Commission Regulation (EU) 2017/2400 of 12 December 2017 implementing Regulation (EC) 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 (Text with EEA relevance)

ANNEX VIII

VERIFYING AIR DRAG DATA

1. Introduction

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

2. Definitions

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 air drag pre-processing tool which determines product of drag coefficient by cross sectional area for zero crosswind conditions $C_d \cdot A_{cr}\ (0)$ as input for the simulation tool. The applicant for a certificate shall declare a value $C_d \cdot A_{declared}$ in a range from equal up to a maximum of + 0,2 m^2 higher than $C_d \cdot A_{cr}\ (0)$. The value $C_d \cdot A_{declared}$ shall be the input for the simulation tool CO_2 simulation tool and the reference value for conformity of the certified CO_2 emissions and fuel consumption related properties 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 7 to this Annex. In this case no input data on air drag shall be provided. The allocation of standard values is done automatically by the simulation tool.

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 items vii. and viii. 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 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 at 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.

iii. The grid points as provided to the air drag pre-processing tool shall have a distance to the centre line of the measurement section of less than 1 m.

iv 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.

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

vi. 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 the air drag pre-processing tool 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 the air drag pre-processing tool 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 the air drag pre-processing 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 vii. 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 4 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: $< \pm 6$ Nm

ii. Repeatability: $< \pm 6$ Nm

iii. Crosstalk: $< \pm 1$ % 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 air drag pre-processing 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 the air drag pre-processing tool is identical to the signal to be used for in-service testing as set out in Annex I of Regulation (EU) No 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 the air drag pre-processing tool. 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 the air drag pre-processing tool 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 2 000 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 : ≤ 6 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

(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, whichever 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 air drag pre-processing 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

iii. 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 vii. 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 viii. of this Annex

v. the beginning and the end of the measurement sections are 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 vii. 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 viii. of this Annex

v. the beginning and the end of the measurement sections are 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 air drag pre-processing 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 appendix 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 vii.

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 vii)
- 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 latest available version of the air drag pre-processing tool shall be obligatory. Besides the above mentioned data processing, all evaluation steps including validity checks (with exception of the list as specified above) are performed by the air drag pre-processing tool.

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 air drag pre-processing 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 the air drag pre-processing tool – vehicle data file

Input data	Unit	Remarks
Vehicle group code	[-]	1 - 17 for trucks
Vehicle configuration with trailer	[-]	if the vehicle was measured without trailer (input ‘No’) or with trailer i.e. as a truck/

a	Specification of transmission ratios with at least 3 digits after decimal separator
b	If the wheel speed signal is provided to the air drag pre-processing tool (option for vehicles with torque converters, see section 3.4.3 the axle ratio shall be set to ‘1.000’.
c	Input only required if value is lower than 88 km/h.

		trailer or tractor semitrailer combination (input 'Yes')
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[ab]
Gear ratio high speed	[-]	transmission ratio of gear engaged during high speed test[a]
Gear ratio low speed	[-]	transmission ratio of gear engaged during low speed test[a]
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 vii.
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[c]

a Specification of transmission ratios with at least 3 digits after decimal separator

b If the wheel speed signal is provided to the air drag pre-processing tool (option for vehicles with torque converters, see section 3.4.3 the axle ratio shall be set to '1.000'.

c Input only required if value is lower than 88 km/h.

TABLE 3

Input data for the air drag pre-processing tool – ambient conditions file

Signal	Column identifier in input file	Unit	Measurement rate	Remarks
Time	<t>	[s] since day start (first day)	—	—
Ambient temperature	<t_amb_stat>	[°C]	At least 1 averaged value per 6 minutes	Stationary weather station
Ambient pressure	<p_amb_stat>	[mbar]		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 measurement section
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
Path and/or filename of altitude file	[-]	only required for the constant speed tests (not the misalignment test) and if the altitude correction is enabled.

TABLE 5

Input data for the air drag pre-processing tool – measurement data file

Signal	Column identifier in input file	Unit	Measurement rate	Remarks
Time	<t>	[s] since day start (of first day)	100 Hz	rate fixed to 100 Hz; 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	
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')
Proving ground temperature	<t_ground>	[°C]	≥ 1 Hz	
Validity	<valid>	[-]	—	optional signal (1=valid; 0=invalid);

TABLE 6

Input data for the air drag pre-processing tool – altitude profile file

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

3.10. Validity criteria

This sections sets out the criteria to obtain valid results in the air drag pre-processing tool.

