
Changes to legislation: There are outstanding changes not yet made to Commission Regulation (EU) 2017/2400. Any changes that have already been made to the legislation appear in the content and are referenced with annotations. (See end of Document for details) View outstanding changes

ANNEX V

VERIFYING ENGINE DATA

3. General requirements

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

Engines shall be grouped into engine CO₂-families defined in accordance with Appendix 3. Paragraph 4.1 explains which testruns shall be performed for the purpose of certification of one specific engine CO₂-family.

3.1 Test conditions

All testruns performed for the purpose of certification of one specific engine CO₂-family defined in accordance with Appendix 3 to this Annex shall be conducted on the same physical engine and without any changes to the setup of the engine dynamometer and the engine system, apart from the exceptions defined in paragraph 4.2 and Appendix 3.

3.1.1 Laboratory test conditions

The tests shall be conducted under ambient conditions meeting the following conditions over the whole testrun:

- (1) The parameter f_a describing the laboratory test conditions, determined in accordance with paragraph 6.1 of Annex 4 to UN/ECE Regulation 49 Rev.06, shall be within the following limits: $0,96 \leq f_a \leq 1,04$.
- (2) The absolute temperature (T_a) of the engine intake air expressed in Kelvin, determined in accordance with paragraph 6.1 of Annex 4 to UN/ECE Regulation 49 Rev.06 shall be within the following limits: $283 \text{ K} \leq T_a \leq 303 \text{ K}$.
- (3) The atmospheric pressure expressed in kPa, determined in accordance with paragraph 6.1 of Annex 4 to UN/ECE Regulation 49 Rev.06 shall be within the following limits: $90 \text{ kPa} \leq p_s \leq 102 \text{ kPa}$.

If tests are performed in test cells that are able to simulate barometric conditions other than those existing in the atmosphere at the specific test site, the applicable f_a value shall be determined with the simulated values of atmospheric pressure by the conditioning system. The same reference value for the simulated atmospheric pressure shall be used for the intake air and exhaust path and all other relevant engine systems. The actual value of the simulated atmospheric pressure for the intake air and exhaust path and all other relevant engine systems shall be within the limits specified in subpoint (3).

In cases where the ambient pressure in the atmosphere at the specific test site exceeds the upper limit of 102 kPa, tests in accordance with this Annex may still be performed. In this case tests shall be performed with the specific ambient air pressure in the atmosphere.

In cases where the test cell has the ability to control temperature, pressure and/or humidity of engine intake air independent of the atmospheric conditions the same settings for those parameters shall be used for all testruns performed for the purpose of certification of one specific engine CO₂-family defined in accordance with Appendix 3 to this Annex.

3.1.2 Engine installation

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The test engine shall be installed in accordance with paragraphs 6.3 to 6.6 of Annex 4 to UN/ECE Regulation 49 Rev.06.

If auxiliaries/equipment necessary for operating the engine system are not installed as required in accordance with paragraph 6.3 of Annex 4 to UN/ECE Regulation 49 Rev.06, all measured engine torque values shall be corrected for the power required for driving these components for the purpose of this Annex in accordance with paragraph 6.3 of Annex 4 to UN/ECE Regulation 49 Rev.06.

The power consumption of the following engine components resulting in the engine torque required for driving these engine components shall be determined in accordance with Appendix 5 to this Annex:

- (1) fan
- (2) electrically powered auxiliaries/equipment necessary for operating the engine system

3.1.3 Crankcase emissions

In the case of a closed crankcase, the manufacturer shall ensure that the engine's ventilation system does not permit the emission of any crankcase gases into the atmosphere. If the crankcase is of an open type, the emissions shall be measured and added to the tailpipe emissions, following the provisions set out in paragraph 6.10. of Annex 4 to UN/ECE Regulation 49 Rev.06.

3.1.4 Engines with charge air-cooling

During all testruns the charge air cooling system used on the test bed shall be operated under conditions which are representative for in-vehicle application at reference ambient conditions. The reference ambient conditions are defined as 293 K for air temperature and 101,3 kPa for pressure.

The laboratory charge air cooling for tests according to this regulation should comply with the provisions specified in paragraph 6.2 of Annex 4 to UN/ECE Regulation 49 Rev.06.

