POLICY UPDATE

JULY 2017

CERTIFICATION OF CO_2 EMISSIONS AND FUEL CONSUMPTION OF ON-ROAD HEAVY-DUTY VEHICLES IN THE EUROPEAN UNION

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

On May 11, 2017, during the 67th meeting of the Technical Committee—Motor Vehicles, member states of the European Union unanimously adopted[1] a draft implementing act put forward by the European Commission on the certification of the CO_2 emissions and fuel consumption of heavy-duty vehicles. Starting January 1, 2019, heavy-duty vehicles belonging to one of the four vehicle groups with the highest contribution to on-road freight carbon emissions will be certified for their CO_2 emissions and fuel consumption. Six additional heavy-duty vehicle groups will be required to be certified for CO_2 emissions and fuel consumption by January 1, 2020. The certification procedure is based on a vehicle simulation tool that uses as inputs the measured performance of the different vehicle components.

POLICY BACKGROUND

Until now, a European Union regulatory procedure to determine and certify the CO_2 emissions and fuel consumption of heavy-duty vehicles did not exist. Heavy-duty vehicles (HDVs) are currently responsible for about a quarter[2] of the CO_2 emissions from road transportation in the European Union, and are set to increase by as much as 10% by 2030, representing 32% of the on-road CO_2 emissions[3] in 2030.[4] To attain the EU target of reducing CO_2 emissions from transport by 60% in 2050 compared with 1990 levels, it is necessary to introduce policy measures that accelerate the introduction of energy-efficient HDVs into the market. The first of these policy measures is the introduction of a certification procedure for the CO_2 emissions and fuel consumption of

1 At the time of writing of this paper, the regulation had not been published in the *Official Journal of the European Union*. The final adopted draft text can be found in the Comitology Register: http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.documentdetail&Dos_ID=14393&DS_ID=51106&Version=1

2 European Commission, "A European Strategy for Low-Emission Mobility: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions" (2016). http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52016DC0501

3 CO_2 emissions from private cars and motorcycles are expected to decrease 15% in the same time period, accounting for 65% the on-road CO_2 emissions in 2030, compared to the current share of approximately 70%.

4 Capros, P., et al. "EU Reference Scenario 2016—Energy, Transport and GHG Emissions Trends to 2050" (International Institute for Applied Systems Analysis, 2016). http://pure.iiasa.ac.at/13656/.

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HDVs. Regulation (EC) No 595/2009[5] mandated the European Commission to develop such a certification procedure.

Because of the diversity of configurations in the heavy-duty sector and associated testing challenges, carrying out the CO_2 certification in the same fashion as passenger and light commercial vehicles is not viable. Therefore, a simulation-based approach was selected to determine the CO_2 emissions and fuel consumption of HDVs. Internationally, the use of component testing and vehicle simulation for the CO_2 certification of HDVs is not a new approach; the United States, Canada, China, and Japan use vehicle simulation in some form for certification in their HDV CO_2 standards. In the EU, Directive 2007/46/EC established the general framework that allows virtual testing in the type-approval process.

Following the mandate established in Regulation (EC) No 595/2009, and in cooperation with other stakeholders[6], the European Commission started working in 2009 on the development of the Vehicle Energy Consumption Calculation Tool, VECTO, to serve as the backbone of the CO_2 certification methodology. Concurrently, an expert editing board was assembled to refine the details of the certification process. The Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) led this process. The resulting regulatory text is the object of this policy update.

The CO_2 emissions and fuel consumption certification procedure will be included in the type-approval process of certain vehicle groups starting in 2019, amending Regulation (EU) No 582/2011.[7] The CO_2 emissions and fuel consumption certification procedure enables the introduction of policy measures aiming to curb greenhouse gas emissions from the heavy-duty sector in the EU. On May 31, 2017, as part of its most recent package of regulatory initiatives related to transportation called "Europe on the Move,"[8] the European Commission released a regulatory proposal for the monitoring and reporting of CO_2 emissions and fuel consumption of new heavy-duty vehicles.[9] All relevant vehicle and component data measured and calculated by manufacturers in the context of the CO_2 type-approval process would be monitored, reported, and published at EU level. Further details on this monitoring and reporting proposal can be found at the end of this policy update.

KEY ELEMENTS OF THE REGULATION

The backbone of the CO_2 emissions and fuel consumption certification procedure is the VECTO tool, which is publicly available, open-source, downloadable, executable software. The adopted CO_2 certification regulation establishes the input parameters to the simulation tool and outlines the details for the measurement of the performance data and the respective default values of the vehicle components which have a significant impact on the CO_2 emissions and fuel consumption of heavy-duty vehicles. The components to be tested, whose measurements form the VECTO input data, are:

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5 Regulation (EU) No 595/2009 establishes the type-approval requirements of heavy-duty vehicles and engines with respect to emissions (Euro VI).

