains at least the following data:

i. General vehicle description (specifications see Appendix 2 - Information Document)

ii. Actual maximum vehicle height as determined according to 3.5.3.1. item 0

iii. Start time and date of the test

iv. Vehicle mass within a range of ± 500 kg

v. Tyre pressures

vi. Filenames of measurement data

vii. Documentation of extraordinary events (with time and number of measurement sections), e.g.

- close passing of another vehicle
- manoeuvres to avoid accidents, driving errors

- technical errors
- measurement errors

3.8. Data processing

3.8.1. The recorded data shall be synchronised and aligned to 100 Hz temporal resolution, either by arithmetical average, nearest neighbour or linear interpolation.

3.8.2. All recorded data shall be checked for any errors. Measurement data shall be excluded from further consideration in the following cases:

- Datasets became invalid due to events during the measurement (see 3.7 item 0)
- Instrument saturation during the measurement sections (e.g. high wind gusts which might have led to anemometer signal saturation)
- Measurements in which the permitted limits for the torque meter drift were exceeded

3.8.3. For the evaluation of the constant speed tests the application of the Vehicle Energy Consumption calculation Tool Air Drag tool as provided by the European Commission is obligatory. Besides the above mentioned data processing, all evaluation steps including validity checks (with exception of the list as specified above) are performed by Vehicle Energy Consumption calculation Tool Air Drag.

3.9. Input data for Vehicle Energy Consumption calculation Tool Air Drag tool

The following tables show the requirements for the measurement data recording and the preparatory data processing for the input into the Vehicle Energy Consumption calculation Tool Air Drag tool:

Table 2 for the vehicle data file

Table 3 for the ambient conditions file

Table 4 for the measurement section configuration file

Table 5 for the measurement data file

Table 6 for the altitude profile files (optional input data)

A detailed description of the requested data formats, the input files and the evaluation principles can be found in the technical documentation of the Vehicle Energy Consumption calculation Tool Air Drag tool. The data processing shall be applied as specified in section 3.8 of this Annex.

Table 2: Input data for Vehicle Energy Consumption calculation Tool Air Drag – vehicle data file

Input data	**Unit**	**Remarks**
Vehicle class code	[-]	1 - 17 for trucks, 21 - 23 for buses

Input data	Unit	Remarks
Vehicle configuration	[-]	"rigid" or "tractor" for truck/tractor and trailer configuration
Vehicle test mass	[kg]	actual mass during measurements
Gross vehicle mass	[kg]	Gross vehicle mass of the rigid or tractor (w/o trailer or semitrailer)
Axle ratio	[-]	axle transmission ratio*[1], *[2]
Gear ratio high speed	[-]	transmission ratio of gear engaged during high speed test*[1]
Gear ratio low speed	[-]	transmission ratio of gear engaged during low speed test*[1]
Anemometer height	[m]	height above ground of the measurement point of installed anemometer
Vehicle height	[m]	maximum vehicle height according to 3.5.3.1 item 0.
Gear box type	[-]	manual or automated transmission: "MT_AMT" automatic transmission with torque converter: "AT"
Vehicle maximum speed	[km/h]	Maximum speed the vehicle can be practically operated at the test track *[3]

*[1] specification of transmission ratios with at least 3 digits after decimal separator
*[2] if the wheel speed signal is provided to Vehicle Energy Consumption calculation Tool Air Drag (option for vehicles with torque converters, see section 3.4.3) the axle ratio shall be set to "1.000"

*[3] input only required if value is lower than 88 km/h

Table 3: Input data for Vehicle Energy Consumption calculation Tool Air Drag – ambient conditions file

Signal	Column identifier in input file	Unit	Measurement rate	Remarks
Time	<t>	[s] since daystart	-	-

Ambient temperature	<t_amb_stat>	[°C]		Stationary weather station
Ambient pressure	<p_amb_stat>	[mbar]	At least 1 averaged value per 5 minutes	Stationary weather station
Relative air humidity	<rh_stat>	[%]		Stationary weather station

Table 4: Input data for Vehicle Energy Consumption calculation Tool Air Drag – measurement section configuration file

Input data	**Unit**	**Remarks**
Trigger signal used	[-]	1 = trigger signal used; 0 = no trigger signal used
Measurement section ID	[-]	user defined ID number
Driving direction ID	[-]	user defined ID number
Heading	[°]	Heading of the driving direction
Length of the measurement section	[m]	-
Latitude start point of section	decimal degrees or decimal minutes	standard GPS, unit decimal degrees: minimum 5 digits after decimal separator
Longitude start point of section		standard GPS, unit decimal minutes: minimum 3 digits after decimal separator
Latitude end point of section		DGPS, unit decimal degrees: minimum 7 digits after decimal separator
Longitude end point of section		DGPS, unit decimal minutes: minimum 5 digits after decimal separator

Table 5: Input data for Vehicle Energy Consumption calculation Tool Air Drag – measurement data file

Signal	Column identifier in input file	Unit	Measurement rate	Remarks
Time	<t>	[s] since day start	100 Hz	rate fixed to 100Hz; time signal used for correlation with weather data and for check of frequency
(D)GPS latitude	<lat>	decimal degrees or decimal minutes	GPS: ≥ 4 Hz DGPS: ≥ 100 Hz	standard GPS, unit decimal degrees: minimum 5 digits after decimal separator
(D)GPS longitude	<long>			standard GPS, unit decimal minutes: minimum 3 digits after decimal separator DGPS, unit decimal degrees: minimum 7 digits after decimal separator DGPS, unit decimal minutes: minimum 5 digits after decimal separator
(D)GPS heading	<hdg>	[°]	≥ 4Hz	
DGPS velocity	<v_veh_GPS>	[km/h]	≥ 20 Hz	not used in analysis if opto-electronic barriers are used
Vehicle velocity	<v_veh_CAN>	[km/h]	≥ 20 Hz	raw CAN bus front axle signal
Air speed	<v_air>	[m/s]	≥ 4 Hz	raw data (instrument reading)
Inflow angle (beta)	<beta>	[°]	≥ 4 Hz	raw data (instrument reading); "180°" refers to air flow from front
Engine speed or Cardan speed	<n_eng> or <n_card>	[rpm]	≥ 20 Hz	cardan speed for vehicles with torque converter not locked during low speed test
Torque meter (left wheel)	<tq_l>	[Nm]	≥ 20 Hz	-
Torque meter (right wheel)	<tq_r>	[Nm]	≥ 20 Hz	
Ambient temperature on vehicle	<t_amb_veh>	[°C]	≥ 1 Hz	
Trigger signal	<trigger>	[-]	100 Hz	optional signal; required if measurement sections are identified by opto electronic barriers (option "trigger_used=1")

Signal	Column identifier in input file	Unit	Measurement rate	Remarks
Proving ground temperature	<t_ground>	[°C]	≥ 1 Hz	
Validity	<valid>	[-]	-	optional signal (1=valid; 0=invalid);

Table 6: Input data for Vehicle Energy Consumption calculation Tool Air Drag – altitude profile file

Input data	Unit	Remarks
Latitude	decimal degrees or decimal minutes	unit decimal degrees: minimum 7 digits after decimal separator unit decimal minutes: minimum 5 digits after decimal separator
Longitude		
Altitude	[m]	minimum 2 digits after decimal separator

3.10. Validity criteria

This sections sets out the criteria to obtain valid results in Vehicle Energy Consumption calculation Tool Air Drag.

3.10.1. Validity criteria for the constant speed test

3.10.1.1. Vehicle Energy Consumption calculation Tool Air Drag accepts datasets as recorded during the constant speed test in case the following validity criteria are met:

i. the average vehicle speed is inside the criteria as defined in 3.5.2

ii. the ambient temperature is inside the range as described in 3.2.2. This criterion is checked by Vehicle Energy Consumption calculation Tool Air Drag based on the ambient temperature measured on the vehicle.

iii. the proving ground temperature is in the range as described in 3.2.3

iv. valid average wind speed conditions according to point 3.2.5 item 0

v. valid gust wind speed conditions according to point 3.2.5 item 0

vi. valid average yaw angle conditions according to point 3.2.5 item 0

vii. stability criteria for vehicle speed met:

Low speed test:

$$(v_{lms,avrg} - 0.5\ km/h) \leq v_{lm,avrg} \leq (v_{lms,avrg} + 0.5\ km/h)$$

where:

$v_{lms,avrg}$	=	average of vehicle speed per measurement section [km/h]
$v_{lm,avrg}$	=	central moving average of vehicle speed with X_{ms} seconds time base [km/h]
X_{ms}	=	time needed to drive 25 m distance at actual vehicle speed [s]

High speed test:

$$(v_{hms,avrg} - 0.3\ km/h) \leq v_{hm,avrg} \leq (v_{hms,avrg} + 0.3\ km/h)$$

where:

$v_{hms,avrg}$	=	average of vehicle speed per measurement section [km/h]
$v_{hm,avrg}$	=	1 s central moving average of vehicle speed [km/h]

viii. stability criteria for vehicle torque met:

Low speed test:

$$(T_{lms,avrg} - T_{grd}) * 0.7 \leq (T_{lm,avrg} - T_{grd}) \leq (T_{lms,avrg} - T_{grd}) * 1.3$$

$$T_{grd} = F_{grd,avrg} * r_{dyn,avrg}$$

where:

$T_{lms,avrg}$	=	average of T_{sum} per measurement section
T_{grd}	=	average torque from gradient force
$F_{grd,avrg}$	=	average gradient force over measurement section
$r_{dyn,avrg}$	=	average effective rolling radius over measurement section (formula see item ix.) [m]
T_{sum}	=	T_L+T_R; sum of corrected torque values left and right wheel [Nm]
$T_{lm,avrg}$	=	central moving average of T_{sum} with X_{ms} seconds time base
X_{ms}	=	time needed to drive 25 m distance at actual vehicle speed [s]

High speed test

$$(T_{hms,avrg} - T_{grd}) * 0.8 \leq (T_{hm,avrg} - T_{grd}) \leq (T_{hms,avrg} - T_{grd}) * 1.2$$

where:

$T_{hms,avrg}$	=	average of T_{sum} per measurement section [Nm]
T_{grd}	=	average torque from gradient force (see Low speed test) [Nm]
T_{sum}	=	T_L+T_R; sum of corrected torque values left and right wheel [Nm]
$T_{hm,avrg}$	=	1 s central moving average of T_{sum} [Nm]

ix. valid heading of the vehicle during passing a measurement section (< 10° deviation from target heading applicable for low speed test, high speed test and misalignment test)

x. driven distance inside measurement section calculated from the calibrated vehicle speed does not differ from target distance by more than 3 meters (applicable for low speed test and high speed test)

xi. plausibility check for engine speed or cardan speed whichever is applicable passed:

Engine speed check for high speed test:

$$\frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{(v_{hms,avrg} - 0.3)}{3.6}}{r_{dyn,ref,HS} \cdot \pi} \cdot (1 - 2\%) \leq n_{eng,1s} \leq \frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{(v_{hms,avrg} + 0.3)}{3.6}}{r_{dyn,ref,HS} \cdot \pi} \cdot (1 + 2\%)$$

$$r_{dyn,avrg} = \frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{v_{hms,avrg}}{3.6}}{n_{eng,avrg} \cdot \pi}$$

$$r_{dyn,ref,HS} = \frac{1}{n}\sum_{j=1}^{n} r_{dyn,avrg,j}$$

where:

i_{gear}	=	transmission ratio of the gear selected in high speed test [-]
i_{axle}	=	axle transmission ratio [-]
$v_{hms,avrg}$	=	average vehicle speed (high speed measurement section) [km/h]
$n_{eng,1s}$	=	1 s central moving average of engine speed (high speed measurement section) [rpm]
$r_{dyn,avrg}$	=	average effective rolling radius for a single high speed measurement section [m]
$r_{dyn,ref,HS}$	=	reference effective rolling radius calculated from all valid high speed measurement sections (number = n) [m]

Engine speed check for low speed test:

$$\frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{(v_{lms,avrg} - 0.5)}{3.6}}{r_{dyn,ref,LS1/LS2} \cdot \pi} \cdot (1 - 2\%) \leq n_{eng,float} \leq \frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{(v_{lms,avrg} + 0.5)}{3.6}}{r_{dyn,ref,LS1/LS2} \cdot \pi} \cdot (1 + 2\%)$$

$$r_{dyn,avrg} = \frac{30 \cdot i_{gear} \cdot i_{axle} \cdot \frac{v_{hms,avrg}}{3.6}}{n_{eng,avrg} \cdot \pi}$$

$$r_{dyn,ref,LS1/LS2} = \frac{1}{n} \sum_{j=1}^{n} r_{dyn,avrg,j}$$

where:

i_{gear}	=	transmission ratio of the gear selected in low speed test [-]
i_{axle}	=	axle transmission ratio [-]
$v_{lms,avrg}$	=	average vehicle speed (low speed measurement section) [km/h]
$n_{eng,float}$	=	central moving average of engine speed with X_{ms} seconds time base (low speed measurement section) [rpm]
X_{ms}	=	time needed to drive 25 meter distance at low speed [s]
$r_{dyn,avrg}$	=	average effective rolling radius for a single low speed measurement section [m]
$r_{dyn,ref,LS1/LS2}$	=	reference effective rolling radius calculated from all valid measurement sections for low speed test 1 or low speed test 2 (number = n) [m]

The plausibility check for cardan speed is performed in an analogue way with $n_{eng,1s}$ replaced by $n_{card,1s}$ (1 s central moving average of cardan speed in the high speed measurement section) and $n_{eng,float}$ replaced by $n_{card,float}$ (moving average of cardan speed with X_{ms} seconds time base in the low speed measurement section) and i_{gear} set to a value of 1.

xii. the particular part of the measurement data was not marked as “invalid” in the Vehicle Energy Consumption calculation Tool Air Drag input file.

3.10.1.2. Vehicle Energy Consumption calculation Tool Air Drag excludes single datasets from the evaluation in the case of unequal number of datasets for a particular combination of measurement section and driving direction for the first and the second low speed test. In this case the first datasets from the low speed run with the higher number of datasets are excluded.

3.10.1.3. Vehicle Energy Consumption calculation Tool Air Drag excludes single combinations of measurement sections and driving directions from the evaluation if:

i. no valid dataset is available from low speed test 1 or/and low speed test 2

ii. less than two valid datasets from the high speed test are available

3.10.1.4. Vehicle Energy Consumption calculation Tool Air Drag considers the complete constant speed test invalid in the following cases:

i. test track requirements as described in 3.1.1 not met

ii. less than 10 datasets per heading available (high speed test)

iii. less than 5 valid datasets per heading available (misalignment calibration test)

iv. the rolling resistance coefficients (RRC) as calculated according to Appendix 1 point 4 step 4 for the first and the second low speed test differ more than 0.40 kg/t

3.10.2. Validity criteria for the misalignment test

3.10.2.1. Vehicle Energy Consumption calculation Tool Air Drag accepts datasets as recorded during the misalignment test in case the following validity criteria are met:

i. the average vehicle speed is inside the criteria as defined in 3.5.2 for the high speed test

ii. valid average wind speed conditions according to point 3.2.5 item 0

iii. valid gust wind speed conditions according to point 3.2.5 item 0

iv. valid average yaw angle conditions according to point 3.2.5 item 0

v. stability criteria for vehicle speed met:

$$(v_{hms,avrg} - 1\ km/h) \leq v_{hm,avrg} \leq (v_{hms,avrg} + 1\ km/h)$$

where:

$v_{hms,avrg}$ = average of vehicle speed per measurement section [km/h]

$v_{hm,avrg}$ = 1 s central moving average of vehicle speed [km/h]

3.10.2.2. Vehicle Energy Consumption calculation Tool Air Drag considers the data from a single measurement section invalid in the following cases:

i. the average vehicle speeds from all valid datasets from each driving directions differ by more than 2 km/h.

ii. less than 5 datasets per heading available

3.10.2.3. Vehicle Energy Consumption calculation Tool Air Drag considers the complete misalignment test invalid in case no valid result for a single measurement section is available.

3.11. Declaration of air drag value

Base value for the declaration of the air drag value is the final result for $C_d{\cdot}A_{cr}\ (0)$ as calculated by the Vehicle Energy Consumption calculation Tool Air Drag tool. The applicant for a certificate shall declare a value $C_d{\cdot}A_{declared}$ in a range from equal to a maximum of +0.2 m² higher than $C_d{\cdot}A_{cr}\ (0)$. This tolerance shall take into account uncertainties in the selection of the parent vehicles as the worst case for all testable members of the family. The value $C_d{\cdot}A_{declared}$ shall be the input for the Vehicle Energy Consumption calculation Tool CO_2 simulation tool and the reference value for conformity of production testing.

Appendix 1

MODEL OF A CERTIFICATE OF A COMPONENT, SEPARATE TECHNICAL UNIT OR SYSTEM

Maximum format: A4 (210 x 297 mm)

CERTIFICATE

Stamp administration

Communication concerning:

– granting[(1)]

– extension [(1)]

– refusal [(1)]

– withdrawal [(1)]

of a certificate for components, separate technical units and systems with regard to Regulation (EC) No 595/2009 as implemented by Regulation No … [this Regulation].

Regulation (EC) No XXXXX and Regulation No … [this Regulation] as last amended by ……………..

certification number:

Hash:

Reason for extension:

SECTION I

0.1. Make (trade name of manufacturer):

0.2. Vehicle body and air drag type / family (if applicable):

0.3. Vehicle body and air drag Family member (in case of family)

0.3.1. Vehicle body and air drag parent

0.3.2. Vehicle body and air drag types within the family

0.4. Means of identification of type, if marked

0.4.1. Location of the marking:

0.5. Name and address of manufacturer:

0.6. In the case of components and separate technical units, location and method of affixing of the EC certification mark:

0.7. Name(s) and address(es) of assembly plant(s):

0.9. Name and address of the manufacturer's representative (if any)

SECTION II

1. Additional information (where applicable): see Addendum

2. Technical service responsible for carrying out the tests:

3. Date of test report:

4. Number of test report:

5. Remarks (if any): see Addendum

6. Place:

7. Date:

8. Signature:

Attachments:

Information package. Test report.

Appendix 2

Vehicle body and air drag information document

Description sheet no.:	Issue:
	from:
	Amendment:

pursuant to …

Vehicle Body and Air Drag type or family (if applicable):

General remark: For Vehicle Energy Consumption calculation Tool input data an electronic file format need to be defined which can be used for data import to the Vehicle Energy Consumption calculation Tool. The Vehicle Energy Consumption calculation Tool input data may differ from the data requested in the information document and vice versa (to be defined). A data file is especially necessary wherever large data such as efficiency maps need to be handled (no manual transfer / input necessary).

…

0.0.	GENERAL
0.1.	Name and address of manufacturer
0.2.	Make (trade name of manufacturer):
0.3.	Vehicle Body and Air Drag type (family if applicable):
0.4.	Commercial name(s) (if available):
0.5.	Means of identification of type, if marked on the vehicle:
0.6.	In the case of components and separate technical units, location and method of affixing of the certification mark:
0.7.	Name(s) and address(es) of assembly plant(s):
0.8.	Name and address of the manufacturer's representative:

PART 1

ESSENTIAL CHARACTERISTICS OF THE (PARENT) VEHICLE MODY AND AIR DRAG

Types within a vehicle body and air drag family

Parent

vehicle configuration

1.0.	SPECIFIC AIR DRAG INFORMATION
1.1.0	VEHICLE
1.1.1	HDV class according to HDV CO2 scheme
1.2.0.	Vehicle class
1.2.1.	Vehicle Model
1.2.2.	Axle configuration
1.2.3.	Max. gross vehicle weight
1.2.4.	Cabin line
1.2.5.	Cabin width (max. value in Y direction)
1.2.6.	Cabin length (max. value in X direction)
1.2.7.	Roof height
1.2.8.	Wheel base
1.2.9.	Height cabin over frame
1.2.10.	Frame height
1.2.11.	Aeordynamic accessories or add-ons (e.g. roof spoiler, side extender, side skirts, corner vanes)
1.2.12.	Tire dimensions front axle
1.2.13.	Tire dimensions driven axles(s)
1.3.	Body specifications (according to norm body definition)

Parent

vehicle configuration

1.4.	(Semi-) Trailer specifications (according to norm (semi-) trailer specification)
1.5.	Parameter defining the family in accordance with the description of the applicant (parent criteria and deviated family criteria)

LIST OF ATTACHMENTS

No.	Description	Date of issue
1	Information on test conditions	

Attachment 1 to Information Document

Information on test conditions (if applicable)

Test track on which tests have been conducted:

Total vehicle mass during measurement [kg]:

Maximum vehicle height during measurement [m]:

Average ambient conditions during first low speed test [°C]:

Average vehicle speed during high speed tests [km/h]:

Product of drag coefficient (C_d) by cross sectional area (A_{cr}) for zero crosswind conditions $C_dA_{cr}(0)$ [m²]:

Product of drag coefficient (C_d) by cross sectional area (A_{cr}) for average crosswind conditions during constant speed test $C_dA_{cr}(\beta)$ [m²]:

Average yaw angle during constant speed test β [°]:

Declared air drag value $C_d \cdot A_{declared}$ [m²]:

Appendix 3

Vehicle height requirements

1. Vehicles measured in the constant speed test according to section 3 of this Annex have to meet the vehicle height requirements as shown in Table 7.
2. The vehicle height has to be determined as described in 3.5.3.1. item 0
3. Vehicles of vehicles classes not shown in Table 7 are not subject to constant speed testing.