3.1.5 Engine cooling system

- (1) During all testruns the engine cooling system used on the test bed shall be operated under conditions which are representative for in-vehicle application at reference ambient conditions. The reference ambient conditions are defined as 293 K for air temperature and 101,3 kPa for pressure.
- (2) The engine cooling system should be equipped with thermostats according to the manufacturer specification for vehicle installation. If either a non-operational thermostat is installed or no thermostat is used, subpoint (3) shall apply. The setting of the cooling system shall be performed in accordance with subpoint (4).
- (3) If no thermostat is used or a non-operational thermostat is installed, the test bed system shall reflect the behavior of the thermostat under all test conditions. The setting of the cooling system shall be performed in accordance with subpoint (4).
- (4) ^[F1]The engine coolant flow rate (or alternatively the pressure difference across the engine side of the heat exchanger) and the engine coolant temperature shall be set to a value representative for in-vehicle application at reference ambient conditions when the engine is operated at rated speed and full load with the engine thermostat in fully open position. This setting defines the coolant reference temperature. For all testruns performed for the purpose of certification of one specific engine within one engine CO₂-family, the cooling system setting shall not be changed, neither on the engine side

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nor on the test bed side of the cooling system. The temperature of the test bed side cooling medium shall be kept reasonably constant by good engineering judgement. The cooling medium on the test bed side of the heat exchanger shall not exceed the nominal thermostat opening temperature downstream of the heat exchanger.]

- (5) For all testruns performed for the purpose of certification of one specific engine within one engine CO₂-family the engine coolant temperature shall be maintained between the nominal value of the thermostat opening temperature declared by the manufacturer and the coolant reference temperature in accordance with subpoint (4) as soon as the engine coolant has reached the declared thermostat opening temperature after engine cold start.
- (6) For the WHTC coldstart test performed in accordance with paragraph 4.3.3, the specific initial conditions are specified in paragraphs 7.6.1. and 7.6.2 of Annex 4 to UN/ECE Regulation 49 Rev.06. If simulation of the thermostat behaviour in accordance with subpoint (3) is applied, there shall be no coolant flow across the heat exchanger as long as the engine coolant has not reached the declared nominal thermostat opening temperature after cold start.

Textual Amendments

- F1** Substituted by [Commission Regulation \(EU\) 2019/318 of 19 February 2019 amending Regulation \(EU\) 2017/2400 and Directive 2007/46/EC of the European Parliament and of the Council as regards the determination of the CO₂ emissions and fuel consumption of heavy-duty vehicles \(Text with EEA relevance\).](#)

3.2 Fuels

The respective reference fuel for the engine systems under test shall be selected from the fuel types listed in Table 1. The fuel properties of the reference fuels listed in Table 1 shall be those specified in Annex IX to Commission Regulation (EU) No 582/2011.

To ensure that the same fuel is used for all testruns performed for the purpose of certification of one specific engine CO₂-family no refill of the tank or switch to another tank supplying the engine system shall occur. Exceptionally a refill or switch may be allowed if it can be ensured that the replacement fuel has exactly the same properties as the fuel used before (same production batch).

The NCV for the fuel used shall be determined by two separate measurements in accordance with the respective standards for each fuel type defined in Table 1. The two separate measurements shall be performed by two different labs independent from the manufacturer applying for certification. The lab performing the measurements shall comply with the requirements of ISO/IEC 17025. The approval authority shall ensure that the fuel sample used for determination of the NCV is taken from the batch of fuel used for all testruns.

If the two separate values for the NCV are deviating by more than 440 Joule per gram fuel, the values determined shall be void and the measurement campaign shall be repeated.

[^{F1}The mean value of the two separate NCV that are not deviating by more than 440 Joule per gram fuel shall be documented in MJ/kg rounded to 2 places to the right of the decimal point in accordance with ASTM E 29-06.]

For gas fuels the standards for determining the NCV according to Table 1 contain the calculation of the calorific value based on the fuel composition. The gas fuel composition for determining the NCV shall be taken from the analysis of the reference gas fuel batch used for the certification

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tests. For the determination of the gas fuel composition used for determining the NCV only one single analysis by a lab independent from the manufacturer applying for certification shall be performed. For gas fuels the NCV shall be determined based on this single analysis instead of a mean value of two separate measurements.

[^{F2}For gas fuels, switches between fuel tanks of different production batches are allowed exceptionally; in that case, the NCV of each used fuel batch should be calculated and the highest value should be documented.]