6 The Directorate-General for Climate Action (DG CLIMA), the Joint Research Centre of the European Commission (JRC), and the Graz University of Technology have jointly developed the VECTO tool.

7 Regulation (EU) No 582/2011 implements the Euro VI type-approval requirements.

8 "Europe on the Move: Commission takes action for clean, competitive and connected mobility," European Commission, https://ec.europa.eu/transport/modes/road/news/2017-05-31-europe-on-the-move_en

9 The proposed regulatory text can be found in https://ec.europa.eu/transport/sites/transport/files/com20170279-regulation-hdv.pdf

- Engine
- Transmission (plus torque converter in the case of an automatic transmission)
- Axles and other torque transferring components
- Aerodynamic drag
- Tires
- Vehicle auxiliaries

The established vehicle groups covering the spectrum of possible heavy-duty trucks are shown in Table 1. The classification is done based on axle configuration, chassis configuration, and the technically permissible maximum laden mass, also called gross vehicle weight (GVW).

Table 1. Heavy-duty vehicle classification for the purpose of CO_2 emissions and fuel consumption certification

Axle type	Chassis configuration	Gross vehicle weight (tonnes)	Vehicle group	Regulatory cycles[a] and payloads[b] used in VECTO
4x2	Rigid	>3.5 – <7.5	0	Not considered by the regulation
	Rigid (or tractor)	7.5 – 10	1	RD (50%), UD (50%)
	Rigid (or tractor)	>10 – 12	2	LH (75%), RD (50%), UD (50%)
	Rigid (or tractor)	>12 – 16	3	RD (50%), UD (50%)
	Rigid	>16	4	LH (14.0t), RD (4.4t), MU (4.4t)
	Tractor	>16	5	LH (19.3t), RD (12.9t)
4x4	Rigid	7.5 – 16	6	Not considered by the regulation
	Rigid	>16	7	Not considered by the regulation
	Tractor	>16	8	Not considered by the regulation
6x2	Rigid	all weights	9	LH (19.3t), RD (7.1t), MU (7.1t)
	Tractor	all weights	10	LH (19.3t), RD (12.9t)
6x4	Rigid	all weights	11	LH (19.3t), RD (7.1t), MU (7.1t), C(7.1t)
	Tractor	all weights	12	LH (19.3t), RD (12.9t), C (12.9t)
6x6	Rigid	all weights	13	Not considered by the regulation
	Tractor	all weights	14	Not considered by the regulation
8x2	Rigid	all weights	15	Not considered by the regulation
8x4	Rigid	all weights	16	C (7.1t)
8x6 8x8	Rigid	all weights	17	Not considered by the regulation
(yellow)	New vehicles belonging to groups 4, 5, 9, and 10 will be certified from January 1, 2019.			
(blue)	New vehicles belonging to groups 1, 2, and 3 will be certified from September, 1, 2019.			
(red)	New vehicles belonging to groups 11, 12, and 16, will be certified from January 1, 2020.			

a. Long-Haul (LH), Regional Delivery (RD), Urban Delivery (UD), Municipal Utility (MU), Construction (C). Rigid trucks in the long haul cycle use an additional trailer.
b. Number in brackets is the payload in tonnes. For vehicle groups 1,2, and 3, the payload is dependent on the GVW; the percentage number in brackets refers the approximate fraction of the maximum payload that is used in the vehicle simulation.

Table 1 also shows the payloads and driving cycles included in the latest available release of VECTO.[10] The adopted regulation does not establish the details of the simulation tool itself. The driving cycles[11] and payloads used by the simulation tool in the certification of the different vehicle groups are not defined as part of the adopted regulation and are built into the simulation tool.

The first four HDV groups to be affected by the CO_2 certification regulation beginning January 1, 2019, are groups 4, 5, 9, and 10. These groups correspond to the 4x2 and 6x2 rigid and tractor trucks with a GVW over 16 tonnes. They represent the majority of HDV sales; in 2016, groups 4, 5, 9 and 10 accounted for approximately 77% of total HD truck sales.[12] As of September 1, 2019, HDV groups 1, 2, and 3 will have to be certified for CO_2 emissions and fuel consumption. These three vehicle groups represent mostly[13] 4x2 rigid trucks with GVW between 7.5 and 16 tonnes. They account for approximately 12% of HD truck sales. Lastly, groups 11, 12, and 16 will be affected starting January 1, 2020. These three groups represent 6x4 rigid and tractor trucks as well as 8x4 trucks, which are used mainly in construction. They account for about 7% of new HD truck sales. For the certification process, standard box bodies are defined for rigid trucks and trailers for tractor-trailers. Consequently, only the effects of the chassis cabin and tractor designs are captured by the certification methodology. The impacts of the box body or trailer designs are outside of the scope of the adopted regulation.

