Transmitted by the expert from the European Commission

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Justification: this proposal aims at ensuring the full benefit of the switch to quiet electric vehicles.
The emission of additional exterior sound is acceptable as long as it addresses safety concerns. It shall be strictly prohibited whenever safety is not at stake.

Regulation No. 51

Uniform provisions concerning the approval of motor vehicles having at least four wheels with regard to their sound emissions

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1. Scope

This Regulation contains provisions on the sound emitted by motor vehicles and applies to vehicles of categories M and N.[1]

The specifications in this Regulation are intended to reproduce the sound levels which are generated by vehicles during normal driving in urban traffic.

This regulation provides, as well, additional sound emission provisions for vehicles of categories M_1 and N_1 referring to driving conditions with extreme accelerations in an extended speed range representative for urban and suburban traffic.[2]

2. Definitions

For the purpose of this Regulation,

2.1. "*Approval of a vehicle*" means the approval of a vehicle type with regard to sound;

2.2. "*Vehicle type*" means a category of motor vehicles which do not differ in such essential respects as:

2.2.1. For vehicles tested according to Annex 3, paragraph 3.1.2.1.:

2.2.1.1. The shape or materials of the engine compartment and its soundproofing;

2.2.1.2. The type of engine (positive or compression ignition, two- or four-stroke, reciprocating or rotary piston), number and capacity of cylinders, number and type of carburettors or injection system, arrangement of valves, or the type of electric motor;

2.2.1.3. Rated maximum net power and corresponding rated engine speed(s); however if the rated maximum net power and the corresponding rated engine speed differs only due to different engine mappings, these vehicles may be regarded as from the same type;

2.2.1.4. The silencing system.

2.2.2. For vehicles tested according to Annex 3, paragraph 3.1.2.2.:

2.2.2.1. The shape or materials of the engine compartment and its soundproofing;

[1] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.3, para. 2 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html

[2] Additional Sound Emission Provisions refer to the specifications of paragraph 6.2.3. of the main body and Annex 7. A new Annex 9 was introduced for a sound evaluation of a vehicle under Real Driving Conditions (RD-ASEP) for evaluation purposes without impact on the type approval. RD-ASEP covers an extended control range with driving conditions outside of normal driving with higher accelerations and vehicle speeds up to 100 km/h. See also the provisions in paragraph 5.1.

2.2.2.2. The type of engine (positive or compression ignition, two- or four-stroke, reciprocating or rotary piston), number and capacity of cylinders, type of injection system, arrangement of valves, rated engine speed (S), or the type of electric motor;

2.2.2.3. Vehicles having the same type of engine and/or different overall gear ratios may be regarded as vehicles of the same type;

2.3. However, if the differences in paragraph 2.2.2. provide for different target conditions, as described in paragraph 3.1.2.2. of Annex 3, these differences are to be considered as a change of type;

2.4. "*Mass of a vehicle in running order (m_{ro})*" means

(a) In the case of a motor vehicle:

The mass of the vehicle, with its fuel tank(s) filled to at least 90 per cent of its or their capacity/ies, including the mass of the driver, of the fuel and liquids, fitted with the standard equipment in accordance with the manufacturer's specifications and, when they are fitted, the mass of the bodywork, the cabin, the coupling and the spare wheel(s) as well as the tools;

(b) In the case of a trailer:

The mass of the vehicle including the fuel and liquids, fitted with the standard equipment in accordance with the manufacturer's specifications, and, when they are fitted, the mass of the bodywork, additional coupling(s), the spare wheel(s) and the tools.

2.5. "*Technically permissible maximum laden mass (M)*" means the maximum mass allocated to a vehicle on the basis of its construction features and its design performances; the technically permissible laden mass of a trailer or of a semi-trailer includes the static mass transferred to the towing vehicle when coupled;

2.6. "*Vehicle length*" means a dimension which is measured according to ISO standard 612-1978, term No. 6.1. In addition to the provisions of that standard, when measuring the vehicle structural length the following devices shall not be taken into account:

(a) Wiper and washer devices;

(b) Front or rear marker-plates;

(c) Customs sealing devices and their protection;

(d) Devices for securing the tarpaulin and their protection;

(e) Lighting equipment;

(f) Rear view mirrors;

(g) Rear space watching aids;

(h) Air-intake pipes;

(i) Length stops for demountable bodies;

(j) Access steps;

(k) Ram rubbers;

(l) Lifting platforms, access ramps and similar equipment in running order, not exceeding 200 mm, provided that the loading capacity of the vehicle is not increased;

(m) Coupling devices for motor vehicles.

2.7 "*Vehicle width*" means a dimension which is measured according to ISO standard 612-1978, term No. 6.2. In addition to the provisions of that standard, when measuring the vehicle structural width the following devices shall not be taken into account:

(a) Customs sealing devices and their protection;

(b) Devices for securing the tarpaulin and their protection;

(c) Tyre failure tell-tale devices;

(d) Protruding flexible parts of a spray-suppression system;

(e) Lighting equipment.

2.8. "Maximum net power, Pn" means the declared engine power available for propulsion expressed in kW and measured dependent on the drive train concepts pursuant to UN Regulation No. 85 or UN GTR No. 21.

Applicable power sources are those, which provide drive power for forward motion to the vehicle.

2.8.1. For vehicles with combustion engine(s) only (ICE)

The maximum engine power is the net power P_n of the combustion engine(s) measured at full engine load pursuant to UN Regulation No.85 paragraph 5.2.

2.8.2. For battery electric vehicles (BEV) or fuel cell electric vehicle (FCEV) that have only one propulsion energy converter

The net power P_n of the electric motor of the electric drive train is determined pursuant to UN Regulation No.85 paragraph 5.3.

2.8.3. For hybrid electric vehicles (HEV), or pure electric vehicles that have more than one propulsion energy converter

The maximum engine power is the "vehicle system power rating" according to the arithmetic sum of parallel propulsive engines on the vehicle or GTR 21, paragraph 6.9.1.(b) “sustained vehicle system power.

2.9. "*Rated engine speed, S*" means the declared engine speed in min^{-1} (rpm) at which the engine develops its rated maximum net power pursuant to Regulation No. 85 or, where the rated maximum net power is reached at several engine speeds, the highest one of those speeds.

2.10. "*Power to Mass Ratio index (PMR)*" means a numerical quantity (see Annex 3, paragraph 3.1.2.1.1.) with no dimension used for the calculation of acceleration.

2.11. "*Reference point*" means one of the following points:

2.11.1. In the case of vehicles of categories M_1, N_1 and $M_2 \leq 3{,}500$ kg technically permissible maximum laden mass:

(a) For front engine vehicles: the front end of the vehicle;

(b) For mid-engine vehicles: the centre of the vehicle;

(c) For rear engine vehicles: the rear end of the vehicle.

For vehicles having multiple propulsion sources, the reference point is determined by the position of the propulsion source having the highest power. If there are multiple propulsion sources of equivalent power, then the position of the most forward propulsion source shall prevail.

2.11.2. In the case of vehicles of categories M_2 > 3,500kg technical permissible maximum laden mass, M_3, N_2, N_3:

(a) For front-engine vehicles, the front end of the vehicle;

(b) For all other vehicles, the border of the engine closest to the front of the vehicle;

2.12. "*Engine*" means the power source without detachable accessories.

Power source includes in this context all sources of motive power; for example, electric or hydraulic power sources used alone or in combination with other power sources.

2.13. "*Target acceleration*" means acceleration at a partial throttle condition in urban traffic and is derived from statistical investigations.

2.14. "*Reference acceleration*" means the required acceleration during the acceleration test on the test track.

2.15. "*Gear ratio weighting factor k*" means a dimensionless numerical quantity used to combine the test results of two gear ratios for the acceleration test and the constant speed test.

2.16. "*Partial power factor* k_p" means a numerical quantity with no dimension used for the weighted combination of the test results of the acceleration test and the constant speed test for vehicles.

2.17. "*Pre-acceleration*" means application of acceleration control device prior to AA' for the purpose of achieving stable acceleration between AA' and BB' as referred to in Figure 1 of Appendix 1 to Annex 3.

2.18. Gear[3]

2.18.1. "*Gear ratios*"

2.18.1.1. "*Internal gearbox ratio*" means the ratios of engine to gearbox output shaft revolutions.

2.18.1.2. "*Final drive ratio*" means the ratio(s) of gearbox output shaft to driven wheel revolutions.

2.18.1.3. "*Total gear ratio*" means the ratios between vehicle speed and engine speed during the passage of the vehicle through the test track.

2.18.1.4. "*Gear ratio*" used in context with vehicles tested according to 3.1.2.1. of Annex 3 and Annex 7 is the total gear ratio as defined in 2.18.1.3. above.

[3] *Note:* The common understanding of a "low gear" or a "high gear" shall not apply to gear ratios. For example, the lowest gear for forward driving, the first gear, has the highest gear ratio of all forward driving gears. While manual transmission has discrete gears, many non-manual transmissions can have more gear ratios engaged by the control unit of the transmission.

2.18.2. "*Locked gear ratio*" means the control of the transmission such that the gear will not change during a test.

2.18.3. "*Gear*" means in the context of this Regulation a discrete gear ratio either selectable by the driver or by an external device.

2.18.4. For vehicles tested according to paragraph 3.1.2.1. of Annex 3 and Annex 7, "$gear_i$" and "$gear_{i+1}$" are defined as two gears in sequence, where $gear_i$ either provides an acceleration within the 5 per cent tolerance according to paragraph 3.1.2.1.4.1. (a) of Annex 3 or an acceleration greater than the reference acceleration, and $gear_{i+1}$ an acceleration lower than the reference acceleration according to paragraph 3.1.2.1.4.1. (b) or (c) of Annex 3.

2.19. "*Silencing system*" means a complete set of components necessary for limiting the sound produced by an engine, its intake and its exhaust (the exhaust manifold(s), the catalyst(s) and emission after-treatment device(s) are not considered part of the silencing system; these parts belong to the engine).

2.20. "*Design family of exhaust silencing system or exhaust silencing system components*" means a group of silencing systems or components thereof in which all of the following characteristics are the same:

(a) The presence of net gas flow of the exhaust gases through the absorbing fibrous material when in contact with that material;

(b) The type of the fibres;

(c) Where applicable, binder material specifications;

(d) Average fibre dimensions;

(e) Minimum bulk material packing density in kg/m³;

(f) Maximum contact surface between the gas flow and the absorbing material.

2.21. "*Exhaust silencing system of different types*" means silencing systems which significantly differ in respect of at least one of the following:

(a) Trade names or trademarks of their components;

(b) The characteristics of the materials constituting their components, except for the coating of those components;

(c) The shape or size of their components;

(d) The operating principles of at least one of their components;

(e) The assembly of their components;

(f) The number of exhaust silencing systems or components.

2.22. "*Replacement silencing system*" means any part of the silencing system or its components intended for use on a vehicle, other than a part of the type fitted to this vehicle when submitted for type-approval pursuant to this Regulation.

2.23. "*R-point*" means R-point as defined in paragraph 2.4. of Annex 1 to the Consolidated Resolution on the Construction of Vehicles (R.E.3.).

2.24. Table of symbols

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
m_{ro}	kg	Annex 3	2.2.1.	mass in running order; value to be reported and used for calculations to a precision of 10 kg
m_t	kg	Annex 3	2.2.1.	test mass of the vehicle; value to be reported and used for calculations to a precision of 10 kg
m_{target}	kg	Annex 3	2.2.1.	target mass of the vehicle
m_{xload}	kg	Annex 3	2.2.1.	extra loading
$m_{fa\ load\ unladen}$	kg	Annex 3	2.2.1.	front axle load in unladen condition
$m_{ra\ load\ unladen}$	kg	Annex 3	2.2.1.	rear axle load in unladen condition
$m_{unladen}$	kg	Annex 3	2.2.1.	unladen vehicle mass
$m_{ac\ ra\ max}$	kg	Annex 3	2.2.1.	Technically permissible maximum laden mass allowed for the rear axle as declared by the manufacturer
m_d	kg	Annex 3	2.2.1.	mass of driver
$m_{chassis\ M2M3}$	kg	Annex 3	2.2.1.	mass of the incomplete vehicle (M_2 or M_3)
$m_{xload\ M2M3}$	kg	Annex 3	2.2.1.	extra load to be added to the incomplete vehicle (M_2 or M_3) to reach the mass of the vehicle in running order as chosen by the manufacturer
$m_{fa\ load\ laden}$	kg	Annex 3	2.2.7.2.	front axle load in laden condition
$m_{ra\ load\ laden}$	kg	Annex 3	2.2.7.2.	rear axle load in laden condition
$m_{t\ (2\ axles\ virtual)}$	kg	Annex 3	2.2.7.4.	test mass of a virtual vehicle with two axles (4x2 or 4x4)
v_{rf}	—	Annex 3	2.2.7.4.	vehicle with more than two axles representing the vehicle family
$m_{unladen\ (2\ axles\ virtual)}$	kg	Annex 3	2.2.7.4.	unladen vehicle mass of the virtual vehicle with two axles
$m_{xload\ (2\ axles\ virtual)}$	kg	Annex 3	2.2.7.4.	extra loading for the virtual vehicle with two axles
$m_{ac\ ra\ max\ (chosen)}$	kg	Annex 3	2.2.7.4.	Technically permissible maximum laden mass allowed for the chosen rear axle as defined in paragraph 2.2.7.4. in Annex 3
AA'	—	Annex 3	3.1.1.	line perpendicular to vehicle travel which indicates beginning of zone in which to record sound pressure level during test

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
BB'	—	Annex 3	3.1.1.	line perpendicular to vehicle travel which is 10.00 m behind line PP'
CC'	—	Annex 3	3.1.1.	line of vehicle travel through test surface defined in ISO 10844
PP'	—	Annex 3	3.1.1.	line perpendicular to vehicle travel which indicates location of microphones
v_{test}	km/h	Annex 3	3.1.2.1.	vehicle test speed
PMR	—	Annex 3	3.1.2.1.1.	power-to-mass ratio index to be used for calculations; value to be reported and used for calculations to the first decimal place
P_n	kW	Annex 3	3.1.2.1.1.	rated total engine net power
l	m	Annex 3	3.1.2.1.2.	reference length; value to be reported and used for calculations to a precision of 0.01 m (1 cm)
l_{veh}	m	Annex 3	3.1.2.1.2.	length of vehicle; value to be reported and used for calculations to a precision of 0.01 m (1 cm)
$v_{AA'}$	km/h	Annex 3	3.1.2.1.2.	vehicle velocity when the reference point passes line AA' (see paragraph 2.11. for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{BB'}$	km/h	Annex 3	3.1.2.1.2.	vehicle velocity when the reference point or rear of vehicle passes line BB' (see paragraph 2.11. for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{PP'}$	km/h	Annex 3	3.1.2.1.2.	vehicle velocity when the reference point passes line PP' (see paragraph 2.11. for definition of reference point); value to be reported and used for calculations to the first decimal place
$a_{wot\ test}$	m/s^2	Annex 3	3.1.2.1.2.1.	acceleration at wide-open throttle from AA' to BB'; value to be reported and used for calculations to the second decimal place
$a_{wot\ test,i}$	m/s^2	Annex 3	3.1.2.1.2.1.	acceleration at wide-open throttle achieved in a particular gear i; value to be reported and used for calculations to the second decimal place