Textual Amendments

- F2** Inserted by [Commission Regulation \(EU\) 2019/318 of 19 February 2019 amending Regulation \(EU\) 2017/2400 and Directive 2007/46/EC of the European Parliament and of the Council as regards the determination of the CO₂ emissions and fuel consumption of heavy-duty vehicles \(Text with EEA relevance\).](#)

TABLE 1

Reference fuels for testing

Fuel type / engine type	Reference fuel type	Standard used for determination of NCV
Diesel / CI	B7	at least ASTM D240 or DIN 59100-1 (ASTM D4809 is recommended)
Ethanol / CI	ED95	at least ASTM D240 or DIN 59100-1 (ASTM D4809 is recommended)
Petrol / PI	E10	at least ASTM D240 or DIN 59100-1 (ASTM D4809 is recommended)
Ethanol / PI	E85	at least ASTM D240 or DIN 59100-1 (ASTM D4809 is recommended)
LPG / PI	LPG Fuel B	ASTM 3588 or DIN 51612
[^{F1} Natural gas / PI	G ₂₅ or G _R	ISO 6976 or ASTM 3588]

3.3 Lubricants

The lubricating oil for all testruns performed in accordance with this Annex shall be a commercially available oil with unrestricted manufacturer approval under normal in-service conditions as defined in paragraph 4.2 of Annex 8 to UN/ECE Regulation 49 Rev.06. Lubricants for which the usage is restricted to certain special operation conditions of the engine system or having an unusually short oil change interval shall not be used for the purpose of testruns

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in accordance with this Annex. The commercially available oil shall not be modified by any means and no additives shall be added.

All testruns performed for the purpose of certification of the CO₂ emissions and fuel consumption related properties of one specific engine CO₂-family shall be performed with the same type of lubricating oil.

3.4 Fuel flow measurement system

All fuel flows consumed by the whole engine system shall be captured by the fuel flow measurement system. Additional fuel flows not directly supplied to the combustion process in the engine cylinders shall be included in the fuel flow signal for all testruns performed. Additional fuel injectors (e.g. cold start devices) not necessary for the operation of the engine system shall be disconnected from the fuel supply line during all testruns performed.

3.5 Measurement equipment specifications

The measurement equipment shall meet the requirements of paragraph 9 of Annex 4 to UN/ECE Regulation 49 Rev.06.

Notwithstanding the requirements defined in paragraph 9 of Annex 4 to UN/ECE Regulation 49 Rev.06, the measurement systems listed in Table 2 shall meet the limits defined in Table 2.

TABLE 2

Requirements of measurement systems

Measurement system	Linearity				Accuracy ^a	Rise time ^b
	Intercept $x_{\min} \times (a_1 - 1) + a_0$	Slope a_1	Standard error of estimate SEE	Coefficient of determination ²		
Engine speed	$\leq 0,2$ % max calibration ^c	0,999 - 1,001	$\leq 0,1$ % max calibration ^c	$\geq 0,9985$	0,2 % of reading or 0,1 % of max. calibration ^c of speed whichever is larger	≤ 1 s
Engine torque	$\leq 0,5$ % max calibration ^c	0,995 - 1,005	$\leq 0,5$ % max calibration ^c	$\geq 0,995$	0,6 % of reading or 0,3 % of max. calibration ^c of torque whichever is larger	≤ 1 s

a 'Accuracy' means the deviation of the analyzer reading from a reference value which is traceable to a national or international standard.

b 'Rise time' means the difference in time between the 10 percent and 90 percent response of the final analyzer reading ($t_{90} - t_{10}$).

c The 'max calibration' values shall be 1,1 times the maximum predicted value expected during all testruns for the respective measurement system.