The inputs and outputs of the certification process are summarized in two separate files: the manufacturer's records file and the customer information file.[14] The manufacturer's records file includes all the necessary information to reproduce the certification process through the simulation tool. This file is to be kept by the manufacturer for at least 20 years and has to be made available to the type-approval authority, the European Commission, or to a competent authority of an EU member state upon request. Based on the manufacturer's records file, the type-approval authority must ensure that at least 1% of the simulations performed by the manufacturer are verified by at least performing a repetition of the simulations.

The customer information file includes a significantly more limited set of input information. With the exception of the average rolling resistance coefficient, the customer information file does not contain any vehicle information in addition to the characteristics that can be currently found in the publicly available vehicle specification sheets. Most notably, there is no information on aerodynamic performance. The output data in the customer information file includes the CO_2 emissions and fuel consumption performance for the predetermined payload[15] and the applicable mission profiles. The results are presented in three forms: by distance (gCO_2/km, L/100 km), payload specific ($gCO_2/t\text{-}km$, L/t-km), and volume specific ($gCO_2/m^3\text{-}km$, $L/m^3\text{-}km$).

10 VECTO version 3.1.2.810

11 The driving cycles are named *mission profiles* in the adopted regulation.

12 HD trucks with a GVW equal to or over 7.5 tons. New vehicle sales data for heavy-duty trucks provided by IHS/Polk for 2016.

13 In the GVW segment of 4x2 trucks between 7.5 and 16 tonnes, the rigid truck chassis configuration represents the vast majority of the sales. Tractor trucks account for only 0.3% of the sales in groups 1, 2, and 3.

14 The detailed data available in the manufacturer's and customer's files can be found in Annex I of the adopted regulation, Appendices 1 and 2 respectively.

15 The predetermined payloads vary with vehicle groups and mission profile and are predetermined in the simulation software. See Table 1.

DETAILED OVERVIEW OF THE REGULATION

The adopted regulation establishes the detailed principles governing the CO_2 emissions and fuel consumption certification procedure, specifically concerning the measurement of the CO_2-related properties of the vehicle components and characteristics. Table 2 presents an overview of the components and subsystems considered in the present regulation and the respective measured parameters that affect CO_2 emissions and fuel consumption of the entire vehicle. The following paragraphs describe, for each of the components and subsystems presented in Table 2, the specific details concerning the measurement procedure, the type-approval process, and conformity of production.

Table 2. Vehicle components included in the adopted certification regulation and their CO_2 related properties

Component / subsystem	Parameters required by the certification methodology
Engine	Displacement, idle speed, fuel consumption map, full load torque curve, motoring friction curve, brake-specific fuel consumption over the Worldwide Harmonized Transient and Stationary Cycles (WHTC and WHSC)
Transmission	Transmission type, gear ratios, torque loss map as a function of torque and speed for each gear, maximum torque and speed per gear
Torque converter [a]	Torque ratio as a function of the speed ratio and the input torque
Angle drive	Torque loss map as a function of input torque and speed
Retarder	Braking torque as a function of the input speed to the retarder
Axle	Axle ratio and torque loss map as a function of torque and speed
Aerodynamic drag	Air drag area [b] corrected to zero yaw angle [c] as calculated by the *VECTO Air Drag Tool* [d]
Tires	Tire dimensions, rolling resistance coefficient, load applied during the rolling resistance test
Auxiliaries	Technology used for the following auxiliary components: cooling fan, steering system, electric system, pneumatic system, air conditioning system, and power take-off
Vehicle	Curb vehicle weight, GVW rating, axle configuration, retarder type, angle drive type, power take off type

a. Torque converters are applicable only for automatic transmissions.
b. The air drag area (C_dA) corresponds to the multiplication of the drag coefficient and the vehicle frontal area.
c. The yaw angle refers to the crosswind conditions. Zero yaw angle represents no crosswind.
d. The VECTO Air Drag Tool is an executable software that receives as input the results of the standardized constant-speed air drag measurement and calculates the air drag at zero yaw.

ENGINES

The regulation establishes laboratory test conditions, engine installation requirements, cooling requirements, and reference fuels. It also establishes the testing equipment requirements for the measurement of the fuel consumption map and of the full load and motoring curves. In general, the requirements included in the adopted certification regulation are in accordance with those established in regulation UN/ECE R.49.06.[16] The adopted CO_2 emissions and fuel consumption certification procedure establishes

16 Regulation UN/ECE R.49.06 dictates the provisions concerning the measurement of emission of gaseous and particulate pollutants in combustion engines for vehicle applications. Its provisions are already in use, for example, in the type approval of Euro VI engines.

definitions for the number of points in the engine map, the engine speed and torque set-points, and the test sequence during the measurement of the fuel consumption map.

As is the case for the Euro VI emissions standards, the certification of several engine types under a single engine family is allowed, and the family membership criteria are the same. The CO_2 parent of the engine family must have the highest power rating of all engines within the engine CO_2 family. Furthermore, and as is the case for all of the components and subsystems impacted by the certification methodology, the CO_2-related properties of the parent component cannot be better than the properties of any member of the same family.