3.10.1. Validity criteria for the constant speed test

3.10.1.1. The air drag pre-processing tool 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 the air drag pre-processing tool 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 i

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

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

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:

$$(T_{lms,avrg} - T_{grd}) \times 0{,}7 \leq (T_{lm,avrg} - T_{grd}) \leq (T_{lms,avrg} - T_{grd}) \times 1{,}3$$

$$T_{grd} = F_{grd,avrg} \times r_{dyn,avrg}$$

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

$$(T_{hms,avrg} - T_{grd}) \times 0{,}8 \leq (T_{hm,avrg} - T_{grd}) \leq (T_{hms,avrg} - T_{grd}) \times 1{,}2$$

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 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:

$$\frac{30\times i_{gear}\times i_{axle}\times\frac{\left(v_{hms,avrg}-0{,}3\right)}{3{,}6}}{r_{dyn,ref,HS}\times\pi}\times(1-2\,\%)\leq n_{eng,1s}\leq\frac{30\times i_{gear}\times i_{axle}\times\frac{\left(v_{hms,avrg}+0{,}3\right)}{3{,}6}}{r_{dyn,ref,HS}\times\pi}\times(1+2\,\%)$$

$$r_{dyn,avrg}=\frac{30\times i_{gear}\times i_{axle}\times\frac{v_{hms,avrg}}{3{,}6}}{n_{eng,avrg}\times\pi}$$

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

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:

$$\frac{30\times i_{gear}\times i_{axle}\times\frac{\left(v_{lms,avrg}-0{,}5\right)}{3{,}6}}{r_{dyn,ref,LS1/LS2}\times\pi}\times(1-2\,\%)\leq n_{eng,float}\leq\frac{30\times i_{gear}\times i_{axle}\times\frac{\left(v_{lms,avrg}+0{,}5\right)}{3{,}6}}{r_{dyn,ref,LS1/LS2}\times\pi}\times(1+2\,\%)$$

$$r_{dyn,avrg}=\frac{30\times i_{gear}\times i_{axle}\times\frac{v_{lms,avrg}}{3{,}6}}{n_{eng,avrg}\times\pi}$$

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

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 air drag pre-processing tool input file.

3.10.1.2. The air drag pre-processing tool 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. The air drag pre-processing tool 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. The air drag pre-processing tool 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) for the first and the second low speed test differ more than 0,40 kg/t. This criterion is checked for each combination of measurement section and driving direction separately.

3.10.2. Validity criteria for the misalignment test

3.10.2.1. The air drag pre-processing tool 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 i

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

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

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. The air drag pre-processing tool 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. The air drag pre-processing tool 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 air drag pre-processing tool. The applicant for a certificate shall declare a value $C_d \cdot A_{declared}$ in a range from equal up to a maximum of + 0,2 m^2 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 simulation tool and the reference value for conformity of the certified CO_2 emissions and fuel consumption related properties testing.

More families with different declared values $C_d \cdot A_{declared}$ can be created based on a single measured $C_d \cdot A_{cr}\,(0)$ as long as the family provisions according to point 4 of Appendix 5 are fulfilled.

Appendix 1

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

Maximum format: A4 (210 × 297 mm)

CERTIFICATE ON CO_2 EMISSIONS AND FUEL CONSUMPTION RELATED PROPERTIES OF AN AIR DRAG FAMILY

Communication concerning: — granting ([1]) — extension ([1]) — refusal ([1]) — withdrawal ([1])	Administration stamp

of a certificate on CO_2 emission and fuel consumption related properties of an air drag family in accordance with Commission Regulation (EU) 2017/2400.

Commission Regulation (EU) 2017/2400 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

2. Additional information (where applicable): see Addendum

2. Approval authority 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 group according to HDV CO_2 scheme	

1.2.0.	Vehicle Model	
1.2.1.	Axle configuration	
1.2.2.	Max. gross vehicle weight	
1.2.3.	Cabin line	
1.2.4.	Cabin width (max. value in Y direction)	
1.2.5.	Cabin length (max. value in X direction)	
1.2.6.	Roof height	
1.2.7.	Wheel base	
1.2.8.	Height cabin over frame	
1.2.9.	Frame height	
1.2.10.	Aerodynamic accessories or add-ons (e.g. roof spoiler, side extender, side skirts, corner vanes)	
1.2.11.	Tire dimensions front axle	
1.2.12.	Tire dimensions driven axles(s)	
1.3.	Body specifications (according to standard body definition)	
1.4.	(Semi-) Trailer specifications (according to (semi-) trailer specification by standard body)	
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 $C_dA_{cr}(0)$ [m^2]:

Product of drag coefficient (C_d) by cross sectional area (A_{cr}) for average crosswind conditions during constant speed test $C_dA_{cr}(\beta)$ [m^2]:

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

Declared air drag value $C_d \cdot A_{declared}$ [m^2]:

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 vii

3. Vehicles of vehicles groups not shown in Table 7 are not subject to constant speed testing.

TABLE 7

Vehicle Height Requirements

Vehicle group	**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 as for rigid with same maximum gross vehicle weight (group 1, 2, 3 or 4)	
10	3,90	4,00

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 group	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 Regulation (EC) No 1230/2012, 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
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	

Table 11

Specifications of standard body 'B3'

Width	[mm]	2 550 (– 10)	legal limit (96/53/EC), 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

Table 13

Specifications of standard body 'B5'

Width	[mm]	2 550 (– 10)	legal limit (96/53/EC), 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	
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	

Table 15

Specifications standard trailer 'ST1'

Total width (Body width)	[mm]	2 550 (– 10)	
Body height	[mm]	2 850 (± 10)	max. full height: 4 000 (96/53/EC)
Full height, unloaded	[mm]	4 000 (– 10)	height over the complete length specification for semi-trailer, not relevant for 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 (96/53/EC)
Front overhang	[mm]	1 685	radius: 2 040 (legal limit, 96/53/EC)
Front wall			flat wall with attachments for compressed air and electricity
Corner front/side panel	[mm]	broken with a strip and edge radii ≤ 5	secant of a circle with the kingpin as centre and a radius of 2 040 (legal limit, 96/53/EC)
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

Table 15

Specifications standard trailer 'ST1'

			01 (2010), +/– 100 depending on wheelbase
Stripe profile	[mm^2]	100 × 30	ECE- R 73, Amendment 01 (2010)
Technical gross vehicle weight	[kg]	39 000	legal GVWR: 24 000 (96/53/EC)
Vehicle curb weight	[kg]	7 500	has not be verified during air drag testing
Allowable axle load	[kg]	24 000	legal limit (96/53/EC)
Technical axle load	[kg]	27 000	3 × 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:

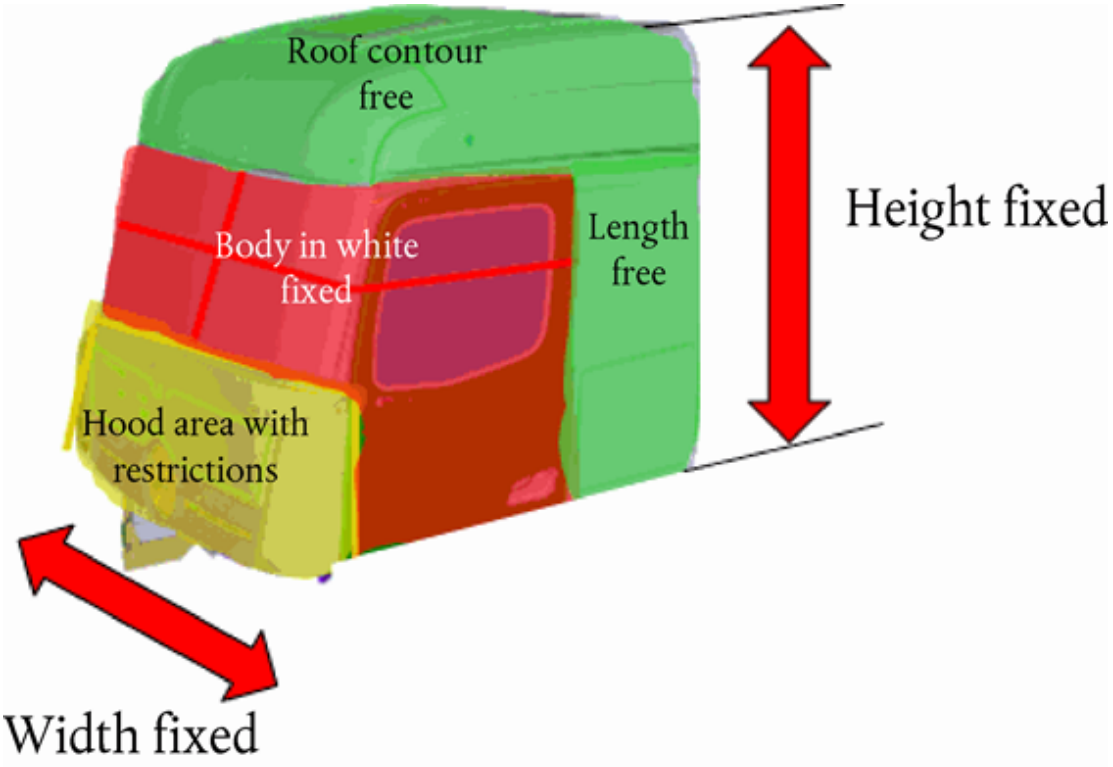
(a) Same cabin width and body in white geometry up to B-pillar and above the heel point excluding the cab bottom (e.g. engine tunnel). All members of the family stay within a range of ± 10 mm to the parent vehicle.