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
l_{pa}	m	Annex 3	3.1.2.1.2.1.	point of depressing the accelerator before line AA'; value to be reported in full meter
$a_{wot\ test,\ PP\text{-}BB}$	m/s^2	Annex 3	3.1.2.1.2.2.	acceleration at wide-open throttle from PP' to BB'; value to be reported and used for calculations to the second decimal place
a_{urban}	m/s^2	Annex 3	3.1.2.1.2.3.	target acceleration representing urban traffic acceleration; value to be reported and used for calculations to the second decimal place
$a_{wot\ ref}$	m/s^2	Annex 3	3.1.2.1.2.4.	reference acceleration for the wide-open-throttle test; value to be reported and used for calculations to the second decimal place
k_P	—	Annex 3	3.1.2.1.3.	partial power factor; value to be reported and used for calculations to the second decimal place
$a_{wot\ i}$	m/s^2	Annex 3	3.1.2.1.4.1.	acceleration at wide-open-throttle in gear ratio i; value to be reported and used for calculations to the second decimal place
$a_{wot\ (i+1)}$	m/s^2	Annex 3	3.1.2.1.4.1.	acceleration at wide-open-throttle in gear ratio (i + 1); value to be reported and used for calculations to the second decimal place
gear ratio i	—	Annex 3	3.1.2.1.4.1.	gear ratio which provides an acceleration within the 5 per cent tolerance of the reference acceleration a_{wot_ref} or greater than the reference acceleration a_{wot_ref}
gear ratio i+1	—	Annex 3	3.1.2.1.4.1.	second of two gear ratios, with an acceleration lower than gear ratio i
gear ratio i+2, i+3, …	—	Annex 3	3.1.2.1.4.1.	gear ratios selectable for the pass-by test of Annex 3, if gear ratio i and gear ratio i+1 exceed an acceleration of 2.0 m/s^2
k	—	Annex 3	3.1.2.1.4.1.	gear ratio weighting factor; value to be reported and used for calculations to the second decimal place
n_{MAX}	1/min	Annex 3	3.1.2.1.4.1.	Maximum engine rotational speed permitted for M_1, N_1, and M_2 less than 3500 kg; value to be reported and used for calculations to a precision of 10 min^{-1} (xxx0)

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
S	1/min	Annex 3	3.1.2.1.4.1.	rated engine rotational speed in revs per minute, synonymous with the engine rotational speed at maximum power
$n_{BB'}$	1/min	Annex 3	3.1.2.2.	engine rotational speed of the vehicle, when the reference point passes BB'; value to be reported and used for calculations to a precision of 10 min^{-1}
$n_{target\ BB'}$	1/min	Annex 3	3.1.2.2.1.1.(a)	target engine rotational speed of the vehicle when the reference point has to pass line BB' (see 2.11.2. for definition of reference point)
$v_{target\ BB'}$	km/h	Annex 3	3.1.2.2.1.1.(a)	target vehicle velocity when it is necessary that the reference point has to pass line BB' (see 2.11.2. for definition of reference point)
$v_{BB'\ gear\ I}$	km/h	Annex 3	3.1.2.2.1.1.(b)	target vehicle velocity when certain conditions are met
$v_{BB'\ gear\ i,\ i=\ 1,2}$	km/h	Annex 3	3.1.2.2.1.1.(c)	target vehicle velocity when certain conditions are met
$gear_x$	-	Annex 3	3.1.2.2.1.1.(d)	first of two gear ratios used for testing of M_2 having a maximum authorized mass of more than 3 500 kg, M_3, N_2, and N_3 where certain criteria on test conditions are met
$gear_y$	-	Annex 3	3.1.2.2.1.1.(d)	second of two gear ratios used for testing of M_2 having a maximum authorized mass of more than 3,500 kg, M_3, N_2, and N_3 where certain criteria on test conditions are met
$v_{BB'x}$	km/h	Annex 3	3.1.2.2.1.1.(d)	target vehicle velocity when certain conditions are met
$v_{BB'y}$	km/h	Annex 3	3.1.2.2.1.1.(d)	target vehicle velocity when certain conditions are met
$v_{BB'1}$	km/h	Annex 3	3.1.2.2.1.2.(b)	target vehicle velocity when certain conditions are met
$v_{BB'2}$	km/h	Annex 3	3.1.2.2.1.2.(b)	target vehicle velocity when certain conditions are met
$n_{BB'i}$, i=1,2	1/min	Annex 3	3.1.2.2.1.2.(d)	engine rotational speed when the reference point passes BB' when certain conditions are met

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$L_{crs\ (i)}$	dB(A)	Annex 3	3.1.3.4.1.2.	vehicle sound pressure level at constant speed test for gear i; value to be reported and used for calculations to the first decimal place
$L_{crs\ (i+1)}$	dB(A)	Annex 3	3.1.3.4.1.2.	vehicle sound pressure level at constant speed test for gear (i + 1); value to be reported and used for calculations to the first decimal place
$L_{crs\ rep}$	dB(A)	Annex 3	3.1.3.4.1.2.	reported vehicle sound pressure level at constant speed test; value to be reported and used for calculations to the first decimal place
$L_{wot\ (i)}$	dB(A)	Annex 3	3.1.3.4.1.2.	vehicle sound pressure level at wide-open-throttle test for gear i; value to be reported and used for calculations to the first decimal place
$L_{wot\ (i+1)}$	dB(A)	Annex 3	3.1.3.4.1.2.	vehicle sound pressure level at wide-open-throttle test for gear (i + 1); ; value to be reported and used for calculations to the first decimal place
$L_{wot\ rep}$	dB(A)	Annex 3	3.1.3.4.1.2.	reported vehicle sound pressure level at wide-open-throttle; value to be reported and used for calculations to the first decimal place
L_{urban}	dB(A)	Annex 3	3.1.3.4.1.2.	reported vehicle sound pressure level representing urban operation; value to be reported mathematically rounded to the nearest integer
$L_{TR,9ref,(vTR,ref)}$	dB(A)	Annex 3 - Appendix 2 Annex 3 – Appendix 3	3.1. 4.3	Reported reference test result of the tyre rolling sound measurements at left/right side according to method described in Annex 3 Appendix 3
slp_{ref}	dB(A)/log(v)	Annex 3 - Appendix 2	3.1.	Slope of the tyre rolling sound measurements as determined by Annex 3 Appendix 3

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$v_{TR,ref}$	km/h	Annex 3 - Appendix 2 Annex 3 – Appendix 3	3.1. 4.3.	The reference vehicle speed for the reference tyre rolling sound; this speed may be different from v_{wot} or v_{crs} if tyre rolling sound data have been generated independently from the type approval test concerned. (see Annex 3 Appendix 3 paragraph 2.4.1. (b))
$v_{crs,j}$	km/h	Annex 3 - Appendix 2	3.2./4.3.	Vehicle speed when the reference point of the vehicle passes line PP' during a pass-by test according Annex paragraph 3.1.2.1.6.
$v_{wot,PP',j}$	km/h	Annex 3 - Appendix 2	3.3./4.4.	Vehicle speed when the reference point of the vehicle passes line PP' during a pass-by test according Annex paragraph 3.1.2.1.5.
$v_{wot,BB',j}$	km/h	Annex 3 - Appendix 2	3.3./4.4.	Vehicle speed when the rear of the vehicle passes line BB' during a pass-by test according Annex paragraph 3.1.2.1.5.
ϑ_{ref}	°C	Annex 3 - Appendix 2	3.	Reference air temperature: 20 °C
$\vartheta_{crs,j}$	°C	Annex 3 - Appendix 2	3.2.	Air temperature representative for one pass-by test run j under constant speed condition
$\vartheta_{wot,j}$.	°C	Annex 3 - Appendix 2	3.3.	Air temperature representative for one pass-by test run j under acceleration condition
$L_{TR,crs,j,\vartheta crs}$	dB(A)	Annex 3 - Appendix 2	3.2.3.	Tyre rolling sound adjusted to the speed condition of the constant speed test
$L_{PT,crs,j}$	dB(A)	Annex 3 - Appendix 2	3.2.4.	Extracted power train component from each valid constant speed test
$L_{TR,crs,j,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	3.2.2.	Tyre rolling sound adjusted to the speed condition of the constant speed test and the reference temperature

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$L_{crs,j,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	3.2.5.	Air temperature adjusted constant speed test result
$L_{TR,wot,j,\vartheta wot}$	dB(A)	Annex 3 - Appendix 2	3.3.3.	Tyre rolling sound adjusted to the speed condition of the acceleration test
$L_{PT,wot,j}$	dB(A)	Annex 3 - Appendix 2	3.3.4	Extracted power train component from each valid acceleration test
$L_{TR,wot,j,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	3.3.2.	Tyre rolling sound adjusted to the speed condition of the acceleration test and the reference temperature
$L_{wot,j,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	3.3.5.	Air temperature adjusted acceleration test result
$L_{TR,DB,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	4.1.	Reported reference test result of the tyre rolling sound measurement left/right side according to Annex 3 Appendix 3 taken from a database
$L_{TR,DB,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	4.1.	Reported reference test result of the tyre rolling sound measurement at v_{TEST} left/right side according to Annex 3 Appendix 3 taken from a database
$slp_{DB,ref}$	kg	Annex 3 - Appendix 2	4.1.	Slope of the tyre rolling sound measurements as determined by Annex 3 Appendix 3 taken from a database
$v_{DB,TR,ref}$	km/h	Annex 3 - Appendix 2	4.1.	The reference vehicle speed for the reference tyre rolling sound; this speed may be different from v_{crs} or v_{wot}, if tyre rolling sound data have been generated independently from the type approval test concerned. (see Annex 3 Appendix 3 paragraph 2.4.1. (b))
$L_{TR,DB,crs,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	4.1.	Reported reference test result of the tyre rolling sound measurement at v_{crs} left/right side according to Annex 3 Appendix 3 taken from a database
$L_{TR,DB,wot,\vartheta ref}$	dB(A)	Annex 3 - Appendix 2	4.1.	Reported reference test result of the tyre rolling sound measurement at v_{wot} left/right side according to Annex 3 Appendix 3 taken from a database

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
a_{wot_ASEP}	m/s^2	Annex 7	2.3.	maximum required acceleration at wide-open-throttle
κ	—	Annex 7	2.3.	gears to be tested under "Additional Sound Emission Provisions" (ASEP)
n_{BB_ASEP}	1/min	Annex 7	2.3.	maximum test engine speed; value to be reported and used for calculations to a precision of 10 min-1
$v_{AA'\_ASEP}$	km/h	Annex 7	2.3.	Target vehicle velocity for test point P1 of the assessment method according paragraph 2.4.
$v_{BB'\_ASEP}$	km/h	Annex 7	2.3.	Target vehicle velocity for test point P4 of the assessment method according paragraph 2.4.
P_j	—	Annex 7	2.4.	test point(s) under ASEP
j	—	Annex 7	2.4.	index for the test points under ASEP
v_{BB_j}	km/h	Annex 7	2.4.	vehicle test speed at BB' for a particular ASEP test point
$a_{wot,test,\ \kappa j}$	m/s^2	Annex 7	2.5.	acceleration at wide-open throttle achieved in gear κ and at test point j
$L_{wot,\kappa j}$	dB(A)	Annex 7	2.5.	sound pressure level measured for a gear κ and at a test point j; value to be reported and used for calculations to the first decimal place
$n_{BB,\kappa j}$	1/min	Annex 7	2.5.	vehicle test engine speed at BB' for a gear κ and at test point j
$v_{AA,\kappa j}$	km/h	Annex 7	2.5.	vehicle test speed at AA' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
$v_{BB,\kappa j}$	km/h	Annex 7	2.5.	vehicle test speed at BB' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
$v_{PP,\kappa j}$	km/h	Annex 7	2.5.	vehicle test speed at PP' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
L_{anchor}	dB(A)	Annex 7	3.1.	reported vehicle sound pressure level for gear ratio i from Annex 3; value to be reported and used for calculations to the first decimal place
$n_{anchor,\kappa}$	1/min	Annex 7	3.1.	reported vehicle engine speed for gear ratio i from Annex 3

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$v_{anchor,\kappa}$	km/h	Annex 7	3.1.	reported vehicle test speed for gear ratio i at BB' from Annex 3; value to be reported and used for calculations to the first decimal place
$L_{\kappa j}$	dB(A)	Annex 7	3.5.	sound pressure level measured for a gear κ and at a test point j; value to be reported and used for calculations to the first decimal place
k_{P_ASEP}	—	Annex 7	4.2.1.	partial power factor determined for the L_{urban} principle of ASEP
L_{wot_ASEP}	dB(A)	Annex 7	4.2.1.	vehicle sound pressure level measured for the L_{urban} principle of ASEP; value to be reported and used for calculations to the first decimal place
$L_{urban\_measured\_ASEP}$	dB(A)	Annex 7	4.2.1.	interim result for calculation of ΔL_{urban_ASEP}; value to be reported and used for calculations to the first decimal place
$L_{urban\_normalized}$	dB(A)	Annex 7	4.2.1.	interim result for calculation of ΔL_{urban_ASEP}; value to be reported and used for calculations to the first decimal place
ΔL_{urban_ASEP}	dB(A)	Annex 7	4.2.1.	estimated deviation from urban sound pressure level; value to be reported to the first decimal place
α	—	Annex 7	5.2	gear to be determined for the reference sound assessment according to the type of transmission
L_{ref}	dB(A)	Annex 7	5.3.	reference sound pressure level for reference sound assessment; value to be reported and used for calculations to the first decimal place
$n_{BB'\_ref}$	1/min	Annex 7	5.3.	Reference vehicle test engine speed for reference sound assessment

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$v_{BB'\_ref}$	km/h	Annex 7	5.3.	reference vehicle test speed for reference sound assessment

2.25. Modes

2.25.1. "*Mode*" means a distinct driver-selectable condition which does affect the sound emission of the vehicle.

2.26. Stable acceleration

For the purpose of this Regulation, three conditions are defined for stable acceleration.

2.26.1. "Stable acceleration" applicable to all vehicles subject to this Regulation for low engine speed conditions, which eliminates power train reactions such as bumping and jerking.

2.26.2. "Stable acceleration" applicable to vehicles of category M_1, N_1 and M_2 < 3,500 kg technically permissible maximum laden mass avoids acceleration delays in acceleration due to engine control application, at the moment when the acceleration unit is depressed. This is typically ensured by using pre-acceleration.

2.26.3. "Stable acceleration" for the purpose of Annex 7 is based on the assumption of a constant acceleration over the complete measurement distance between AA' and BB' plus the vehicle length.

2.27. "Kickdown" means a driver initiated automated gear shift to a test condition outside the specific target conditions for the vehicle as defined in Annex 3.

2.28. "Prevention of downshift" means a measure by the vehicle manufacturer to ensure that the vehicle is tested within its specific target conditions as defined in Annex 3 and Annex 7.

2.29. "Exterior sound producing and amplifying system (ESPAS)" means any system that is installed to a vehicle for producing or amplifying exterior sound, with the exception of safety-related devices required by UN-Regulations or national legislations such as AVAS, reverse warning systems, horns and sirens.

3. Application for approval

3.1. The application for approval of a vehicle type with regard to sound shall be submitted by its manufacturer or by his duly accredited representative.

3.2. It shall be accompanied by the undermentioned documents and the following particulars in triplicate:

3.2.1. A description of the vehicle type with regard to the items mentioned in paragraph 2.2. above. The numbers and/or symbols identifying the engine type and the vehicle type shall be specified;

3.2.2. A list of the components, duly identified, constituting the sound reduction system;

3.2.3. A drawing of the assembled sound reduction system and an indication of its position on the vehicle;

3.2.4. Detailed drawings of each component to enable it to be easily located and identified, and a specification of the materials used.

3.2.5. A technical information document including the information as outlined in Annex 1, Appendix 2.

3.3. In the case of paragraph 2.2.2. the single vehicle, representative of the type in question, will be selected by the Technical Service conducting approval tests, in accordance with the vehicle manufacturer, following the specification laid down in paragraph 3.1.2.2. in Annex 3.

3.4. Approval tests

3.4.1. At the request of the Technical Service conducting approval tests, the vehicle manufacturer shall, in addition, submit a sample of the sound reduction system and an engine of at least the same cylinder capacity and rated maximum net power as that fitted to the vehicle in respect of which type-approval is sought.