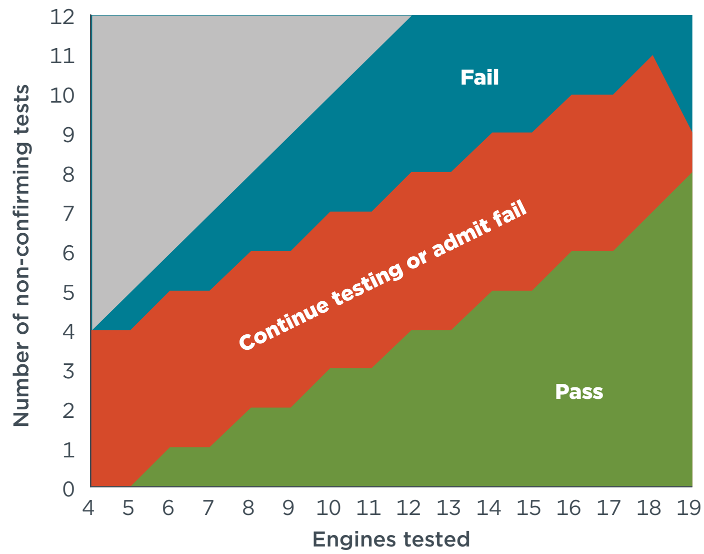

Figure 1. Pass and fail criteria for conformity of production testing of engine CO_2 families

To ensure the conformity of the declared fuel consumption map of the engine, a number of engine families needs to be tested for conformity of production. This number of engine CO_2 families to be tested corresponds to 0.0125% of all engines produced in the previous year rounded to the next whole number, with a minimum of three engine CO_2 families. The engine CO_2 families selected must include the two with the highest production volumes. The respective engines are to be randomly selected from the production line and tested for conformity of production. A minimum of four engines per CO_2 family are to be tested. The metric for assessing the conformity of production is the fuel consumption over the Worldwide Harmonized Stationary Cycle (WHSC).[17] A test is considered a fail if the measured fuel consumption over the WHSC is higher than 3% of the reported value. The pass/fail criteria follow the guidelines established in regulation UN/ECE R.49.06 and are represented in Figure 1.

17 The maximum run-in time of the engine at the start of the conformity of production testing is 15 hours. The engine maybe be tested up to a maximum of 125 hours at the request of the manufacturer. The fuel consumption over the WHSC is corrected to account for the efficiency improvement as the engine run-in time increases from 15 to 125 hours, or alternatively by a factor of 0.99.

TRANSMISSIONS AND OTHER TORQUE TRANSFERRING COMPONENTS

The testing procedure for transmissions focuses on the measurement and estimation of torque losses for each transmission gear over different input speeds and torques. The CO_2 emissions and fuel consumption certification procedure allows for the measurement and estimation of the transmission torque losses through three options with increasing levels of complexity. In option 1, only the torque independent[18] losses are measured, and the torque dependent[19] losses are calculated. In option 2, the measurements include the torque independent losses and the torque losses at the maximum allowable torque; the torque dependent losses are then linearly interpolated. Lastly, in option 3 the torque independent and dependent losses are fully measured. The test setup for option 3 is shown in Figure 2.

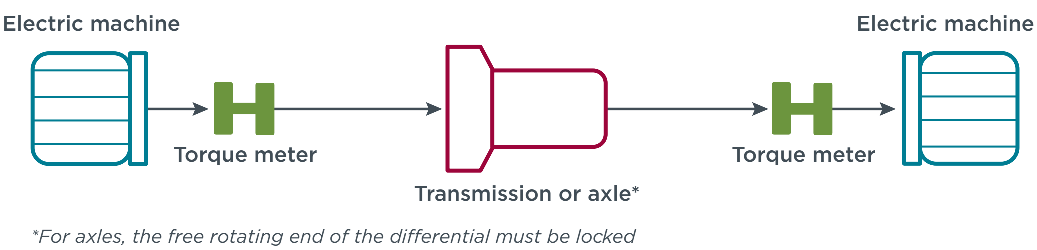

Figure 2. Test setup for torque loss map measurement under option 3

For the determination of torque converter characteristics in automatic transmissions, the measurement can be carried out at either constant input speed or constant input torque. For the retarder, torque losses as a function of input speed can be measured with the retarder as a stand-alone unit, or in combination with the transmission. For the characterization of the propulsion axle, the torque independent and dependent losses must be fully measured using a test setup similar to the one shown in Figure 2.