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Fuel mass flow for liquid fuels	$\leq 0,5\%$ max calibration ^c	0,995 - 1,005	$\leq 0,5\%$ max calibration ^c	$\geq 0,995$	0,6 % of reading or 0,3 % of max. calibration ^c of flow whichever is larger	≤ 2 s
Fuel mass flow for gaseous fuels	$\leq 1\%$ max calibration ^c	0,99 - 1,01	$\leq 1\%$ max calibration ^c	$\geq 0,995$	1 % of reading or 0,5 % of max. calibration ^c of flow whichever is larger	≤ 2 s
Electrical Power	$\leq 1\%$ max calibration ^c	0,98 - 1,02	$\leq 2\%$ max calibration ^c	$\geq 0,990$	n.a.	≤ 1 s
Current	$\leq 1\%$ max calibration ^c	0,98 - 1,02	$\leq 2\%$ max calibration ^c	$\geq 0,990$	n.a.	≤ 1 s
Voltage	$\leq 1\%$ max calibration ^c	0,98 - 1,02	$\leq 2\%$ max calibration ^c	$\geq 0,990$	n.a.	≤ 1 s

a 'Accuracy' means the deviation of the analyzer reading from a reference value which is traceable to a national or international standard.

b 'Rise time' means the difference in time between the 10 percent and 90 percent response of the final analyzer reading ($t_{90} - t_{10}$).

c The 'max calibration' values shall be 1,1 times the maximum predicted value expected during all testruns for the respective measurement system.

' x_{\min} ', used for calculation of the intercept value in Table 2, shall be 0,9 times the minimum predicted value expected during all testruns for the respective measurement system.

The signal delivery rate of the measurement systems listed in Table 2, except for the fuel mass flow measurement system, shall be at least 5 Hz (≥ 10 Hz recommended). The signal delivery rate of the fuel mass flow measurement system shall be at least 2 Hz.

All measurement data shall be recorded with a sample rate of at least 5 Hz (≥ 10 Hz recommended).

3.5.1 Measurement equipment verification

A verification of the demanded requirements defined in Table 2 shall be performed for each measurement system. At least 10 reference values between x_{\min} and the 'max calibration' value defined in accordance with paragraph 3.5 shall be introduced to the measurement system and the response of the measurement system shall be recorded as measured value.

For the linearity verification the measured values shall be compared to the reference values by using a least squares linear regression in accordance with paragraph A.3.2 of Appendix 3 to Annex 4 to UN/ECE Regulation 49 Rev.06.

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Changes and effects yet to be applied to the whole legislation item and associated provisions

- Signature words omitted by [S.I. 2022/1273 reg. 82\(18\)](#)
- Annex 5 Appendix 6 point 1.3 substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(i\)](#)
- Annex 5 Appendix 6 point 1.4.1 image substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(iii\)\(aa\)](#)
- Annex 5 Appendix 6 point 1.5.1 image substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(iv\)\(aa\)](#)
- Annex 5 Appendix 4 point 7.4 word substituted by [S.I. 2022/1273 reg. 83\(4\)\(a\)](#)
- Annex 5 Appendix 6 point 2.1 word substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(v\)](#)
- Annex 5 Appendix 6 point 1.4.1 words omitted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(iii\)\(bb\)](#)
- Annex 5 Appendix 6 point 1.5.1 words omitted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(iv\)\(bb\)](#)
- Annex 5 Appendix 6 point 1.4 words substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(ii\)](#)
- Annex 5 Appendix 6 point 2.1 table words substituted by [S.I. 2022/1273 reg. 83\(4\)\(b\)\(vi\)](#)
- Annex 10 Appendix 4 point 1.1 word substituted by [S.I. 2022/1273 reg. 83\(8\)\(d\)\(i\)](#)
- Annex 10 Appendix 1 words substituted by [S.I. 2022/1273 reg. 83\(8\)\(c\)](#)
- Annex 10 Appendix 4 point 1.1 table words substituted by [S.I. 2022/1273 reg. 83\(8\)\(d\)\(ii\)](#)
- Annex 7 Appendix 5 point 1.3 substituted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(i\)](#)
- Annex 7 Appendix 5 point 1.4.1 image substituted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(iii\)\(aa\)](#)
- Annex 7 Appendix 1s. 1 point 000.5 word substituted by [S.I. 2022/1273 reg. 83\(6\)\(b\)\(ii\)](#)
- Annex 7 Appendix 1 words inserted by [S.I. 2022/1273 reg. 83\(6\)\(b\)\(i\)\(aa\)](#)
- Annex 7 Appendix 1 words omitted by [S.I. 2022/1273 reg. 83\(6\)\(b\)\(i\)\(bb\)](#)
- Annex 7 Appendix 5 point 1.4.1 words omitted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(iii\)\(bb\)](#)
- Annex 7 Appendix 5 point 1.4 words substituted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(ii\)](#)
- Annex 7 Appendix 5 point 2.1 words substituted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(iv\)](#)
- Annex 7 Appendix 5 point 2.1 table words substituted by [S.I. 2022/1273 reg. 83\(6\)\(c\)\(v\)](#)
- Annex 8 Appendix 8 point 1.3 substituted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(i\)](#)
- Annex 8 Appendix 8 point 1.4.1 image substituted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(iii\)\(aa\)](#)
- Annex 8 Appendix 4 table 11 word omitted by [S.I. 2022/1273 reg. 83\(7\)\(c\)\(i\)](#)
- Annex 8 Appendix 4 table 13 word omitted by [S.I. 2022/1273 reg. 83\(7\)\(c\)\(i\)](#)
- Annex 8 Appendix 4 table 15 word omitted by [S.I. 2022/1273 reg. 83\(7\)\(c\)\(ii\)\(aa\)](#)
- Annex 8 Appendix 4 table 15 word omitted by [S.I. 2022/1273 reg. 83\(7\)\(c\)\(ii\)\(bb\)](#)
- Annex 8 Appendix 1s. 1 point 000.6 word substituted by [S.I. 2022/1273 reg. 83\(7\)\(b\)\(ii\)](#)
- Annex 8 Appendix 8 point 2.1 word substituted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(iv\)](#)
- Annex 8 Appendix 1 words inserted by [S.I. 2022/1273 reg. 83\(7\)\(b\)\(i\)\(aa\)](#)
- Annex 8 Appendix 1 words omitted by [S.I. 2022/1273 reg. 83\(7\)\(b\)\(i\)\(bb\)](#)
- Annex 8 Appendix 8 point 1.4.1 words omitted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(iii\)\(bb\)](#)
- Annex 8 Appendix 8 point 1.4 words substituted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(ii\)](#)
- Annex 8 Appendix 8 point 2.1 table words substituted by [S.I. 2022/1273 reg. 83\(7\)\(d\)\(v\)](#)

