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Light vehicles: UN Global Technical Regulations Nos. 15 (Worldwide harmonized Light vehicles Test Procedures (WLTP)) and 19 (Evaporative emission test procedure for the Worldwide harmonized Light vehicle Test Procedure (WLTP EVAP))

Proposal for Amendment 6 to global technical regulation No. 15 (Worldwide harmonized Light vehicles Test Procedures (WLTP))

Submitted by the Informal Working Group on Worldwide harmonized Light vehicles Test Procedure (WLTP)*

The text reproduced below was prepared by the Informal Working Group (IWG) on Worldwide harmonized Light vehicles Test Procedure (WLTP) in line with Phase 2 of its mandate (ECE/TRANS/WP.29/AC.3/44). The modifications to the current text of UN GTR No. 15 are marked in track changes.

KEY:	
1. Description of tests	= Is referenced and should be referenced
1.2.4. Determination	= Was referencd but should not be referenced
2.2.2.1.3. Humidity	= Should not be referenced
2.8.1. The test cell temperature	= Requires amendment
2.8.3. Starting of the powertrain	= Was not referenced but should be
In the case of a road load matrix family	= Needs further thought/discussion

* In accordance with the programme of work of the Inland Transport Committee for 2020 as outlined in proposed programme budget for 2020 (A/74/6 (part V sect. 20) para 20.37), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

Annex 6

Type 1 test procedures and test conditions

1. Description of tests

1.1. The Type 1 test is used to verify the emissions of gaseous compounds, particulate matter, particle number (if applicable), CO_2 mass emission, fuel consumption, electric energy consumption and electric ranges over the applicable WLTP test cycle.

1.1.1. The tests shall be carried out according to the method described in paragraph 2. of this annex or paragraph 3. of Annex 8 for pure electric, hybrid electric and compressed hydrogen fuel cell hybrid vehicles. Exhaust gases, particulate matter and particle number (if applicable) shall be sampled and analysed by the prescribed methods.

1.1.2. When the reference fuel to be used is LPG or NG/biomethane, the following provisions shall apply additionally.

1.1.2.1. Exhaust emissions approval of a parent vehicle

1.1.2.1.1. The parent vehicle should demonstrate its capability to adapt to any fuel composition that may occur across the market. In the case of LPG there are variations in C3/C4 composition. In the case of NG/biomethane there are generally two types of fuel, high calorific fuel (H-gas) and low calorific fuel (Lgas), but with a significant spread within both ranges; they differ significantly in Wobbe index. These variations are reflected in the reference fuels.

1.1.2.1.2. In the case of vehicles fuelled by LPG, NG/biomethane, the parent vehicle(s) shall be tested in the Type 1 test on the two extreme reference fuels of Annex 3. In the case of NG/biomethane, if the transition from one fuel to another is in practice aided through the use of a switch, this switch shall not be used during type approval. In such a case on the manufacturer's request and with the agreement of the approval authority the pre-conditioning cycle referred in paragraph 2.6. of this annex may be extended.

1.1.2.1.3. The vehicle is considered to conform if, under the tests and reference fuels mentioned in paragraph 1.1.2.1.2. of this annex, the vehicle complies with the emission limits.

1.1.2.1.4. In the case of vehicles fuelled by LPG or NG/biomethane, the ratio of emission results "r" shall be determined for each pollutant as follows:

Type(s) of fuel	Reference fuels	Calculation of "r"
LPG and petrol or LPG only	Fuel A	$r = \frac{B}{A}$
	Fuel B	
NG/biomethane and petrol or NG/biomethane only	Fuel G_{20}	$r = \frac{G_{25}}{G_{20}}$
	Fuel G_{25}	

1.1.2.2. Exhaust emissions approval of a member of the family:

For the type approval of a mono fuel gas vehicle and bi fuel gas vehicles operating in gas mode, fuelled by LPG or NG/Biomethane, as a member of the family, a Type 1 test shall be performed with one gas reference fuel. This reference fuel may be either of the gas reference fuels. The vehicle is considered to comply if the following requirements are met:

1.1.2.2.1. The vehicle complies with the definition of a family member as defined in paragraph 5.10.3. of this UN GTR;

1.1.2.2.2. If the test fuel is reference fuel A for LPG or G20 for NG/biomethane, the emission result shall be multiplied by the relevant factor "r" calculated in paragraph 1.1.2.1.4. of this annex if $r > 1$; if $r < 1$, no correction is needed;

1.1.2.2.3. If the test fuel is reference fuel B for LPG or G25 for NG/biomethane, the emission result shall be divided by the relevant factor "r" calculated in paragraph 1.1.2.1.4. of this annex if $r < 1$; if $r > 1$, no correction is needed;

1.1.2.2.4. On the manufacturer's request, the Type 1 test may be performed on both reference fuels, so that no correction is needed;

1.1.2.2.5. The vehicle shall comply with the emission limits valid for the relevant category for both measured and calculated emissions;

1.1.2.2.6. If repeated tests are made on the same engine the results on reference fuel G_{20}, or A, and those on reference fuel G_{25}, or B, shall first be averaged; the "r" factor shall then be calculated from these averaged results;

1.1.2.2.7. Without prejudice to paragraph 2.6.4.1.2. of this annex, during the Type 1 test it is permissible to use petrol only or simultaneously with gas when operating in gas mode provided that the energy consumption of gas is higher than 80 per cent of the total amount of energy consumed during the test. This percentage shall be calculated in accordance with the method set out in Appendix 3 to this annex.

1.2. The number of tests shall be determined according to the flowchart in Figure A6/1. The limit value is the maximum allowed value for the respective criteria emission as defined by the Contracting Party.

1.2.1. The flowchart in Figure A6/1 shall be applicable only to the whole applicable WLTP test cycle and not to single phases.

1.2.2. The test results shall be the values after the applicable adjustments specified in the post-processing tables in Annex 7 and Annex 8 are applied.

1.2.3. Determination of total cycle values

1.2.3.1. If during any of the tests a criteria emissions limit is exceeded, the vehicle shall be rejected.

1.2.3.2. Depending on the vehicle type, the manufacturer shall declare as applicable the total cycle values of the CO_2 mass emission, the electric energy consumption, fuel consumption, fuel efficiency, as well as PER and AER according to Table A6/1.

1.2.3.3. At the choice of the Contracting Party, one of the following options shall be selected:

Option A:

The declared value of the electric energy consumption for OVC-HEVs under charge-depleting operating condition shall not be determined according to Figure A6/1. It shall be taken as the type approval value if the declared CO_2 value is accepted as the approval value. If that is not the case, the measured value of electric energy consumption shall be taken as the type approval value. Evidence of a correlation between declared CO_2 mass emission and electric energy consumption shall be submitted to the responsible authority in advance, if applicable.

Option B:

The declared value of the fuel efficiency for OVC-HEVs under charge-depleting operating condition shall not be determined according to Figure A6/1. It shall be taken as the type approval value if the declared electric energy consumption value is accepted as the approval value. If that is not the case, the measured value of fuel efficiency shall be taken as the type approval value. Evidence of a correlation between declared fuel efficiency and electric

energy consumption shall be submitted to the responsible authority in advance, if applicable.

1.2.3.4. If after the first test all criteria in row 1 of the applicable Table A6/2 are fulfilled, all values declared by the manufacturer shall be accepted as the type approval value. If any one of the criteria in row 1 of the applicable Table A6/2 is not fulfilled, a second test shall be performed with the same vehicle.

[If the number of cycles in the Charge-Depleting Type 1 test of an OVC-HEV is different in the first test to the expected number of Charge-Depleting Cycles, the first test shall be repeated at the request of the manufacturer and with approval of the responsible authority. The manufacturer shall provide technical justification to the responsible authority.]

1.2.3.5. After the second test, the arithmetic average results of the two tests shall be calculated. If all criteria in row 2 of the applicable Table A6/2 are fulfilled by these arithmetic average results, all values declared by the manufacturer shall be accepted as the type approval value. If any one of the criteria in row 2 of the applicable Table A6/2 is not fulfilled, a third test shall be performed with the same vehicle.

[If the number of cycles in the Charge-Depleting Type 1 test of an OVC-HEV is different in the second test to the expected number of Charge-Depleting Cycles, the second test shall be repeated at the request of the manufacturer and with approval of the responsible authority. The manufacturer shall provide technical justification to the responsible authority.]

1.2.3.6. After the third test, the arithmetic average results of the three tests shall be calculated. For all parameters which fulfil the corresponding criterion in row 3 of the applicable Table A6/2, the declared value shall be taken as the type approval value. For any parameter which does not fulfil the corresponding criterion in row 3 of the applicable Table A6/2, the arithmetic average result shall be taken as the type approval value.

[If the number of cycles in the Charge-Depleting Type 1 test of an OVC-HEV is different in the third test to the expected number of Charge-Depleting Cycles, the third test shall be repeated at the request of the manufacturer and with approval of the responsible authority. The manufacturer shall provide technical justification to the responsible authority.]

1.2.3.7. In the case that any one of the criterion of the applicable Table A6/2 is not fulfilled after the first or second test, at the request of the manufacturer and with the approval of the responsible authority, the values may be re-declared as higher values for emissions or consumption, or as lower values for electric ranges, in order to reduce the required number of tests for type approval.

1.2.3.8. Determination of the acceptance values $dCO2_1$, $dCO2_2$ and $dCO2_3$

1.2.3.8.1. Additional to the requirement of paragraph 1.2.3.8.2., the Contracting Party shall determine a value for $dCO2_1$ ranging from 0.990 to 1.020, a value for $dCO2_2$ ranging from 0.995 to 1.020, and a value for $dCO2_3$ ranging from 1.000 to 1.020 in the Table A6/2.

1.2.3.8.2. If the charge depleting Type 1 test for OVC-HEVs consists of two or more applicable WLTP test cycles and the dCO2x value is below 1.0, the dCO2x value shall be replaced by 1.0.

1.2.3.9. In the case that a test result or an average of test results was taken and confirmed as the type approval value, this result shall be referred to as the "declared value" for further calculations.

Table A6/1
Applicable rules for a manufacturer's declared values (total cycle values)[a] (as applicable)

Powertrain		*M_{CO2} [b] (g/km)*	*FC (kg/100 km)*	*FE (km/l or km/kg)*	*Electric energy consumption[c] (Wh/km)*	*All electric range / Pure Electric Range [c] (km)*
Vehicles tested according to Annex 6 (pure ICE)		M_{CO2} Paragraph 3. of Annex 7.	FC Paragraph 1.4. of Annex 7.	FE Paragraph 1.4. of Annex 7.	-	-
NOVC-FCHV		-	FC_{CS} Paragraph 4.2.1.2.1. of Annex 8.	FE_{CS} Paragraph 4.2.1.2.1. of Annex 8.	-	-
OVC-FCHV	CD	-	$FC_{,CD}$	-	$EC_{AC,CD}$	AER
	CS	-	FC_{CS}	-	-	-
NOVC-HEV		$M_{CO2,CS}$ Paragraph 4.1.1. of Annex 8.	-	FE_{CS} Paragraph 4.1.1.1. of Annex 8.	-	-
OVC-HEV	CD	$M_{CO2,CD}$ Paragraph 4.1.2. of Annex 8.	-	FE_{CD} Paragraph 4.6.1. of Annex 8.	For 4 phase WLTP test: $EC_{AC,CD}$ Paragraph 4.3.1. of Annex 8. For 3 phase WLTP test: EC Paragraph 4.6.2. of Annex 8	AER Paragraph 4.4.1.1. of Annex 8.
	CS	$M_{CO2,CS}$ Paragraph 4.1.1. of Annex 8.	-	FE_{CS} Paragraph 4.1.1.1. of Annex 8.	-	-
PEV		-	-	-	EC_{WLTC} Paragraph 4.3.4.2. of Annex 8.	PER_{WLTC} Paragraph 4.4.2. of Annex 8.