Table 3. Family criteria for transmissions and torque transferring components

Component	Shared criteria across family members
Transmission	Gear ratios, gear scheme,[a] shaft distances, shifting clutches and synchronizers, surface roughness of the teeth, number of dynamic shaft seals, oil flow, oil viscosity (± 10%), and oil level
Torque converter	Outer and inner torus diameters and widths, arrangement of pump, turbine and stator, oil type, and blade design
Angle drive	Gear ratio, angle between input/output shaft and type of bearings at corresponding positions
Retarder	Outer and inner torus diameters, number of rotors, number of cooling blades, and fluid viscosity (± 50%)
Axle	Axle category (e.g., single reduction, hub reduction, single portal, tandem), inner axle housing geometry, vertical hypoid offset, axle ratio, oil type, oil level, bearing type, and seal type

a. Gear scheme refers to the arrangement of shafts, gearwheels and clutches in a transmission

18 The torque independent losses are those associated with spin and lubricant drag.

19 The torque dependent losses are mostly originated at the teeth of the transmission gears.

The grouping of transmissions and other torque transferring components into families is dictated by a set of design and performance characteristics. The requirements for membership into a family are shown in Table 3. The selection of the parent of a family takes into consideration all the features considered to affect torque losses. The parent is the component within the family that is likely to have the highest torque loss level.

To ensure conformity of production of transmissions and torque transferring components (except axles), manufacturers with total annual production volumes of more than 1,000 units will have to carry out conformity-of-production testing of at least one component family. Manufacturers with annual production volumes of more than 10,000 units shall test at least two component families, including the one with the highest production volume. For production volumes surpassing 30,000, manufacturers will have to test three component families, and for more than 100,000, four component families. Torque losses and associated mechanical efficiencies[20] must be measured for 18 torque-speed points, whose selection satisfies specific requirements established in the regulation. The arithmetic average of the 18 efficiency values is compared against the respective type-approved values. Conformity of production is passed if the efficiency difference is less than 0.015, or less than 0.03 for automatic transmissions. If the test is not passed, three additional transmissions from the same family must be tested. If at least one of them fails on conformity of production, the manufacturer must submit a plan for remedial measures to the type-approval authority.

For axles, the conformity-of-production provisions establish a greater number of axles to be tested, with an emphasis on single reduction axles and the families with the highest production volumes. At least three axles must be tested regardless of the production volume, and as many as eight for production volumes of more than 80,000 units. In production conformity testing, four torque-speed points are selected according to axle type. The mechanical efficiencies for the four operating points are measured and averaged. A conformity-of-production test is passed if the measured mechanical efficiency does not deviate more than 1.5%[21] from the corresponding average efficiency of the type-approved axle. If the test is not passed, three additional axles from the same family must be tested. If at least one of them fails on conformity of production, the manufacturer must submit a plan for remedial measures to the type-approval authority.

Contrary to conformity-of-production testing in engines, the transmissions and torque transferring components are not selected randomly from the production line, but are identified with the support of the producer and specially manufactured under the supervision of the technical service.

AERODYNAMIC DRAG

The determination of aerodynamic performance, one of the most relevant vehicle characteristics for fuel consumption, is done through a constant-speed procedure.[22] During the constant speed test the driving torque at the traction wheels, vehicle speed,

20 Mechanical efficiency is defined as the output power divided by the input power.

21 1.5% applies for single reduction axles. 2.0% is permitted for other axle types.

22 In the United States, Canada, and China, the aerodynamic drag of HDVs is measured through the coastdown methodology. In the United States and Canada, constant-speed testing is allowed as long as a correlation to the coastdown procedure can be established. The EU is the first region to establish constant-speed measurement of aerodynamic drag as the first and only option.

air flow velocity, and yaw angle[23] are measured at two vehicle speeds under defined conditions on a test track. The two vehicle speeds are selected to provide data in two distinct regimes. At the low-speed test between 10 and 15 km/h, aerodynamic drag is not significant, allowing identification of the aerodynamic-independent road loads. During the high-speed test between 85 and 95 km/h, aerodynamic drag is responsible for the largest share of tractive power dissipation. The testing protocol includes a warm-up period followed by a low-speed, high-speed, low-speed testing sequence. The resulting data is post-processed using the VECTO Air Drag Tool, which determines the product of the drag coefficient by the cross-sectional area of the vehicle, corrected to zero crosswind conditions. Due to the influence of ambient and test track conditions on the measurement results, the allowable ranges for boundary conditions during testing are carefully defined in the CO_2 emissions and fuel consumption certification regulation. The requirements for the test-track, the ambient conditions, and the measurement equipment are summarized in Table 4. Figure 3 illustrates the vehicle setup and instrumentation for the constant-speed air-drag test.