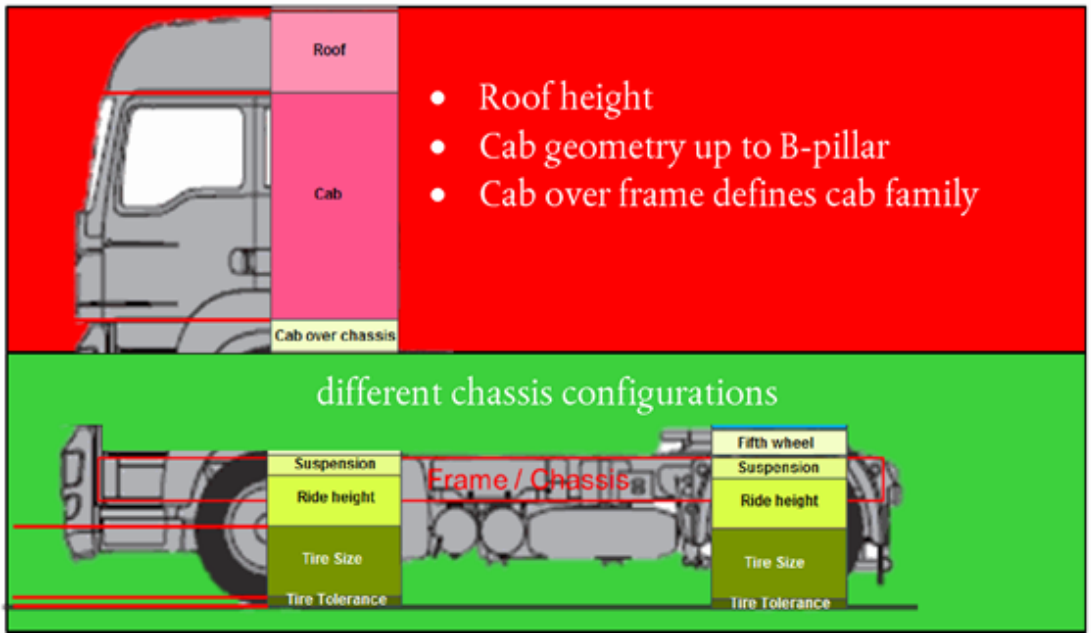
(b) Same roof height in vertical Z. All members of the family stay within a range of ± 10 mm to the parent vehicle.

(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 fulfil 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 4 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 group	Transfer formula	Remarks
1	Vehicle group 2 – 0,2 m^2	Only allowed if value for related family in group 2 was measured
2	Vehicle group 3 – 0,2 m^2	Only allowed if value for related family in group 3 was measured
3	Vehicle group 4 – 0,2 m^2	
4	No transfer allowed	
5	No transfer allowed	
9	Vehicle group 1,2,3,4 + 0,1 m^2	Applicable group for transfer has to match with gross vehicle weight. Transfer of already transferred values allowed.
10	Vehicle group 1,2,3,5 + 0,1 m^2	
11	Vehicle group 9	Transfer of already transferred values allowed
12	Vehicle group 10	Transfer of already transferred values allowed
16	No transfer allowed	Only table value applicable

Appendix 6

Conformity of the certified CO_2 emissions and fuel consumption related properties

1. The conformity of the certified CO_2 emissions and fuel consumption related properties shall be verified by constant speed tests as laid down in section 3 of the main part of this Annex. For conformity of the certified CO_2 emissions and fuel consumption related properties 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 air drag pre-processing 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.

All conformity of the certified CO_2 emissions and fuel consumption related properties tests shall be supervised by the approval authority.