[a] The declared value shall be the value to which the necessary corrections are applied (i.e. Ki correction and the other regional corrections)
[b] Rounding to 2 places of decimal according to paragraph 7. of this UN GTR
[c] Rounding to one place of decimal according to paragraph 7. of this UN GTR

Figure A6/1
Flowchart for the number of Type 1 tests

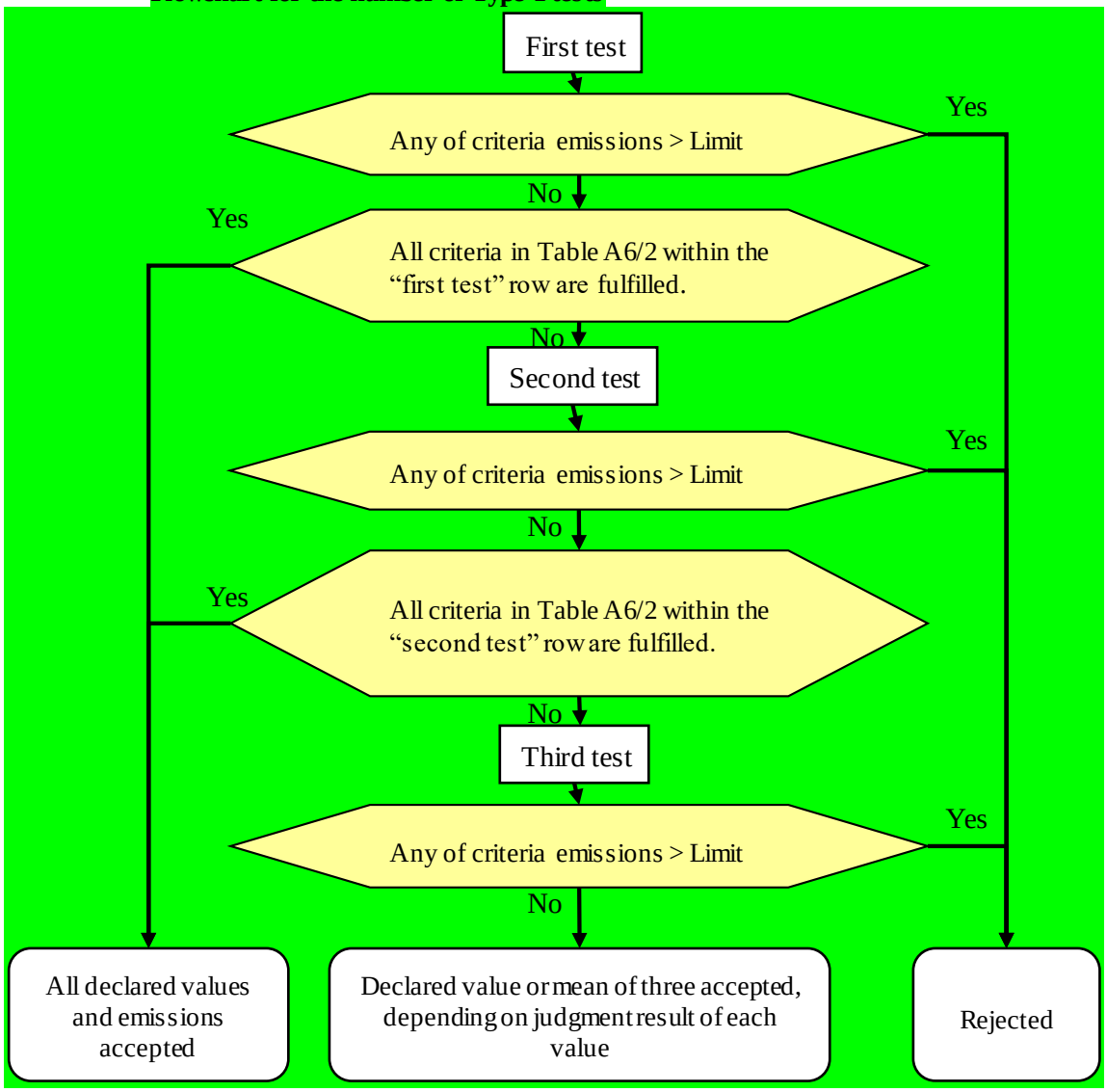


Table A6/2

Criteria for number of tests

For pure ICE vehicles, NOVC-HEVs and OVC-HEVs charge-sustaining Type 1 test (as applicable).

	Test	*Judgement parameter*	*Criteria emission*	For 4 phase WLTP test: M_{CO2}	For 3 phase WLTP test: *FE*
Row 1	First test	First test results	≤ Regulation limit × 0.9	≤ Declared value × $dCO2_1$[b]	≥ Declared value × 1.0
Row 2	Second test	Arithmetic average of the first and second test results	≤ Regulation limit × 1.0[a]	≤ Declared value × $dCO2_2$[b]	≥ Declared value × 1.0
Row 3	Third test	Arithmetic average of three test results	≤ Regulation limit × 1.0[a]	≤ Declared value × $dCO2_3$[b]	≥ Declared value × 1.0

[a] Each test result shall fulfil the regulation limit.
[b] $dCO2_1$, $dCO2_2$ and $dCO2_3$ shall be determined according to paragraph 1.2.3.8. of this annex

For OVC-HEVs charge-depleting Type 1 test (as applicable).

	Test	*Judgement parameter*	*Criteria emissions*	For 4 phase WLTP test: $M_{CO2,CD}$	For 3 phase WLTP test: *EC*	For 4 phase WLTP test: *AER*
Row 1	First test	First test results	≤ Regulation limit × 0.9[a]	≤ Declared value × $dCO2_1$[c]	≤ Declared value ×1.0	≥ Declared value × 1.0
Row 2	Second test	Arithmetic average of the first and second test results	≤ Regulation limit × 1.0[b]	≤ Declared value × $dCO2_2$[c]	≤ Declared value ×1.0	≥ Declared value × 1.0
Row 3	Third test	Arithmetic average of three test results	≤ Regulation limit × 1.0[b]	≤ Declared value × $dCO2_3$[c]	≤ Declared value ×1.0	≥ Declared value × 1.0

[a] "0.9" shall be replaced by "1.0" for charge-depleting Type 1 test for OVC-HEVs, only if the charge-depleting test contains two or more applicable WLTC cycles.
[b] Each test result shall fulfil the regulation limit.
[c] $dCO2_1$, $dCO2_2$ and $dCO2_3$ shall be determined according to paragraph 1.2.3.8. of this annex.

For PEVs

	Test	*Judgement parameter*	*Electric energy consumption*	*PER*
Row 1	First test	First test results	≤ Declared value × 1.0	≥ Declared value × 1.0
Row 2	Second test	Arithmetic average of the first and second test results	≤ Declared value × 1.0	≥ Declared value × 1.0
Row 3	Third test	Arithmetic average of three test results	≤ Declared value × 1.0	≥ Declared value × 1.0

For OVC-FCHVs charge-depleting Type 1 test.

	Test	*Judgement parameter*	*FC,CD*	$EC_{AC,CD}$	*AER*
Row 1	First test	First test results	≤ Declared value x 1.0	≤ Declared value x 1.0	≥ Declared value × 1.0
Row 2	Second test	Arithmetic average of the first and second test results	≤ Declared value x1.0	≤ Declared value x1.0	≥ Declared value × 1.0
Row 3	Third test	Arithmetic average of three test results	≤ Declared value x 1.0	≤ Declared value x 1.0	≥ Declared value × 1.0

For NOVC-FCHVs and OVC-FCHVs in CS condition (as applicable)

	Test	*Judgement parameter*	For 4 phase WLTP test: FC_{CS}	For 3 phase WLTP test: FE_{CS} (lower value)
Row 1	First test	First test results	≤ Declared value × 1.0	≥ Declared value × 1.0
Row 2	Second test	Arithmetic average of the first and second test results	≤ Declared value × 1.0	≥ Declared value × 1.0
Row 3	Third test	Arithmetic average of three test results	≤ Declared value × 1.0	≥ Declared value × 1.0

1.2.4. Determination of phase-specific values

1.2.4.1. Phase-specific value for CO_2

1.2.4.1.1. After the total cycle declared value of the CO_2 mass emission is accepted, the arithmetic average of the phase-specific values of the test results in g/km shall be multiplied by the adjustment factor CO2_AF to compensate for the difference between the declared value and the test results. This corrected value shall be the type approval value for CO_2.

$$CO2\_AF = \frac{\text{Declared value}}{\text{Phase combined value}}$$

where:

$$\text{Phase combined value} = \frac{(CO2_{ave_L} \times D_L) + (CO2_{ave_M} \times D_M) + (CO2_{ave_H} \times D_H) + (CO2_{ave_{exH}} \times D_{exH})}{D_L + D_M + D_H + D_{exH}}$$

where:

$CO2_{ave_L}$ is the arithmetic average CO_2 mass emission result for the L phase test result(s), g/km;

$CO2_{ave_M}$ is the arithmetic average CO_2 mass emission result for the M phase test result(s), g/km;

$CO2_{ave_H}$ is the arithmetic average CO_2 mass emission result for the H phase test result(s), g/km;

$CO2_{ave_{exH}}$ is the arithmetic average CO_2 mass emission result for the exH phase test result(s), g/km;

D_L is theoretical distance of phase L, km;

D_M is theoretical distance of phase M, km;

D_H is theoretical distance of phase H, km;

D_{exH} is theoretical distance of phase exH, km.

1.2.4.1.2. If the total cycle declared value of the CO_2 mass emission is not accepted, the type approval phase-specific CO_2 mass emission value shall be calculated by taking the arithmetic average of the all test results for the respective phase.

1.2.4.2. Phase-specific values for fuel consumption

The fuel consumption value shall be calculated by the phase-specific CO_2 mass emission using the equations in paragraph 1.2.4.1. of this annex and the arithmetic average of the emissions.

2. Type 1 test

2.1. Overview

2.1.1. The Type 1 test shall consist of prescribed sequences of dynamometer preparation, fuelling, soaking, and operating conditions.

2.1.2. The Type 1 test shall consist of vehicle operation on a chassis dynamometer on the applicable WLTC for the interpolation family. A proportional part of the diluted exhaust emissions shall be collected continuously for subsequent analysis using a constant volume sampler.

2.1.3. Background concentrations shall be measured for all compounds for which dilute mass emissions measurements are conducted. For exhaust emissions testing, this requires sampling and analysis of the dilution air.

2.1.3.1. Background particulate measurement

2.1.3.1.1. Where the manufacturer requests and the Contracting Party permits subtraction of either dilution air or dilution tunnel background particulate mass from emissions measurements, these background levels shall be determined according to the procedures listed in paragraphs 2.1.3.1.1.1. to 2.1.3.1.1.3. inclusive of this annex.

2.1.3.1.1.1. The maximum permissible background correction shall be a mass on the filter equivalent to 1 mg/km at the flow rate of the test.

2.1.3.1.1.2. If the background exceeds this level, the default figure of 1 mg/km shall be subtracted.

2.1.3.1.1.3. Where subtraction of the background contribution gives a negative result, the background level shall be considered to be zero.

2.1.3.1.2. Dilution air background particulate mass level shall be determined by passing filtered dilution air through the particulate background filter. This shall be drawn from a point immediately downstream of the dilution air filters. Background levels in $\mu g/m^3$ shall be determined as a rolling arithmetic average of at least 14 measurements with at least one measurement per week.

2.1.3.1.3. Dilution tunnel background particulate mass level shall be determined by passing filtered dilution air through the particulate background filter. This shall be drawn from the same point as the particulate matter sample. Where secondary dilution is used for the test, the secondary dilution system shall be active for the purposes of background measurement. One measurement may be performed on the day of test, either prior to or after the test.

2.1.3.2. Background particle number determination (if applicable)

2.1.3.2.1. Where the Contracting Party permits subtraction of either dilution air or dilution tunnel background particle number from emissions measurements and a manufacturer requests a background correction, these background levels shall be determined as follows:

2.1.3.2.1.1. The background value may be either calculated or measured. The maximum permissible background correction shall be related to the maximum allowable leak rate of the particle number measurement system (0.5 particles per cm^3) scaled from the particle concentration reduction factor, PCRF, and the CVS flow rate used in the actual test;

2.1.3.2.1.2. Either the Contracting Party or the manufacturer may request that actual background measurements are used instead of calculated ones.

2.1.3.2.1.3. Where subtraction of the background contribution gives a negative result, the PN result shall be considered to be zero.