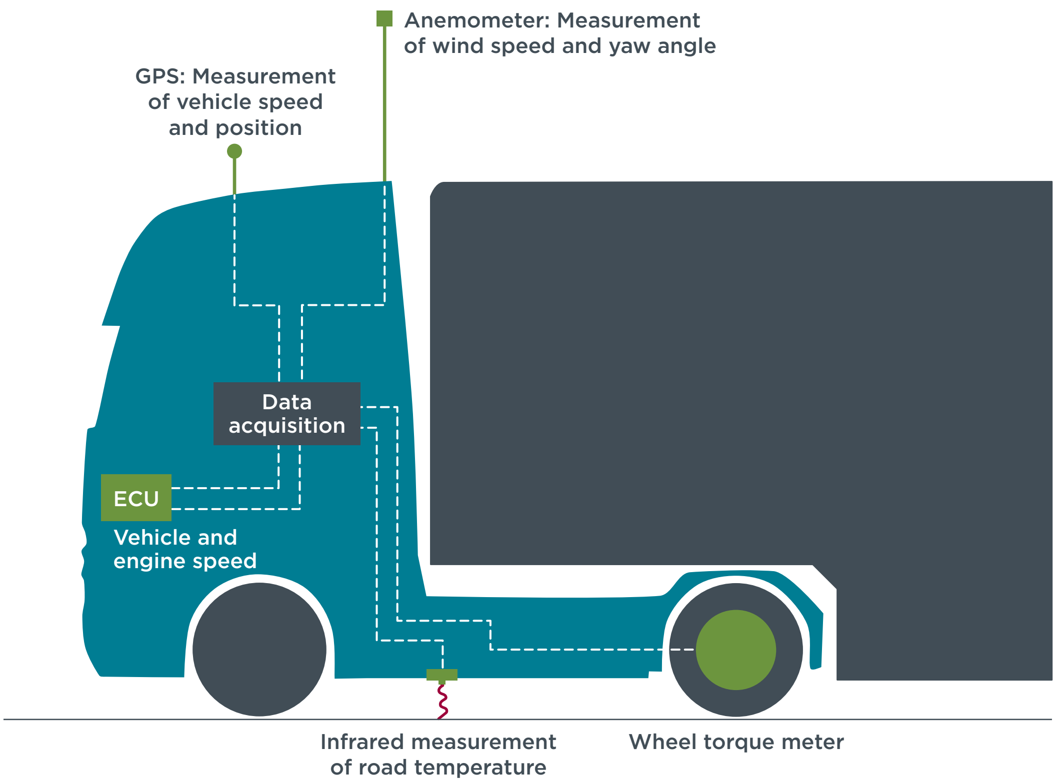

Figure 3. Vehicle setup and instrumentation for the constant-speed measurement of the aerodynamic resistance

23 The yaw angle is a metric for quantifying the crosswind conditions. It is defined as the apparent angle of the wind from the vehicle perspective with respect to the longitudinal axis of the vehicle.

Table 4. General requirements for the constant speed air drag measurement

Test track	• The test track can be a circuit or a straight line. If only one straight measurement section of at least 250 meters is available, the test-track must be drivable in both directions. • A 25-meter speed stabilization section at the entry of the measurement section must exist. • The average road inclination of each measurement section and of the stabilization sections cannot be greater than ± 1%. • The altitude profile of the test track must be measured as a function of the GPS coordinates at a grid distance of lower than or equal to 50 m in driving direction. • The road surface shall consist of asphalt or concrete. Each measurement section can have only one surface type. • Obstacles within 5 m of both sides of the vehicle are not permitted. Nevertheless, safety barriers up to a height of 1 m with more than 2.5 m distance to the vehicle are permitted.
Ambient conditions	• The ambient temperature must be between 0° and 25°C. • The road surface in the measurement section must be dry, and its temperature cannot be higher than 40°C. • The average wind speed must be lower than 5 m/s, and wind gusts cannot be greater than 8 m/s. • The average yaw angle during the high-speed measurement must be lower than or equal to 3 degrees.
Vehicle	• The body and trailer (if applicable) must be within the ranges specified by the standard body/trailers definitions. • The vehicle's tires must belong to one of the two tire classes with the lowest rolling resistance (A or B), must have a maximum tread depth of 10 mm, and must be inflated to the maximum allowable pressure. • The vehicle can carry no payload.
Measurement equipment	• Torque must be measured at the driven axle by a hub, rim, or shaft torque meter, with a maximum measurement error of 6 Nm and a cross sensitivity to vertical forces lower than 1% of the full-scale output of the torque meter. • Latitude and longitude of start and end points of each measurement section must be determined with an accuracy better than or equal to 0.15 m. • The vehicle and engine speed information available in the CAN-bus of the vehicle must be recorded. • The vehicle speed must be calibrated with the aid of either opto-electronic barriers, or a high accuracy GPS with a 0.15m 95% circular error probability, that is 95% of the time the positioning error will be equal to or less than 0.15m. • The mobile anemometer mounted on the vehicle must have an accuracy better than 3.5% for the measurement of the wind speed and better than ± 1 degrees for the yaw angle measurement. • The road temperature must be measured by a contactless IR sensor with an accuracy of ± 2.5°C.