3.4.2. Tyre rolling sound reference measurements according to Annex 3 Appendix 3 which are carried out independent of the type approval tests of a vehicle (see Case 2 of Annex 3 Appendix 2) are not mandatory but can be performed at the option and responsibility of the vehicle manufacturer.

Where the vehicle manufacturer decides to perform such tests, they shall

(a) either be carried out by the vehicle manufacturer witnessed by the Type Approval Authority or by a Technical Service, or

(b) be carried out by the vehicle manufacturer by its laboratories and test facilities which may be designated as an approved laboratory, or

(c) by laboratories and test facilities of a Technical Service designated by the Type Approval Authority ~~and selected by the vehicle manufacturer~~.

The test results shall be submitted to the Type Approval Authority as reference data to be used when tests other than type approval test[4] are carried out on a different test track.

Where no reference data have been established, no test track compensation is applicable for above mentioned tests. Therefore, only Case 1 temperature correction is applicable.

3.5. The Type Approval Authority shall verify the existence of satisfactory arrangements for ensuring effective control of the conformity of production before type approval is granted.

4. Markings

4.1. The components of the sound reduction system, excluding fixing hardware and piping, shall bear:

4.1.1. The trade name or mark of the manufacturer of the sound reduction system and of its components; and

4.1.2. The manufacturer's trade description;

[4] For example, but not limited to, conformity of production, or extensions of already existing approvals, or in-service conformity.

4.2. These markings shall be clearly legible and be indelible even after fitting.

4.3. A component may carry several approval numbers if it has been approved as component of several replacement silencing systems.

5. Approval

5.1. Type approval shall only be granted if the vehicle type meets the requirements of paragraphs 6. and 7. below.

5.1.1. Starting from 1 July 2023 and for a period of twelve months, during type approval of a vehicle, measurements in accordance with Annex 9 (RD-ASEP) shall be performed. The complete test report (in pdf format) shall be communicated to the Type Approval Authority by their Technical Services and in addition, the monitoring information shall be entered into the data entry file "RD-ASEP Monitoring Data Sheet", which is published on the UN-ECE website.[5]

For the purpose of type approval, it is not mandatory to comply with the provisions of Annex 9.

For vehicles with PMR not exceeding 60, the performance of RD-ASEP tests is not mandatory.

RD-ASEP tests are not applicable to any tests done for the purpose of extension of existing approvals according to UN Regulation No. 51.

In case the type approval tests of Annex 3 and Annex 7 were carried out in an indoor facility, the test and the delivery of data according to Annex 9 are not mandatory.

Notwithstanding the provisions above, the Type Approval Authorities, Technical Services, and vehicle manufacturers may digitally submit additional vehicle tests of approved vehicles6 in the format as specified above, provided that all data have been determined on a single vehicle. This is applicable but not limited to

(a) extensions of type approval, or

(b) vehicles not falling under the scope of RD-ASEP, or

(c) approvals not falling within the monitoring period.

All tests for Annex 3 and for Annex 9 shall be carried out on the same test track and under similar environmental conditions.

5.2. An approval number shall be assigned to each type approved. Its first two digits (at present 03 corresponding to the 03 series of amendments) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The

[5] https://unece.org/documents-reference-only-0
In the “monitoring data sheet” the address, where the file shall be submitted to, is on the top of the sheet table “(0) instructions”.

[6] Where the Type Approval Authorities, Technical Services or vehicle manufacturers decide to submit additional test reports, the measured vehicles shall be in such a condition that they can be used for type approval (e.g., the vehicles should not be older than one year, originally equipped, without manipulation and maintained according to the manufacturer's specifications) and type approved according to the 03 series of UN Regulation No. 51.

same Contracting Party shall not assign the same number to another vehicle type.

5.3. Notice of approval or of extension or of refusal or withdrawal of approval or of production definitively discontinued of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in Annex 1 to this Regulation.

5.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation an international approval mark consisting of:

5.4.1. A circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval;[7]

5.4.2. The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 5.4.1.

5.5. If the vehicle conforms to a vehicle type approved under one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 5.4.1. need not be repeated; in such a case the regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 5.4.1.

5.6. The approval mark shall be clearly legible and be indelible.

5.7. The approval mark shall be placed close to or on the vehicle data plate affixed by the manufacturer.

5.8. Annex 2 to this Regulation gives examples of arrangements of the approval mark.

6. Specifications

6.1. General specifications ~~for durability and against manipulation~~

~~6.1.1. The vehicle, its engine and its sound reduction system shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.~~

6.1.1. The sound reduction system shall be so designed, constructed and assembled as to be able to reasonably resist the corrosive phenomena to which it is exposed having regard to the conditions of use of the vehicle, including regional climate differences~~, and against manipulation~~.

6.1.2. The sound reduction system shall be so designed, constructed and assembled as to be able to reasonably resist manipulations.

[7] The distinguishing numbers of the Contracting Parties to the 1958 Agreement are reproduced in Annex 3 to the Consolidated Resolution on the Construction of Vehicles (R.E.3)

6.1.3. **The installation of Exterior sound producing and amplifying systems (ESPAS) is prohibited.**

6.2. Specifications regarding sound levels

6.2.1. Methods of measurement

6.2.1.1. The sound made by the vehicle type submitted for approval shall be measured either indoors or outdoors by the methods described in Annex 3 to this Regulation . The specific conditions for indoor testing are provided in Annex 8 to this Regulation. The results of the outdoor and indoor tests are deemed equivalent.

For each specific test condition for vehicles, the manufacturer can select to test the vehicle either indoors or outdoors. The Type Approval Authority shall always have the option to mandate an outdoor test for verification. The option of the type approval authority to mandate an outdoor test shall apply to any test specified in this Regulation, including conformity of production testing.

In addition, the sound shall be measured on the vehicle when stationary;[8] in the case of a vehicle where an internal combustion engine cannot operate when the vehicle is stationary, the emitted sound shall only be measured in motion. In the case of a hybrid electrical vehicle of category M1 where an internal combustion engine cannot operate when the vehicle is stationary, the emitted sound shall be measured according to Annex 3, paragraph 4.

Vehicles having a technically maximum permissible laden mass exceeding 2,800 kg shall be subjected to an additional measurement of the compressed air noise with the vehicle stationary in accordance with the specifications of Annex 5, if the corresponding brake equipment is part of the vehicle.

6.2.1.2. The values measured in accordance with the provisions of paragraph 6.2.1.1. above shall be entered in the test report and a certificate corresponding to the model shown in Annex 1.

6.2.2. Sound level limits

The sound level measured in accordance with the provisions of paragraph 3.1. of Annex 3 to this Regulation, mathematically rounded to the nearest integer value, shall not exceed the following limits:

[8] A test is made on a stationary vehicle in order to provide a reference value for administrations which use this method to check vehicles in use.

Vehicle category	*Vehicles used for the carriage of passengers*	*Limit Values (dB(A))*		
		Phase 1	*Phase 2*	*Phase 3*
M_1	PMR ≤ 120	72	70	68
	120 < PMR ≤ 160	73	71	69
	PMR > 160	75	73	71
	PMR > 200, no. of seats ≤ 4, R-point height < 450mm from the ground	75	74	72
M_2	$M \leq$ 2.5 t	72	70	69
	2.5 t < M ≤ 3.5 t	74	72	71
	M > 3.5 t; $P_n \leq$ 135 kW	75	73	72
	M > 3.5 t; P_n > 135 kW	75	74	72
M_3	$P_n \leq$ 150 kW	76	74	73
	150 kW < $P_n \leq$ 250 kW	78	77	76
	P_n > 250 kW	80	78	77
Vehicle category	*Vehicles used for the carriage of goods*	*Phase 1*	*Phase 2*	*Phase 3*
N_1	$M \leq$ 2.5 t	72	71	69
	M > 2.5 t	74	73	71
N_2	$P_n \leq$ 135kW	77	75	74
	P_n > 135 kW	78	76	75
N_3	$P_n \leq$ 150 kW	79	77	76
	150 kW < $P_n \leq$ 250 kW	81	79	77
	P_n > 250 kW	82	81	79

6.2.2.1. For vehicle types of category M_1 derived from N_1 vehicle types having a technically permissible maximum laden mass above 2.5 tons and a R-point height greater than 850 mm from the ground, the limits of vehicles types of category N_1 having a technically permissible maximum laden mass above 2.5 tons apply.

6.2.2.2. For vehicle types designed for off-road[9] use, the limit values shall be increased by 2 dB(A) for M_3 and N_3 vehicles category and 1 dB(A) for any other vehicle category.

For vehicle types of category M_1 the increased limit values for off-road vehicles are only valid if the technically permissible maximum laden mass > 2 tons.

6.2.2.3. Limit values shall be increased by 2 dB(A) for wheelchair accessible vehicles of category M_1 constructed or converted specifically so that they accommodate one or more persons seated in their wheelchairs when travelling on the road, and armoured vehicles, as defined in paragraph 2.5.2. of R.E.3.

6.2.2.4. For vehicle types of category M_3 having a gasoline only engine, the applicable limit value is increased by 2 dB(A).

6.2.2.5. For vehicle types of category N_1 having a technically permissible maximum laden mass of less than or equal to 2.5 tons, the engine capacity not exceeding

[9] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), ECE/TRANS/WP.29/78/Rev.6

660 cc and the power-to-mass ratio (PMR) calculated by using the technically permissible maximum laden mass not exceeding 35 and a horizontal distance "d" between the front axle and the driver's seat R point of less than 1,100 mm, the limits of the vehicle types of category N_1 having a technically permissible maximum laden mass above 2.5 tons apply.

6.2.3. Additional sound emission provisions

The Additional Sound Emission Provisions (ASEP) apply only to vehicles of categories M_1 and N_1 equipped with an internal combustion engine.

Vehicles are deemed to fulfil the requirements of Annex 7, if the vehicle manufacturer provides technical documents to the type approval authority showing, that the difference between maximum and minimum engine speed of the vehicles at BB' for any test condition inside the ASEP control range defined in paragraph 2.3. of Annex 7 to this Regulation (including Annex 3 conditions) does not exceed 0.15 x S. This article is intended especially for non-lockable transmissions with variable gear ratios (CVT).

Vehicles are exempted from ASEP **testing during type-approval** if one of the following conditions is fulfilled:

(a) For vehicles of category N_1, if the engine capacity does not exceed 660 cc and the power-to-mass ratio PMR calculated by using the technically permissible maximum laden mass does not exceed 35.

(b) For vehicles of category N_1, if the payload is at least 850 kg and the power-to-mass ratio calculated by using the technically permissible maximum laden mass does not exceed 40.

(c) For vehicles of category N_1 or M_1 derived from N_1 if the technically permissible maximum laden mass is greater than 2.5 tons and the R-point height is greater than 850 mm from the ground and the power- to-mass ratio calculated by using the technically permissible maximum laden mass does not exceed 40.

The sound emission of the vehicle under typical on-road driving conditions, which are different from those under which the type-approval test set out in Annex 3 and Annex 7 was carried out, shall not deviate from the test result in a significant manner.

~~Any electric sound enhancement system for the purpose of the exterior sound emission shall be operational during the type-approval test.~~

6.2.3.1. The vehicle manufacturer shall not intentionally alter, adjust, or introduce any mechanical, electrical, thermal, or other device or procedure solely for the purpose of fulfilling the sound emission requirements as specified under this Regulation which is not operational during typical on-road operation.

6.2.3.2. The vehicle shall meet the requirements of Annex 7 to this Regulation.

6.2.3.3. In applying for type approval, the manufacturer shall provide a statement, in conformity with Appendix 1 of Annex 7, that the vehicle type to be approved complies with the requirements of paragraph 6.2.3. of this Regulation.

6.3. Specifications regarding exhaust systems containing fibrous materials

6.3.1. Requirements of Annex 4 shall be applied.

7. Modification and extension of approval of a vehicle type

7.1. Every modification of the vehicle type shall be notified to the Type Approval Authority which approved the vehicle type. The Type Approval Authority may then either:

7.1.1. Consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirements, or

7.1.2. Require a further test report from the Technical Service responsible for conducting the tests.

7.2. Confirmation or refusal of approval, specifying the alterations shall be communicated by the procedure specified in paragraph 5.3. above to the Parties to the Agreement applying this Regulation.

7.3. The Type Approval Authority issuing the extension of approval shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

8. Conformity of production

8.1 The conformity of production procedures shall comply with those set out in the Agreement, Appendix 2 (E/ECE/324-E/ECE/TRANS/505/Rev.2) with the following requirements:

8.1.1. Vehicles approved according to this Regulation shall be so manufactured as to conform to the type approved by meeting the requirements of paragraph 6. above.

8.1.2. The minimum requirements for conformity of production control procedures of Annex 6 to this Regulation shall be complied with.

8.2. The authority which has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be one every two years.

9. Penalties for non-conformity of production

9.1. The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements set forth above are not met.

9.2. If a Contracting Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of a communication form conforming to the model in Annex 1 to this Regulation.

10. Production definitively discontinued

10.1. If the holder of the approval completely ceases to manufacture a vehicle type approved in accordance with this Regulation, he shall so inform the authority

which granted the approval. Upon receiving the relevant communication that authority shall inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

11. Transitional provisions

11.1. As from the official date of entry into force of the 03 series of amendments to this Regulation, no Contracting Party applying this Regulation shall refuse to grant or refuse to accept type-approvals under this Regulation as amended by the 03 series of amendments.

11.2. Transitional Provisions for Phase 1 (see paragraph 6.2.2. above)

11.2.1. As from 1 July 2016, Contracting Parties applying this Regulation shall grant type-approvals only if the vehicle type to be approved meets the requirements of phase 1 (see paragraph 6.2.2. above) of this Regulation as amended by the 03 series of amendments.

As from the official date of entry into force of the 03 series of amendments, Contracting Parties applying this Regulation shall grant type approvals to the vehicle type which meets the requirements of phase 2 or phase 3 of this Regulation as amended by the 03 series of amendments.

11.2.2. Contracting Parties applying this Regulation shall not refuse to grant extensions of type approvals for existing types which have been granted according to the 02 series of amendments to this Regulation.

11.2.3. Until 30 June 2022, no Contracting Party applying this Regulation shall refuse national or regional type approval of a vehicle type-approved to the 02 series of amendments to this Regulation.

11.2.4. As from 1 July 2022, Contracting Parties applying this Regulation shall not be obliged to accept for the purpose of national or regional type approval, a vehicle type approved to the preceding series of amendments to this Regulation.

11.2.5. Even after the date of entry into force of the 03 series of amendments to this Regulation, Contracting Parties applying this Regulation may continue for national or regional purposes granting type approvals and extensions of type approvals to the preceding series of amendments to this Regulation.

11.3. Transitional Provisions for Phase 2 (see paragraph 6.2.2. above)

11.3.1. As from 1 July 2020 for vehicle types other than N_2 and as from 1 July 2022 for vehicles types of category N_2, Contracting Parties applying this Regulation shall grant type approvals only if the vehicle type to be approved meets the requirements of phase 2 (see paragraph 6.2.2. above) of this Regulation as amended by the 03 series of amendments.

Furthermore, as from the official date of entry into force of the 03 series of amendments, Contracting Parties applying this Regulation shall grant type approvals to the vehicle type which meets the requirements of phase 3 of this Regulation as amended by the 03 series of amendments.

11.3.2. Contracting Parties applying this Regulation shall not refuse to grant extensions of type approvals for existing types which have been granted

according to phase 1 (see paragraph 6.2.2. above) or the 02 series of amendments to this Regulation.

11.3.3. Until 30 June 2022 for vehicle types other than N_2 and until 30 June 2023 for vehicles types of category N_2, no Contracting Party applying this Regulation shall refuse national or regional type approval of a vehicle type-approved to phase 1 (see paragraph 6.2.2. above) or the 02 series of amendments to this Regulation.