2.1.3.2.2. The dilution air background particle number level shall be determined by sampling filtered dilution air. This shall be drawn from a point immediately downstream of the dilution air filters into the PN measurement system. Background levels in particles per cm^3 shall be determined as a rolling arithmetic average of least 14 measurements with at least one measurement per week.

2.1.3.2.3. The dilution tunnel background particle number level shall be determined by sampling filtered dilution air. This shall be drawn from the same point as the PN sample. Where secondary dilution is used for the test the secondary dilution system shall be active for the purposes of background measurement. One measurement may be performed on the day of test, either prior to or after the test using the actual PCRF and the CVS flow rate utilised during the test.

2.2. General test cell equipment

2.2.1. Parameters to be measured

2.2.1.1. The following temperatures shall be measured with an accuracy of ±1.5 °C:

(a) Test cell ambient air;

(b) Dilution and sampling system temperatures as required for emissions measurement systems defined in Annex 5.

2.2.1.2. Atmospheric pressure shall be measurable with a precision of ±0.1 kPa.

2.2.1.3. Specific humidity H shall be measurable with a precision of ±1 g H_2O/kg dry air.

2.2.2. Test cell and soak area

2.2.2.1. Test cell

2.2.2.1.1. The test cell shall have a temperature set point of 23 °C. The tolerance of the actual value shall be within ±5 °C. The air temperature and humidity shall be measured at the test cell's cooling fan outlet at a minimum frequency of 0.1 Hz. For the temperature at the start of the test, see paragraph 2.8.1. of this annex.

2.2.2.1.2. The specific humidity H of either the air in the test cell or the intake air of the engine shall be such that:

$$5.5 \leq H \leq 12.2 \text{ (g } H_2O\text{/kg dry air)}$$

2.2.2.1.3. Humidity shall be measured continuously at a minimum frequency of 0.1 Hz.

2.2.2.2. Soak area

The soak area shall have a temperature set point of 23 °C and the tolerance of the actual value shall be within ±3 °C on a 5-minute running arithmetic average and shall not show a systematic deviation from the set point. The temperature shall be measured continuously at a minimum frequency of 0.033 Hz (every 30 s).

2.3. Test vehicle

2.3.1. General

The test vehicle shall conform in all its components with the production series, or, if the vehicle is different from the production series (e.g. for worst case testing), a full description shall be recorded. In selecting the test vehicle, the manufacturer and the responsible authority shall agree which vehicle model is representative for the interpolation family.

In the case that vehicles within an interpolation family are equipped with different emission control systems that could have an effect on the emission behaviour, the manufacturer shall either demonstrate to the responsible authority that the test vehicle(s) selected and its (their) results from the Type 1 test are representative for the interpolation family, or demonstrate the fulfilment of the criteria emission within the interpolation family by testing one or more individual vehicles that differ in their emission control systems.

For the measurement of emissions, the road load as determined with test vehicle H shall be applied. In the case of a road load matrix family, for the measurement of emissions, the road load as calculated for vehicle H_M according to paragraph 5.1. of Annex 4 shall be applied.

If at the request of the manufacturer the interpolation method is used (see paragraph 3.2.3.2. of Annex 7), an additional measurement of emissions shall be performed with the road load as determined with test vehicle L. Tests on vehicles H and L should be performed with the same test vehicle and shall be tested with the shortest n/v ratio (with a tolerance of ±1.5 per cent) within the interpolation family. In the case of a road load matrix family, an additional measurement of emissions shall be performed with the road load as calculated for vehicle L_M according to paragraph 5.1. of Annex 4.

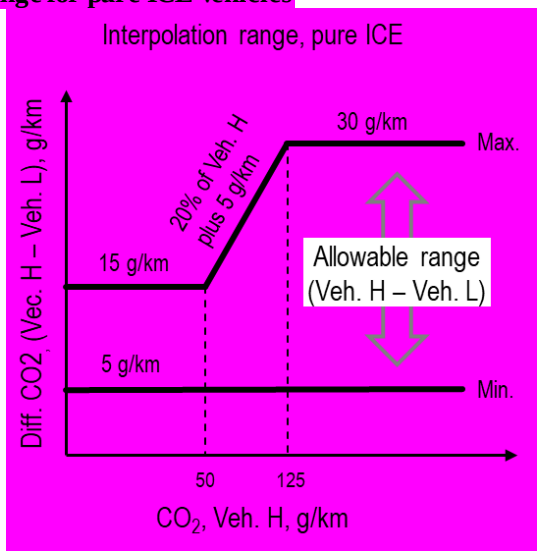
Road load coefficients and the test mass of test vehicle L and H may be taken from different road load matrix families. They may also be taken from different road load families as long as the difference between these road load families has been demonstrated to and accepted by the responsible authority, and results from either applying paragraph 6.8. of Annex 4 or tyres taken from different tyre categories, while the requirements in paragraph 2.3.2. of this annex are maintained.

2.3.2. CO_2 interpolation range

2.3.2.1. The interpolation method shall only be used if the difference in CO_2 over the applicable cycle resulting from step 9 in Table A7/1 of Annex 7 between test vehicles L and H is between a minimum of 5 g/km and a maximum defined in paragraph 2.3.2.2. of this annex.

2.3.2.2. The maximum difference in CO_2 emissions allowed over the applicable cycle resulting from step 9 in Table A7/1 of Annex 7 between test vehicles L and H shall be 20 per cent plus 5 g/km of the CO_2 emissions from vehicle H, but at least 15 g/km and not exceeding 30 g/km. See Figure A6/2.

Figure A6/2
Interpolation range for pure ICE vehicles

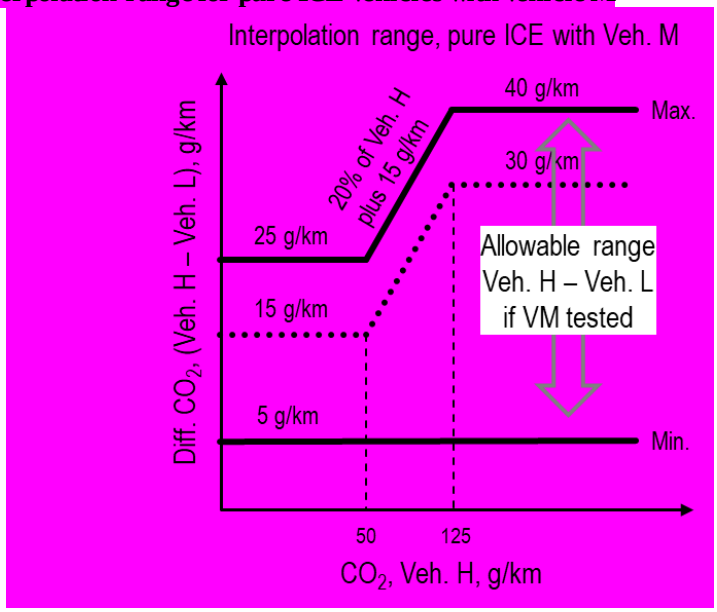


This restriction does not apply for the application of a road load matrix family or when the calculation of the road load of vehicles L and H is based on the default road load.

2.3.2.2.1. The allowed interpolation range defined in paragraph 2.3.2.2. of this annex may be increased by 10 g/km CO_2 (see Figure A6/3) if a vehicle M is tested within that family and the conditions according to paragraph 2.3.2.4. of this annex are fulfilled. This increase is allowed only once within an interpolation family.

Figure A6/3

Interpolation range for pure ICE vehicles with vehicle M



2.3.2.3. At the request of the manufacturer and with approval of the responsible authority, the application of the interpolation method on individual vehicle values within a family may be extended if the maximum extrapolation of an individual vehicle (Step 10 in Table A7/1 of Annex 7) is not more than 3 g/km above the CO_2 emission of vehicle H (Step 9 in Table A7/1 of Annex 7) and/or is not more than 3 g/km below the CO_2 emission of vehicle L (Step 9 in Table A7/1 of Annex 7). This extrapolation is valid only within the absolute boundaries of the interpolation range specified in paragraph 2.3.2.2.

For the application of a road load matrix family, or when the calculation of the road load of vehicles L and H is based on the default road load, extrapolation is not permitted.

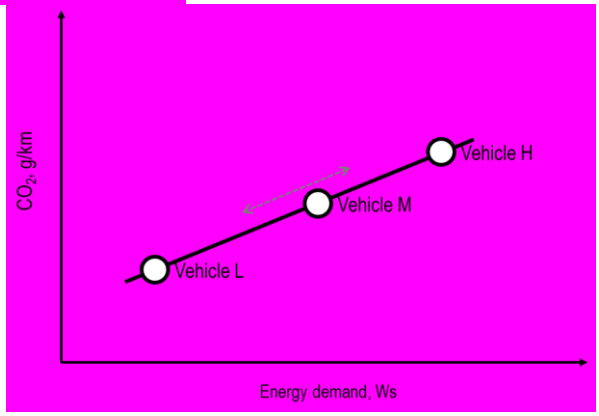
2.3.2.4. Vehicle M

Vehicle M is a vehicle within the interpolation family between the vehicles L and H with a cycle energy demand which is preferably closest to the average of vehicles L and H.

The limits of the selection of vehicle M (see Figure A6/4) are such that neither the difference in CO_2 emission values between vehicles H and M nor the difference in CO_2 emission values between vehicles M and L is greater than the allowed CO_2 range in accordance with paragraph 2.3.2.2. of this annex. The defined road load coefficients and the defined test mass shall be recorded.

Figure A6/4

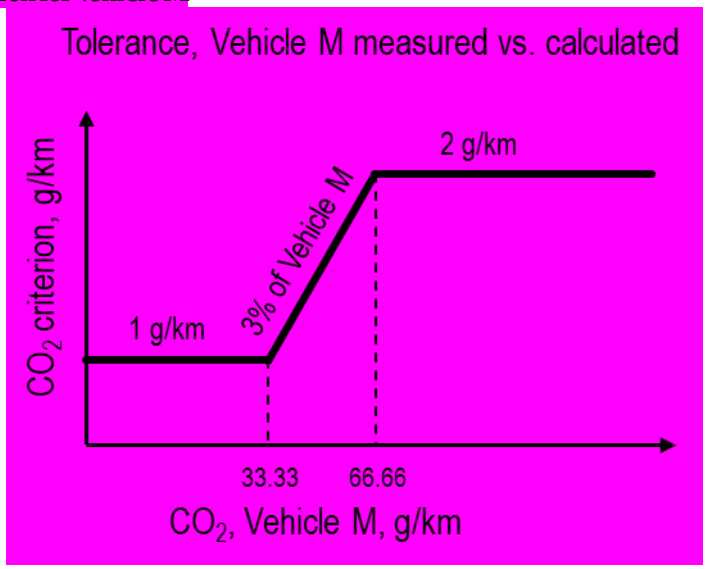
Limits for the selection of vehicle M



The linearity of CO_2 mass emission for vehicle M shall be verified against the linearly interpolated CO_2 mass emission between vehicles L and H over the applicable cycle by using the corrected measured values referring to the step used in Table A7/1 of Annex7.

The linearity criterion for vehicle M (see Figure A6/5) shall be considered fulfilled, if the CO_2 mass emission of the vehicle M over the applicable WLTC minus the CO_2 mass emission derived by interpolation is less than 2 g/km or 3 per cent of the interpolated value, whichever value is lower, but at least 1 g/km.

Figure A6/5
Linearity criterion for vehicle M



If the linearity criterion is fulfilled, the CO_2 values of individual vehicles shall be interpolated between vehicles L and H.

If the linearity criterion is not fulfilled, the interpolation family shall be split into two sub-families for vehicles with a cycle energy demand between vehicles L and M, and vehicles with a cycle energy demand between vehicles M and H. In such a case, the final CO_2 mass emissions of vehicle M shall be determined in accordance with the same process as for vehicles L or H. See step 9 in Table A7/1 of Annex7.

For vehicles with a cycle energy demand between that of vehicles L and M, each parameter of vehicle H necessary for the application of the interpolation method on individual values shall be substituted by the corresponding parameter of vehicle M.

For vehicles with a cycle energy demand between that of vehicles M and H, each parameter of vehicle L necessary for the application of the interpolation method on individual values shall be substituted by the corresponding parameter of vehicle M.