The design and performance parameters characterizing an air-drag family include the cabin width, the roof height, and cabin height over the chassis frame, and in general the cabin geometry up to the B pillar.[24] These must be shared by all vehicles within the family. The parent vehicle of an air-drag family must have the highest air-drag value of the family. To take into account uncertainties in the selection of the parent vehicles as the worst case for all members of the family, the vehicle manufacturer is allowed to declare an air-drag area up to 0.2 m^2 higher than the measured value.

Conformity of production of the declared air-drag values is verified by following the same constant speed test described above, considering the test conditions that were

24 The B pillar is the supporting structure connecting the cabin floor and the cabin roof in the middle of the cabin.

present during the original certification measurement.[25] The number of vehicles to be tested for conformity of production is a function of the vehicles produced the year before, with a minimum of one vehicle. Every 25,000 vehicles produced by the manufacturer adds one additional vehicle to the testing requirements for conformity of production. If the production volume is higher than 100,000 units, a maximum of five vehicles must be tested. The first two vehicles selected for testing must be chosen from the two biggest families with the highest production volumes. A vehicle fails the conformity-of-production test if the measured air drag value is more than 7.5% higher than the declared value of the parent vehicle.

TIRES

The CO_2 emissions and fuel consumption certification regulation does not establish specific provisions for the measurement of the tire rolling resistance coefficient, as these are already laid out in Regulation EC 1222/2009[26] and UNECE Regulation No 117.[27] In accordance with those regulations, the measurement of tire rolling resistance takes place on a steel test drum under predetermined ambient conditions, speed, vertical load, and inflation pressure. Depending on the testing method selected, the measured parameters for the determination of the rolling resistance coefficient can include the horizontal reaction force, the torque input at the drum, the tire-drum system deceleration, or the power input at the drum.

The conformity-of-production provisions included in the certification regulation establish that a certain number of samples are to be taken randomly from the production line for testing. For the tire types being sold as original equipment in new vehicles, the regulation mandates the testing of rolling resistance of at least one tire for every production batch of 20,000 units or fewer. The conformity-of-production test is passed if the rolling resistance value measured does not exceed the declared value by more than 0.3 N/kN. If the value measured in the first production test exceeds the declared value by more than 0.3 N/kN, three additional tires of the same type must be tested. In this case, none of the three additional tires tested can exceed the declared value by more than 0.3 N/kN. If one of them does, the conformity-of-production testing of the tire type is failed and a plan for remedial measures must be put forward by the manufacturer.

AUXILIARIES

The auxiliaries' power consumption is considered in VECTO through selection of the equipped technologies in the vehicle being certified from a predetermined list provided by the simulation tool. To this end, VECTO incorporates default power consumption values for the systems and technologies shown in Table 5. The standard power consumption values are a function of the driving cycle and vehicle groups. These can be found in the adopted CO_2 emissions and fuel consumption certification regulation. Given that only default values are used, no provisions for testing, families, or conformity of production are included in the regulation.

25 The ambient temperature must be within a ± 5°C range of the original type-approval test. Similarly, the high-speed selection must be within ± 2 km/h of the original type-approval test.

26 Regulation EC 1222/2009 establishes the framework for the provision of tire fuel efficiency information through labeling.

27 UNECE Regulation No 117 establishes, among others, the test procedure for measuring rolling resistance.

Table 5. Auxiliary systems and technologies considered

System	Technologies considered
Cooling fan	• Crankshaft mounted (with electronic visco-clutch, bimetallic visco-clutch, discrete step clutch or on/off clutch) • Belt or transmission driven (with electronic visco-clutch, bimetallic visco-clutch, discrete step clutch or on/off clutch) • Hydraulically driven (variable or fixed displacement) • Electrically driven
Steering system	• Fixed displacement (with or without electronical control) • Dual displacement • Variable displacement (with mechanical or electronical control) • Electric
Electric system	• LED main front headlights
Pneumatic system	• Air compressors with different displacements • Air compressor with energy saving system • Air management system with optimal regeneration • Visco-clutches • Mechanical clutches
Transmission Power Take-Off (PTO)	• Sliding gearwheel or tooth clutch • Multi-disc clutch • Oil pump

SUMMARY AND NEXT STEPS

The formal release of the proposed CO_2 emissions and fuel consumption certification procedure for HDVs takes place with the publication of the text adopted by the Technical Committee—Motor Vehicles in the Official Journal of the European Union. The adopted certification regulation is a fundamental first step to address the CO_2 emissions of HDVs in the EU. Figure 4 and Table 6 present a summary of the CO_2 emissions and fuel consumption type-approval process, and the respective conformity-of-production tolerances necessary to ensure the validity of the declared input data.