11.3.4. As from 1 July 2022 for vehicle types other than N_2 and as from 1 July 2023 for vehicles types of category N_2, Contracting Parties applying this Regulation shall not be obliged to accept for the purpose of national or regional type approval, a vehicle type approved to phase 1 (see paragraph 6.2.2.1. above) or the preceding series of amendments to this Regulation.

11.3.5. Even after the date of entry into force of the 03 series of amendments to this Regulation, Contracting Parties applying this Regulation may continue for national or regional purposes granting type approvals and extensions of type approvals to phase 1 (see paragraph 6.2.2. above) or the preceding series of amendments to this Regulation.

11.4. Transitional Provisions for Phase 3 (see paragraph 6.2.2. above)

11.4.1. As from 1 July 2024 for vehicle types other than N_2, N_3 and M_3 and as from 1 July 2026 for vehicles types of category N_2, N_3 and M_3, Contracting Parties applying this Regulation shall grant type-approvals only if the vehicle type to be approved meets the requirements of phase 3 (see paragraph 6.2.2. above) of this Regulation as amended by the 03 series of amendments.

11.4.2. Contracting Parties applying this Regulation shall not refuse to grant extensions of type approvals for existing types which have been granted according to phase 2 according to paragraph 6.2.2. above.

11.4.3. Until 30 June 2026 for vehicle types other than N_2, N_3 and M_3 and until 30 June 2027 for vehicles types of category N_2, N_3 and M_3, no Contracting Party applying this Regulation shall refuse national or regional type approval of a vehicle type-approved to phase 2 according to paragraph 6.2.2. above.

11.4.4. As from 1 July 2026 for vehicle types other than N_2, N_3 and M_3 and as from 1 July 2027 for vehicles types of category N_2, N_3 and M_3, Contracting Parties applying this Regulation shall not be obliged to accept for the purpose of national or regional type approval, a vehicle type approved to phase 2 according to paragraph 6.2.2. above.

11.4.5. Even after the date of entry into force of the 03 series of amendments to this Regulation, Contracting Parties applying this Regulation may continue for national or regional purposes granting type approvals and extensions of type approvals to phase 1 or phase 2 (see paragraph 6.2.2. above) or the preceding series of amendments to this Regulation.

11.5. Notwithstanding the transitional provisions above, Contracting Parties whose application of this Regulation comes into force after the date of entry into force of the most recent series of amendments are not obliged to accept type approvals which were granted in accordance with any of the preceding series of amendments to this Regulation.

11.6. Until 30 June 2028, vehicles with a serial hybrid drive train which have a combustion engine with no mechanical coupling to the power train are excluded from the requirements of paragraph 6.2.3. above.

11.7. Until 30 June 2019, Contracting Parties applying this Regulation can continue to grant approvals using test sites which comply with the specifications of the preceding series of amendments to this Regulation as an alternative to Annex 3, paragraph 2.1. of this Regulation.

11.8. Until 31 December 2023 for vehicle types of category N_1 or for vehicle types of category M_1 derived from N_1 the limits according to paragraph 6.2.2. of the vehicle types of category N_1 having a technically permissible maximum laden mass above 2.5 tons apply, if all the following specifications are met:

(a) Having a technically permissible maximum laden mass of less than or equal to 2.5 tons;

(b) An R-point height greater or equal to 800 mm from the ground;

(c) An engine capacity exceeding 660cc but less than 1495cc;

(d) An engine where the centre point of gravity of the engine is between 300 mm and 1,500 mm behind the front axle;

(e) And having a rear axle drive.

11.9. Until 18 months after the date of entry into force of the Supplement 3, it shall not apply to extensions of existing approvals, originally granted prior to the date of entry into force of Supplement 3.

11.10. Until May 1, 2020 Supplement 4 does not apply to existing approvals, originally granted prior to the date of entry into force of Supplement 4.

11.11. Until May 1, 2020 Supplement 5 does not apply to existing approvals, originally granted prior to the date of entry into force of Supplement 5.

11.12. Until 12 months after the date of entry into force of the Supplement 6, it shall not apply to extensions of existing approvals, originally granted prior to the date of entry into force of Supplement 6.

11.13. Supplement 7 (in particular, but not limited to Appendices 2 and 3 to Annex 3 and Annex 9) does not apply to existing type approvals, originally granted prior to the date of entry into force of Supplement 7.

11.14. Supplement 8 does not apply to existing type approvals, originally granted prior to the date of entry into force of Supplement 7.

11.15. From the entry into force of Supplement 8, ISO 10844:2021 shall be accepted for all approvals granted under this Regulation. Until five years from the entry into force of Supplement 8, ISO 10844:2014 shall be accepted for all approvals granted under this Regulation.

11.16. Supplement 9 does not apply to existing type approvals and their extensions, granted prior to the date of entry into force of Supplement 9.

11.17. Supplement 11 applies immediately to new type approvals and applies to existing type approvals and their extensions after a lead time of 2 years from the entry into force of the Supplement.

12. Names and addresses of Technical Services responsible for conducting approval tests and of Type Approval Authorities

12.1. The Contracting Parties to the 1958 Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the Technical Services responsible for conducting approval tests and of the Type Approval Authorities which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

12.2. The Contracting Parties to the 1958 Agreement which apply this Regulation may designate laboratories of vehicle manufacturers as approved test laboratories for the purpose of tyre rolling sound measurements according to paragraph 3.4.2.

12.3. Where a Contracting Party to the 1958 Agreement applies paragraph 12.2. above, it may, if it so desires, be represented at the tests by one or more persons of its choice.

Annex 1

Communication

(maximum format: A4 (210 x 297 mm))

issued by: Name of administration:
.....
.....
.....

concerning:[2] Approval granted
Approval extended
Approval refused
Approval withdrawn
Production definitively discontinued

of a vehicle type with regard to its sound emission pursuant to Regulation No. 51

Approval No. …….. Extension No. ……

Section I

0.1. Make (trade name of manufacturer): .....

0.2. Type:.....

0.3. Means of identification of type if marked on the vehicle: [3].....

0.3.1. Location of that marking: .....

0.4. Category of vehicle:[4] .....

0.4.1. Subcategory according to paragraph 6.2.2., the 2nd column of the table and the paragraphs 6.2.2.1. to 6.2.2.5.....

0.5. Company name and address of manufacturer:.....

0.6. Names and Address(es) of assembly plant(s):.....

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

---

[1] Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

[2] Delete what does not apply.

[3] If the means of identification of type contains characters not relevant to describe the vehicle types covered by the type-approval certificate such characters shall be represented in the documentation by the symbol: '?' (e.g. ABC??123??).

[4] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.3, para. 2 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html

Section II

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

Attachments:

Information package

Test report(s)

Annex 1 – Appendix 1

Addendum to the communication form No …

1.	Additional information
1.1.	Power plant
1.1.1.	Manufacturer of the engine:.....
1.1.2.	Manufacturer's engine code:.....
1.1.3	Rated maximum net power: ..... kW at ..... min^{-1} or maximum continuous rated power (electric motor) ..... kW
1.1.4.	Pressure charger(s), Make and Type:.....
1.1.5.	Air filter, Make and Type:.....
1.1.6.	Intake silencer(s), Make and Type:.....
1.1.7.	Exhaust Silencer(s), Make and Type:.....
1.1.8.	Catalyst(s), Make and Type:.....
1.1.9.	Particulate Trap(s), Make and Type: .....
1.2.	Transmission
1.2.1.	Type (mechanical, hydraulic, electric, etc.):.....
1.3.	Non-engine devices designed to reduce noise: .....
2.	Test results
2.1.	Sound level of moving vehicle (Annex 3): ..... dB(A)
2.1.1.	Selected mode for tests of the vehicle in motion: .....
2.2.	Sound level of stationary vehicle: ..... dB(A) at . min^{-1} in mode ……[1]
	Sound level of stationary vehicle: ..... dB(A) at ..... min^{-1} in mode ……[1]
	Sound level of stationary vehicle: ..... dB(A) at ..... min^{-1} in mode ……[1]
	Sound level of stationary vehicle: ..... dB(A) at ..... min^{-1} in mode ……[1]
	Sound level of stationary vehicle: ..... dB(A) at ..... min^{-1} in mode ……[1]
2.2.1.	Sound level of compressed air, service brake: ..... dB(A)
2.2.2.	Sound level of compressed air, parking brake: ..... dB(A)
2.2.3.	Sound level of compressed air, during the pressure regulator actuation: ….. dB(A)

[1] If applicable

2.3. Data to facilitate in-use compliance test of hybrid vehicles, where an internal combustion engine cannot operate when the vehicle is stationary

2.3.1. Gear (i) or position of the gear selector chosen for the test:

2.3.2. Position of the operating switch during measurement Lwot (i), (if switch is fitted)

2.3.3. If applicable, pre-acceleration length l_{PA} (Point of the accelerator depression in meter before line AA'). If the pre-acceleration length differs per gear, reporting per gear is required."

2.3.4. Sound pressure level L wot (i) ..... dB(A)

2.4. Testing method information

2.4.1. Test method selected: Outdoor/Indoor[2]

3. Remarks:.....

.....

[2] Delete what does not apply.

Annex 1 – Appendix 2

Technical Information Document

0.	General
0.1.	Make (trade name of manufacturer): .....
0.2.	Type: ……
0.3.	Means of identification of type, if marked on the vehicle:[1] .....
0.3.1.	Location of that marking: .....
0.4.	Category of vehicle:[2] .....
0.5.	Company name and address of manufacturer:.....
0.6.	Name and address of the manufacturer's representative (if any): .....
0.7.	Name(s) and address(es) of assembly plant(s):.....
1.	General construction characteristics of the vehicle
1.1.	Photographs and/or drawings of a representative vehicle:.....
1.2.	Number of axles and wheels:[3] .....
1.2.1.	Powered axles (number, position, interconnection):.....
1.3.	Position and arrangement of the engine:.....
2.	Masses and dimensions[4] (in kg and mm) (Refer to drawing where applicable): .....
2.1.	Range of vehicle dimensions (overall): .....
2.1.1.	For chassis without bodywork: .....
2.1.1.1.	Length:.....
2.1.1.2.	Width: .....
2.1.2.	For chassis with bodywork .....
2.1.2.1.	Length:.....
2.1.2.2.	Width: .....

[1] If the means of identification of type contains characters not relevant to describe the vehicle types covered by the type-approval certificate such characters shall be represented in the documentation by the symbol: '?' (e.g. ABC??123??).

[2] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.3, para. 2 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html

[3] Only for the purpose of defining "off-road vehicles".

[4] Standard ISO 612: 1978 — Road vehicles — Dimensions of motor vehicles and towed vehicles - terms and definitions.

(a) Where there is one version with a normal cab and another with a sleeper cab, both sets of masses and dimensions are to be stated.

(b) Optional equipment that affects the dimensions of the vehicle shall be specified.

2.2. Mass in running order[5]

(a) Minimum and maximum for each variant: .....

(b) Mass of each version (a matrix shall be provided): .....

2.3. Technically permissible maximum laden mass stated by the manufacturer:[6, 7]

3. Power plant[8]

3.1. Manufacturer of the engine:.....

3.1.1. Manufacturer's engine code (as marked on the engine, or other means of identification): .....

3.2. Internal combustion engine

3.2.1. Specific engine information

3.2.1.1. Working principle: positive ignition/compression ignition, cycle four stroke/two stroke/rotary[9]

3.2.1.2. Number and arrangement of cylinders:.....

3.2.1.2.1. Firing order:.....

3.2.1.3. Engine capacity:[10] …. cm^3

3.2.1.4. Rated maximum net power: …. kW at ….. min^{-1} (manufacturer's declared value)

3.2.2. Fuel feed

3.2.2.1. By fuel injection (compression ignition only): yes/no[9]

3.2.2.1.1. Working principle: Direct injection/pre-chamber/swirl chamber[9]

3.2.2.1.2. Governor

3.2.2.1.2.1. Type:.....

3.2.2.1.2.2. Speed at which Cut-off starts under load: …. min^{-1}

3.2.2.2. By fuel injection (positive ignition only): yes/no[9]

3.2.2.2.1. Working principle: Intake manifold (single-/multi-point[2])/direct injection/other (specify)[9]

---

[5] The mass of the driver is assessed at 75 kg. The liquid containing systems (except those for used water that shall remain empty) are filled to 90 per cent of the capacity specified by the manufacturer. The information referred to in points 2.2. (b) do not need to be provided for vehicle categories N_2, N_3, M_2 and M_3.

[6] For vehicles coupled with a trailer or a semi-trailer, which exert a significant vertical load on the coupling device or the fifth wheel, this load, divided by standard acceleration of gravity, is included in the maximum technically permissible mass. Please fill in here the upper and lower values for each variant.

[7] Please fill in here the upper and lower values for each variant.

[8] In the case of a vehicle that can run either on petrol, diesel, etc., or also in combination with another fuel, items shall be repeated. In the case of non-conventional engines and systems, particulars equivalent to those referred here shall be supplied by the manufacturer.

[9] Delete what does not apply.

[10] This value shall be calculated ($\pi = 3.1416$) and rounded off to the nearest cm^3.

3.2.3. Intake system

3.2.3.1. Air filter, drawings, or

3.2.3.1.1. Make(s):.....

3.2.3.1.2. Type(s):.....

3.2.3.2. Intake silencer, drawings,

3.2.3.2.1. Make(s):.....

3.2.3.2.2. Type(s):.....

3.2.4. Exhaust system

3.2.4.1. Description and/or drawing of the exhaust system: .....

3.2.4.2. Exhaust silencer(s):.....

Type, marking of exhaust silencer(s):.....

Where relevant for exterior noise, reducing measures in the engine compartment and on the engine:.....

3.2.4.3. Location of the exhaust outlet:.....

3.2.4.4. Exhaust silencer containing fibrous materials: .....

3.2.5. Catalytic convertor: yes/no[9]

3.2.5.1. Number of catalytic convertors and elements (provide the information below for each separate unit):.....

3.2.6. Pressure charger(s)

3.2.6.1. Make(s): ……

3.2.6.2. Type(s): …….

3.3. Electric motor (describe each type of electric motor separately)

3.3.1. Make: .....

3.3.2. Type: .....

3.3.3. Rated maximum net power: …. kW

3.3.4. Operating voltage: …. V”

3.4. Engine or motor combination: .....

3.4.1. Hybrid electric vehicle: yes/no[9]

3.4.2. Category of hybrid electric vehicle: off-vehicle charging/not off-vehicle charging:[9]

3.4.3. Operating mode switch: with/without[9]

3.4.3.1. Selectable modes

3.4.3.1.1. Pure electric: yes/no[9]

3.4.3.1.2. Pure fuel consuming: yes/no[9]

3.4.3.1.3. Hybrid modes: yes/no[9] (if yes, short description):

3.4.4. Electric motor (describe each type of electric motor separately)

3.4.4.1. Make:.....

3.4.4.2. Type:.....

3.4.4.3. Rated maximum net power: …… kW

4. Transmission[11]

4.1. Type (mechanical, hydraulic, electric, etc.):.....

4.2. Gear ratios

Gear	*Internal gearbox ratios (ratios of engine to gearbox output shaft revolutions)*	*Final drive ratio(s) (ratio of gearbox output shaft to driven wheel revolutions)*	*Total gear ratios*
Maximum for CVT[12]			
1			
2			
3			
…			
Minimum for CVT			
Reverse			

4.3. Maximum vehicle design speed (in km/h):[13] .....

5. Suspension

5.1. Tyres and wheels

5.1.1. Tyre/wheel combination(s)

(a) For tyres indicate size designation, load-capacity index and speed category symbol;

(b) For wheels indicate rim size(s) and off-set(s).

5.1.2. Upper and lower limits of rolling radii

5.1.2.1. Axle 1: .....

5.1.2.2. Axle 2: .....

5.1.2.3. Axle 3: .....

5.1.2.4. Axle 4: .....

etc.