2.3.3. Run-in

The vehicle shall be presented in good technical condition. It shall have been run-in and driven between 3,000 and 15,000 km before the test. The engine, transmission and vehicle shall be run-in in accordance with the manufacturer's recommendations.

2.4. Settings

2.4.1. Dynamometer settings and verification shall be performed according to Annex4.

2.4.2. Dynamometer operation

2.4.2.1. Auxiliary devices shall be switched off or deactivated during dynamometer operation unless their operation is required by regional legislation.

2.4.2.1.1. At the option of the Contracting Party, if the vehicle is equipped with a coasting functionality, this functionality shall be deactivated either by a switch or by the vehicle's dynamometer operation mode during chassis dynamometer testing, except for tests where the coasting functionality is explicitly required by the test procedure.

2.4.2.2. The vehicle's dynamometer operation mode, if any, shall be activated by using the manufacturer's instruction (e.g. using vehicle steering wheel buttons in a special sequence, using the manufacturer's workshop tester, removing a fuse).

At the choice of the Contracting Party, one of the following options shall be selected:

Option A:

The manufacturer shall provide the responsible authority a list of the deactivated devices and/or functionalities and justification for the deactivation. The dynamometer operation mode shall be approved by the responsible authority and the use of a dynamometer operation mode shall be recorded.

Option B:

The manufacturer shall provide the responsible authority a list of the deactivated devices and justification for the deactivation. The dynamometer operation mode shall be approved by the responsible authority and the use of a dynamometer operation mode shall be recorded.

2.4.2.3. At the choice of the Contracting Party, one of the following options shall be selected:

Option A:

The vehicle's dynamometer operation mode shall not activate, modulate, delay or deactivate the operation of any part (with the exclusion of the coasting functionality) that affects the emissions and fuel consumption under the test conditions. Any device that affects the operation on a chassis dynamometer shall be set to ensure a proper operation.

Option B:

The vehicle's dynamometer operation mode shall not activate, modulate, delay or deactivate the operation of any part that affects the emissions and fuel consumption under the test conditions. Any device that affects the operation on a chassis dynamometer shall be set to ensure a proper operation.

2.4.2.4. Allocation of dynamometer type to test vehicle

2.4.2.4.1. If the test vehicle has two powered axles, and under WLTP conditions it is partially or permanently operated with two axles being powered or recuperating energy over the applicable cycle the vehicle shall be tested on a dynamometer in 4WD operation which fulfils the specifications in paragraphs 2.2. and 2.3. of Annex 5.

2.4.2.4.2. If the test vehicle is tested with only one powered axle, the test vehicle shall be tested on a dynamometer in 2WD operation which fulfils the specifications in paragraph 2.2. of Annex 5.

At the request of the manufacturer and with the approval of the approval authority a vehicle with one powered axle may be tested on a 4WD dynamometer in 4WD operation mode.

2.4.2.4.3. If the test vehicle is operated with two axles being powered in dedicated driver-selectable modes which are not intended for normal daily operation but only for special limited purposes, such as 'mountain mode' or 'maintenance mode', or when the mode with two powered axles is only activated in an off-road

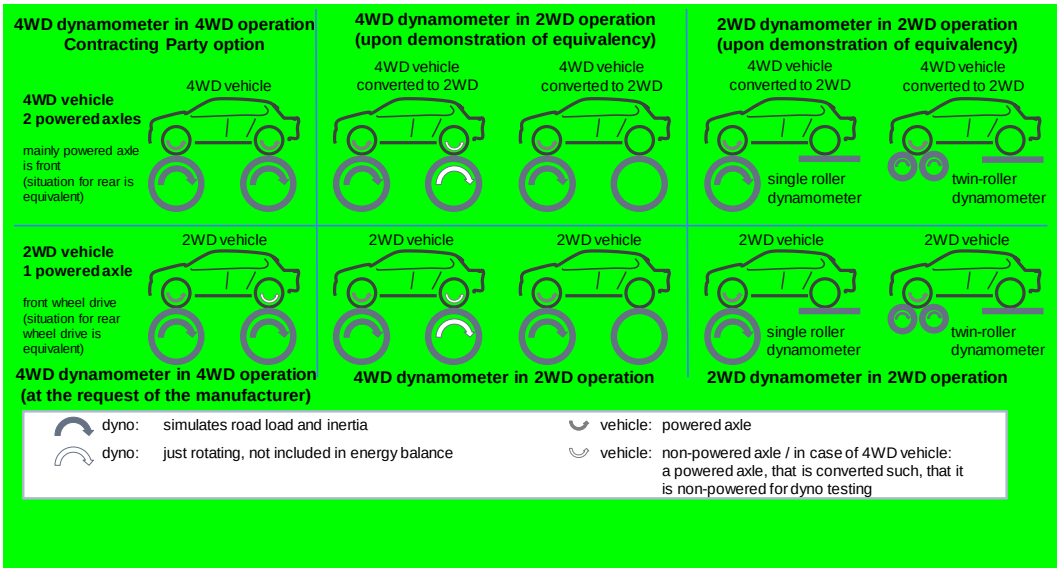
situation, the vehicle shall be tested on a dynamometer in 2WD operation which fulfils the specifications in paragraph 2.2. of Annex 5.

At the request of the manufacturer and with the approval of the approval authority, the vehicle may be tested on a 4WD dynamometer in 4WD operation mode.

2.4.2.4.4. If the test vehicle is tested on a 4WD dynamometer in 2WD operation the wheels on the non-powered axle may rotate during the test, provided that the vehicle dynamometer operation mode and vehicle coastdown mode support this way of operation.

Figure A6/5a

Possible test configurations on 2WD and 4WD dynamometers



2.4.2.5. Demonstration of equivalency between a dynamometer in 2WD operation and a dynamometer in 4WD operation

2.4.2.5.1. At the request of the manufacturer and with the approval of the approval authority, the vehicle which has to be tested on a dynamometer in 4WD operation may alternatively be tested on a dynamometer in 2WD operation if the following conditions are met:

(a) the test vehicle is converted to have only one powered axle;

(b) the manufacturer demonstrates to the approval authority that the CO_2, fuel consumption and/or electrical energy consumption of the converted vehicle is the same or higher as for the non-converted vehicle being tested on a dynamometer in 4WD operation;

(c) a safe operation is ensured for the test (e.g. by removing a fuse or dismounting a drive shaft) and an instruction is provided together with the dynamometer operation mode;

(d) the conversion is only applied to the vehicle tested at the chassis dynamometer, the road load determination procedure shall be applied to the unconverted test vehicle.

2.4.2.5.2. This demonstration of equivalency shall apply to all vehicles in the same road load family. At the request of the manufacturer, and with approval of the approval authority, this demonstration of equivalency may be extended to other road load families upon evidence that a vehicle from the worst-case road load family was selected as the test vehicle.

2.4.2.6. Information on whether the vehicle was tested on a 2WD dynamometer or a 4WD dynamometer and whether it was tested on a dynamometer in 2WD operation or 4WD operation shall be included in all relevant test reports. In the case that the vehicle was tested on a 4WD dynamometer, with that

dynamometer in 2WD operation, this information shall also indicate whether or not the wheels on the non-powered wheels were rotating.

2.4.3. The vehicle's exhaust system shall not exhibit any leak likely to reduce the quantity of gas collected.

2.4.4. The settings of the powertrain and vehicle controls shall be those prescribed by the manufacturer for series production.

2.4.5. Tyres shall be of a type specified as original equipment by the vehicle manufacturer. Tyre pressure may be increased by up to 50 per cent above the pressure specified in paragraph 4.2.2.3. of Annex 4. The same tyre pressure shall be used for the setting of the dynamometer and for all subsequent testing. The tyre pressure used shall be recorded.

2.4.6. Reference fuel

The appropriate reference fuel as specified in Annex 3 shall be used for testing.

2.4.7. Test vehicle preparation

2.4.7.1. The vehicle shall be approximately horizontal during the test so as to avoid any abnormal distribution of the fuel.

2.4.7.2. If necessary, the manufacturer shall provide additional fittings and adapters, as required to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle, and to provide for exhaust sample collection.

2.4.7.3. For PM sampling during a test when the regenerating device is in a stabilized loading condition (i.e. the vehicle is not undergoing a regeneration), it is recommended that the vehicle has completed more than 1/3 of the mileage between scheduled regenerations or that the periodically regenerating device has undergone equivalent loading off the vehicle.

2.5. Preliminary testing cycles

Preliminary testing cycles may be carried out if requested by the manufacturer to follow the speed trace within the prescribed limits.

2.6. Test vehicle preconditioning

2.6.1. Vehicle preparation

2.6.1.1. Fuel tank filling

The fuel tank(s) shall be filled with the specified test fuel. If the existing fuel in the fuel tank(s) does not meet the specifications contained in paragraph 2.4.6. of this annex, the existing fuel shall be drained prior to the fuel fill. The evaporative emission control system shall neither be abnormally purged nor abnormally loaded.

2.6.1.2. REESSs charging

Before the preconditioning test cycle, the REESSs shall be fully charged. At the request of the manufacturer, charging may be omitted before preconditioning. The REESSs shall not be charged again before official testing.

2.6.1.3. Tyre pressures

The tyre pressure of the driving wheels shall be set in accordance with paragraph 2.4.5. of this annex.

2.6.1.4. Gaseous fuel vehicles

Between the tests on the first gaseous reference fuel and the second gaseous reference fuel, for vehicles with positive ignition engines fuelled with LPG or NG/biomethane or so equipped that they can be fuelled with either petrol or LPG or NG/biomethane, the vehicle shall be preconditioned again before the test on the second reference fuel. Between the tests on the first gaseous

reference fuel and the second gaseous reference fuel, for vehicles with positive ignition engines fuelled with LPG or NG/biomethane or so equipped that they can be fuelled with either petrol or LPG or NG/biomethane, the vehicle shall be preconditioned again before the test on the second reference fuel.

2.6.2. Test cell

2.6.2.1. Temperature

During preconditioning, the test cell temperature shall be the same as defined for the Type 1 test (paragraph 2.2.2.1.1. of this annex).

2.6.2.2. Background measurement

In a test facility in which there may be possible contamination of a low particulate emitting vehicle test with residue from a previous test on a high particulate emitting vehicle, it is recommended, for the purpose of sampling equipment preconditioning, that a 120 km/h steady state drive cycle of 20 minutes duration be driven by a low particulate emitting vehicle. Longer and/or higher speed running is permissible for sampling equipment preconditioning if required. Dilution tunnel background measurements, if applicable, shall be taken after the tunnel preconditioning, and prior to any subsequent vehicle testing.

2.6.3. Procedure

2.6.3.1. The test vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through the applicable WLTCs. The vehicle need not be cold, and may be used to set the dynamometer load.

2.6.3.2. The dynamometer load shall be set according to paragraphs 7. and 8. of Annex 4. In the case that a dynamometer in 2WD operation is used for testing, the road load setting shall be carried out on a dynamometer in 2WD operation, and in the case that a dynamometer in 4WD operation is used for testing the road load setting shall be carried out on a dynamometer in 4WD operation.

2.6.4. Operating the vehicle

2.6.4.1. The powertrain start procedure shall be initiated by means of the devices provided for this purpose according to the manufacturer's instructions.

A non-vehicle initiated switching of mode of operation during the test shall not be permitted unless otherwise specified.

2.6.4.1.1. If the initiation of the powertrain start procedure is not successful, e.g. the engine does not start as anticipated or the vehicle displays a start error, the test is void, preconditioning tests shall be repeated and a new test shall be driven.

2.6.4.1.2. In the cases where LPG or NG/biomethane is used as a fuel, it is permissible that the engine is started on petrol and switched automatically to LPG or NG/biomethane after a predetermined period of time that cannot be changed by the driver. This period of time shall not exceed 60 seconds.

It is also permissible to use petrol only or simultaneously with gas when operating in gas mode provided that the energy consumption of gas is higher than 80 per cent of the total amount of energy consumed during the Type 1 test. This percentage shall be calculated in accordance with the method set out in Appendix 3 to this annex.

2.6.4.2. The cycle starts on initiation of the powertrain start procedure.

2.6.4.3. For preconditioning, the applicable WLTC shall be driven.

At the request of the manufacturer or the responsible authority, additional WLTCs may be performed in order to bring the vehicle and its control systems to a stabilized condition.