Table 7: Vehicle Height Requirements

Vehicle class	minimum vehicle height [m]	maximum vehicle height [m
1	3.40	3.60
2	3.50	3.75
3	3.70	3.90
4	3.85	4.00
5	3.90	4.00
9	similar values than rigid with same maximum gross vehicle weight (class 1, 2, 3 or 4)	
10	3.90	4.00

4. For buses and coaches vehicle height requirements do not apply.

Appendix 4

Standard body and semitrailer configurations

1. Vehicles measured in the constant speed test according to section 3 of this Annex have to fulfill the requirements on standard bodies and standard semitrailer as described in this Appendix.

2. The applicable standard body or semitrailer shall be determined from Table 8.

Table 8: Allocation of standard bodies and semitrailer for constant speed testing

Vehicle class	**Standard body or trailer**
1	B1
2	B2
3	B3
4	B4
5	ST1
9	depending on maximum gross vehicle weight: 7.5 – 10t: B1 >10 – 12t: B2 >12 – 16t: B3 >16t: B5
10	ST1

3. The standard bodies B1, B2, B3, B4 and B5 shall be constructed as a hard shell body in dry-out box design. They shall be equipped with two rear doors and without any side doors. The standard bodies shall not be equipped with tail lifts, front spoilers or side fairings for reduction of aerodynamic drag. The specifications of the standard bodies are given in:

Table 9 for standard body “B1”

Table 10 for standard body “B2”

Table 11 for standard body “B3”

Table 12 for standard body “B4”

Table 13 for standard body “B5”

Mass indications as given in Table 9 to Table 13 are not subject to inspection for air drag testing.

4. The type and chassis requirements for the standard semitrailer ST1 are listed in Table 14. The specifications are given in Table 15.

5. All dimensions and masses without tolerances mentioned explicitly shall be in line with Reg.1230/2012/EC, Annex 1, Appendix 2 (i.e. in the range of ± 3% of the target value).

Table 9: Specifications of standard body "B1"

Specification	**Unit**	**External dimension (tolerance)**	**Remarks**
Length	[mm]	6,200	
Width	[mm]	2,550 **(**-10)	
Height	[mm]	2,680 **(**±10)	box: external height: 2,560 longitudinal beam: 120
Corner radius side & roof with front panel	[mm]	50 - 80	
Corner radius side with roof panel	[mm]	50 - 80	
Remaining corners	[mm]	broken with radius ≤ 10	
Mass	[kg]	1,600	has not be verified during air drag testing

Table 10: Specifications of standard body "B2"

Specification	**Unit**	**External dimension (tolerance)**	**Remarks**
Length	[mm]	7,400	
Width	[mm]	2,550 **(**-10)	
Height	[mm]	2,760 **(**±10)	box: external height: 2,640 longitudinal beam: 120

EN EN

Specification	Unit	External dimension (tolerance)	Remarks
Corner radius side & roof with front panel	[mm]	50 - 80	
Corner radius side with roof panel	[mm]	50 - 80	
Remaining corners	[mm]	broken with radius ≤-10	
Mass	[kg]	1,900	has not be verified during air drag testing

Table 11: Specifications of standard body "B3"

Specification	Unit	External dimension (tolerance)	Remarks
Length	[mm]	7,450	
Width	[mm]	2,550 **(**-10)	legal limit (96/53EU), internal ≥ 2,480
Height	[mm]	2,880 **(**±10)	box: external height: 2,760 longitudinal beam: 120
Corner radius side & roof with front panel	[mm]	50 - 80	
Corner radius side with roof panel	[mm]	50 - 80	
Remaining corners	[mm]	broken with radius ≤ 10	
Mass	[kg]	2,000	has not be verified during air drag testing

Table 12: Specifications of standard body "B4"

Specification	Unit	External dimension (tolerance)	Remarks
Length	[mm]	7,450	
Width	[mm]	2,550 **(**-10)	
Height	[mm]	2,980 **(**±10)	box: external height: 2,860 longitudinal beam: 120
Corner radius side & roof with front panel	[mm]	50 - 80	
Corner radius side with roof panel	[mm]	50 - 80	
Remaining corners	[mm]	broken with radius ≤ 10	
Mass	[kg]	2,100	has not be verified during air drag testing

Table 13: Specifications of standard body "B5"

Specification	Unit	External dimension (tolerance)	Remarks
Length	[mm]	7,820	internal ≥ 7,650
Width	[mm]	2,550 **(**-10)	legal limit (96/53EU), internal ≥ 2,460
Height	[mm]	2,980 **(**±10)	box: external height: 2,860 longitudinal beam: 120
Corner radius side & roof with front panel	[mm]	50 - 80	
Corner radius side with roof panel	[mm]	50 - 80	
Remaining corners	[mm]	broken with radius ≤ 10	

Specification	Unit	External dimension (tolerance)	Remarks
Mass	[kg]	2,200	has not be verified during air drag testing

Table 14: Type and chassis configuration of standard semitrailer “ST1”

Type of trailer	3-axle semi-trailer w/o steering axle(s)
Chassis configuration	• End to end ladder frame • Frame w/o underfloor cover • 2 stripes at each side as underride protection • Rear underride protection (UPS) • Rear lamp holder plate • w/o pallet box • Two spare wheels after the 3rd axle • One toolbox at the end of the body before UPS (left or right side) • Mud flaps before and behind axle assembly • Air suspension • Disc brakes • Tyre size: 385/65 R 22.5 • 2 back doors • w/o side door(s) • w/o tail lift • w/o front spoiler • w/o side fairings for aero

Table 15: Specifications standard trailer “ST1”

Specification	Unit	External dimension (tolerance)	Remarks
Total length	[mm]	13,685	
Total width (Body width)	[mm]	2,550 (-10)	
Body height	[mm]	2,850 (±10)	max. full height: 4,000 (96/53EU)
Full height, unloaded	[mm]	4,000 (-10)	height over the complete length specification for semi-trailer, not relevant for

Specification	Unit	External dimension (tolerance)	Remarks
			checking of vehicle height during constant speed test
Trailer coupling height, unloaded	[mm]	1,150	specification for semitrailer, not subject to inspection during constant speed test
Wheelbase	[mm]	7,700	
Axle distance	[mm]	1,310	3-axle assembly, 24t (96/53EU)
Front overhang	[mm]	1,685	radius: 2,040 (legal limit, 96/53EU)
Front wall			flat wall with attachments for compressed air and electricity
Corner front/side panel	[mm]	broken with strip under 45° and edge radii ≤ 5	within a radius of 2,040 (origin: kingpin), (legal limit, 96/53EU)
Remaining corners	[mm]	broken with radius ≤ 10	
Toolbox dimension vehicle x-axis	[mm]	655	Tolerance: ± 10% of target value
Toolbox dimension vehicle y-axis	[mm]	445	Tolerance: ± 5% of target value
Toolbox dimension vehicle z-axis	[mm]	495	Tolerance: ± 5% of target value
Side underride protection length	[mm]	3,045	2 stripes at each side, acc. ECE- R 73, Amendment 01 (2010), +/- 100 depending on wheelbase
Stripe profile	[mm^2]	100 x 30	ECE- R 73, Amendment 01 (2010)
Technical cross vehicle weight	[kg]	39,000	legal CVWR: 24,000 (96/53EU)

Specification	Unit	External dimension (tolerance)	Remarks
Vehicle curb weight	[kg]	7,500	has not be verified during air drag testing
Allowable axle load	[kg]	24,000	legal limit (96/53EU)
Technical axle load	[kg]	27,000	3 x 9,000

Appendix 5

Air drag family for trucks

1. General

An air drag family is characterized by design and performance parameters. These shall be common to all vehicles within the family. The manufacturer may decide which vehicles belong to an air drag family as long as the membership criteria listed in paragraph 4 are respected. The air drag family shall be approved by the approval authority. The manufacturer shall provide to the approval authority the appropriate information relating to the air drag of the members of the air drag family.

2. Special cases

In some cases there may be interaction between parameters. This shall be taken into consideration to ensure that only vehicles with similar characteristics are included within the same air drag family. These cases shall be identified by the manufacturer and notified to the approval authority. It shall then be taken into account as a criterion for creating a new air drag family.

In addition to the parameters listed in paragraph 4, the manufacturer may introduce additional criteria allowing the definition of families of more restricted size.

3. All vehicles within a family get the same air drag value than the corresponding "parent vehicle" of the family. This air drag value has to be measured on the parent vehicle according to the constant speed test procedure as described in section 3 of the main part of this Annex.

4. Parameter defining the air drag family :

4.1. Vehicles are allowed to be grouped within a family if the following criteria are fulfilled:

a) Same cabin width and body in white geometry up to B-pillar and above the heel point excluding the cab bottom (e.g. engine tunnel). All members of the family stay within a range of ± 10 mm to the parent vehicle.

b) Same roof height in vertical Z. All members of the family stay within a range of ± 10 mm to the parent vehicle.

c) Same height of cabin over frame. This criterion is fulfilled if the height difference of the cabins over frame stays within Z < 175mm.

The fulfillment of the family concept requirements shall be demonstrated by CAD (computer-aided design) data.

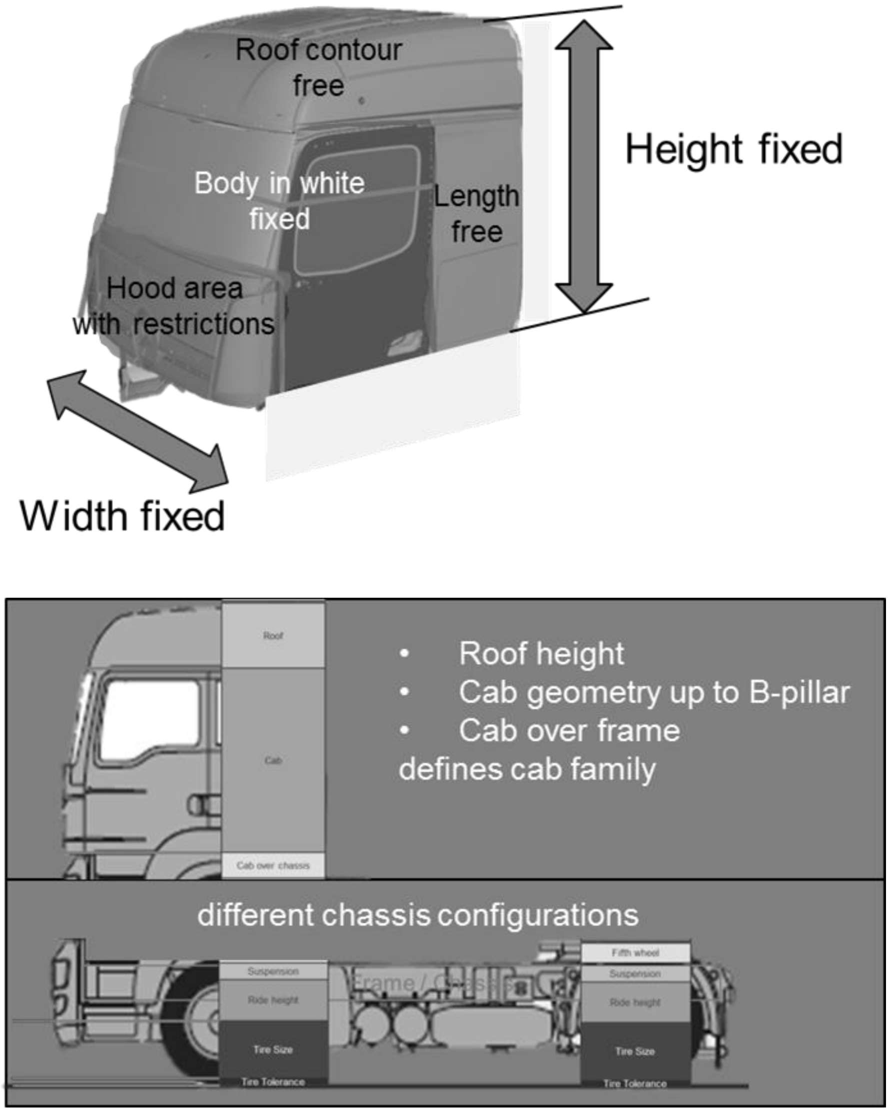


Figure 1: Family definition

4.2. An air drag family consist of testable members and vehicle configurations which can not be tested in accordance with this regulation.