6. Bodywork

6.1. Type of bodywork: .....

6.2. Materials used and methods of construction:.....

7. Miscellaneous

7.1. Details of any non-engine devices designed to reduce noise (if not covered by other items):.....

Signed: .....

Position in company:.....

[11] The specified particulars are to be given for any proposed variants.

[12] Continuous Variable Transmission (CVT): transmission with variable gear ratios.

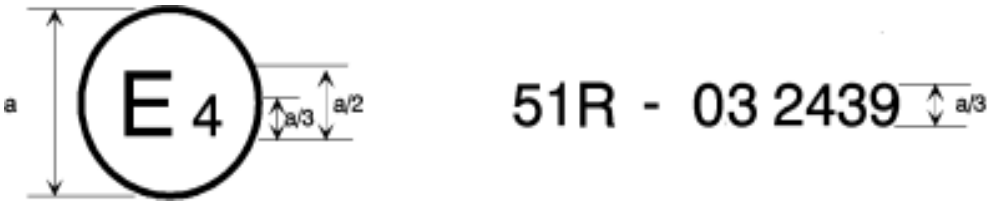
[13] With respect to trailers, maximum speed permitted by the manufacturer.

Date: ....

Annex 2

Arrangements of the approval mark

Model A
(See paragraph 5.4. of this Regulation)

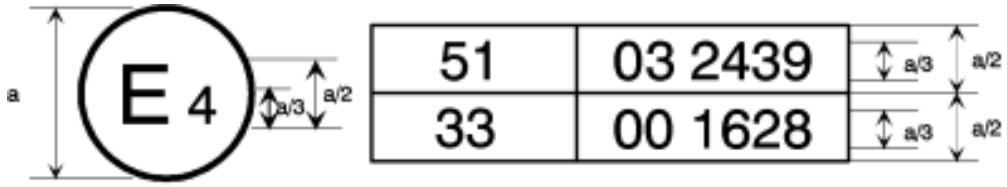


a = 8 mm min.

The above approval mark affixed to a vehicle shows that the vehicle type concerned has, with regard to its noise emission, been approved in the Netherlands (E 4) pursuant to Regulation No. 51 under approval No. 032439.

The first two digits of the approval number indicate that Regulation No. 51 already included the 03 series of amendments when the approval was granted.

Model B
(See paragraph 5.5. of this Regulation)



a = 8 mm min.

The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in the Netherlands (E 4) pursuant to Regulations Nos. 51 and 33.[1] The approval numbers indicate that, at the dates when the respective approvals were granted, Regulation No. 51 included the 03 series of amendments while Regulation No. 33 was in its original form.

[1] The latter number is given as an example only.

Annex 3

Methods and instruments for measuring the sound made by motor vehicles

1. Measuring instruments

1.1. Acoustic measurements

The apparatus used for measuring the sound level shall be a precision sound-level meter or equivalent measurement system meeting the requirements of Class 1 instruments (inclusive of the recommended windscreen, if used). These requirements are described in "IEC 61672-1:2002: Precision sound level meters", second edition, of the International Electrotechnical Commission (IEC).

For indoor testing, when no general statement or conclusion can be made about conformance of the sound level meter by each channel of the array conformance (e.g. when pass-by sound level simulation algorithms do not compute the overall level but spectrum or temporal to recompose it), a simulated pass-by run shall be performed at a constant speed of 50 km/h while a constant tone signal is supplied to all channels of the arrays. The simulated A-weighted sound level is processed and the deviation from a reference tone signal shall be checked in accordance to IEC 61672-3.

Measurements shall be carried out using the "fast" response of the acoustic measurement instrument and the "A" weighting curve also described in "IEC 61672-1:2002". When using a system that includes a periodic monitoring of the A-weighted sound pressure level, a reading should be made at a time interval not greater than 30 ms.

The instruments shall be maintained and calibrated in accordance to the instructions of the instrument manufacturer.

1.2. ~~Calibration~~ **Verification and adjustment** of the entire Acoustic Measurement System ~~for a~~ **before and after every** Measurement Session

At the beginning ~~and at the end~~ of every measurement session**,** the entire **acoustic** measurement system shall be checked by means of a sound calibrator ~~that fulfils the requirements for sound calibrators~~ of at least precision Class 1 according to IEC 60942:2003**, and – if necessary – adjusted to the reference values given by the calibrator**.

At the end of every measurement session, the entire acoustic measurement system shall be re-checked by the same calibrator which has been used for the calibration in the beginning. Without any further adjustment**,** the difference between the readings at the beginning and at the end ~~of two consecutive checks~~ shall be less than or equal to 0.5 dB**(A)**.

If ~~this value~~ **the difference is greater than 0.5 dB(A)** ~~is exceeded~~**,** the results of the **whole** measurement~~s~~ **session** ~~obtained after the previous satisfactory check~~ shall be discarded.

For indoor testing, the entire measurement system shall be checked at the beginning and at the end of a series of sessions.

A qualified calibration method (i.e. electrical calibration) is recommended to be provided by the hardware supplier and, in that case, shall be implemented in the measurement software used. Simulation algorithms using sound source localization detection should deactivate that feature for these tests.

1.3. Compliance with requirements

Compliance of the acoustic measurement instrumentation shall be verified by the existence of a valid certificate of compliance. These certificates shall be deemed to be valid if certification of compliance with the standards was conducted within the previous 12 month period for the sound calibration device and within the previous 24 month period for the instrumentation system. All compliance testing shall be conducted by a laboratory, which is authorized to perform calibrations traceable to the appropriate standards.

1.4. Instrumentation for speed measurements

The engine speed shall be measured with instrumentation having an accuracy of ±2 per cent or better at the engine speeds required for the measurements being performed.

The road speed of the vehicle shall be measured with a continuous speed measuring device having an accuracy of at least ±0.5 km/h.

1.5. Meteorological instrumentation

The meteorological instrumentation used to monitor the environmental conditions during the test shall include the following devices, which meet at least the given accuracy:

(a) Temperature measuring device, ±1 °C;

(b) Wind speed-measuring device, ±1.0 m/s;

(c) Barometric pressure measuring device, ±5 hPa;

(d) A relative humidity measuring device, ±5 per cent.

A monitoring of the wind speed is not mandated when tests are carried out in an indoor facility.

2. Conditions of measurement

2.1. Test Site and ambient conditions

The specifications for the test site provide the necessary acoustic environment to carry out the vehicle tests documented in this Regulation. Outdoor and indoor test environments that meet the specifications of this Regulation provide equivalent acoustic environments and produce results that are equally valid.

2.1.1. Test Site Outdoor

The surface of the test track and the dimensions of the test site shall be in accordance with ISO 10844:2021.

2.1.2. Test Site Indoor

Test Site Indoor requirements shall be as specified below.

(a) The test room dimensions are described in paragraph 7.2. of ISO 362-3:2016. All room dimensions may be adjusted to meet the specific application for the products being tested according to Annex 8, paragraph 4.

(b) The test facility shall meet the requirements of ISO 26101:2012 with the qualification criteria and measurement requirements appropriate to this test method as described in ISO 362-3:2016, paragraph 7.3.

(c) Condition of the floor is described in ISO 362-3:2016, paragraph 7.4.

(d) Cooling, ventilation, and exhaust gas management are described in ISO 362-3:2016, paragraph 7.5.

(e) Dynamometer requirements are described in ISO 362-3:2016, paragraph 8.

(f) Vehicle fixing system is described in ISO 362-3:2016, paragraph 9.3.

2.1.3. Ambient conditions

2.1.3.1. Ambient condition indoor

2.1.3.1.1. General

Meteorological conditions are specified to provide a range of normal operating temperatures and to prevent abnormal readings due to extreme environmental conditions.

The meteorological instrumentation shall deliver data representative for the test site and values of temperature, relative humidity, and barometric pressure shall be recorded during the measurement interval.

2.1.3.1.2. Temperature

The measurements shall be made when the ambient air temperature is within the range from 5 °C to 40 °C.

The ambient temperature may of necessity be restricted to a narrower temperature range such that all key vehicle functionalities (e.g. start/stop, hybrid propulsion, battery propulsion, fuel-cell stack operation) are enabled according to manufacturer's specifications.

2.1.3.1.3. Wind

n.a.

2.1.3.1.4. Background noise

For indoor testing, background noise shall take into account noise emissions produced by the dynamometer rollers, ventilation systems, and facility exhaust gas systems.

2.1.3.2. Ambient condition outdoor

2.1.3.2.1. General

The surface of the site shall be free of powdery snow, tall grass, loose soil or cinders. There shall be no obstacle which could affect the sound field within the vicinity of the microphone and the sound source. The observer carrying out the measurements shall so position themself as not to affect the readings of the measuring instrument.

Measurements shall not be made under adverse weather conditions. It shall be ensured that the results are not affected by gusts of wind.

The meteorological instrumentation should be positioned adjacent to the test area at a height of 1.20 m ± 0.02 m.

A value representative of air and road surface temperature, wind speed and direction, relative humidity, and barometric pressure shall be recorded during the sound measurement interval.

2.1.3.2.2. Temperature

The measurements shall be made when the ambient air temperature is within the range from 5 °C to 40 °C and the test surface temperature within the range from 5 °C to 60 °C.

Tests carried out on request of the manufacturer at air temperatures below 5° C shall be accepted as well.

The ambient temperature may of necessity be restricted to a narrower temperature range such that all key vehicle functionalities (e.g. start/stop, hybrid propulsion, battery propulsion, fuel-cell stack operation) are enabled according to manufacturer's specifications.

2.1.3.2.3. Wind

The tests shall not be carried out if the wind speed, including gusts, at microphone height exceeds 5 m/s, during the sound measurement interval.

2.1.3.2.4. Background noise

Any sound peak which appears to be unrelated to the characteristics of the general sound level of the vehicle shall be ignored in taking the readings.

The background noise shall be measured for duration of 10 seconds immediately before and after a series of vehicle tests. The measurements shall be made with the same microphones and microphone locations used during the test. The A-weighted maximum sound pressure level shall be reported.

The background noise (including any wind noise) shall be at least 10 dB(A) below the A-weighted sound pressure level produced by the vehicle under test. If the difference between the ambient noise and the measured sound is between 10 and 15 dB(A), in order to calculate the test results the appropriate correction shall be subtracted from the readings on the sound-level meter, as in the following table:

Difference between ambient noise and sound to be measured dB(A)	*10*	*11*	*12*	*13*	*14*	*15*
Correction dB(A)	0.5	0.4	0.3	0.2	0.1	0.0

2.2. Vehicle

2.2.1. Vehicle selection

The vehicle shall be representative of vehicles to be put on the market as specified by the manufacturer in agreement with the Technical Service to fulfil the requirements of this Regulation.

Measurements shall be made without any trailer, except in the case of non-separable vehicles. At the request of the manufacturer, measurements may be made on vehicles with lift axle(s) in a raised position.

2.2.2. Vehicle test mass m_t and vehicle target mass m_{target}

2.2.2.1. Measurements shall be made on vehicles at the test mass m_t specified according to the Table 2 below**.**

When testing indoors, the test mass, m_t shall be utilized by the control system of the dyno roller. Actual mass of the vehicle has no effect on results and it is permitted to load the vehicle as necessary to prevent slip between the tyres and the dyno rolls. To detect excessive slip, it is recommended to control the ratio of engine rotational speed and vehicle speed between the acceleration phase and the constant-speed status. To avoid slip, it is possible to increase the axle load.

2.2.2.2. Target mass, m_{target}, is used to denote the mass that N_2 and N_3 vehicles should be tested at. The actual test mass of the vehicle can be less due to limitations on vehicle and axle loading.

Table 2: Specification of test mass for the various vehicle categories

Vehicle category	*Vehicle test mass*
M_1	The test mass m_t of the vehicle shall be between $0.9\ m_{ro} \leq m_t \leq 1.2\ m_{ro}$
N_1	The test mass m_t of the vehicle shall be between $0.9\ m_{ro} \leq m_t \leq 1.2\ m_{ro}$
N_2, N_3	m_{target} = 50 [kg/kW] x P_n [kW] Extra loading, m_{xload}, to reach the target mass, m_{target}, of the vehicle shall be placed above the rear axle(s). If the test mass m_t is equal to the target mass m_{target}, the test mass m_t shall be $0.95\ m_{target} \leq m_t \leq 1.05\ m_{target}$ The sum of the extra loading and the rear axle load in an unladen condition, $m_{ra\ load\ unladen}$, is limited to 75 per cent of the technically permissible maximum laden mass allowed for the rear axle, $m_{ac\ ra\ max}$. If the test mass m_t is lower than the target mass m_{target}, the test mass m_t shall be achieved with a tolerance of ±5 per cent. If the centre of gravity of the extra loading cannot be aligned with the centre of the rear axle, the test mass, m_t, of the vehicle shall not exceed the sum of the front axle in an unladen condition, $m_{fa\ load\ unladen}$, and the rear axle load in an unladen condition, $m_{ra\ load\ unladen}$ plus the extra loading, $m_{xload,}$ and the mass of the driver m_d. The test mass for vehicles with more than two axles shall be the same as for a two-axle vehicle. If the vehicle mass of a vehicle with more than two axles in an unladen condition, $m_{unladen}$, is greater than the test mass for the two-axle vehicle, then this vehicle shall be tested without extra loading.

Vehicle category	*Vehicle test mass*
	If the vehicle mass of a vehicle with two axles, $m_{unladen}$, is greater than the target mass, then this vehicle shall be tested without extra loading.
M_2 ($M \leq 3{,}500$ kg)	The test mass m_t of the vehicle shall be between $0.9m_{ro} \leq m_t \leq 1.2m_{ro}$
Complete M_2 ($M > 3{,}500$ kg), M_3	If the tests are carried out with a complete vehicle having a bodywork, m_{target} = 50 [kg/kW] x P_n [kW] is calculated either in compliance with conditions above (see N_2, N_3 category) or the test mass m_t of the vehicle shall be $0.9\ m_{ro} \leq m_t \leq 1.1\ m_{ro}$.
Incomplete M_2 ($M > 3{,}500$ kg), M_3	If the tests are carried with an incomplete vehicle not having a bodywork, m_{target} = 50 [kg/kW] x P_n [kW] is calculated either in compliance with conditions above (see N_2, N_3 category), or the test mass m_t of the vehicle shall be $0.9\ m_{ro} \leq m_t \leq 1.1\ m_{ro}$. where $m_{ro} = m_{chassisM2M3} + m_{xloadM2M3}$

2.2.2.3. Calculation procedure to determine extra loading of N_2 and N_3 vehicles only

2.2.2.3.1. Calculation of extra loading

The target mass, m_{target}, (per kW rated power) for two-axle vehicles of category N_2 and N_3 is specified in the Table in paragraph 2.2.1: above.

$$m_{target} = 50\ [kg / kW] \times P_n\ [kW] \quad (1)$$

To reach the required target mass, m_{target}, for a vehicle being tested, the unladen vehicle, including the mass of the driver, m_d, shall be loaded with an extra mass, m_{xload}, which shall be placed above the rear axle as given in Formula (8):

$$m_{target} = m_{unladen} + m_d + m_{xload} \quad (2)$$

The target mass, m_{target}, shall be achieved with a tolerance of ±5 per cent.