The extent of such additional preconditioning shall be recorded.

2.6.4.4. Accelerations

The vehicle shall be operated with the necessary accelerator control movement to accurately follow the speed trace.

The vehicle shall be operated smoothly following representative shift speeds and procedures.

For manual transmissions, the accelerator control shall be released during each shift and the shift shall be accomplished in minimum time.

If the vehicle cannot follow the speed trace, it shall be operated at maximum available power until the vehicle speed reaches the respective target speed again.

2.6.4.5. Deceleration

During decelerations, the driver shall deactivate the accelerator control but shall not manually disengage the clutch until the point specified in paragraphs 3.3. or 4.(f) of Annex 2.

If the vehicle decelerates faster than prescribed by the speed trace, the accelerator control shall be operated such that the vehicle accurately follows the speed trace.

If the vehicle decelerates too slowly to follow the intended deceleration, the brakes shall be applied such that it is possible to accurately follow the speed trace.

2.6.4.6. Brake application

During stationary/idling vehicle phases, the brakes shall be applied with appropriate force to prevent the drive wheels from turning.

2.6.5. Use of the transmission

2.6.5.1. Manual shift transmissions

2.6.5.1.1. The gear shift prescriptions specified in Annex 2 shall be followed. Vehicles tested according to Annex 8 shall be driven according to paragraph 1.5. of that annex.

2.6.5.1.2. The gear change shall be started and completed within ±1.0 second of the prescribed gear shift point.

2.6.5.1.3. The clutch shall be depressed within ±1.0 second of the prescribed clutch operating point.

2.6.5.2. Automatic shift transmissions

2.6.5.2.1. After initial engagement, the selector shall not be operated at any time during the test. Initial engagement shall be done 1 second before beginning the first acceleration.

2.6.5.2.2. Vehicles with an automatic transmission with a manual mode shall not be tested in manual mode.

2.6.6. Driver-selectable modes

2.6.6.1. Vehicles equipped with a predominant mode shall be tested in that mode. At the request of the manufacturer, the vehicle may alternatively be tested with the driver-selectable mode in the worst-case position for CO_2 emissions.

The manufacturer shall provide evidence to the responsible authority of the existence of a mode that fulfils the requirements of paragraph 3.5.9. of this UN GTR. With the agreement of the responsible authority, the predominant mode may be used as the only mode for the determination of criteria emissions, CO_2 emissions, and fuel consumption.

2.6.6.2. If the vehicle has no predominant mode because it has two or more configurable start modes, the worst case mode for CO_2 emissions and fuel consumption within those configurable start modes shall be tested and may be used as the only mode for the determination of criteria emissions, CO_2 emissions and fuel consumption.

2.6.6.3. If the vehicle has no predominant mode or the requested predominant mode is not agreed by the responsible authority as being a predominant mode, or there are not two or more configurable start modes, the vehicle shall be tested for criteria emissions, CO_2 emissions, and fuel consumption in the best case mode and worst case mode. Best and worst case modes shall be identified by the evidence provided on the CO_2 emissions and fuel consumption in all modes. CO_2 emissions and fuel consumption shall be the arithmetic average of the test results in both modes. Test results for both modes shall be recorded.

At the request of the manufacturer, the vehicle may alternatively be tested with the driver-selectable mode in the worst case position for CO_2 emissions.

2.6.6.4. On the basis of technical evidence provided by the manufacturer and with the agreement of the responsible authority, the dedicated driver-selectable modes for very special limited purposes shall not be considered (e.g. maintenance mode, crawler mode). All remaining modes used for forward driving shall be considered and the criteria emissions limits shall be fulfilled in all these modes.

2.6.6.5. Paragraphs 2.6.6.1. to 2.6.6.4. inclusive of this annex shall apply to all vehicle systems with driver-selectable modes, including those not solely specific to the transmission.

2.6.7. Voiding of the Type 1 test and completion of the cycle

If the engine stops unexpectedly, the preconditioning or Type 1 test shall be declared void.

After completion of the cycle, the engine shall be switched off. The vehicle shall not be restarted until the beginning of the test for which the vehicle has been preconditioned.

2.6.8. Data required, quality control

2.6.8.1. Speed measurement

During the preconditioning, speed shall be measured against time or collected by the data acquisition system at a frequency of not less than 1 Hz so that the actual driven speed can be assessed.

2.6.8.2. Distance travelled

The distance actually driven by the vehicle shall be recorded for each WLTC phase.

2.6.8.3. Speed trace tolerances

Vehicles that cannot attain the acceleration and maximum speed values required in the applicable WLTC shall be operated with the accelerator control fully activated until they once again reach the required speed trace. Speed trace violations under these circumstances shall not void a test. Deviations from the driving cycle shall be recorded.

2.6.8.3.1. Unless otherwise stated in the specific sections, the following tolerances shall be permitted between the actual vehicle speed and the prescribed speed of the applicable test cycles based on the driving events:

2.6.8.3.1.1. Tolerance (1)

(a) Upper limit: 2.0 km/h higher than the highest point of the trace within ±5.0 second of the given point in time;

(b) Lower limit: 2.0 km/h lower than the lowest point of the trace within ±5.0 second of the given time.

2.6.8.3.1.2. Tolerance (2)

(a) Upper limit: 2.0 km/h higher than the highest point of the trace within ±1.0 second of the given point in time;

(b) Lower limit: 2.0 km/h lower than the lowest point of the trace within ±1.0 second of the given time.

(i) Speed tolerances greater than those prescribed shall be accepted provided the tolerances are never exceeded for more than 1 second on any one occasion.

(ii) There shall be no more than ten such deviations per test cycle.

2.6.8.3.1.3. Tolerance (3)

In the case of a type approval test, the following indices shall fulfil the following criteria:

(a) IWR shall be in the range of (- 2.0 < IWR < + 4.0) per cent;

(b) RMSSE, at the option of the Contracting Party, shall be less than 0.8 km/h or less than 1.3 km/h.

2.6.8.3.1.4. Tolerance (4)

In the case of a type approval test, the following indices shall fulfil the following criteria:

(a) IWR shall be in the range of (- 2.0 < IWR < + 4.0) per cent;

(b) RMSSE, at the option of the Contracting Party, shall be less than 1.3 km/h. At the option of the Contracting Party the manufacturer may declare a lower RMSSE threshold value.

2.6.8.3.1.5. IWR and RMSSE drive trace indices shall be calculated in accordance with the requirements of paragraph 7. of Annex 7.

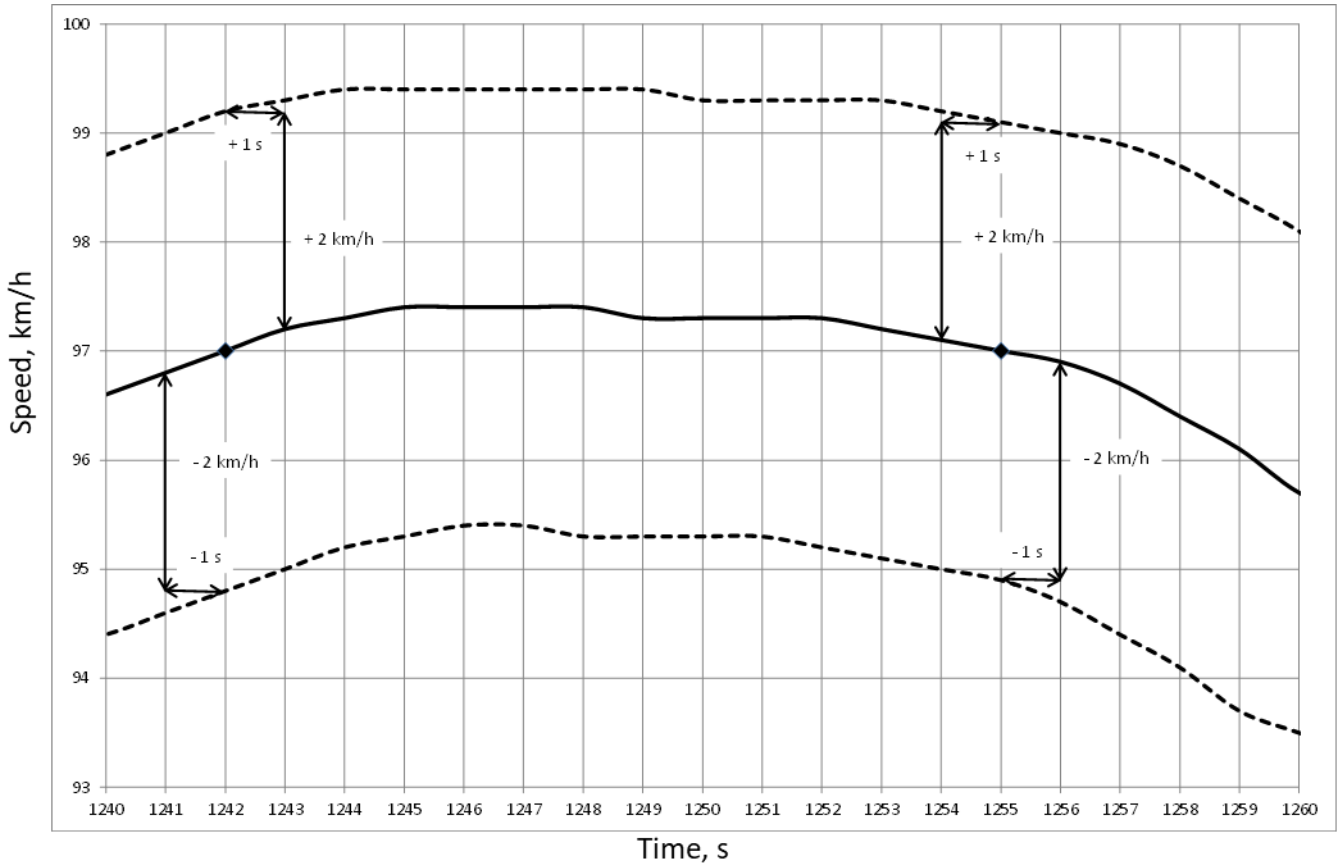
2.6.8.3.2. The vehicle operation events and tolerances to be permitted for these events are as follows:

Vehicle operation	*Warm-up cycle for dynamometer setting*	*Pre-conditioning*	*Performance parameter measurement test after preconditioning*
Annex 6 and 8; Type 1 Tests	Tolerance (1)	Tolerance (2)	Tolerance (2)* and Tolerance (3)
Annex 11 Appendix 1; OBD Demonstration Tests	Tolerance (1)	Tolerance (2)	Tolerance (2)*
COP Tests (Annex 14)	Tolerance (1)	Tolerance (2)	Tolerance (2)* and Tolerance (4)
Derive run-in factor for COP (Annex 14)	Tolerance (1)	Tolerance (2)	Tolerance (2)* and Tolerance (3)

*) the tolerance shall not be shown to the driver

If the speed trace is outside the respective validity range for any of the tests, those individual tests shall be considered invalid.

Figure A6/6
Speed trace tolerances



2.7. Soaking

2.7.1. After preconditioning and before testing, the test vehicle shall be kept in an area with ambient conditions as specified in paragraph 2.2.2.2. of this annex.

2.7.2. The vehicle shall be soaked for a minimum of 6 hours and a maximum of 36 hours with the engine compartment cover opened or closed. If not excluded by specific provisions for a particular vehicle, cooling may be accomplished by forced cooling down to the set point temperature. If cooling is accelerated by fans, the fans shall be placed so that the maximum cooling of the drive train, engine and exhaust after-treatment system is achieved in a homogeneous manner.

2.8. Emission and fuel consumption test (Type 1 test)

2.8.1. The test cell temperature at the start of the test shall be 23 °C ±3 °C. The engine oil temperature and coolant temperature, if any, shall be within ±2 °C of the set point of 23 °C.

2.8.2. The test vehicle shall be pushed onto a dynamometer.

2.8.2.1. The drive wheels of the vehicle shall be placed on the dynamometer without starting the engine.

2.8.2.2. The drive-wheel tyre pressures shall be set in accordance with the provisions of paragraph 2.4.5. of this annex.