4.3. Testable members of a family are vehicle configurations, which fulfill the installation requirements as defined in 3.3 in the main part of this Annex.

5. Choice of the air drag parent vehicle

5.1. The parent vehicle of each family shall be selected according to the following criteria:

5.2. The vehicle chassis shall fit to the dimensions of the standard body or semi-trailer as defined in Appendix 5 of this Annex.

5.3. All testable members of the family shall have an equal or lower air drag value than the value $C_d \cdot A_{declared}$ declared for the parent vehicle.

5.4. The applicant for a certificate shall be able to demonstrate that the selection of the parent vehicle meets the provisions as stated in 5.3 based on scientific methods e.g. CFD, wind tunnel results or good engineering practice. This provision applies for all vehicle variants which can be tested by the constant speed procedure as described in this Annex. Other vehicle configurations (e.g. vehicle heights not in accordance with the provisions in Appendix 4, wheel bases not compatible with the standard body dimensions of Appendix 5) shall get the same air drag value as the testable parent within the family without any further demonstration. As tires are considered as part of the measurement equipment, their influence shall be excluded in proving the worst case scenario.

5.5. Air drag values can be used for creation of families in other vehicle classes if the family criteria in accordance with point 5 of this Appendix are met based on the provisions given in Table 16.

Table 16: Provisions for transfer of air drag values to other vehicle classes

Vehicle class	**Transfer formula**	**Remarks**
1	Class 2 – 0.2 m²	Only allowed if value for class 2 was measured
2	Class 3 – 0.2 m²	Only allowed if value for class 3 was measured
3	Class 4 – 0.2 m²	
4	No transfer allowed	
5	No transfer allowed	
9	Class 1,2,3,4 + 0.1 m²	Applicable class for transfer has to match with gross vehicle weight. Transfer of already transferred values allowed.
10	Class 1,2,3,5 + 0.1 m²	
11	Class 9	Transfer of already transferred values allowed
12	Class 10	Transfer of already transferred values allowed
16	No transfer allowed	Only table value applicable

Appendix 6

Conformity of production

1. The conformity of production shall be verified by constant speed tests as laid down in section 3 of the main part of this Annex. For conformity of production (CoP) the following additional provisions apply:

   i. The ambient temperature of the constant speed test shall be within a range of ± 5°C to the value from the certification measurement. This criterion is verified based on the average temperature from the first low speed tests as calculated by the Vehicle Energy Consumption calculation Tool Air Drag tool.

   ii. The high speed test shall be performed in a vehicle speed range within ± 2 km/h to the value from the certification measurement.

2. A vehicle fails the conformity of production test if the measured $C_d\,A_{cr}\,(0)$ value is higher than the $C_d{\cdot}A_{declared}$ value declared for the parent vehicle plus 7,5% conformity of production tolerance margin representing the reproducibility range of a constant speed test.

3. The number of vehicles to be conformity of production tested per year of production shall be determined based on Table 17.

Table 17: Number of vehicles to be conformity of production tested per year of production

Number of CoP tested vehicles	Number of CoP relevant vehicles produced the year before
1	≤ 25,000
2	≤ 50,000
3	≤ 75,000
4	≤ 100,000
5	100,001 and more

For the purpose of establishing the production numbers, only air drag data which fall under the requirements of this Regulation and which did not get standard air drag values according to Appendix 8 of this Annex shall be considered.

4. For the selection of vehicles for conformity of production testing the following provisions apply:

4.1. Only vehicles from the production line shall be tested for conformity of production.

4.2. Only vehicles which fulfil the provisions for constant speed testing as laid down in section 3.3 of the main part of this Annex shall be selected.

4.3. Tires are considered part of the measurement equipment and can be selected by the manufacturer.

4.4. Vehicles in families where the air drag value has been determined via transfer from other vehicles according to Appendix 6 point 7 are not subject to conformity of production testing.

4.5. Vehicles which use standard values for air drag according to Appendix 8 are not subject to COP testing.

4.6. The first two vehicles per manufacturer and year to be conformity of production tested shall be selected from the two biggest families in terms of vehicle production. Additional vehicles shall be selected by the technical service.

5. After a vehicle was selected for conformity of production the manufacturer has to verify the conformity of production within a time period of 12 month. If the verification was not possible within this period the manufacturer shall report the reasons to the legal authorities by documentation of test track booking and weather conditions.

Appendix 7

Standard values

1. Standard values for the product of drag coefficient by cross sectional area for zero crosswind conditions $C_d \cdot A_{declared}$ shall be taken from Table 18.

Table 18: Standard values for $C_d \cdot A_{declared}$

Vehicle class	Standard value $C_d \cdot A_{declared}$ [m²]
1	7.1
2	7.2
3	7.4
4	8.4
5	8.7
9	8.5
10	8.8
11	8.5
12	8.8
16	9.0

2. For vehicle configurations "rigid + trailer" the overall air drag value is calculated by the Vehicle Energy Consumption calculation Tool CO_2 simulation tool by adding standard delta values for trailer influence as specified in Table 19 to the $C_d \cdot A_{declared}$ value for the rigid.

Table 19: Standard delta air drag values for trailer influence

Trailer	standard delta air drag values for trailer influence [m²]
T1	1.3
T2	1.5

3. For EMS vehicle configurations the air drag value of the overall vehicle configuration is calculated by the Vehicle Energy Consumption calculation Tool CO_2 simulation tool by adding the standard delta values for EMS influence as specified in Table 20 to the air drag value for the baseline vehicle configuration..

Table 20: Standard delta $C_d A_{cr} (0)$ values for EMS influence

EMS configuration	**standard delta air drag values for EMS influence [m²]**
(Class 5 tractor + ST1) + T2	2.1
(Class 9 / 11 truck) + dolly + ST 1	2.5
(Class 10/12 tractor + ST1) + T2	2.1

Appendix 8

Markings

In the case of a vehicle being type approved accordant to this Annex, the cabin shall bear:

1.1 The manufacturer’s name and trade mark

1.2 The make and identifying type indication as recorded in the information referred to in paragraph 0.2 and 0.3 of Appendix 2 to this Annex

1.3 The certification mark as a rectangle surrounding the lower-case letter ‘e’ followed by the distinguishing number of the Member State which has granted the certificate:

1 for Germany;

2 for France;

3 for Italy;

4 for the Netherlands;

5 for Sweden;

6 for Belgium;

7 for Hungary;

8 for the Czech Republic;

9 for Spain;

11 for the United Kingdom;

12 for Austria;

13 for Luxembourg;

17 for Finland;

18 for Denmark;

19 for Romania;

20 for Poland;

21 for Portugal;

23 for Greece;

24 for Ireland;

25 for Croatia;

26 for Slovenia;

27 for Slovakia;

29 for Estonia;

32 for Latvia;

34 for Bulgaria;

36 for Lithuania;

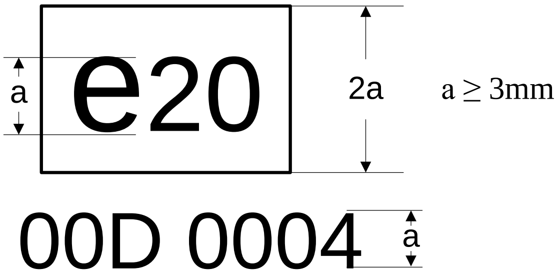
49 for Cyprus;

50 for Malta

1.4 The certification mark shall also include in the vicinity of the rectangle the ‘base certification number’ as specified for Section 4 of the type-approval number set out in Annex VII to Directive 2007/46/EC, preceded by the two figures indicating the sequence number assigned to the latest technical amendment to this Regulation and by a character 'D' indicating that the approval has been granted for an air drag.

For this Regulation, the sequence number shall be 00.

1.4.1 Example and dimensions of the certification mark



The above certification mark affixed to a cabin shows that the type concerned has been approved in Poland (e20), pursuant to this Regulation. The first two digits (00) are indicating the sequence number assigned to the latest technical amendment to this Regulation. The following digit indicates that the certificate was granted for an air-drag (D). The last four digits (0004) are those allocated by the type-approval authority to the engine as the base certification number.

1.5 The certification mark shall be affixed to the cabin in such a way as to be indelible and clearly legible. It shall be visible when the cabin is installed on the vehicle and shall be affixed to a part necessary for normal cabin operation and not normally requiring replacement during cabin life. The markings, labels, plates or stickers must be durable for the useful life of the engine and must be clearly legible and indelible. The manufacturer shall ensure that the markings, labels, plates or sticker cannot be removed without destroying or defacing them.

2 Numbering

2.1 Certification number for air-drag shall comprise the following:

eX*YYY/YYYY*ZZZZ/ZZD*0000*00

section 1	section 2	section 3	Additional character to section 3	section 4	section 5
Indication of country issuing the certificate	Basic act (595/2009)	Latest version of the implementing act (2017/xx)	D=Air-drag	Base certification number 0000	Extension 00

Appendix 8

Input parameters for the vehicle energy consumption calculation tool

Introduction

This Appendix describes the list of parameters to be provided by the vehicle manufacturer as input to the simulation tool. The applicable XML schema as well as example data are available at the dedicated electronic distribution platform.

The XML is automatically generated by the "Vehicle Energy Consumption calculation Tool" Air Drag Tool.