The vehicle mass of the test vehicle in the unladen condition, $m_{unladen}$, is calculated by measuring on a scale the unladen front axle load, $m_{fa\ load\ unladen}$, and the unladen rear axle load, $m_{ra\ load\ unladen}$, as given in Formula (3):

$$m_{unladen} = m_{fa\ load\ unladen} + m_{ra\ load\ unladen} \quad (3)$$

By using Formulae (2) and (3), the extra loading, m_{xload}, is calculated as given in Formulae (4) and (5):

$$m_{xload} = m_{target} - (m_d + m_{unladen}) \quad (4)$$

$$m_{xload} = m_{target} - (m_d + m_{fa\ load\ unladen} + m_{ra\ load\ unladen}) \quad (5)$$

The sum of the extra loading, m_{xload}, and the unladen rear axle load, $m_{ra\ load\ unladen}$, is limited to 75 per cent of the technically permissible maximum laden mass for the rear axle, $m_{ac\ ra\ max}$, as given in Formula (6):

$$0.75\ m_{ac\ ra\ max} \geq m_{xload} + m_{ra\ load\ unladen} \quad (6)$$

The m_{xload} is limited according to Formula (7):

$$m_{xload} \leq 0.75\ m_{ac\ ra\ max} - m_{ra\ load\ unladen} \quad (7)$$

If the calculated extra loading, m_{xload}, in Formula (5) fulfils Formula (7), then the extra loading is equal to Formula (5). The test mass, m_t, of the vehicle is as calculated from Formula (8):

$$m_t = m_{xload} + m_d + m_{fa\ load\ unladen} + m_{ra\ load\ unladen} \quad (8)$$

In this case, the test mass of the vehicle is equal to the target mass

$$m_t = m_{target} \quad (9)$$

If the calculated extra loading, m_{xload}, in Formula (5) does not fulfil Formula (7), but rather fulfils Formula (10)

$$m_{xload} > 0.75\ m_{ac\ ra\ max} - m_{ra\ load\ unladen} \quad (10)$$

then, the extra loading, m_{xload}, shall be as given by Formula (11):

$$m_{xload} = 0.75\ m_{ac\ ra\ max} - m_{ra\ load\ unladen} \quad (11)$$

and the test mass, m_t, of the vehicle shall be as given by Formula (12):

$$m_t = 0.75\ m_{ac\ ra\ max} + m_d + m_{fa\ load\ unladen} \quad (12)$$

In this case, the test mass of the vehicle is lower than the target mass

$$m_t < m_{target} \quad (13)$$

The test mass, m_t, shall be achieved with a tolerance of ± 5 per cent.

2.2.2.3.2. Loading considerations if load cannot be aligned with the centre of rear axle

If the centre of gravity of the extra loading, m_{xload}, cannot be aligned with the centre of the rear axle, the test mass of the vehicle, m_t, shall not exceed the sum of the unladen front axle load, $m_{fa\ load\ unladen}$, and the unladen rear axle load, $m_{ra\ load\ unladen}$, plus the extra loading, m_{xload}, and the mass of the driver, m_d.

This means that if the actual front and rear axle loads are measured on a scale when the extra loading, m_{xload}, is placed onto the vehicle and it is aligned with the centre of the rear axle, the test mass of the vehicle minus the mass of the driver is as given by Formula (14):

$$m_t - m_d = m_{fa\ load\ laden} + m_{ra\ load\ laden} \quad (14)$$

Where:

$$m_{fa\ load\ laden} = m_{fa\ load\ unladen} \quad (15)$$

If the centre of gravity of the extra loading cannot be aligned with the centre of the rear axle, Formula (14) is still fulfilled, but

$$m_{fa\ load\ laden} > m_{fa\ load\ unladen} \quad (16)$$

because the extra loading has partly distributed its mass to the front axle. In that case, it is not allowed to add more mass onto the rear axle to compensate for the mass moved to the front axle.

2.2.2.3.3. Test mass for vehicles with more than two axles

If a vehicle with more than two axles is tested, then the test mass of this vehicle shall be the same as the test mass for the two-axle vehicle.

If the unladen vehicle mass of a vehicle with more than two axles is greater than the test mass for the two-axle vehicle, then this vehicle shall be tested without extra loading.

2.2.2.3.4. Calculation of the test mass of a virtual vehicle with two axles:

When a vehicle family is not represented by a two-axle vehicle because it is physically not available, the vehicle family can be represented by a vehicle with more than two axles (vrf). In that case the test mass of a virtual two-axle vehicle ($m_{t\ (2\ axles\ virtual)}$) can be calculated in the following way:

For the calculation of the unladen vehicle mass of the virtual two-axle vehicle ($m_{unladen\ (2\ axles\ virtual)}$), take from the vehicle with more than two axles (vrf) the measured unladen front axle load ($m_{fa\ (vrf)\ load\ unladen}$) and the measured unladen rear axle load of that driven rear axle ($m_{ra\ (vrf)\ load\ unladen}$) which has the highest unladen load.

If the vehicle (vrf) has more than one front axle, take the one with the highest unladen front axle load.

➔ $m_{unladen\ (2\ axles\ virtual)} = m_{fa\ (vrf)\ load\ unladen} + m_{ra\ (vrf)\ load\ unladen}$

➔ $m_{xload\ (2\ axles\ virtual)} = m_{target} - (m_d + m_{unladen\ (2\ axles\ virtual)})$

Due to the requirement that the sum of the extra loading ($m_{xload\ (2\ axles\ virtual)}$) and the unladen rear axle load, $m_{ra\ (vrf)\ load\ unladen}$, is limited to 75 per cent of the technically permissible maximum laden mass allowed for the rear axle, $m_{ac\ ra\ max\ (2\ axles\ virtual)}$, this value, $m_{ac\ ra\ max\ (2\ axles\ virtual)}$, has to be chosen in such a way that it represents the rear axle of the forecasted highest production-volume in the manufacturer's variation with a technically permissible maximum laden mass allowed for the rear axle ($m_{ac\ ra\ max\ (chosen)}$) for the vehicle family as declared by the manufacturer.

➔ $m_{ac\ ra\ max\ (4x2\ virtual)} = m_{ac\ ra\ max\ (chosen)}$

If $m_{xload\ (2\ axles\ virtual)} \leq 0.75\ m_{ac\ ra\ max\ (chosen)} - m_{ra\ (vrf)\ load\ unladen}$

then

$m_{t\ (2\ axles\ virtual)} = m_{xload\ (2\ axles\ virtual)} + m_d + m_{fa\ (vrf)\ load\ unladen} + m_{ra\ (vrf)\ load\ unladen}$

and

$m_{t\ (2\ axles\ virtual)} = m_{target}$

If $m_{xload\ (2\ axles\ virtual)} > 0.75\ m_{ac\ ra\ max\ (chosen)} - m_{ra\ (vrf)\ load\ unladen}$

then

$m_{t\ (2\ axles\ virtual)} = 0.75\ m_{ac\ ra\ max\ (chosen)} + m_d + m_{fa\ (vrf)\ load\ unladen}$

and

$m_{t\ (2\ axles\ virtual)} < m_{target}$

The test mass of the vehicle with more than two axles representing the vehicle family is defined as followed:

$m_{t\,(vrf)} = m_{t\,(2\ axles\ virtual)}$

and the extra loading is calculated as

$m_{xload\,(vrf)} = m_{t\,(2\ axles\ virtual)} - m_d - m_{unladen\,(vrf)}$

2.2.2.4. At the applicant's request the vehicle of a category M_2, M_3, N_2 or N_3 is deemed representative of its completed type if the tests are carried out to an incomplete vehicle not having a bodywork. In the test of an incomplete vehicle all relevant soundproofing materials, panels and noise reduction components and systems shall be fitted on the vehicle as designed by the manufacturer except a part of bodywork which is built in a later stage.

No new test shall be required due to fitting of a supplement fuel tank or re-location of the original fuel tank on condition that other parts or structures of the vehicle apparently affecting sound emissions have not been altered.

.....

2.2.3. Preparation of the vehicle before testing

2.2.3.1. General

The vehicle shall be equipped as specified by the vehicle manufacturer. Before the measurements are started, the vehicle shall be brought to its normal operating conditions, which means that essential components for the operation of the vehicle are at their nominal temperatures as specified by the manufacturer. This applies especially, but is not limited to

- the cooling water (if applicable);
- oil temperature (if applicable).

2.2.3.2. Battery state of charge

If so equipped, propulsion batteries shall have a state-of-charge sufficiently high to enable all key functionalities according to the specifications of the vehicle manufacturer. Propulsion batteries shall be within their component temperature window to enable all key functionalities. Any other type of rechargeable energy storage system shall be ready to operate during the test.

~~2.2.3.3.~~ ~~Active Sound Systems~~

~~Any active sound devices, either for noise control, or sound enhancement, shall operate as foreseen by the vehicle manufacturer and not be interfered with during the measurements.~~

2.2.3.~~4.~~**3.** Tyres

2.2.3.~~4.~~**3.**1. Tyre Selection

The tyres and rims to be used for the test shall be representative for the vehicle and shall be selected by the vehicle manufacturer and recorded in Addendum to the Communication form (Annex 1, Appendix 1). They shall correspond to one of the tyre sizes designated for the vehicle as original equipment. The tyre is or will be commercially available on the market at the same time as the vehicle.[1] The tyres

[1] Given that the tyre contribution for overall sound emission is significant, regard shall be given for existing regulatory provisions concerning tyre/road sound emissions. Traction tyres, snow tyres and

shall be inflated to the pressure recommended by the vehicle manufacturer for the test mass of the vehicle. The tyres shall have at least 1.6 mm tread depth.

When performing indoor testing, tyre/road sound is evaluated independently on the test track with the tyres to be used, according to this paragraph. Propulsion sound is independently evaluated on the dynamometer using tyres and other sound control measures to produce tyre/road sound which does not influence the measurement result.

2.2.3.~~4.~~**3.**2. Tyre conditioning

Tyres with special fitment requirements, such as asymmetric or directional design, shall also be mounted in accordance with these requirements.

Before testing, tyres shall be conditioned (broken-in). Tyre break-in shall be representative to about 100 km of normal on-road operation. Tyres with special fitment requirements shall be broken-in in accordance with these requirements. The tyres fitted to the test vehicle shall rotate in the same direction as when they were broken-in.

Test tyres shall be warmed-up immediately prior to testing for at least 10min in the range of the test speed, with moderate lateral & longitudinal acceleration. The lateral acceleration shall be selected in a way to avoid excessive tire tread wear effects.

If test tyres have operational temperature limits that do not cover the full temperature range of this regulation, the tyres shall be conditioned to their operational temperature regarding the provisions described in paragraph 2.2.3.1."

2.2.3.~~5.~~**4.** If the vehicle is fitted with more than two-wheel drive, it shall be tested in the drive which is intended for normal road use.

2.2.3.~~6.~~**5.** If the vehicle is fitted with fan(s) having an automatic actuating mechanism, this system shall not be interfered with during the measurements.

2.2.3.~~7.~~**6.** If the vehicle is equipped with an exhaust system containing fibrous materials, it might be necessary to carry out a conditioning test prior to testing. The provisions of Annex 4, paragraph 1. in conjunction with the flowchart (Figure 2) of the appendix to Annex 4 shall be followed.

2.2.3.~~8.~~**7.** Suspension Trim Level

If fitted, the trim level of a height adjustable suspension shall be set to its normal level for on-road operation as specified by the vehicle manufacturer.

3. Methods of testing

Outdoor tests shall be performed according to paragraph 3.1.

Indoor tests shall be performed according to paragraph 3.1. using the specifications of ISO 362-3:2016, variant A. For indoor application, the manufacturer shall provide to the technical service, documentation according

special-use tyres as defined in paragraph 2. of UN Regulation No. 117 shall be excluded during type-approval and conformity of production measurements at the request of the manufacturer in accordance with UN Regulation No. 117.

to Annex 8, paragraph 1. Variant A is a combination of indoor testing (power train sound) and outdoor testing (tyre/road sound).

3.1. Measurement of sound of vehicles in motion

3.1.1. General conditions of test

For outdoor testing, two lines, AA' and BB', parallel to line PP' and situated respectively 10 m ± 0.05m forward and 10 m ± 0.05m rearward of line PP' shall be marked out on the test runway.

For indoor testing, the virtual line AA' indicates the beginning of the test track, PP' indicates the virtual position of the two pass-by microphones, and BB' indicates the end of the test track. The simulated vehicle speed at AA', $v_{AA'}$, or vehicle speed at PP', $v_{PP'}$, is defined by the roller speed when the reference point of the vehicle passes the virtual line AA' or PP', respectively. The simulated vehicle speed at BB', $v_{BB'}$, is defined when the rear of the vehicle passes the virtual line BB'.

At least four measurements shall be made on each side of the vehicle and for each gear. Preliminary measurements may be made for adjustment purposes, but shall be disregarded.

For outdoor testing the microphone shall be located on both sides of the pathway at a distance of 7.5 m ± 0.05 m from the reference line CC' of the track and 1.2 m ± 0.02 m above the ground. For indoor testing microphones on one side of the roller bench can be used.

The reference axis for free field conditions (see IEC 61672-1:2002) shall be horizontal and directed perpendicularly towards the path of the vehicle line CC'.

3.1.2. Specific test conditions for vehicles

3.1.2.1. Vehicles of category M_1, N_1 and $M_2 \leq$ 3,500 kg technically permissible maximum laden mass:

The path of the centreline of the vehicle shall follow line CC' as closely as possible throughout the entire test, from the approach to line AA' until the rear of the vehicle passes line BB' +20 m.

If the vehicle is fitted with an auxiliary manual transmission or a multi-gear axle, the position used for normal urban driving shall be used. In all cases, the gear ratios for slow movements, parking or braking shall be excluded.

The test mass of the vehicle shall be according to the table of paragraph 2.2.1.

The test speed v_{test} is 50 km/h ± 1 km/h. The test speed shall be reached, when the reference point is at line PP'.

If the test speed is modified according to paragraph 3.1.2.1.4.1.(d) of Annex 3 to this Regulation, the modified test speed shall be used for both the acceleration and constant speed test.

3.1.2.1.1. Power to mass ratio index (PMR)

PMR is defined as follows:

PMR = (P_n / m_{ro}) * 1000 kg/kW, where P_n is measured in kW and defined according to paragraph 2.8. of the main body and m_{ro} is measured in kg and defined according to paragraph 2.4. of the main body.

The PMR with no dimension is used for the calculation of acceleration.

3.1.2.1.2. Calculation of acceleration

Acceleration calculations are applicable to M_1, N_1 and $M_2 \leq 3{,}500$ kg technically permissible maximum laden mass categories only.

All accelerations are calculated using different speeds of the vehicle on the test track. [2] The formulae given are used for the calculation of $a_{wot\ i}$, $a_{wot\ i+1}$ and $a_{wot\ test}$. The speed either at AA' or PP' is defined as the vehicle speed when the reference point passes AA' ($v_{AA'}$) or PP' ($v_{PP'}$). The speed at BB' is defined when the rear of the vehicle passes BB' ($v_{BB'}$). The method used for determination of the acceleration shall be indicated in the test report.

Due to the definition of the reference point for the vehicle the length of the vehicle (l_{veh}) is considered differently in the formula below. If the reference point is in the front of the vehicle, then $l = l_{veh}$, mid: $l = ½\ l_{veh}$ and rear: $l = 0$.

At the choice of the vehicle manufacturer, front engine vehicles may use $l = 5$ m, and mid-engine vehicles may use $l = 2.5$ m.

3.1.2.1.2.1. Calculation procedure for vehicles with manual transmission, automatic transmission, adaptive transmissions and transmissions with continuous variable transmissions (CVT's) tested with locked gear ratios:

$$a_{wot\ test} = ((v_{BB'}/3.6)^2 - (v_{AA'}/3.6)^2) / (2*(20+l))$$

$a_{wot\ test}$ used in the determination of gear selection shall be the average of the four $a_{wot\ test,\ i}$ during each valid measurement run.

Pre-acceleration may be used. The point of depressing the accelerator before line AA' shall be reported in the Addendum to the Communication form (Annex 1, Appendix 1).

3.1.2.1.2.2. Calculation procedure for vehicles with automatic transmissions, adaptive transmissions and CVT's tested with non-locked gear ratios:

$a_{wot\ test}$ used in the determination of gear selection shall be the average of the four $a_{wot\ test,\ i}$ during each valid measurement run.