2.8.2.3. The engine compartment cover shall be closed.

2.8.2.4. An exhaust connecting tube shall be attached to the vehicle tailpipe(s) immediately before starting the engine.

2.8.2.5. The tested vehicle shall be placed on the chassis dynamometer according to paragraphs 7.3.3. to 7.3.3.1.4. of Annex4.

2.8.3. Starting of the powertrain and driving

2.8.3.1. The powertrain start procedure shall be initiated by means of the devices provided for this purpose according to the manufacturer's instructions.

2.8.3.2. The vehicle shall be driven as described in paragraphs 2.6.4. to 2.6.8. inclusive of this annex over the applicable WLTC, as described in Annex1.

2.8.4. RCB data shall be measured for each phase of the WLTC as defined in Appendix2 to this annex.

2.8.5. Actual vehicle speed shall be sampled with a measurement frequency of 10 Hz and the drive trace indices described in paragraph 7. of Annex 7 shall be calculated and documented.

2.9. Gaseous sampling

Gaseous samples shall be collected in bags and the compounds analysed at the end of the test or a test phase, or the compounds may be analysed continuously and integrated over the cycle.

2.9.1. The following steps shall be taken prior to each test:

2.9.1.1. The purged, evacuated sample bags shall be connected to the dilute exhaust and dilution air sample collection systems.

2.9.1.2. Measuring instruments shall be started according to the instrument manufacturer's instructions.

2.9.1.3. The CVS heat exchanger (if installed) shall be pre-heated or pre-cooled to within its operating test temperature tolerance as specified in paragraph 3.3.5.1. of Annex5.

2.9.1.4. Components such as sample lines, filters, chillers and pumps shall be heated or cooled as required until stabilised operating temperatures are reached.

2.9.1.5. CVS flow rates shall be set according to paragraph 3.3.4. of Annex5, and sample flow rates shall be set to the appropriate levels.

2.9.1.6. Any electronic integrating device shall be zeroed and may be re-zeroed before the start of any cycle phase.

2.9.1.7. For all continuous gas analysers, the appropriate ranges shall be selected. These may be switched during a test only if switching is performed by changing the calibration over which the digital resolution of the instrument is applied. The gains of an analyser's analogue operational amplifiers may not be switched during a test.

2.9.1.8. All continuous gas analysers shall be zeroed and calibrated using gases fulfilling the requirements of paragraph 6. of Annex5.

2.10. Sampling for PM determination

2.10.1. The steps described in paragraphs 2.10.1.1. to 2.10.1.2.2. inclusive of this annex shall be taken prior to each test.

2.10.1.1. Filter selection

A single particulate sample filter without back-up shall be employed for the complete applicable WLTC. In order to accommodate regional cycle variations, a single filter may be employed for the first three phases and a separate filter for the fourth phase.

2.10.1.2. Filter preparation

2.10.1.2.1. At least 1 hour before the test, the filter shall be placed in a petri dish protecting against dust contamination and allowing air exchange, and placed in a weighing chamber (or room) for stabilization.

At the end of the stabilization period, the filter shall be weighed and its weight shall be recorded. The filter shall subsequently be stored in a closed petri dish or sealed filter holder until needed for testing. The filter shall be used within 8 hours of its removal from the weighing chamber (or room).

The filter shall be returned to the stabilization room within 1 hour after the test and shall be conditioned for at least 1 hour before weighing.

2.10.1.2.2. The particulate sample filter shall be carefully installed into the filter holder. The filter shall be handled only with forceps or tongs. Rough or abrasive filter handling will result in erroneous weight determination. The filter holder assembly shall be placed in a sample line through which there is no flow.

2.10.1.2.3. It is recommended that the microbalance be checked at the start of each weighing session, within 24 hours of the sample weighing, by weighing one reference item of approximately 100 mg. This item shall be weighed three times and the arithmetic average result recorded. If the arithmetic average result of the weighings is ±5 µg of the result from the previous weighing session, the weighing session and balance are considered valid.

2.11. PN sampling (if applicable)

2.11.1. The steps described in paragraphs 2.11.1.1. to 2.11.1.2. inclusive of this annex shall be taken prior to each test:

2.11.1.1. The particle specific dilution system and measurement equipment shall be started and made ready for sampling;

2.11.1.2. The correct function of the PNC and VPR elements of the particle sampling system shall be confirmed according to the procedures listed in paragraphs 2.11.1.2.1. to 2.11.1.2.4. inclusive of this annex.

2.11.1.2.1. A leak check, using a filter of appropriate performance attached to the inlet of the entire PN measurement system, VPR and PNC, shall report a measured concentration of less than 0.5 particles per cm^3.

2.11.1.2.2. Each day, a zero check on the PNC, using a filter of appropriate performance at the PNC inlet, shall report a concentration of ≤ 0.2 particles per cm^3. Upon removal of the filter, the PNC shall show an increase in measured concentration to at least 100 particles per cm^3 when sampling ambient air and a return to ≤ 0.2 particles per cm^3 on replacement of the filter.

2.11.1.2.3. It shall be confirmed that the measurement system indicates that the evaporation tube, where featured in the system, has reached its correct operating temperature.

2.11.1.2.4. It shall be confirmed that the measurement system indicates that the diluter PND_1 has reached its correct operating temperature.

2.12. Sampling during the test

2.12.1. The dilution system, sample pumps and data collection system shall be started.

2.12.2. The PM and, if applicable, PN sampling systems shall be started.

2.12.3. Particle number, if applicable, shall be measured continuously. The arithmetic average concentration shall be determined by integrating the analyser signals over each phase.

2. 12.4. Sampling shall begin before or at the initiation of the powertrain start procedure and end on conclusion of the cycle.

2.12.5. Sample switching

2.12.5.1. Gaseous emissions

Sampling from the diluted exhaust and dilution air shall be switched from one pair of sample bags to subsequent bag pairs, if necessary, at the end of each phase of the applicable WLTC to be driven.

2.12.5.2. Particulate

The requirements of paragraph 2.10.1.1. of this annex shall apply.

2.12.6. Dynamometer distance shall be recorded for each phase.

2.13. Ending the test

2.13.1. The engine shall be turned off immediately after the end of the last part of the test.

2.13.2. The constant volume sampler, CVS, or other suction device shall be turned off, or the exhaust tube from the tailpipe or tailpipes of the vehicle shall be disconnected.

2.13.3. The vehicle may be removed from the dynamometer.

2.14. Post-test procedures

2.14.1. Gas analyser check

Zero and calibration gas reading of the analysers used for continuous diluted measurement shall be checked. The test shall be considered acceptable if the difference between the pre-test and post-test results is less than 2 per cent of the calibration gas value.

2.14.2. Bag analysis

2.14.2.1. Exhaust gases and dilution air contained in the bags shall be analysed as soon as possible. Exhaust gases shall, in any event, be analysed not later than 30 minutes after the end of the cycle phase.

The gas reactivity time for compounds in the bag shall be taken into consideration.

2.14.2.2. As soon as practical prior to analysis, the analyser range to be used for each compound shall be set to zero with the appropriate zero gas.

2.14.2.3. The calibration curves of the analysers shall be set by means of calibration gases of nominal concentrations of 70 to 100 per cent of the range.

2.14.2.4. The zero settings of the analysers shall be subsequently rechecked: if any reading differs by more than 2 per cent of the range from that set in paragraph 2.14.2.2. of this annex, the procedure shall be repeated for that analyser.

2.14.2.5. The samples shall be subsequently analysed.

2.14.2.6. After the analysis, zero and calibration points shall be rechecked using the same gases. The test shall be considered acceptable if the difference is less than 2 per cent of the calibration gas value.

2.14.2.7. The flow rates and pressures of the various gases through analysers shall be the same as those used during calibration of the analysers.

2.14.2.8. The content of each of the compounds measured shall be recorded after stabilization of the measuring device.

2.14.2.9. The mass and number of all emissions, where applicable, shall be calculated according to Annex 7.

2.14.2.10. Calibrations and checks shall be performed either:

(a) Before and after each bag pair analysis; or

(b) Before and after the complete test.

In case (b), calibrations and checks shall be performed on all analysers for all ranges used during the test.

In both cases, (a) and (b), the same analyser range shall be used for the corresponding ambient air and exhaust bags.

2.14.3. Particulate sample filter weighing

2.14.3.1. The particulate sample filter shall be returned to the weighing chamber (or room) no later than 1 hour after completion of the test. It shall be conditioned in a petri dish, which is protected against dust contamination and allows air exchange, for at least 1 hour, and weighed. The gross weight of the filter shall be recorded.

2.14.3.2. At least two unused reference filters shall be weighed within 8 hours of, but preferably at the same time as, the sample filter weighings. Reference filters shall be of the same size and material as the sample filter.

2.14.3.3. If the specific weight of any reference filter changes by more than ±5µg between sample filter weighings, the sample filter and reference filters shall be reconditioned in the weighing chamber (or room) and reweighed.

2.14.3.4. The comparison of reference filter weighings shall be made between the specific weights and the rolling arithmetic average of that reference filter's specific weights. The rolling arithmetic average shall be calculated from the specific weights collected in the period after the reference filters were placed in the weighing chamber (or room). The averaging period shall be at least one day but not more than 15 days.

2.14.3.5. Multiple reconditionings and reweighings of the sample and reference filters are permitted until a period of 80 hours has elapsed following the measurement of gases from the emissions test. If, prior to or at the 80-hour point, more than half the number of reference filters meet the ±5 µg criterion, the sample filter weighing may be considered valid. If, at the 80-hour point, two reference filters are employed and one filter fails the ±5 µg criterion, the sample filter weighing may be considered valid under the condition that the sum of the absolute differences between specific and rolling means from the two reference filters shall be less than or equal to 10 µg.

2.14.3.6. In the case that less than half of the reference filters meet the ±5 µg criterion, the sample filter shall be discarded, and the emissions test repeated. All reference filters shall be discarded and replaced within 48 hours. In all other cases, reference filters shall be replaced at least every 30 days and in such a manner that no sample filter is weighed without comparison to a reference filter that has been present in the weighing chamber (or room) for at least one day.

2.14.3.7. If the weighing chamber (or room) stability criteria outlined in paragraph 4.2.2.1. of Annex5 are not met, but the reference filter weighings meet the above criteria, the vehicle manufacturer has the option of accepting the sample filter weights or voiding the tests, repairing the weighing chamber (or room) control system and re-running the test.

Annex 6 - Appendix 1

Emissions test procedure for all vehicles equipped with periodically regenerating systems

1. General

1.1. This appendix defines the specific provisions regarding testing a vehicle equipped with periodically regenerating systems as defined in paragraph 3.8.1. of this UN GTR.

1.2. During cycles where regeneration occurs, emission standards need not apply. If a periodic regeneration occurs at least once per Type 1 test and has already occurred at least once during vehicle preparation or the distance between two successive periodic regenerations is more than 4,000 km of driving repeated Type 1 tests, it does not require a special test procedure. In this case, this appendix does not apply and a Ki factor of 1.0 shall be used.

1.3. The provisions of this appendix shall not apply to PN emissions.

1.4. At the request of the manufacturer, and with approval of the responsible authority, the test procedure specific to periodically regenerating systems need not apply to a regenerative device if the manufacturer provides data demonstrating that, during cycles where regeneration occurs, emissions remain below the emissions limits applied by the Contracting Party for the relevant vehicle category. In this case, a fixed Ki value of 1.05 shall be used for CO_2 and fuel consumption.

2. Test procedure

The test vehicle shall be capable of inhibiting or permitting the regeneration process provided that this operation has no effect on original engine calibrations. Prevention of regeneration is only permitted during loading of the regeneration system and during the preconditioning cycles. It is not permitted during the measurement of emissions during the regeneration phase. The emission test shall be carried out with the unchanged, original equipment manufacturer's (OEM) control unit. At the request of the manufacturer and with agreement of the responsible authority, an "engineering control unit" which has no effect on original engine calibrations may be used during K_i determination.