Definitions

(1) "Parameter ID": Unique identifier as used in "Vehicle Energy Consumption calculation Tool" for a specific input parameter or set of input data

(2) "Type": Data type of the parameter

string …….. sequence of characters in ISO8859-1 encoding

date ……… date and time in UTC time in the format: YYYY-MM-DD*T*HH:MM:SS*Z* with italic letters denoting fixed characters e.g. "2002-05-30T09:30:10Z"

integer …… value with an integral data type, no leading zeros, e.g. "1800"

double, X .... fractional number with exactly X digits after the decimal sign (".") and no leading zeros e.g. for "double, 2": "2345.67"; for "double, 4": "45.6780"

(3) "Unit" … physical unit of the parameter

Set of input parameters

Table 1: Input parameters “AirDrag”

Parameter name	Param ID	Type	Unit	Description/Reference
Manufacturer	P240	string		
Make	P241	string		Trade name of manufacturer
TypeID	P242	string		Identifier of the component as used in the certification process
Date	P243	date		Date and Time when the component file is created.
AppVersion	P244	string		Version number identifying the evaluation tool
CdxA_0	P245	double, 2	[m²]	Final result of “Vehicle Energy Consumption calculation Tool” Air Drag Tool
TransferredCdxA	P246	double, 2	[m²]	CdxA_0 transferred to other vehicle class according to Table 18 of Appendix 5. In case no transfer rule was applied CdxA_0 shall be provided.
DeclaredCdxA	P146	double, 2	[m²]	Declared value for Air Drag Family

In case standard values according to Appendix 7 shall be used in “Vehicle Energy Consumption calculation Tool”, no input data for air drag component shall be provided. The standard values are allocated automatically according to the vehicle classification scheme.

ANNEX VII

VERIFYING TRUCK AUXILIARY DATA

1. Introduction

This annex describes the provisions regarding the power consumption of auxiliaries for heavy duty vehicles for the purpose of the determination of vehicle specific CO_2 emissions.

The power consumption of the following auxiliaries shall be considered within the Vehicle Energy Consumption calculation tool by using technology specific average standard power values:

(a) Fan

(b) Steering system

(c) Electric system

(d) Pneumatic system

(e) Air Conditioning (AC) system

(f) Transmission Power Take Off (PTO)

The standard values are integrated in the Vehicle Energy Consumption calculation Tool and automatically used by choosing the corresponding technology.

2. Definitions

For the purposes of this Annex the following definitions shall apply:

(1) “Crankshaft mounted fan” means a fan installation where the fan is driven in the prolongation of the crankshaft, often by a flange;

(2) “Belt or transmission driven fan” means a fan that is installed in a position where additional belt, tension system or transmission is needed.;

(3) “Hydraulic driven fan” means a fan propelled by hydraulic oil, often installed away from the engine. A hydraulic system with oil system, pump and valves are influencing losses and efficiencies in the system;

(4) ‘Electrically driven fan’ means a fan propelled by an electric motor. The efficiency for complete energy conversion, included in/out from battery, is considered;

(5) ‘Electronically controlled visco clutch’ means a clutch in which a number of sensor inputs together with SW logic are used to electronically actuate the fluid flow in the visco clutch;

(6) ‘Bimetallic controlled visco clutch’ means a clutch in which a bimetallic connection is used to convert a temperature change into mechanical displacement. The mechanical displacement is then working as an actuator for the visco clutch;

(7) ‘Discrete step clutch’ means a mechanical device where the grade of actuation can be made in distinct steps only (not continuous variable).

(8) “On/off clutch” means a mechanical device where the actuation is either fully engaged or fully disengaged;

(9) ‘Variable displacement pump’ means a device that converts mechanical energy to hydraulic fluid energy. The amount of fluid pumped per revolution of the pump can be varied while the pump is running;

(10) ‘Constant displacement pump’ means a device that converts mechanical energy to hydraulic fluid energy. The amount of fluid pumped per revolution of the pump cannot be varied while the pump is running

(11) For an ‘electric motor control’ an electric motor can be used to propel the fan. The electrical machine converts electrical energy into mechanical energy. Power and speed are controlled by conventional technology for electric motors;

(12) ‘Fixed displacement pump (default technology)’ means a pump having an internal limitation of the flow rate;

(13) ‘Fixed displacement pump with electronical control’ means a pump using an electronically control of the flow rate;

(14) ‘Dual displacement pump’ means a pump with two chambers (with the same or different displacement) which can be combined or only one of these is used; internal limitation of flow rate;

(15) ‘Variable displacement pump mech. controlled’ means a pump where the displacement is mechanically controlled internally (internal pressure scales);

(16) ‘Variable displacement pump elec. controlled’ means a pump where the displacement is mechanically controlled internally (internal pressure scales). Additionally, the flow rate is elec. controlled by a valve;

(17) ‘Electric steering pump’ means a pump using an electric system without fluid;

(18) ‘Baseline air compressor’ means a conventional air compressor without any fuel saving technology;

(19) ‘Air compressor with Energy Saving System (ESS)’ means a compressor reducing the power consumption during blow off, e.g. by closing intake side, ESS is controlled by system air pressure;

(20) ‘Compressor clutch (visco)’ means a disengageable compressor where the clutch is controlled by the system air pressure (no smart strategy), minor losses during disengaged state caused by visco clutch

(21) ‘Compressor clutch (mechanically)’ means a disengageable compressor where the clutch is controlled by the system air pressure (no smart strategy);

(22) ‘Air Management System with optimal regeneration (AMS)’ means an electronic air processing unit that combines an electronically controlled air dryer for optimized air regeneration and an air delivery preferred during overrun conditions (requires a clutch or ESS).

(23) ‘Light Emitting Diodes (LED)’ mean semiconductor devices that emit visible light when an electrical current passes through them.

(24) “Air conditioning system” means a system consisting of a refrigerant circuit with compressor and heat exchangers to cool down the interior of a truck cab or bus body.

(25) ‘Power take-off (PTO)’ means a device on a transmission or an engine to which an auxiliary driven device, e.g., a hydraulic pump, can be connected; a power take-off is usually optional;

(26) ‘Power take-off drive mechanism’ means a device in a transmission that allows the installation of a power take-off (PTO);

(27) ‘Tooth clutch’ means a (manoeuvrable) clutch where torque is transferred mainly by normal forces between mating teeth. A tooth clutch can either be engaged or disengaged. It is operated in load-free conditions, only (e.g. at gear shifts in a manual transmission);

(28) ‘Synchroniser’ means a type of tooth clutch where a friction device is used to equalise the speeds of the rotating parts to be engaged;

(29) ‘Multi-disc clutch’ means a clutch where several friction linings are arranged in parallel whereby all friction pairs get the same pressing force. Multi-disc clutches are compact and can be engaged and disengaged under load. They may be designed as dry or wet clutches;

(30) ‘Sliding wheel’ means a gearwheel used as shift element where the shifting is realized by moving the gearwheel on its shaft into or out of the gear mesh of the mating gear.

3. Determination of technology specific average standard power values

3.1 Fan

For the fan power the standard values shown in Table 1 shall be used depending on mission profile and technology:

Fan drive cluster	Fan control	Fan power consumption [W]				
		Long haul	Regional delivery	Urban delivery	Municipal utility	Construction
Crankshaft mounted	Electronic controlled visco clutch	618	671	516	566	1037
	Bimetallic controlled visco clutch	818	871	676	766	1277
	Discrete step clutch	668	721	616	616	1157
	On/off cluch	718	771	666	666	1237
Belt driven or driven via transmission	Electronic controlled visco clutch	989	1044	833	933	1478
	Bimetallic controlled visco clutch	1189	1244	993	1133	1718
	Discrete step clutch	1039	1094	983	983	1598
	On/off cluch	1089	1144	1033	1033	1678
Hydraulically driven	Variable displacement pump	938	1155	832	917	1872
	Constant displacement pump	1200	1400	1000	1100	2300
Electrically driven	Electronically	700	800	600	600	1400

Table 1: Mechanical power demand of the fan

If a new technology within a fan drive cluster (e.g. crankshaft mounted) cannot be found in the list the highest power values within that cluster shall be taken. If a new technology cannot be found in any cluster the values of the worst technology at all shall be taken (hydraulic driven constant displacement pump)

3.2 Steering System

For the steering pump power the standard values [W] shown in Table 2 shall be used depending on the application in combination with correction factors:

Identification of vehicle configuration					**Steering power consumption P [W]**														
Number of axles	**Axle configuration**	**Chassis configuration**	**Technically permissible maximum laden mass (tons)**	**Vehicle class**	**Long haul**			**Regional delivery**			**Urban delivery**			**Municipal utility**			**Construction**		
					U+F	B	S	U+F	B	S	U+F	B	S	U+F	B	S	U+F	B	S
2	4x2	Rigid + (Tractor)	7,5t - 10t	1				240	20	20	220	20	30						
		Rigid + (Tractor)	>10t - 12t	2	340	30	0	290	30	20	260	20	30						
		Rigid + (Tractor)	>12t - 16t	3				310	30	30	280	30	40						
		Rigid	> 16t	4	510	100	0	490	40	40				430	30	50			
		Tractor	> 16t	5	600	120	0	540	90	40	480	80	60						
	4x4	Rigid	7,5 - 16t	6	-														
		Rigid	> 16t	7	-														
		Tractor	> 16t	8	-														
3	6x2/2-4	Rigid	all	9	600	120	0	490	60	40				430	30	50			
		Tractor	all	10	450	120	0	440	90	40									
	6x4	Rigid	all	11	600	120	0	490	60	40				430	30	50	640	50	80
		Tractor	all	12	450	120	0	440	90	40							640	50	80
	6x6	Rigid	all	13	-														
		Tractor	all	14															
4	8x2	Rigid	all	15	-														
	8x4	Rigid	all	16													640	50	80
	8x6/8x8	Rigid	all	17	-														

Table 2: Mechanical power demand of steering pump

where:

U = Unloaded – pumping oil without steering pressure demand
F = Friction – friction in the pump
B = Banking – steer correction due to banking of the road or side wind
S = Steering – steer pump power demand due to cornering and manoeuvring

To consider the effect of different technologies, technology depending scaling factors as shown in Table 3 and Table 4 shall be applied.

	Factor c1 depending on technology		
Technology	$c_{1,U+F}$	$c_{1,B}$	$c_{1,S}$
Fixed displacement	1	1	1
Fixed displacement with electronical control	0,95	1	1
Dual displacement	0,85	0,85	0,85
Variable displacement, mech. controlled	0,75	0,75	0,75
Variable displacement, elec. controlled	0,6	0,6	0,6
Electric	0	$1,5/\eta_{alt}$	$1/\eta_{alt}$

Table 3: Scaling factors depending on technology

If a new technology is not listed, the technology “fixed displacement” shall be considered in the Vehicle Energy Consumption calculation Tool.