Table 6. Summary of conformity-of-production tolerances

Component	Conformity-of-production metric	Tolerance for pass
Engine	Fuel consumption over the WHSC: $\left(\frac{FC_{CoP}}{FC_{TA}} - 1\right) \times 100\%$	< 3%
Transmission	Average mechanical efficiency over 18 different torque-speed points: $\eta_{TA} - \eta_{CoP} \times 100\%$	< 3% (Automatic) < 1.5% (all others)
Axle	Average mechanical efficiency over 4 different torque-speed points: $\left(1 - \frac{\eta_{CoP}}{\eta_{TA}}\right) \times 100\%$	< 1.5% (Single reduction) < 2% (all others)
Aerodynamic drag	Air drag area as determined by the constant-speed test $\left(\frac{C_dA_{CoP}}{C_dA_{TA}} - 1\right) \times 100\%$	< 7.5%
Tires	Coefficient of rolling resistance $C_{rr,CoP} - C_{rr,TA}$	< 0.3 N/kN

Notes on abbreviations and symbols: Type approval (TA), conformity of production (CoP), fuel consumption (FC), mechanical efficiency (η), air drag area (C_dA), coefficient of rolling resistance (C_{rr}).

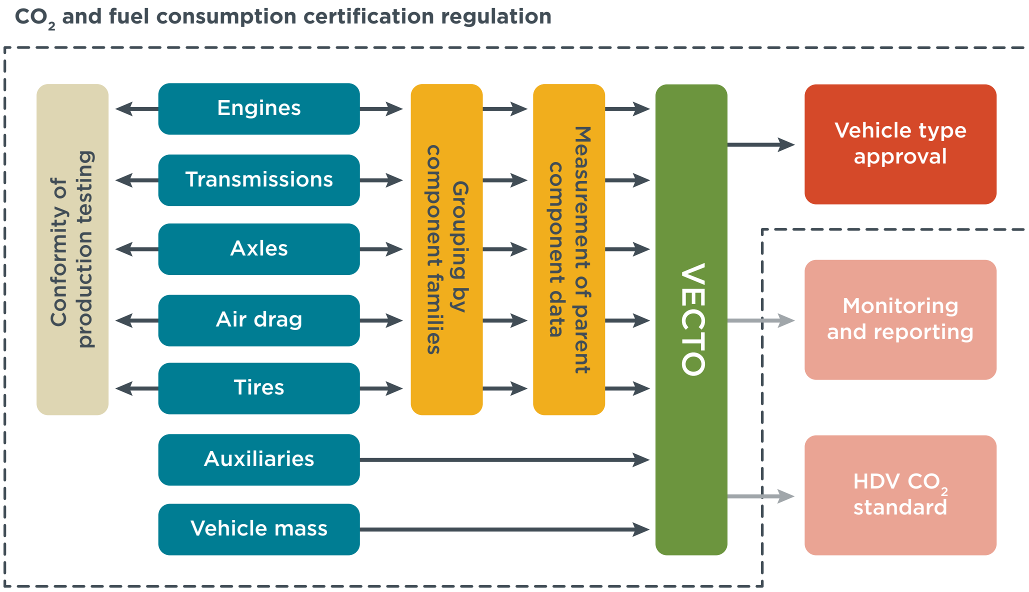

Figure 4. Summary of the elements of the adopted HDV CO_2 certification regulation

The CO_2 emissions and fuel consumption certification procedure sets the necessary groundwork for the implementation of the proposal[28] on monitoring and reporting CO_2 emissions and for the introduction of CO_2 standards[29] for HDVs.

Under the regulatory proposal for the monitoring and reporting of CO_2 emissions and fuel consumption of new HDVs, the vehicle and component data necessary for CO_2 type approval of HDVs would be monitored, reported, and published at the EU level. Starting in 2019, the national type-approval authorities are required to report the registration data of newly registered HDVs to the European Environment Agency (EEA), in particular the vehicle identification numbers. The EEA would then extract detailed technical data from the manufacturers' databases. Starting in 2020, the data would be made publicly available by the EEA, covering data collected for the year 2019. The data resulting from the monitoring and reporting, and its respective analysis, would indicate the CO_2 performance of the EU heavy-duty vehicle fleet as a whole, as well as for each manufacturer. It would also allow following of the market penetration of certain fuel-efficiency technologies.

The adoption and implementation of the HDV CO_2 monitoring and reporting proposal will take place under the ordinary, co-decision legislative approval procedure.

28 The proposed regulatory text from May 31, 2017 can be found in: https://ec.europa.eu/transport/sites/transport/files/com20170279-regulation-hdv.pdf

29 According to the communication "EUROPE ON THE MOVE—An agenda for a socially fair transition towards clean, competitive and connected mobility for all" a proposal for CO_2 standards for heavy duty vehicles in the EU is envisaged respectively for the first half of 2018. https://ec.europa.eu/transport/sites/transport/files/com20170283-europe-on-the-move.pdf