2.1. Exhaust emissions measurement between two WLTCs with regeneration events

2.1.1. The arithmetic average emissions between regeneration events and during loading of the regenerative device shall be determined from the arithmetic mean of several approximately equidistant (if more than two) Type 1 tests. As an alternative, the manufacturer may provide data to show that the emissions remain constant (±15 per cent) on WLTCs between regeneration events. In this case, the emissions measured during the Type 1 test may be used. In any other case, emissions measurements for at least two Type 1 cycles shall be completed: one immediately after regeneration (before new loading) and one as close as possible prior to a regeneration phase. All emissions measurements shall be carried out according to this annex and all calculations shall be carried out according to paragraph 3. of this appendix.

2.1.2. The loading process and K_i determination shall be made during the Type 1 driving cycle on a chassis dynamometer or on an engine test bench using an equivalent test cycle. These cycles may be run continuously (i.e. without the need to switch the engine off between cycles). After any number of completed cycles, the vehicle may be removed from the chassis dynamometer and the test continued at a later time.

For Class 2 and Class 3 vehicles, at the request of the manufacturer and with the agreement of the responsible authority the K_i can be determined either with or without the Extra High phase.

Upon request of the manufacturer and with approval of the responsible authority, a manufacturer may develop an alternative procedure and demonstrate its equivalency, including filter temperature, loading quantity and distance driven. This may be done on an engine bench or on a chassis dynamometer.

2.1.3. The number of cycles D between two WLTCs where regeneration events occur, the number of cycles over which emission measurements are made n and the mass emissions measurement M'_{sij} for each compound i over each cycle j shall be recorded.

2.2. Measurement of emissions during regeneration events

2.2.1. Preparation of the vehicle, if required, for the emissions test during a regeneration phase, may be completed using the preconditioning cycles in paragraph 2.6. of this annex or equivalent engine test bench cycles, depending on the loading procedure chosen in paragraph 2.1.2. of this appendix.

2.2.2. The test and vehicle conditions for the Type 1 test described in this UN GTR apply before the first valid emission test is carried out.

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

(a) A "dummy" regenerating system or partial system may be fitted for the preconditioning cycles;

(b) Any other method agreed between the manufacturer and the responsible authority.

2.2.4. A cold start exhaust emissions test including a regeneration process shall be performed according to the applicable WLTC.

2.2.5. If the regeneration process requires more than one WLTC, each WLTC shall be completed. Use of a single particulate sample filter for multiple cycles required to complete regeneration is permissible.

If more than one WLTC is required, subsequent WLTC(s) shall be driven immediately, without switching the engine off, until complete regeneration has been achieved. In the case that the number of gaseous emission bags required for the multiple cycles would exceed the number of bags available, the time necessary to set up a new test shall be as short as possible. The engine shall not be switched off during this period.

2.2.6. The emission values during regeneration M_{ri} for each compound i shall be calculated according to paragraph 3. of this appendix. The number of applicable test cycles d measured for complete regeneration shall be recorded.

3. Calculations

3.1. Calculation of the exhaust and CO_2 emissions, and fuel consumption of a single regenerative system

$$M_{si} = \frac{\sum_{j=1}^{n} M'_{sij}}{n} \text{ for } n \geq 1$$

$$M_{ri} = \frac{\sum_{j=1}^{d} M'_{rij}}{d} \text{ for } d \geq 1$$

$$M_{pi} = \frac{M_{si} \times D + M_{ri} \times d}{D + d}$$

where for each compound i considered:

M'_{sij} are the mass emissions of compound i over test cycle j without regeneration, g/km;

M'_{rij} are the mass emissions of compound i over test cycle j during regeneration, g/km (if $d > 1$, the first WLTC test shall be run cold and subsequent cycles hot);

M_{si} are the mean mass emissions of compound i without regeneration, g/km;

M_{ri} are the mean mass emissions of compound i during regeneration, g/km;

M_{pi} are the mean mass emissions of compound i, g/km;

n is the number of test cycles, between cycles where regenerative events occur, during which emissions measurements on Type 1 WLTCs are made, ≥ 1;

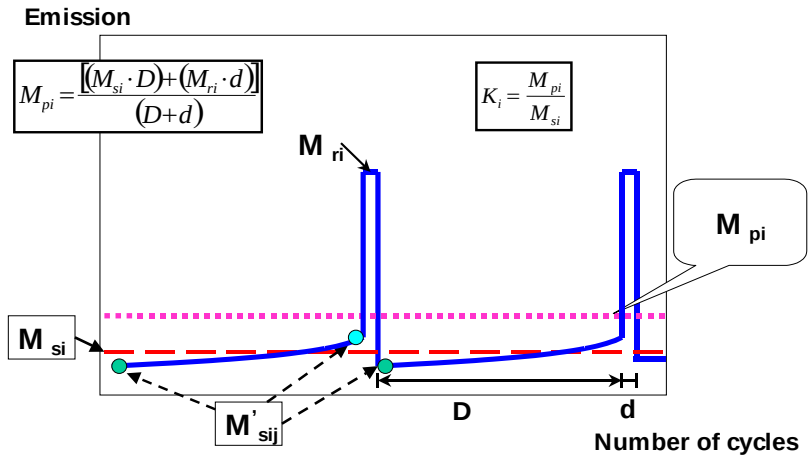
d is the number of complete applicable test cycles required for regeneration;

D is the number of complete applicable test cycles between two cycles where regeneration events occur.

The calculation of M_{pi} is shown graphically in Figure A6.App1/1.

Figure A6.App1/1

Parameters measured during emissions test during and between cycles where regeneration occurs (schematic example, the emissions during D may increase or decrease)



3.1.1. Calculation of the regeneration factor K_i for each compound i considered

The manufacturer may elect to determine for each compound independently either additive offsets or multiplicative factors.

K_i factor: $K_i = \frac{M_{pi}}{M_{si}}$

K_i offset: $K_i = M_{pi} - M_{si}$

M_{si}, M_{pi} and K_i results, and the manufacturer's choice of type of factor shall be recorded.

K_i may be determined following the completion of a single regeneration sequence comprising measurements before, during and after regeneration events as shown in Figure A6.App1/1.

3.2. Calculation of exhaust and CO_2 emissions, and fuel consumption of multiple periodically regenerating systems

The following shall be calculated for one Type 1 operation cycle for criteria emissions and for CO_2 emissions. The CO_2 emissions used for that calculation shall be from the result of step 3 described in Table A7/1 of Annex7.

$$M_{sik} = \frac{\sum_{j=1}^{n_k} M'_{sik,j}}{n_k} \text{ for } n_j \geq 1$$

$$M_{rik} = \frac{\sum_{j=1}^{d_k} M'_{rik,j}}{d_k} \text{ for } d \geq 1$$

$$M_{si} = \frac{\sum_{k=1}^{x} M_{sik} \times D_k}{\sum_{k=1}^{x} D_k}$$

$$M_{ri} = \frac{\sum_{k=1}^{x} M_{rik} \times d_k}{\sum_{k=1}^{x} d_k}$$

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

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

K_i factor: $\quad K_i = \frac{M_{pi}}{M_{si}}$

K_i offset: $\quad K_i = M_{pi} - M_{si}$

where:

M_{si} are the mean mass emissions of all events k of compound i without regeneration, g/km;

M_{ri} are the mean mass emissions of all events k of compound i during regeneration, g/km;

M_{pi} are the mean mass emission of all events k of compound i, g/km;

M_{sik} are the mean mass emissions of event k of compound i without regeneration, g/km;

M_{rik} are the mean mass emissions of event k of compound i during regeneration, g/km;

$M'_{sik,j}$ are the mass emissions of event k of compound i in g/km without regeneration measured at point j where $1 \leq j \leq n_k$, g/km;

$M'_{rik,j}$ are the mass emissions of event k of compound i during regeneration (when $j > 1$, the first Type 1 test is run cold, and subsequent cycles are hot) measured at test cycle j where $1 \leq j \leq d_k$, g/km;

n_k are the number of complete test cycles of event k, between two cycles where regenerative phases occur, during which emissions measurements (Type 1 WLTCs or equivalent engine test bench cycles) are made, ≥ 2;

d_k is the number of complete applicable test cycles of event k required for complete regeneration;

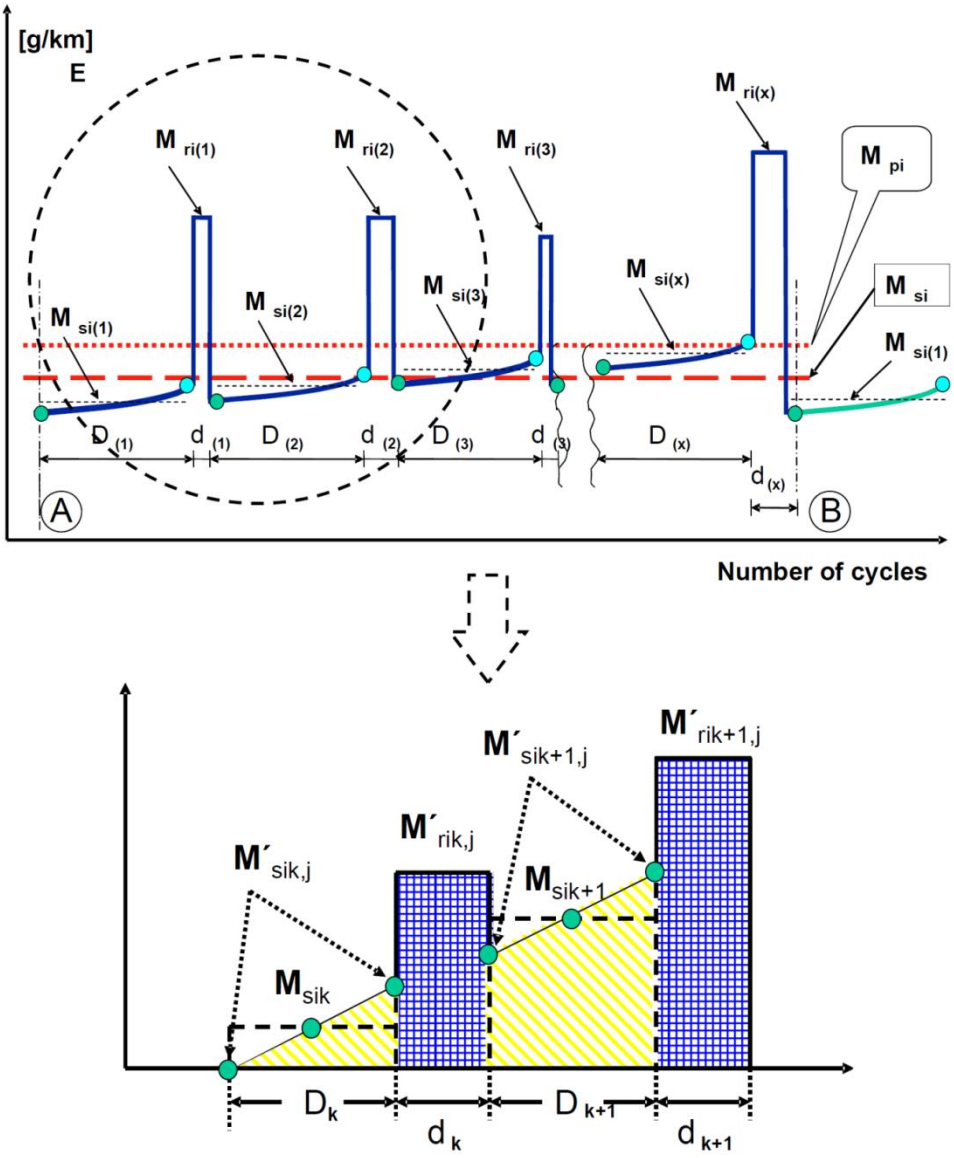
D_k is the number of complete applicable test cycles of event k between two cycles where regenerative phases occur;

x is the number of complete regeneration events.

The calculation of M_{pi} is shown graphically in Figure A6.App1/2.

Figure A6.App1/2

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



The calculation of K_i for multiple periodically regenerating systems is only possible after a certain number of regeneration events for each system.

After performing the complete procedure (A to B, see Figure A6.App1/2), the original starting condition A should be reached again.

3.3. Ki factors and Ki offsets shall be rounded to four places of decimal. For Ki offsets, the rounding shall be based on the physical unit of the emission standard value.

Annex 6 - Appendix 2

Test procedure for rechargeable electric energy storage system monitoring

1. General

In the case that NOVC-HEVs, OVC-HEVs NOVC-FCHVs and OVC-FCHVs are tested, Appendices 2 and 3 to Annex8 shall apply.