	Factor c2 depending on number of steered axles														
number of steered axles	**Long haul**			**Regional delivery**			**Urban delivery**			**Municipal utility**			**Construction**		
	$c_{2,U+F}$	$c_{2,B}$	$c_{2,S}$	$c_{2,U+F}$	$c_{2,B}$	$c_{2,S}$	$c_{2,U+F}$	$c_{2,B}$	$c_{2,S}$	$c_{2,U+F}$	$c_{2,B}$	$c_{2,S}$	$c_{2,U+F}$	$c_{2,B}$	$c_{2,S}$
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0,7	0,7	1,0	0,7	0,7	1,0	0,7	0,7	1,0	0,7	0,7	1,0	0,7	0,7
3	1	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5
4	1,0	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5	1,0	0,5	0,5

Table 4: Scaling factor depending on number of steered axles

with η_{alt} = alternator efficiency = const. = 0,7

The final power demand is calculated by:

If different technologies are used for multi-steered axles, the mean values of the corresponding factors c1 shall be used.

The final power demand is calculated by:

$$P_{tot} = \Sigma_i(P_{U+F}*mean(c_{1,U+F})*(c_{2i,U+F})) + \Sigma_i(P_B*mean(c_{1,B})*(c_{2i,B})) + \Sigma_i(P_S*mean(c_{1,S})*(c_{2i,S}))$$

where:

P_{tot} = Total power demand [W]

P = Power demand [W]

c_1 = Correction factor depending on technology

c_2 = Correction factor depending on number of steered axles

$U+F$ = Unloaded + friction [-]

B = Banking [-]

S = Steering [-]

i = Number of steered axles [-]

3.3 Electric system

For the electric system power the standard values [W] as shown in Table 5 shall be used depending on the application and technology in combination with the alternator efficiencies:

Technologies influencing electric power consumption	**Electric power consumption [W]**				
	Long haul	Regional delivery	Urban delivery	Municipal utility	Construction
Standard technology electric power [W]	1200	1000	1000	1000	1000
LED main front headlights	-50	-50	-50	-50	-50

Table 5: Electrical power demand of electric system

To derive the mechanical power, an alternator technology dependent efficiency factor as shown in Table 6 shall be applied.

Alternator (power conversion) technologies **Generic efficiency values for specific technologies**	**Efficiency η_{alt}**				
	Long haul	Regional delivery	Urban delivery	Municipal utility	Construction
Standard alternator	0,7	0,7	0,7	0,7	0,7

Table 6: Alternator efficiency factor

If the technology used in the vehicle is not listed, the technology “standard alternator” shall be considered in the Vehicle Energy Consumption calculation Tool.

The final power demand is calculated by:

$$P_{tot} = \frac{P_{el}}{\eta_{alt}}$$

where:

P_{tot} = Total power demand [W]

P_{el} = Electrical power demand [W]

η_{alt} = Alternator efficiency [-]

3.4 Pneumatic system

For pneumatic systems working with over pressure the standard power values [W] as shown in Table 7 shall be used depending on application and technology.

Size of air supply	**Technology**	**Long Haul**	**Regional Delivery**	**Urban Delivery**	**Municipal Utility**	**Construction**
		Pmean [W]	Pmean [W]	Pmean [W]	Pmean [W]	Pmean [W]
small displ. ≤ 250 cm^3 **1 cyl. / 2 cyl.**	Baseline	1400	1300	1200	1200	1300
	+ ESS	-500	-500	-400	-400	-500
	+ visco clutch	-600	-600	-500	-500	-600
	+ mech. clutch	-800	-700	-550	-550	-700
	+ AMS	-400	-400	-300	-300	-400
medium $250cm^3$ < displ. ≤ 500 cm^3 **1 cyl. / 2 cyl. 1-stage**	Baseline	1600	1400	1350	1350	1500
	+ ESS	-600	-500	-450	-450	-600
	+ visco clutch	-750	-600	-550	-550	-750
	+ mech. clutch	-1000	-850	-800	-800	-900
	+ AMS	-400	-200	-200	-200	-400
medium $250cm^3$ < displ. ≤ 500 cm^3 **1 cyl. / 2 cyl. 2-stage**	Baseline	2100	1750	1700	1700	2100
	+ ESS	-1000	-700	-700	-700	-1100
	+ visco clutch	-1100	-900	-900	-900	-1200
	+ mech. clutch	-1400	-1100	-1100	-1100	-1300
	+ AMS	-400	-200	-200	-200	-500
large displ. > 500 cm^3 **1 cyl. / 2 cyl.** **1-stage / 2-stage**	Baseline	4300	3600	3500	3500	4100
	+ ESS	-2700	-2300	-2300	-2300	-2600
	+ visco clutch	-3000	-2500	-2500	-2500	-2900
	+ mech. clutch	-3500	-2800	-2800	-2800	-3200
	+ AMS	-500	-300	-200	-200	-500

Table 7: Mechanical power demand of pneumatic systems (over pressure)

For pneumatic systems working with vacuum (negative pressure) the standard power values [W] as shown in Table 8 shall be used.

	Long Haul	**Regional Delivery**	**Urban Delivery**	**Municipal Utility**	**Construction**
	Pmean [W]	Pmean [W]	Pmean [W]	Pmean [W]	Pmean [W]
Vaccum pump	190	160	130	130	130

Table 8: Mechanical power demand of pneumatic systems (vaccum pressure)

Fuel saving technologies can be considered by subtracting the corresponding power demand from the power demand of the baseline compressor.

The following combinations of technologies are not considered:

– (a) ESS and clutches

– (b) Visco clutch and mechanical clutch

In case of a two-stage compressor, the displacement of the first stage shall be used to describe the size of the air compressor system

3.5 Air Conditioning system

For vehicles having an air conditioning system, the standard values [W] as shown in Table 9 shall be used depending on the application.

Identification of vehicle configuration					**AC power consumption [W]**				
Number of axles	**Axle configuration**	**Chassis configuration**	**Technically permissible maximum laden mass (tons)**	**Vehicle class**	**Long haul**	**Regional delivery**	**Urban delivery**	**Municipal utility**	**Construction**
2	4x2	Rigid + (Tractor)	7,5t - 10t	1		150	150		
		Rigid + (Tractor)	> 10t - 12t	2	200	200	150		
		Rigid + (Tractor)	>12t - 16t	3		200	150		
		Rigid	> 16t	4	350	200		300	
		Tractor	> 16t	5	350	200			
	4x4	Rigid	7,5 - 16t	6	-				
		Rigid	> 16t	7	-				
		Tractor	> 16t	8	-				
3	6x2/2-4	Rigid	all	9	350	200		300	
		Tractor	all	10	350	200			
	6x4	Rigid	all	11	350	200		300	200
		Tractor	all	12	350	200			200
	6x6	Rigid	all	13	-				
		Tractor	all	14					
4	8x2	Rigid	all	15	-				
	8x4	Rigid	all	16					200
	8x6/8x8	Rigid	all	17	-				

Table 9: Mechanical power demand of AC system

3.6 Transmission Power Take-Off (PTO)

For vehicles with PTO and/or PTO drive mechanism installed on the transmission, the power consumption shall be considered by determined standard values. The

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corresponding standard values represent these power losses in usual drive mode when the PTO is switched off / disengaged. Application related power consumptions at engaged PTO are added additionally by the Vehicle Energy Consumption calculation Tool and are not described in the following.

Design variants regarding power losses (in comparison to a transmission without PTO and / or PTO drive mechanism)			
Additional drag loss relevant parts		PTO incl. drive mechanism	only PTO drive mechanism
Shafts / gear wheels	**Other elements**	**Power loss [W]**	**Power loss [W]**
only one engaged gearwheel positioned above the specified oil level (no additional gearmesh)	-	-	0
only the drive shaft of the PTO	tooth clutch (incl. synchroniser) or sliding gearwheel	50	50
only the drive shaft of the PTO	multi-disc clutch	1000	1000
only the drive shaft of the PTO	multi-disc clutch and oil pump	2000	2000
drive shaft and/or up to 2 engaged gearwheels	tooth clutch (incl. synchroniser) or sliding gearwheel	300	300
drive shaft and/or up to 2 engaged gearwheels	multi-disc clutch	1500	1500
drive shaft and/or up to 2 engaged gearwheels	multi-disc clutch and oil pump	3000	3000
drive shaft and/or more than 2 engaged gearwheels	tooth clutch (incl. synchroniser) or sliding gearwheel	600	600
drive shaft and/or more than 2 engaged gearwheels	multi-disc clutch	2000	2000
drive shaft and/or more than 2 engaged gearwheels	multi-disc clutch and oil pump	4000	4000

Table 10: Mechanical power demand of switched off / disengaged power take-off

ANNEX VIII

APPROVAL PROCEDURE FOR PNEUMATIC TYRES

1. Introduction

This annex describes the approval provisions for tyre with regard to its rolling resistance coefficient. For the calculation of the vehicle rolling resistance to be used as “Vehicle Energy Consumption calculation Tool” input, the applicable tyre rolling resistance coefficient Cr for each tyre supplied to the original equipment manufacturers and the related tyre test load F_{ZTYRE} shall be declared by the applicant for pneumatic tyre approval. Therefore, the tyre manufacturer will provide the approval authority an application for approval with regard to the specific tyre.

2. Definitions

For the purposes of this Annex, in addition to the definitions contained in UN Regulation 54 and 117, the following definitions shall apply:

(1) “Rolling resistance coefficient Cr” - Ratio of the rolling resistance to the load on the tyre

(2) "The load on the tyre" FZ_{TYRE} - load applied to the tyre during the rolling resistance test.

(3) "Type of tyre" - in relation to this Regulation, a range of tyres which do not differ in such characteristics as:

(a) Manufacturer's name;

(b) Brand name or Trade mark

(c) Tyre class (in accordance with R661/2009)

(d) Tyre-size designation;

(e) Tyre structure (diagonal (bias-ply); radial);

(f) Category of use (normal tyre, snow tyre, special use tyre);

(g) Speed category (categories);

(h) Load-capacity index (indices);

(i) Trade description/commercial name;

(j) Tyre rolling resistance coefficient

3. General requirements

3.1. Tyre rolling resistance coefficient

The tyre rolling resistance coefficient shall be the value measured and aligned in accordance with Regulation EC 1222/2009 Annex I part A, expressed in N/kN and rounded to the first decimal place, according to ISO 80000-1 Appendix B, section B.3, rule B (example1).

3.2. Marking and traceability

3.2.1. The tyre shall be clearly identifiable in respect to the certificate covering it for the corresponding rolling resistance coefficient. This identification is generally possible using the regular tyre markings affixed to the side wall of the tyre and described in Appendix 1 to this Annex.

3.2.2. In case a unique identification of the rolling resistance coefficient is not possible with the markings permanently affixed to the tyre, the tyre manufacturer shall affix an additional identifier to the tyre.

3.2.3. Such an additional identification can be provided by :

– quick response (QR) code,

– barcode,

– radio-frequency identification (RFID) or

– an additional marking

– other tool fulfilling the requirements of 3.2.1

– ensuring a unique identification of the tyre and its rolling resistance coefficient.