If devices or measures described in paragraph 3.1.2.1.4.2. can be used to control transmission operation for the purpose of achieving test requirements, calculate $a_{wot\ test}$ using the equation:

$$a_{wot\ test} = ((v_{BB'}/3.6)^2 - (v_{AA'}/3.6)^2) / (2*(20+l))$$

Pre-acceleration may be used.

If devices or measures described in paragraph 3.1.2.1.4.2. are not used, calculate a_{wot} test using the equation:

$$a_{wot\_testPP\text{-}BB} = ((v_{BB'}/3.6)^2 - (v_{PP'}/3.6)^2) / (2*(10+l))$$

Pre-acceleration shall not be used.

The location of depressing the accelerator shall be where the reference point of the vehicle passes line AA'.

3.1.2.1.2.3. Target acceleration

[2] See Annex 3, Appendix, Figure 1.

The target acceleration a_{urban} defines the typical acceleration in urban traffic and is derived from statistical investigations. This function depends on the PMR of a vehicle.

The target acceleration a_{urban} is defined by:

$a_{urban} = 0.63 * \log_{10} (PMR) - 0.09$

3.1.2.1.2.4. Reference acceleration

The reference acceleration $a_{wot\ ref}$ defines the required acceleration during the acceleration test on the test track. It is a function depending on the power-to-mass ratio of a vehicle. That function is different for specific vehicle categories.

The reference acceleration a_{wot} ref is defined by:

$a_{wot\ ref} = 1.59 * \log_{10} (PMR) - 1.41$ for PMR ≥ 25

$a_{wot\ ref} = a_{\ urban} = 0.63 * \log_{10} (PMR) - 0.09$ for PMR < 25

3.1.2.1.3. Partial power factor k_P

The partial power factor k_P (see paragraph 3.1.3.4.1.2.) is used for the weighted combination of the test results of the acceleration test and the constant speed test for vehicles of category M_1 and N_1 and $M_2 \leq$ 3,500 kg technically permissible maximum laden mass

In cases other than a single gear test, $a_{wot\ ref}$ shall be used instead of $a_{wot\ test}$ (see paragraph 3.1.3.4.1.2.).

3.1.2.1.4. Gear ratio selection

The selection of gear ratios for the test depends on their specific acceleration potential a_{wot} under full throttle condition, according to the reference acceleration $a_{wot\ ref}$ required for the full throttle acceleration test.

If the vehicle allows different transmission setups like automatic or manual gear selection and/or has different software programs or modes (e.g. sporty, winter, adaptive) leading to valid accelerations, the vehicle manufacturer shall prove to the satisfaction of the Technical Service, that the vehicle is tested in the mode which achieves an acceleration being closest to $a_{wot\ ref}$.

The vehicle transmission, gear, or gear ratio may be controlled by electronic or mechanical measures to avoid the activation of a kick-down function."

Appendix 1, Figure 4a to Figure 4f, give gear selection criteria and test run criteria for categories M_1 and M_2 having a technically permissible maximum laden mass not exceeding 3.500 kg and for category N_1, in a flowchart form as an aid to test operation.

3.1.2.1.4.1. Vehicles with manual transmission, automatic transmissions, adaptive transmissions or CVTs tested with locked gear ratios

The following conditions for selection of gear ratios are possible:

(a) If one specific gear ratio gives an acceleration in a tolerance band of ±5 per cent of the reference acceleration $a_{wot\ ref}$, not exceeding 2.0 m/s^2, test with that gear ratio.

(b) If none of the gear ratios give the required acceleration, then choose a gear ratio i, with an acceleration higher and a gear ratio i+1, with an acceleration lower than the reference acceleration. If the acceleration value in gear ratio i does not exceed 2.0 m/s^2, use both gear ratios for

the test. The weighting ratio in relation to the reference acceleration $a_{wot\ ref}$ is calculated by:

$$k = (a_{wot\ ref} - a_{wot\ (i+1)})/(a_{wot\ (i)} - a_{wot\ (i+1)})$$

(c) If the acceleration value of gear ratio i exceeds 2.0 m/s², the first gear ratio shall be used that gives an acceleration below 2.0 m/s² unless gear ratio i+1 (or i+2, or i+3 or …) provides acceleration less than a_{urban}. In this case, two gears, i and i+1 (or i+2, or i+3 or …) shall be used, including the gear i with acceleration exceeding 2.0 m/s². In other cases, no other gear shall be used. The achieved acceleration $a_{wot\ test}$ during the test shall be used for the calculation of the part power factor k_P instead of $a_{wot\ ref}$.

(d) If maximum engine speed n_{MAX} is exceeded in a gear ratio i before the vehicle passes BB' the next higher gear i+1 shall be used. If the next higher gear i+1 results in an acceleration below a_{urban}, the vehicle test speed, v_{test}, in the gear ratio i shall be reduced by 2.5 km/h and the gear ratio selection shall proceed as specified by the options given in this paragraph. In no case shall the vehicle test speed be reduced below 40 km/h.

If the maximum engine speed n_{MAX} is exceeded in gear ratio i before the vehicle passes BB' and the vehicle test speed is equal to 40 km/h, the higher gear ratio i+1 is allowed even if a_{wot} test does not exceed a_{urban}.

The vehicle test speed in the higher gear ratio i+1 shall be 50 km/h.

The maximum engine speed n_{MAX} is given by the formula below:

$n_{MAX} = 1.56 \times PMR^{-0.227} \times S$, but not more than 80% of S.

(e) If no gear ratio is available with an acceleration below 2.0 m/s², the manufacturer shall, if possible take measures to avoid an acceleration value a_{wot} test greater than 2.0 m/s².

Table 1 in Appendix to Annex 3 provides examples for valid measures to control the downshift of gears or to avoid accelerations beyond 2.0 m/s². Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report.

3.1.2.1.4.2. Vehicles with automatic transmission, adaptive transmissions and CVTs tested with non-locked gear ratios:

Manufacturers may take measures to lock discrete gear ratios by electronic or mechanical measures and follow the gear selection previsions of paragraph 3.1.2.1.4.1. above. If so selected, this shall be stated in the test report.

Otherwise, the gear selector position for full automatic operation shall be used.

The acceleration value $a_{wot\ test}$ shall be calculated as defined in paragraph 3.1.2.1.2.2.

The test may then include a gear change to a lower range and a higher acceleration or a higher engine speed. A gear change to a higher range and a lower acceleration is not allowed. A gear shifting to a gear ratio which is not representative for urban traffic shall be avoided.

Therefore, it is permitted to establish and use electronic or mechanical devices, including alternate gear selector positions, to avoid :

(a) accelerations beyond 2.0 m/s². Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report. The achieved acceleration a_{wot_test} shall be greater or equal to a_{urban}.

(b) a test engine speed exceeding n_{MAX} (see Appendix 1, figure 4f).

(i) Therefore, the vehicle test speed v_{test} may be reduced in steps by 2.5 km/h. In no case the vehicle test speed shall be reduced to a vehicle speed below 40 km/h, or

(ii) The engine load is reduced to avoid a downshift to a gear ratio where n_{MAX} is exceeded.

The achieved acceleration $a_{wot\ test}$ shall be greater or equal to a_{urban}.

If possible, the manufacturer shall take measures to avoid an acceleration value $a_{wot\ test}$ greater than 2.0 m/s².

If possible, the manufacturer shall take measures to avoid an engine speed higher than n_{MAX}.

Table 1 in Appendix to Annex 3 provides examples for valid measures to enable a test condition within the above specified boundaries. Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report.

The achieved acceleration $a_{wot\ test}$ is then used for the calculation of the partial power factor k_p (see paragraph 3.1.2.1.3.) instead $a_{wot\ ref}$.

3.1.2.1.4.3. Vehicles with only one gear ratio, like but not limited to Battery Electric Vehicles (BEV) and Fuel Cell Vehicles (FCV)

The gear selector position for forward driving shall be used. The acceleration value $a_{wot\ test}$ shall be calculated as defined in paragraph 3.1.2.1.2.1.

The achieved acceleration $a_{wot\ test}$ shall be greater or equal to a_{urban}.

If possible, the manufacturer shall take measures to avoid an acceleration value $a_{wot\ test}$ greater than 2.0 m/s².

Table 1 in Appendix 1 to Annex 3 provides examples for valid measures to avoid accelerations beyond 2.0 m/s². Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report.

The achieved acceleration a_{wot_test} is then used for the calculation of the partial power factor k_p (see paragraph 3.1.2.1.3.) instead $a_{wot\ ref}$.

3.1.2.1.5. Acceleration test

The manufacturer shall define the position of the reference point in front of line AA' of fully depressing the accelerator. The accelerator shall be fully depressed (as rapidly as is practicable) when the reference point of the vehicle reaches the defined point. The accelerator shall be kept in this depressed condition until the rear of the vehicle reaches line BB'. The accelerator shall then be released as rapidly as possible. The measurement reading shall not end before the rear of the vehicle is 20 m behind the BB' line. The point of fully depressing the accelerator shall be reported in Addendum to the Communication form (Annex 1, Appendix 1). The Technical Service shall have the possibility of pretesting.

If the vehicle length was set according to the provisions of 3.1.2.1.2. the accelerator shall be kept in the depressed condition until the reference point reaches BB' + 5 m for front engine vehicles, and BB' + 2.5 m for mid-engine vehicles.

In the case of articulated vehicles consisting of two non-separable units regarded as a single vehicle, the semi-trailer shall be disregarded in determining when line BB' is crossed.

3.1.2.1.6. Constant speed test

The constant speed test shall be carried out with the same gear(s) specified for the acceleration test and a constant speed of 50 km/h with a tolerance of ±1 km/h between AA' and BB', or if applicable at the speed determined for the acceleration test according **to** 3.1.2.1.4.1. (d) or 3.1.2.1.4.2. with a tolerance of ±1 km/h between AA' and BB'. During the constant speed test the acceleration control shall be positioned to maintain a constant speed between AA' and BB' as specified. If the gear is locked for the acceleration test, the same gear shall be locked for the constant speed test.

The constant speed test is not required for vehicles with a PMR < 25.

3.1.2.2. Vehicles of categories M_2 > 3,500 kg technically permissible maximum laden mass, M_3, N_2, N_3:

The path of the centreline of the vehicle shall follow line CC' as closely as possible throughout the entire test, from the approach to line AA' until the rear of the vehicle passes line BB'. The test shall be conducted without a trailer or semi-trailer. If a trailer is not readily separable from the towing vehicle the trailer shall be ignored when considering the crossing of line BB'. If the vehicle incorporates equipment such as a concrete mixer, a compressor, etc., this equipment shall not be in operation during the test. The test mass of the vehicle shall be according to the table of paragraph 2.2.1. of Annex 3 to this Regulation.

The value of $n_{BB'}$ and $v_{BB'}$ used in the determination of gear and vehicle speed selection shall be the average of the four $n_{BB',j}$ and $v_{BB',j}$ values during each valid measurement run.

The value of $n_{BB'}$ shall be reported to a precision of 10 revolutions per minute. The reported $n_{BB'}$ shall be used in all subsequent calculation.

The value of $v_{BB'}$ shall be reported to the first digit after the decimal (xx,x). The reported $v_{BB''}$ shall be used in all subsequent calculation.

Target conditions of category M_2 > 3,500 kg technically permissible maximum laden mass, N_2:

When the reference point passes line BB', the engine speed $n_{BB'}$ shall be between 70 and 74 per cent of speed S, at which the engine develops its rated maximum net power, and the vehicle speed shall be 35 km/h ± 5 km/h. Between line AA' and line BB' a stable acceleration condition according to definition 2.26.1. shall be ensured.

Target conditions of category M_3, N_3:

When the reference point passes line BB', the engine speed $n_{BB'}$ shall be between 85 and 89 per cent of speed S, at which the engine develops its rated maximum

net power, and the vehicle speed shall be 35 km/h ± 5 km/h. Between line AA' and line BB' a stable acceleration condition according to definition 2.26.1. shall be ensured.

3.1.2.2.1. Gear ratio selection

It is the responsibility of the manufacturer to determine the correct manner of testing to achieve the required conditions.

The vehicle transmission, gear, or gear ratio, shall be chosen to be able to fulfil the target conditions according to paragraphs 3.1.2.2.1.1. or 3.1.2.2.1.2. of Annex 3 to this Regulation. The vehicle transmission, gear, or gear ratio may be controlled by electronic or mechanical measures including exclusion of kick-down function.

Appendix 3, Figure 5a to Figure 5d, give gear selection criteria and test run criteria for categories M_2 having a technically permissible maximum laden mass exceeding 3,500 kg, and for category N_2, M_3 and N_3, in a flowchart as an aid to test operation.

3.1.2.2.1.1. Manual transmission, automatic transmissions, adaptive transmissions or transmissions with continuously variable gear ratios (CVTs) tested with locked gear ratios

Stable acceleration condition according to definition 2.26.1. shall be ensured. The gear choice is determined by the target conditions.

The following conditions for fulfilling the target conditions in paragraph 3.1.2.2. of Annex 3 to this Regulation are possible:

(a) If one gear choice fulfils both target conditions for the rotational engine speed $n_{target\ BB'}$ and for the vehicle speed $v_{target\ BB'}$, test with that gear.

(b) If more than one gear choice fulfils both target conditions for the rotational engine speed $n_{target\ BB'}$ and for the vehicle speed $v_{target\ BB'}$, test in gear i that gives velocity $v_{BB',\ gear\ i}$ closest to 35 km/h.

(c) If two gear choices fulfil both target conditions for the rotational engine speed $n_{target\ BB'}$ and for the vehicle speed $v_{target\ BB'}$, and fulfil the following condition.

$$(v_{target\ BB'} - v_{BB',\ gear\ i}) = (v_{BB',\ gear\ i+1} - v_{target\ BB'})$$

then both gears are taken for further calculation of L_{urban}.

(d) If one gear choice fulfils the target condition for the rotational engine speed $n_{target\ BB'}$ but not the target condition for the vehicle speed $v_{target\ BB'}$, use two gears, $gear_x$ and $gear_y$. The target conditions for the vehicle speed for these two gears are as follows:

$gear_x$

$25\ km/h \leq v_{BB'x} \leq 30\ km/h$

and

$gear_y$

$40\ km/h \leq v_{BB'y} \leq 45\ km/h$

Both gears, $gear_x$ and $gear_y$ shall fulfil the target rotational engine speed $n_{target\ BB'}$. Both gears shall be used for further calculation of L_{urban}.

If only one of the gears fulfils the target rotational engine speed, $n_{target\ BB'}$, test with that gear. This gear shall be used for further calculation of L_{urban}.

(e) If none of the two gears fulfils the target rotational engine speed $n_{target\ BB'}$ under condition d) then condition f) shall be chosen.

(f) If no gear choice fulfils the target rotational engine speed choose the gear that fulfils the target vehicle velocity $v_{target\ BB'}$ and is closest to the target rotational engine speed $n_{target\ BB'}$, but not higher than $n_{target\ BB'}$.

$v_{BB',\ gear\ i} = v_{target\ BB'}$

$n_{BB',\ gear\ i} \leq n_{target\ BB'}$

A stable acceleration condition according to definition 2.26.1. shall be ensured. If such a stable acceleration cannot be ensured in a gear, this gear shall be disregarded. In all conditions, the rated engine speed shall not be exceeded while the reference point of the vehicle is in the measurement zone. If the rated engine speed is exceeded within the measurement zone, this gear shall be disregarded.

3.1.2.2.1.2. Automatic transmission, adaptive transmissions, and transmissions with variable gear ratio tested with non-locked gear ratios

The gear selector position for full automatic operation shall be used.

The test may then include a gear change to a lower range and a higher acceleration. A gear change to a higher range and a lower acceleration is not allowed. In any case a gear change to a gear ratio that is typically not used at the specified condition as defined by the manufacturer in urban traffic shall be avoided.