This appendix defines the specific provisions regarding the correction of test results for CO_2 mass emission as a function of the energy balance ΔE_{REESS} for all REESSs.

The corrected values for CO_2 mass emission shall correspond to a zero energy balance ($\Delta E_{REESS} = 0$), and shall be calculated using a correction coefficient determined as defined below.

2. Measurement equipment and instrumentation

2.1. Current measurement

REESS depletion shall be defined as negative current.

2.1.1. The REESS current(s) shall be measured during the tests using a clamp-on or closed type current transducer. The current measurement system shall fulfil the requirements specified in Table A8/1. The current transducer(s) shall be capable of handling the peak currents at engine starts and temperature conditions at the point of measurement.

In order to have an accurate measurement, zero adjustment and degaussing shall be performed before the test according to the instrument manufacturer's instructions.

2.1.2. Current transducers shall be fitted to any of the REESS on one of the cables connected directly to the REESS and shall include the total REESS current.

In case of shielded wires, appropriate methods shall be applied in accordance with the responsible authority.

In order to easily measure REESS current using external measuring equipment, manufacturers should preferably integrate appropriate, safe and accessible connection points in the vehicle. If this is not feasible, the manufacturer shall support the responsible authority by providing the means to connect a current transducer to the REESS cables in the manner described above.

2.1.3. The measured current shall be integrated over time at a minimum frequency of 20 Hz, yielding the measured value of Q, expressed in ampere-hours Ah. The measured current shall be integrated over time, yielding the measured value of Q, expressed in ampere-hours Ah. The integration may be done in the current measurement system.

2.2. Vehicle on-board data

2.2.1. Alternatively, the REESS current shall be determined using vehicle-based data. In order to use this measurement method, the following information shall be accessible from the test vehicle:

(a) Integrated charging balance value since last ignition run in Ah;

(b) Integrated on-board data charging balance value calculated at a minimum sample frequency of 5 Hz;

(c) The charging balance value via an OBD connector as described in SAE J1962.

2.2.2. The accuracy of the vehicle on-board REESS charging and discharging data shall be demonstrated by the manufacturer to the responsible authority.

The manufacturer may create a REESS monitoring vehicle family to prove that the vehicle on-board REESS charging and discharging data are correct. The accuracy of the data shall be demonstrated on a representative vehicle.

The following family criteria shall be valid:

(a) Identical combustion processes (i.e. positive ignition, compression ignition, two-stroke, four-stroke);

(b) Identical charge and/or recuperation strategy (software REESS data module);

(c) On-board data availability;

(d) Identical charging balance measured by REESS data module;

(e) Identical on-board charging balance simulation.

2.2.3. All REESS having no influence on CO_2 mass emissions shall be excluded from monitoring.

3. REESS energy change-based correction procedure

3.1. Measurement of the REESS current shall start at the same time as the test starts and shall end immediately after the vehicle has driven the complete driving cycle.

3.2. The electricity balance Q measured in the electric power supply system shall be used as a measure of the difference in the REESS energy content at the end of the cycle compared to the beginning of the cycle. The electricity balance shall be determined for the total driven WLTC.

3.3. Separate values of Q_{phase} shall be logged over the driven cycle phases.

3.4. Correction of CO_2 mass emission over the whole cycle as a function of the correction criterion c

3.4.1. Calculation of the correction criterion c

The correction criterion c is the ratio between the absolute value of the electric energy change $\Delta E_{REESS,j}$ and the fuel energy and shall be calculated using the following equations:

$$c = \left| \frac{\Delta E_{REESS,j}}{E_{fuel}} \right|$$

where:

c is the correction criterion;

$\Delta E_{REESS,j}$ is the electric energy change of all REESSs over period j determined according to paragraph 4.1. of this appendix, Wh;

j is, in this paragraph, the whole applicable WLTP test cycle;

E_{Fuel} is the fuel energy according to the following equation:

$$E_{fuel} = 10 \times HV \times FC_{nb} \times d$$

where:

E_{fuel} is the energy content of the consumed fuel over the applicable WLTP test cycle, Wh;

HV is the heating value according to Table A6.App2/1, kWh/l;

FC_{nb} is the non-balanced fuel consumption of the Type 1 test, not corrected for the energy balance, determined according to

paragraph 6. of Annex 7, and using the results for criteria emissions and CO_2 calculated in step 2 in Table A7/1, l/100 km;

d is the distance driven over the corresponding applicable WLTP test cycle, km;

10 conversion factor to Wh.

3.4.2.

The correction shall be applied if ΔE_{REESS} is negative (corresponding to REESS discharging)

At the request of the manufacturer, the correction may be omitted and uncorrected values may be used if:

(a) ΔE_{REESS} is positive (corresponding to REESS charging);

(b) the manufacturer can prove to the responsible authority by measurement that there is no relation between ΔE_{REESS} and CO_2 mass emission and ΔE_{REESS} and fuel consumption respectively.

3.4.3. The correction shall be omitted and uncorrected values shall be used if the correction criterion c calculated according to paragraph 3.4.1. of this appendix is less than the applicable threshold according to Table A6.App2/2.

3.4.4. The correction may be omitted and uncorrected values may be used if:

(a) ΔE_{REESS} is positive (corresponding to REESS charging) and the correction criterion c calculated according to paragraph 3.4.1. of this appendix is greater than the applicable threshold according to Table A6.App2/2;

(b) the manufacturer can prove to the responsible authority by measurement that there is no relation between ΔE_{REESS} and CO_2 mass emission and ΔE_{REESS} and fuel consumption respectively.

Table A6.App2/1
Energy content of fuel

Fuel	*Petrol*							*Diesel*				
Content Ethanol/Biodiesel per cent	E0	E5	E10	E15	E22	E85	E100	B0	B5 and B5H	B7	B20	B100
Heat value (kWh/l)	8.92	8.78	8.64	8.50	8.30	6.41	5.95	9.85	9.80	9.79	9.67	8.90

Fuel	*LPG*	*CNG*
Heat value	12.86 x ρ kWh/l	11.39 MJ/m³

ρ = test fuel density at 15°C (kg/l)

Table A6.App2/2
RCB correction criteria thresholds

Cycle	*low + medium)*	*low + medium + high*	*low + medium + high + extra high*
Thresholds for correction criterion c	0.015	0.01	0.005

4. Applying the correction function

4.1. To apply the correction function, the electric energy change $\Delta E_{REESS,j}$ of a period j of all REESSs shall be calculated from the measured current and the nominal voltage:

$$\Delta E_{REESS,j} = \sum_{i=1}^{n} \Delta E_{REESS,j,i}$$

where:

$\Delta E_{REESS,j,i}$ is the electric energy change of REESS i during the considered period j, Wh;

and:

$$\Delta E_{REESS,j,i} = \frac{1}{3600} \times U_{REESS} \times \int_{t_0}^{t_{end}} I(t)_{j,i}\, dt$$

where:

U_{REESS} is the nominal REESS voltage determined according to IEC 60050-482, V;

$I(t)_{j,i}$ is the electric current of REESS i during the considered period j, determined according to paragraph 2. of this appendix, A;

t_0 is the time at the beginning of the considered period j, s;

t_{end} is the time at the end of the considered period j, s.

i is the index number of the considered REESS;

n is the total amount of REESS;

j is the index number for the considered period, where a period shall be any applicable cycle phase, combination of cycle phases and the applicable total cycle;

$\frac{1}{3600}$ is the conversion factor from Ws to Wh.

4.2. For correction of CO_2 mass emission, g/km, combustion process-specific Willans factors from Table A6.App2/3 shall be used.

4.3. The correction shall be performed and applied for the total cycle and for each of its cycle phases separately, and shall be recorded.

4.4. For this specific calculation, a fixed electric power supply system alternator efficiency shall be used:

$\eta_{alternator} = 0.67$ for electric power supply system REESS alternators

4.5. The resulting CO_2 mass emission difference for the considered period j due to load behaviour of the alternator for charging a REESS shall be calculated using the following equation:

$$\Delta M_{CO2,j} = 0.0036 \times \Delta E_{REESS,j} \times \frac{1}{\eta_{alternator}} \times Willans_{factor} \times \frac{1}{d_j}$$

where:

$\Delta M_{CO2,j}$ is the resulting CO_2 mass emission difference of period j, g/km;

$\Delta E_{REESS,j}$ is the REESS energy change of the considered period j calculated according to paragraph 4.1. of this appendix, Wh;

d_j is the driven distance of the considered period j, km;

j is the index number for the considered period, where a period shall be any applicable cycle phase, combination of cycle phases and the applicable total cycle;

0.0036 is the conversion factor from Wh to MJ;

$\eta_{alternator}$ is the efficiency of the alternator according to paragraph 4.4. of this appendix;

$Willans_{factor}$ is the combustion process-specific Willans factor as defined in Table A6.App2/3, gCO_2/MJ;

4.5.1. The CO_2 values of each phase and the total cycle shall be corrected as follows:

$M_{CO2,p,3} = (M_{CO2,p,1} - \Delta M_{CO2,j})$

$M_{CO2,c,3} = (M_{CO2,c,2} - \Delta M_{CO2,j})$

where:

$\Delta M_{CO2,j}$ is the result from paragraph 4.5. of this appendix for a period j, g/km.

4.6. For the correction of CO_2 emission, g/km, the Willans factors in Table A6.App2/3 shall be used.

Table A6.App2/3
Willans factors

			Naturally aspirated	*Pressure-charged*
Positive ignition	Petrol (E0)	l/MJ	0.0733	0.0778
		gCO_2/MJ	175	186
	Petrol (E5)	l/MJ	0.0744	0.0789
		gCO_2/MJ	174	185
	Petrol (E10)	l/MJ	0.0756	0.0803
		gCO_2/MJ	174	184
	CNG (G20)	m^3/MJ	0.0719	0.0764
		gCO_2/MJ	129	137
	LPG	l/MJ	0.0950	0.101
		gCO_2/MJ	155	164
	E85	l/MJ	0.102	0.108
		gCO_2/MJ	169	179
Compression ignition	Diesel (B0)	l/MJ	0.0611	0.0611
		gCO_2/MJ	161	161
	Diesel (B5 and B5H)	l/MJ	0.0611	0.0611
		gCO_2/MJ	161	161
	Diesel (B7)	l/MJ	0.0611	0.0611
		gCO_2/MJ	161	161

Annex 6 - Appendix 3

Calculation of gas energy ratio for gaseous fuels (LPG and NG/biomethane)

1. Measurement of the mass of gaseous fuel consumed during the Type 1 test cycle

   Measurement of the mass of gas consumed during the cycle shall be done by a fuel weighing system capable of measuring the weight of the storage container during the test in accordance with the following:

   (a) An accuracy of ±2 per cent of the difference between the readings at the beginning and at the end of the test or better.

   (b) Precautions shall be taken to avoid measurement errors.

   Such precautions shall at least include the careful installation of the device according to the instrument manufacturer's recommendations and to good engineering practice.

   (c) Other measurement methods are permitted if an equivalent accuracy can be demonstrated.

2. Calculation of the gas energy ratio

   The fuel consumption value shall be calculated from the emissions of hydrocarbons, carbon monoxide, and carbon dioxide determined from the measurement results assuming that only the gaseous fuel is burned during the test.

   The gas ratio of the energy consumed in the cycle shall be determined using the following equation:

$$G_{gas} = \left(\frac{M_{gas} \times cf \times 10^4}{FC_{norm} \times dist \times \rho} \right)$$

   where:

   G_{gas} is the gas energy ratio, per cent;

   M_{gas} is the mass of the gaseous fuel consumed during the cycle, kg;

   FC_{norm} is the fuel consumption (l/100km for LPG, m^3/100 km for NG/biomethane) calculated in accordance with paragraphs 6.6. and 6.7. of Annex7;

   dist is the distance recorded during the cycle, km;

   ρ is the gas density:

   ρ = 0.654 kg/m^3 for NG/Biomethane;

   ρ = 0.538 kg/litre for LPG;

   cf is the correction factor, assuming the following values:

   cf = 1 in the case of LPG or G20 reference fuel;

   cf = 0.78 in the case of G25 reference fuel.