3.2.4. If an additional identifier is used it shall remain readable until the moment of sales of the vehicle.

3.2.5. The tyre manufacturer plant shall be certified to ISO/TS 16949.

3.2.6. In line with Article 19(2) of Directive 2007/46/EC, no type-approval mark is required for tyre approved in accordance with this Regulation.

4. Declaration of the Tyre rolling Resistance Coefficient

4.1. Measurement provisions

The tyre manufacturer shall test either in a laboratory of Technical Services as defined in Directive 2007/46/EC Art.41 which carry out in its own facility the test referred to in this annex at paragraph 3.1, or in its own facilities in the case:

(i) of the presence and responsibility of a representative of a Technical Service designated by a Approval Authority, or

(ii) the tyre manufacturer is designated as a technical service of Category A in accordance with Directive 2007/46/EC Art.41.

5. Conformity of production

5.1. Any tyre approved under this Regulation shall be in conformity to the declared rolling resistance value as per paragraph 3.1 of this Annex;

5.2. In order to verify conformity of production, production samples shall be taken randomly from series production and tested in accordance with the provisions set out in paragraph 3.1.

5.3. Frequency of the tests

5.3.1 The tyre rolling resistance of at least one tyre of a specific type intended for the sales to the original equipment manufacturers shall be tested every 20,000 units of this type produced (ex. 2 CoP verifications per year of the type whose annual sales volume to the original equipment manufacturers is between 20,001 and 40,000 units).

5.3.2 In case the sales of a specific tyre type intended for the sales to the original equipment manufacturers is between 500 and 20,000 units per year, at least one CoP verification of the type shall be carried out per year.

5.3.3 In case the sales of a specific tyre type intended for the sales to the original equipment manufacturers is below 500 units, least one CoP verification as described in paragraph 5.3 shall be applied every second year.

5.3.4 If the production volume indicated in 5.3.1 is met within 31 days the maximum number of CoP verifications as described in paragraph 5.3 is limited to one per 31 days.

5.3.5 The manufacturer shall justify (ex. by showing sales numbers) to the approval authority the number of tests which has been performed

5.4 Verification procedure

5.4.1 A single tyre is tested first. If the value measured in accordance with paragraph 3.1 does not exceed the declared value by more than 0.3 N/kN (for possible mass production variations), the tyre is deemed compliant;

5.4.2 If the value measured in accordance with paragraph 3.1 does exceed the declared value by more than 0.3 N/kN, three additional tyres shall be tested. If the value of the rolling resistance of at least one of the three tyres exceeds the declared value by more than 0.3 N/kN, provisions of Article 12 shall apply.

The alignment procedure calculation formula used for the purpose of this section shall be the alignment procedure calculation formula as used for the initial calculation of the rolling resistance in accordance with each version of Regulation EC 1222/2009 applicable.

Appendix 1

MODEL OF A CERTIFICATE OF A COMPONENT, SEPARATE TECHNICAL UNIT, SYSTEM

Maximum format: A4 (210 x 297 mm)

CERTIFICATE

Communication concerning:

Stamp administration

– granting(1)

– extension(1)

– refusal(1)

– withdrawal(1)

(1) 'delete as appropriate'

of a tyre with regard to "rolling resistance coefficient" in relation to Regulation (EC) No 595/2009 as implemented by Regulation No … [this Regulation].

Certification number:……………………………………………………………………………

Reason for extension:…………………………………………………………………………………….

1. Manufacturer's name and address:………………………………… ....……………………….….

2. If applicable, name and address of manufacturer's representative:……………………..………………..

3. Brand name/Trade mark:…………………………………………………………………………….……

4. Tyre type description:…………………………………………………………………………………...

   (a) Manufacturer's name;……………………………………………………………………………….
   (b)Brand name or Trade mark
   (c) Tyre class (in accordance with R661/2009)……………………………………………….………
   (d) Tyre-size designation;………………………………………………………………………………
   (e) Tyre structure (diagonal (bias-ply); radial);……………………………………………………..
   (f) Category of use (normal tyre, snow tyre, special use tyre);…………………………………….
   (g) Speed category (categories);…………………………………………………………………………
   (h) Load-capacity index (indices);…………………………………………………………………….
   (i) Trade description/commercial name;……………………………………………………………….
   (j) Tyre rolling resistance coefficient; ……………………………………….

5. Tyre Identification code(s) and Technology(ies) used to provide identification code(s), if applicable:

Technology:	Code:
. . .	. . .

6. Technical Service and, where appropriate, test laboratory approved for purposes of approvalor of verification of conformity tests: ....

7. Declared values:

7.1 declared Rolling resistance level of the tyre (in N/kN rounded to the first decimal place, according to ISO 80000-1 Appendix B, section B.3, rule B (example1))
Cr , ………………………………………………………………………………..[N/kN]

7.2 tyre test load according to EU 1222/2009 Annex I part A (85% of single load, or 85 % of maximum load capacity for single application specified in applicable tyre standards manuals if not marked on tyre.)

FZ_{TYRE}……………………………………………………………………………………………………[N]

8. Any remarks: ....

9. Place: ..

10. Date: ...

11. Signature: ....

12. Annexed to this communication are: ....

Appendix 2

Tyre Rolling resistance coefficient information document

SECTION I

0.1. Name and address of manufacturer

0.2 Make (trade name of manufacturer)

0.3 Name and address of applicant:

0.4 Brand name/ trade description:

0.5 Tyre class (in accordance with R661/2009)

0.6 Tyre-size designation;

0.7 Tyre structure (diagonal (bias-ply); radial);

0.8 Category of use (normal tyre, snow tyre, special use tyre);

0.9 Speed category (categories);

0.10 Load-capacity index (indices);

0.11 Trade description/commercial name;

0.12 Tyre rolling resistance coefficient;

0.13 Tool(s) to provide additional rolling resistance coefficient identification code (if any);

0.14. Rolling resistance level of the tyre (in N/kN rounded to the first decimal place, according to ISO80000-1 Appendix B, section B.3, rule B (example1)) Cr,……………………………………………………………………….…..[N/kN]

0.15 Load FZTYRE:…………………………………………………………[N]

SECTION II

1. Approval Authority or Technical Service [or Accredited Lab]:

2. Test report No.:

3. Comments (if any):

4. Date of test:

5. Test machine identification and drum diameter/surface:

6. Test tyre details:

6.1. Tyre size designation and service description:

6.2. Tyre brand/ trade description:

6.3. Reference inflation pressure: kPa

7. Test data:

7.1. Measurement method:

7.2. Test speed: km/h

7.3. Load F_{ZTYRE}: N

7.4. Test inflation pressure, initial: kPa

7.5. Distance from the tyre axis to the drum outer surface under steady state conditions,r_L: m

7.6. Test rim width and material:

7.7. Ambient temperature: °C

7.8. Skim test load (except deceleration method): N

8. Rolling resistance coefficient:

8.1 Initial value (or average in the case of more than 1): N/kN

8.2. Temperature corrected:..N/kN

8.3. Temperature and drum diameter corrected: N/kN

8.4. Temperature and drum diameter corrected and aligned to EU network of laboratories, Cr_E: N/kN

9. Date of test:

Appendix 3

Input parameters for the vehicle energy consumption calculation tool

Introduction

This Appendix describes the list of parameters to be provided by the component manufacturer as input to the simulation tool. The applicable XML schema as well as example data are available at the dedicated electronic distribution platform.

Definitions

(1) “Parameter ID”: Unique identifier as used in “Vehicle Energy Consumption calculation Tool” for a specific input parameter or set of input data

(2) “Type”: Data type of the parameter

string …….. sequence of characters in ISO8859-1 encoding

date ……… date and time in UTC time in the format: YYYY-MM-DD***T***HH:MM:SS***Z*** with italic letters denoting fixed characters e.g. “2002-05-30T09:30:10Z”

integer …… value with an integral data type, no leading zeros, e.g. “1800”

double, X .... fractional number with exactly X digits after the decimal sign (“.”) and no leading zeros e.g. for “double, 2”: “2345.67”; for “double, 4”: “45.6780”

(3) “Unit” … physical unit of the parameter

Set of input parameters

Table 1: Input parameters “Tyre”

Parameter name	Param ID	Type	Unit	Description/Reference
Manufacturer	P230	string		
Make	P231	string		Trade name of manufacturer
TypeID	P232	string		Identifier of the component as used in the certification process (TAA)
Date	P233	date		Date and Time when the component file is created.
AppVersion	P234	string		Version number identifying the evaluation tool
RRCISO	P046	double, 5	[N/N]	
FzISO	P047	integer	[N]	
Dimension	P108	string	[-]	Allowed values: "9.00 R20", "9 R22.5", "9.5 R17.5", "10 R17.5", "10 R22.5", "10.00 R20", "11 R22.5", "11.00 R20", "11.00 R22.5", "12 R22.5", "12.00 R20", "12.00 R24", "12.5 R20", "13 R22.5", "14.00 R20", "14.5 R20", "16.00 R20", "205/75 R17.5", "215/75 R17.5", "225/70 R17.5", "225/75 R17.5", "235/75 R17.5", "245/70 R17.5", "245/70 R19.5", "255/70 R22.5", "265/70 R17.5", "265/70 R19.5", "275/70 R22.5", "275/80 R22.5", "285/60 R22.5", "285/70 R19.5", "295/55 R22.5", "295/60 R22.5", "295/80 R22.5", "305/60 R22.5", "305/70 R19.5", "305/70 R22.5", "305/75 R24.5", "315/45 R22.5", "315/60 R22.5", "315/70 R22.5", "315/80 R22.5", "325/95 R24", "335/80 R20", "355/50 R22.5", "365/70 R22.5", "365/80 R20", "365/85 R20", "375/45 R22.5", "375/50 R22.5", "375/90 R22.5", "385/55 R22.5", "385/65 R22.5", "395/85 R20", "425/65 R22.5", "495/45 R22.5", "525/65 R20.5"

ANNEX IX

INPUT INFORMATION RELATING TO THE CHARACTERISTIC OF THE VEHICLE

1. Introduction

This Appendix describes the list of parameters to be provided by the vehicle manufacturer as input to the simulation tool. The applicable XML schema as well as example data are available at the dedicated electronic distribution platform.