- Annex 2 Appendix 2s. 2 point 2 omitted by S.I. 2022/1273 reg. 83(2)(b)(ii)
- Annex 2 Appendix 2 words inserted by S.I. 2022/1273 reg. 83(2)(b)(i)
- Annex 6 Appendix 7 point 1.3 substituted by S.I. 2022/1273 reg. 83(5)(e)(i)
- Annex 6 Appendix 7 point 1.5 image substituted by S.I. 2022/1273 reg. 83(5)(e)(iii)(aa)
- Annex 6 Appendix 7 point 2.1 word substituted by S.I. 2022/1273 reg. 83(5)(e)(iv)
- Annex 6 Appendix 1 words omitted by S.I. 2022/1273 reg. 83(5)(c)
- Annex 6 Appendix 7 point 1.5 words omitted by S.I. 2022/1273 reg. 83(5)(e)(iii)(bb)
- Annex 6 Appendix 2 point 8 words substituted by S.I. 2022/1273 reg. 83(5)(d)
- Annex 6 Appendix 3 point 8 words substituted by S.I. 2022/1273 reg. 83(5)(d)
- Annex 6 Appendix 4 point 8 words substituted by S.I. 2022/1273 reg. 83(5)(d)
- Annex 6 Appendix 5 point 8 words substituted by S.I. 2022/1273 reg. 83(5)(d)
- Annex 6 Appendix 7 point 1.4 words substituted by S.I. 2022/1273 reg. 83(5)(e)(ii)
- Annex 6 Appendix 7 point 2.1 table words substituted by S.I. 2022/1273 reg. 83(5)(e)(v)
- Art. 3(5) omitted by S.I. 2022/1273 reg. 82(4)(a)
- Art. 3(16) words substituted by S.I. 2022/1273 reg. 82(4)(b)
- Art. 3(20) words substituted by S.I. 2022/1273 reg. 82(4)(c)
- Art. 10(1a) inserted by S.I. 2022/1273 reg. 82(8)(b)
- Annex 10a para. 3(f) words inserted by S.I. 2022/1273 reg. 83(9)(a)
- Annex 10a para. 3(f) table words substituted by S.I. 2022/1273 reg. 83(9)(b)(c)
- Art. 12(8) inserted by S.I. 2022/1273 reg. 82(10)