2. A vehicle fails the conformity of the certified CO_2 emissions and fuel consumption related properties 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 % tolerance margin. If a first test fails, up to two additional tests at different days with the same vehicle may be performed. Where the average measured $C_d\,A_{cr}\,(0)$ value of all performed tests is higher than the $C_d \cdot A_{declared}$ value declared for the parent vehicle plus 7,5 % tolerance margin, Article 23 of this Regulation shall apply.

3. The number of vehicles to be tested for conformity with the certified CO_2 emissions and fuel consumption related properties per year of production shall be determined based on Table 17.

Table 17

Number of vehicles to be tested for conformity with the certified CO_2 emissions and fuel consumption related properties per year of production

Number of CoP tested vehicles	Number of CoP relevant vehicles produced the year before
2	≤ 25 000
3	≤ 50 000
4	≤ 75 000
5	≤ 100 000
6	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 the certified CO_2 emissions and fuel consumption related properties testing the following provisions apply:

4.1. Only vehicles from the production line shall be tested.

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 5 point 5 are not subject to conformity of the certified CO_2 emissions and fuel consumption related properties testing.

4.5. Vehicles which use standard values for air drag according to Appendix 8 are not subject to conformity of the certified CO_2 emissions and fuel consumption related properties testing.

4.6. The first two vehicles per manufacturer to be tested for conformity with the certified CO_2 emissions and fuel consumption related properties tested shall be selected from the two biggest families in terms of vehicle production. Additional vehicles shall be selected by the approval authority.

5. After a vehicle was selected for conformity of the certified CO_2 emissions and fuel consumption related properties the manufacturer has to verify the conformity of the certified CO_2 emissions and fuel consumption related properties within a time period of 12 month. The manufacturer may request the approval authority for an extension of that period for up to 6 months if he can prove that the verification was not possible within the required period due to weather conditions.

Appendix 7

Standard values

1. Standard values for the declared air drag value $C_d \cdot A_{declared}$ are defined according to Table 18. In case standard values shall be applied, no input data on air drag shall be provided to the simulation tool. In this case the standard values are allocated automatically by the simulation tool.

Table 18

Standard values for $C_d \cdot A_{declared}$

Vehicle group	**Standard value $C_d \cdot A_{declared}$ [m^2]**
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 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 [m^2]**
T1	1,3
T2	1,5

3. For EMS vehicle configurations the air drag value of the overall vehicle configuration is calculated by the 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 [m^2]
(Class 5 tractor + ST1) + T2	1,5
(Class 9/11 truck) + dolly + ST 1	2,1
(Class 10/12 tractor + ST1) + T2	1,5

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

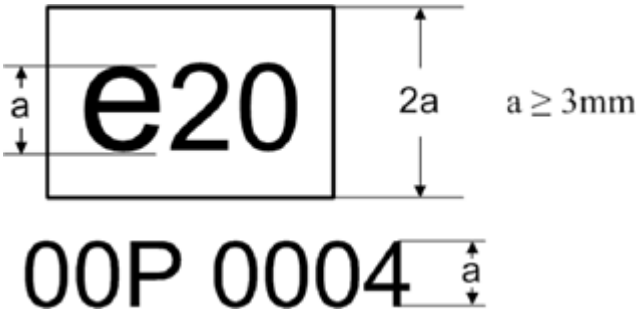
1.3 The certification mark as a rectangle surrounding the lower-case letter ‘e’ followed by the distinguishing number of the Member State which has granted the certificate:

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 ‘P’ 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 letter indicates that the certificate was granted for an air drag (P). 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 air drag 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*ZZZ/ZZZZ*P*0000*00

Section 1	**Section 2**	**Section 3**	**Additional letter to section 3**	**Section 4**	**Section 5**
Indication of country issuing the certificate	CO_2 certification act (…/2017)	Latest amending act (zzz/zzzz)	P = Air drag	Base certification number 0000	Extension 00

Appendix 9

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
token …	sequence of characters in ISO8859-1 encoding, no leading/trailing whitespace
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	token		
Model	P241	token		
TechnicalReportId	P242	token		Identifier of the component as used in the certification process
Date	P243	date		Date and time when the component hash is created.
AppVersion	P244	token		Number identifying the version of the

				air drag pre-processing tool
CdxA_0	P245	double, 2	[m^2]	Final result of the air drag pre-processing tool.
TransferredCdxA	P246	double, 2	[m^2]	CdxA_0 transferred to related families in other vehicle groups according to Table 18 of Appendix 5. In case no transfer rule was applied CdxA_0 shall be provided.
DeclaredCdxA	P146	double, 2	[m^2]	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 group scheme.