2. Definitions

(1) “Parameter ID”: Unique identifier as used in “Vehicle Energy Consumption calculation Tool” for a specific input parameter or set of input data

(2) “Type”: Data type of the parameter

string …….. sequence of characters in ISO8859-1 encoding

date ……… date and time in UTC time in the format: YYYY-MM-DD***T***HH:MM:SS***Z*** with italic letters denoting fixed characters e.g. “2002-05-30T09:30:10Z”

integer …… value with an integral data type, no leading zeros, e.g. “1800”

double, X .... fractional number with exactly X digits after the decimal sign (“.”) and no leading zeros e.g. for “double, 2”: “2345.67”; for “double, 4”: “45.6780”

(3) “Unit” … physical unit of the parameter

(4) “corrected actual mass of the vehicle” shall mean the mass as specified under the 'actual mass of the vehicle' in accordance with Commission Regulation (EC) No 1230/2012 with an exception for the tank(s) which shall be filled to at least 50% of its or their capacity/ies, without superstructure and corrected by the additional weight of the non-installed standard equipment as specified in point 3.3 and the mass of a standard body, standard semi-trailer or standard trailer to simulate the complete vehicle or complete vehicle-(semi-)trailer combination.

3. Set of input parameters

Table 1: Input parameters “Vehicle/General”

Parameter name	Parameter ID	Type	Unit	Description/Reference
Manufacturer	P235	string		
Make	P236	string		Trade name of manufacturer
Model	P237	string		
VIN	P238	string		
Date	P239	date		Date and time when the input data is created.
VehicleCategory	P036	string	[-]	Allowed values: "Rigid Truck", "Tractor"
AxleConfiguration	P037	string	[-]	Allowed values: "4x2", "6x2", "6x4", "8x4". Axles classification shall be performed in accordance with point 5
CurbMassChassis	P038	integer	[kg]	"Corrected actual mass of the vehicle" as determined according to point 4
GrossVehicleMass	P041	integer	[kg]	Maximum gross vehicle mass of the truck / tractor w/o (semi-)trailer
IdlingSpeed	P198	integer	[1/min]	Engine idling speed set on the vehicle according to point 7
RetarderType	P052	string	[-]	Allowed values: "None", "Losses included in Gearbox", "Engine Retarder", "Transmission Input Retarder", "Transmission Output Retarder"
RetarderRatio	P053	double, 3	[-]	only required for cases "Engine Retarder", "Transmission Input Retarder", "Transmission Output Retarder"
AngledriveType	P180	string	[-]	Allowed values: "None", "Losses included in Gearbox", "Separate Angledrive"
PTOType	P186	string	[-]	Allowed values: "None", "Losses included in Gearbox", "only the drive shaft of the PTO - shift claw, synchronizer, sliding gearwheel", "only the drive shaft of the PTO - multi-disc clutch", "only the drive shaft of the PTO - multi-disc clutch, oil pump", "drive shaft and/or up to 2 gear wheels - shift claw, synchronizer, sliding gearwheel", "drive shaft and/or up to 2 gear wheels - multi-disc clutch", "drive shaft and/or up to 2 gear wheels - multi-disc clutch, oil pump", "drive shaft and/or more than 2 gear wheels - shift claw, synchronizer, sliding gearwheel", "drive shaft and/or more than 2 gear wheels - multi-disc clutch", "drive shaft and/or more than 2 gear wheels - multi-disc clutch, oil pump"

Table 2: Input parameters “Vehicle/AxleConfiguration” per wheel axle

Parameter name	Parameter ID	Type	Unit	Description/Reference
TwinTyres	P045	boolean	[-]	
AxleType	P154	string	[-]	Allowed values: "VehicleNonDriven", "VehicleDriven"
Steered	P195	boolean		

Table 3: Input parameters “Vehicle/Auxiliaries”

Parameter name	Parameter ID	Type	Unit	Description/Reference
Fan/Technology	P181	string	[-]	Allowed values: "Crankshaft mounted - Electronically controlled visco clutch", "Crankshaft mounted - Bimetallic controlled visco clutch", "Crankshaft mounted - Discrete step clutch", "Crankshaft mounted - On/off clutch", "Belt driven or driven via transm. - Electronically controlled visco clutch", "Belt driven or driven via transm. - Bimetallic controlled visco clutch", "Belt driven or driven via transm. - Discrete step clutch", "Belt driven or driven via transm. - On/off clutch", "Hydraulic driven - Variable displacement pump", "Hydraulic driven - Constant displacement pump", "Electrically driven - Electronically controlled"
SteeringPump/Technology	P182	string	[-]	Allowed values: "Fixed displacement", "Fixed displacement with elec. control", "Dual displacement", "Variable displacement mech. controlled", "Variable displacement elec. controlled", "Electric" **Separate entry for each steered wheel axle required**
ElectricSystem/Technology	P183	string	[-]	Allowed values: "Standard technology", "Standard technology - LED headlights, all"

PneumaticSystem/Technology	P184	string	[-]	Allowed values: "Small", "Small + ESS", "Small + visco clutch ", "Small + mech. clutch", "Small + ESS + AMS", "Small + visco clutch + AMS", "Small + mech. clutch + AMS", "Medium Supply 1-stage", "Medium Supply 1-stage + ESS", "Medium Supply 1-stage + visco clutch ", "Medium Supply 1-stage + mech. clutch", "Medium Supply 1-stage + ESS + AMS", "Medium Supply 1-stage + visco clutch + AMS", "Medium Supply 1-stage + mech. clutch + AMS", "Medium Supply 2-stage", "Medium Supply 2-stage + ESS", "Medium Supply 2-stage + visco clutch ", "Medium Supply 2-stage + mech. clutch", "Medium Supply 2-stage + ESS + AMS", "Medium Supply 2-stage + visco clutch + AMS", "Medium Supply 2-stage + mech. clutch + AMS", "Large Supply", "Large Supply + ESS", "Large Supply + visco clutch ", "Large Supply + mech. clutch", "Large Supply + ESS + AMS", "Large Supply + visco clutch + AMS", "Large Supply + mech. clutch + AMS"; “Vacuum pump”
HVAC/Technology	P185	string	[-]	Allowed values: "Default"

Table 4: Input parameters “Vehicle/EngineTorqueLimits” per gear (optional)

Parameter name	Parameter ID	Type	Unit	Description/Reference
Gear	P196	integer	[-]	only gear numbers need to be specified where vehicle related engine torque limits according to point 6 are applicable
MaxTorque	P197	integer	[Nm]	

4. Vehicle mass

4.1 The vehicle mass used as input for the simulation tool shall be the corrected actual mass of the vehicle.

This corrected actual mass shall be based on vehicles equipped in such a way that they are compliant to all regulatory acts of Annex IV and Annex XI to Directive 2007/46/EC applicable to the particular vehicle class.

4.2 If not all the standard equipment is installed, the manufacturer shall add the weight of the following construction elements to the corrected actual mass of the vehicle:

a) Front under-run protection in accordance with Regulation (EC) No 661/2009 of the European Parliament and of the Council[1]

b) Rear under-run protection in accordance with Regulation (EC) No 661/2009 of the European Parliament and of the Council

[1] Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor (OJ L 200 31.7.2009, p. 1)

c) Lateral protection in accordance with Regulation (EC) No 661/2009 of the European Parliament and of the Council

d) Fifth wheel in accordance with Regulation (EC) No 661/2009 of the European Parliament and of the Council

4.3 The weight of the construction elements referred to in point 3.3 shall be the following:

For vehicles of groups 1, 2 and 3

a)	Front under-ride protection	45 kg
b)	Rear under-ride protection	40 kg
c)	Lateral protection	8,5 kg/m * wheel base [m] – 2,5 kg
d)	Fifth wheel	210 kg

For vehicles of groups 4, 5, 9 to 12 and16

a)	Front under-ride protection	50 kg
b)	Rear under-ride protection	45 kg
c)	Lateral protection	14 kg/m * wheel base [m] – 17 kg
d)	Fifth wheel	210 kg

5. Hydraulically and mechanically driven axles

In case of vehicles equipped with:

a) a hydraulically driven axles, the axle shall be treated as a non-drivable one and the manufacturer shall not take it into consideration for establishing an axle configuration of a vehicle;

b) a mechanically driven axles, the axle shall be treated as a drivable one and the manufacturer shall not take it into consideration for establishing an axle configuration of a vehicle;

6. Gear dependent engine torque limits set by vehicle control

For the highest 50% of the gears (e.g. for gears 7 to 12 of a 12 gear transmission) the vehicle manufacturer may declare a gear dependent maximum engine torque limit which is not higher than 93% of the maximum engine torque.

7. Vehicle specific engine idling speed

7.1. The engine idling speed has to be declared in VECTO for each individual vehicle. This declared vehicle engine idling shall be equal or higher than specified in the engine input data approval.

ANNEX X

AMENDMENTS TO DIRECTIVE 2007/46/EC

(1) in Annex I the following point 3.5.7. is inserted:

'3.5.7 CO_2 emissions and fuel consumption certification (heavy-duty vehicles specified in Article 6 of the Regulation (EU) XXX)

3.5.7.1 License number:

(2) in Annex III the following point 3.5.7. is inserted:

'3.5.7 CO_2 emissions and fuel consumption certification (heavy-duty vehicles specified in Article 6 of the Regulation (EU) XXX)

3.5.7.1 Licence number :

(3) Annex IV is amended as follows:

(a) in Part 1, the item 41A is replaced by:

‘

41A	Emissions (Euro VI) heavy duty vehicles/ access to information	Regulation (EC) No 595/2009 Regulation (EC) No 582/2011	X (9)	X (9)	X	X (9)	X (9)	X					

‘

(b) in Part 1, the following item 41B is inserted:

‘

41B	CO_2 heavy-duty simulation tool licence	Regulation (EC) 595/2009 Regulation (EU) XXX/2017					X (15)	X					

(15) For vehicles with a maximum gross vehicle mass exceeding 7 500 kg

‘

(4) Annex IX is amended as follows:

(a) in Part 1, Model B, SIDE 2, VEHICLE CATEGORY N2, the following point 49 is inserted:

'49. CO_2 emissions and fuel consumption simulated with a simulation tool

Payload 1[kg]:

Fuel 1:

	CO_2 emissions			Fuel consumption		
Long haul	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Long haul (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

Regional delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Urban delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Municipal utility	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Construction	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

Payload …[kg]:

Fuel …:

	CO_2 emissions			Fuel consumption		
Long haul	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Long haul (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Urban delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Municipal utility	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Construction	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

49.1 Cryptographic hash of the output file……………………….'

(b) in Part 1, Model B, SIDE 2, VEHICLE CATEGORY $N_{3,}$ the following point 49 is inserted:

'49. CO_2 emissions and fuel consumption simulated with a simulation tool

Payload 1[kg]:

Fuel 1:

	CO_2 emissions			Fuel consumption		
Long haul	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Long haul (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

Regional delivery (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Urban delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Municipal utility	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Construction	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

Payload …[kg]:

Fuel …:

	CO_2 emissions			Fuel consumption		
Long haul	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Long haul (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Regional delivery (EMS)	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Urban delivery	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Municipal utility	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km
Construction	……g/km	……g/t-km	……g/m³-km	…...l/100km	……l/t-km	……l/m³-km

49.1 Cryptographic hash of the output file……………………….'

(6) in Annex XV in point 2, the following entry is added:

‘

46B	Rolling resistance determination	Regulation (EU) XXX/2017, Annex VII