Therefore, it is permitted to establish and use electronic or mechanical devices, including alternative gear selector positions, to prevent a downshift to a gear ratio that is typically not used at the specified test condition as defined by the manufacturer in urban traffic.

Table 1 in Appendix 1 to Annex 3 provides examples for valid measures to control the downshift of gears. Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report.

The following conditions for fulfilling the target conditions in paragraph 3.1.2.2. of Annex 3 to this Regulation are possible:

(a) If the choice of the gear selector position fulfils both target conditions for the rotational engine speed $n_{target\ BB'}$ and for the vehicle speed $v_{target\ BB'}$, test with the gear selector in that position.

(b) If the choice of the gear selector position fulfils the target condition for the rotational engine speed $n_{target\ BB'}$ but not the target condition for the vehicle speed $v_{target\ BB'}$, change the target condition for the vehicle speed to two vehicle target speeds as follows:

Define $v_{BB'1}$ as

25 km/h $\leq v_{BB'1} \leq$ 35 km/h

and

Define $v_{BB'2}$ as

35 km/h ≤ $v_{BB'2}$ ≤ 45 km/h.

Conduct two tests, one with $v_{BB'1}$ and one with $v_{BB'2}$.

Both test conditions are used for further calculation of L_{urban}.

(c) If under condition b) the target rotational engine speed $n_{target\ BB'}$ cannot be fulfilled, condition d) shall be chosen.

(d) If the choice of the gear selector position cannot fulfil the target condition for the rotational engine speed $n_{target\ BB'}$ but the target condition for the vehicle speed $v_{target\ BB'}$, change the target condition for the vehicle speed to two vehicle target speeds as follows:

Define $v_{BB'1}$ as

25 km/h ≤ $v_{BB'1}$ ≤ 30 km/h

and

Define $v_{BB'2}$ as

40 km/h ≤ $v_{BB'2}$ ≤ 45 km/h.

Conduct two tests, one with $v_{BB'1}$ and one with $v_{BB'2}$.

Use the test where $n_{BB'}$ is closest to the target rotational engine speed $n_{target\ BB'}$ but not higher than $n_{target\ BB'}$.

$n_{BB',i} \leq n_{target\ BB'}$ for i = 1, 2

If the vehicle cannot fulfil the condition:

$n_{BB',i} \leq n_{target\ BB'}$ for i = 1, 2

condition (e) shall be used.

(e) If the choice of the gear selector position cannot fulfil the target conditions for the rotational engine speed $n_{target\ BB'}$ and the target condition for the vehicle speed $v_{target\ BB'}$, change the target condition for the vehicle speed to the following:

$v_{BB'} = v_{target\ BB'} + 5$ km/h

Conduct the test with that vehicle speed $v_{BB'}$ where $n_{BB'}$ is closest to the target rotational engine speed $n_{target\ BB'}$. A gear change to a higher range and a lower acceleration is allowed after the vehicle passes line PP'.

(f) If the vehicle includes a transmission design that provides only a single gear selection (D) that limits engine speed during the test, the vehicle shall be tested using only the target vehicle speed $v_{target\ BB'}$.

3.1.2.2.1.3. Powertrain with no combustion engine rotational engine speed available

Vehicles with a powertrain where no combustion engine rotational engine speed is available shall fulfil only the target condition for the vehicle speed $v_{target\ BB'}$

The following conditions for fulfilling the target condition $v_{target\ BB'}$ in paragraph 3.1.2.2. of Annex 3 to this Regulation are possible.

(a) If no rotational engine speed is available, it is necessary to fulfil only the target vehicle speed $v_{target\ BB'}$.

(b) If no rotational engine speed is available and the target vehicle speed $v_{target\ BB'}$ cannot be fulfilled, two test conditions shall be conducted as follows:

$v_{BB'1}$ for the first test condition is defined as

$25\ km/h \leq v_{BB'1} \leq 35\ km/h$

and

$v_{BB'2}$ for the second test condition is defined as

$35\ km/h \leq v_{BB'2} \leq 45\ km/h$

Both test conditions are used for further calculation of L_{urban}.

(c) If no rotational engine speed is available and the target vehicle speed $v_{target\ BB'}$ and $v_{BB'1}$ defined as

$25\ km/h \leq v_{BB'1} \leq 35\ km/h$

cannot be fulfilled, it is necessary to conduct, only one test with $v_{BB'2}$ where $v_{BB'2}$ is defined as

$35\ km/h \leq v_{BB'2} \leq 45\ km/h$

The test condition for $v_{BB'2}$ is taken for further calculation of L_{urban}.

3.1.2.2.2. Acceleration test

When the reference point of the vehicle reaches the line AA' the accelerator control shall be fully depressed (without operating the automatic downshift to a lower range than normally used in urban driving) and held fully engaged until the reference point reaches BB' + 5 m. The acceleration control unit can then be released on request of the manufacturer.

In the case of articulated vehicles consisting of two non-separable units regarded as a single vehicle, the semi-trailer shall be disregarded in determining when line BB' is crossed.

3.1.3. Interpretation of results

3.1.3.1. Measurement readings for outdoor tests

For vehicles of categories M_1 and N_1, and for vehicles of category M_2 having a maximum authorized mass not exceeding 3,500 kg, the maximum A-weighted sound pressure level indicated during each passage of the vehicle according to paragraphs 3.1.2.1.5. and 3.1.2.1.6. shall be rounded to the first significant digit after the decimal place (e.g. XX.X).

For vehicles of category M_2 having a maximum authorized mass exceeding 3,500 kg and for vehicles of categories M_3, N_2, and N_3 the maximum A-weighted sound pressure level indicated during each passage of the reference point of the vehicle between line AA' and line BB' + 5 m shall be rounded, to the first significant digit after the decimal place (e.g. XX.X).

3.1.3.2. Measurement readings for indoor tests

The pass-by sound of a vehicle is determined by energetical addition of the power train sound measured in an indoor facility according to paragraph Annex

8, paragraph 2. of this regulation and the separately determined tyre/road sound measured on an outdoor test track according to Annex 8, paragraph 2.3. of this Regulation.

3.1.3.3. Validation of individual test runs

If a sound peak obviously out of character with the general sound pressure level is observed, the measurement shall be discarded. At least four measurements for each test condition shall be made on each side of the vehicle and for each gear ratio. For outdoor tests left and right shall be measured simultaneously, for indoor tests simultaneous measurement is recommended if it is possible. The first four valid consecutive measurement results, within 2 dB(A), allowing for the deletion of non-valid results (see paragraph 2.1.), shall be used for the further calculations below.

3.1.3.4. Calculation of results

3.1.3.4.1. Calculation for vehicles of category M_1 and N_1, and for vehicles of category M_2 having a maximum authorized mass not exceeding 3,500 kg

3.1.3.4.1.1. Each valid test run of the acceleration and – if applicable – of the constant speed tests per vehicle side and per gear ratio shall be subjected to a temperature and if applicable a test track correction according to Appendix 2 to Annex 3.

3.1.3.4.1.2. Per gear, test condition (acceleration and constant speed) and vehicle side the four valid and corrected test results shall be averaged and mathematically rounded to the first significant digit after the decimal place.

All further calculations to derive L_{urban} shall be done separately for the left and right vehicle side. The final value L_{urban} mathematically rounded to the nearest integer shall be the higher value of the two sides.

The speed measurements at AA', BB', and PP' used for reporting and further calculations shall be rounded to the first significant digit after the decimal place.

The calculated acceleration $a_{acc\ test}$ used for reporting and further calculations shall be rounded to the second significant digit after the decimal place.

The calculated interim values for the acceleration test and the constant speed test are given by:

$$L_{wot\ rep} = L_{wot\ (i+n)} + k * (L_{wot(i)} - L_{wot\ (i+n)})$$

$$L_{crs\ rep} = L_{crs(i+n)} + k * (L_{crs\ (i)} - L_{crs\ (i+n)})$$

where $k = (a_{wot\ ref} - a_{wot\ (i+n)})/(a_{wot\ (i)} - a_{wot\ (i+n)})$
with n as determined by paragraph 3.1.2.1.4.1.

In the case of a single gear ratio test inclusive the non-locked condition according to paragraphs 3.1.2.1.4.2. and 3.1.2.1.4.3. the interim values $L_{acc\ rep}$ and $L_{crs\ rep}$ are the averaged test results of each test condition (acceleration and constant speed).

The final result is calculated by combining $L_{acc\ rep}$ and $L_{crs\ rep}$. The equation is:

$$L_{urban} = L_{wot\ rep} - k_P * (L_{wot\ rep} - L_{crs\ rep})$$

The partial power factor k_P is given for urban driving. In cases other than a single gear test, k_P is calculated by:

$k_P = 1 – (a_{urban} / a_{wot\ ref})$

If only one gear was specified for the test, k_P is given by:

$k_P = 1 – (a_{urban} / a_{wot\ test})$

In cases where $a_{wot\ test}$ is less than a_{urban}:

$k_P = 0$

In cases where the PMR of the vehicle is lower than 25, the final result L_{urban} is the result of the acceleration test:

$L_{urban} = L_{wot\ rep}$

In cases where $L_{wot,rep}$ is less than $L_{crs,rep}$:

$k_P=1$

In cases where $L_{wot,rep}$ is less than $L_{crs,rep}$ the final result L_{urban} is the result of the cruise test:

$L_{urban}= L_{crs,rep}$

3.1.3.4.2. Calculation for vehicles of category M_2 having a maximum authorized mass exceeding 3,500 kg and for vehicles of categories M_3, N_2, and N_3

For each gear and vehicle side, the valid test runs shall be averaged separately, rounded to the first decimal place, and be reported as interim results.

All further calculations to derive L_{urban} shall be done separately for the left and right vehicle side. The final value L_{urban} to be reported as the test result mathematically rounded to the nearest integer shall be the higher value of the two sides.

The speed measurements at line BB' shall be noted and used in calculations to the first significant digit after the decimal place.

The engine speed measurements (if applicable) at line BB' shall be noted and used in calculations to the full integer.

In the case of a single gear test, inclusive the non-locked condition, the final result L_{urban} is equal to the intermediate result.

In the case of a two-gear test, the final result is the arithmetic mean of the intermediate results. The final result L_{urban} is the higher value of the two calculated averages.

3.2. Measurement of sound emitted by stationary vehicles

3.2.1. Sound level in the vicinity of vehicles

The measurement results shall be entered into the Addendum to the Communication form (Annex 1, Appendix 1).

3.2.2. Acoustic measurements

A precision sound level meter as defined in paragraph 1.1 of this annex shall be used for the measurements.

3.2.3. Test site - local conditions (see Appendix 1 of Annex 3, Figure 2)

3.2.3.1. In the vicinity of the microphone, there shall be no obstacle that could influence the acoustical field and no person shall remain between the microphone and the sound source. The meter observer shall be positioned so as not to influence the meter reading.

3.2.4. Disturbance noise and wind interference

Readings on the measuring instruments produced by ambient noise and wind shall be at least 10 dB(A) below the sound level to be measured. A suitable windscreen may be fitted to the microphone provided that account is taken of its effect on the sensitivity of the microphone (see paragraph 1.1. of this annex).

3.2.5. Measuring method

3.2.5.1. Nature and number of measurements

The maximum sound level expressed in A-weighted decibels (dB(A)) shall be measured during the operating period referred to in paragraph 3.2.5.3.2.1.

At least three measurements shall be taken at each measuring point.

3.2.5.2. Positioning and preparation of the vehicle

The vehicle shall be located in the centre part of the test area with the gear selector in neutral position and the clutch engaged. If the design of the vehicle does not allow this, the vehicle shall be tested in conformity with the manufacturer's prescriptions for stationary engine testing. Before each series of measurements, the engine shall be brought to its normal operating condition, as specified by the manufacturer.

If the vehicle is fitted with fan(s) having an automatic actuating mechanism, this system shall not be interfered with during the sound level measurements.

The engine hood or compartment cover, if so fitted, shall be closed.

3.2.5.3. Measuring of noise in proximity to the exhaust (see Appendix 1 of Annex 3, Figure 3a)

3.2.5.3.1. Positions of the microphone

3.2.5.3.1.1. The microphone shall be located at a distance of 0.5 m ± 0.01 m from the reference point of the exhaust pipe defined in Figure 2 and at an angle of 45º (±5º) to the vertical plane containing the flow axis of the pipe termination. The microphone shall be at the height of the reference point, but not less than 0.2 m from the ground surface. The reference axis of the microphone shall lie in a plane parallel to the ground surface and shall be directed towards the reference point on the exhaust outlet.

If two microphone positions are possible, the location farthest laterally from the vehicle longitudinal centreline shall be used.

If the flow axis of the exhaust outlet pipe is at 90º to the vehicle longitudinal centreline, the microphone shall be located at the point, which is furthest from the engine.

3.2.5.3.1.2. For vehicles having an exhaust provided with outlets spaced more than 0.3 m apart or more than one silencer, one set of measurement is made for each outlet.

3.2.5.3.1.3.

If a vehicle has two or more exhaust outlets spaced less than or equal to 0.3 m apart and connected to a single silencer, only one set of measurement shall be made. The microphone shall be located relative to the outlet furthest away from the vehicle longitudinal centreline, or when such outlet does not exist, to the outlet, which is highest above the ground.

3.2.5.3.1.4. For vehicles with a vertical exhaust (e.g. commercial vehicles) the microphone shall be placed at the height of the exhaust outlet. Its axis shall be vertical and oriented upwards. It shall be placed at a distance of 0.5 m ± 0.01 m from the exhaust pipe reference point, but never less than 0.2 m from the side of the vehicle nearest to the exhaust.

3.2.5.3.1.5.

For vehicles, where the reference point of the exhaust pipe is not accessible, or located under the vehicle body, as shown in Figure 3b and 3c in Annex 3, because of the presence of obstacles which form part of the vehicle (e.g. spare wheel, fuel tank, battery compartment), the microphone shall be located at least 0.2 m from the nearest obstacle, including the vehicle body, and shall not be located under the vehicle. Its axis of maximum sensitivity shall face the exhaust outlet from the position least concealed by the above-mentioned obstacles. In case the distance from the exhaust outlet to the other side of the vehicle is larger than 0.2 m (Figures 3c and 3d in Annex 3), the following distances of d_1 and d_2 shall be chosen:

Case 1:

d_1 shall be equal to 0.5 m and the distance from the side (outer border of the vehicle) shall be at least 0.2 m.

d_2 shall be equal to 0.5 m and the distance from the side (outer border of the vehicle) shall be at least 0.2 m.

Case 2 (if Case 1 is not fulfilled):

d_1 shall be at least 0.5 m and the distance from the side (outer border of the vehicle) shall be equal to 0.2 m.

d_2 shall be at least 0.5 m and the distance from the side (outer border of the vehicle) shall be equal to 0.2 m.

When several positions are possible, as shown in Figure 3c, the microphone position giving the lowest value of d_1 or d_2 shall be used.

3.2.5.3.1.6. Examples of the position of the microphone, depending on the location of the exhaust pipe, are given in Figures 3a-3d in Appendix 1 to Annex 3.

3.2.5.3.2. Operating conditions of the engine

3.2.5.3.2.1. Target engine speed

The target engine speed is defined as:

(a) 75 per cent of the rated engine speed S for vehicles with a rated engine speed ≤ 5,000 min^{-1};

(b) 3.750 min^{-1} for vehicles with a rated engine speed above 5.000 min^{-1} and below 7,500 min^{-1};

(c) 50 per cent of the rated engine speed S for vehicles with a rated engine speed ≥ 7,500 min^{-1}.

If the vehicle cannot reach the engine speed as stated above, the target engine speed shall be 5 per cent below the maximum possible engine speed for that stationary test.

For vehicles for which the engine speed is a fixed value, (for example, but not limited to, series hybrids) either above or below the target engine speed and cannot be adjusted by the accelerator, the test shall be carried out at the fixed engine speed.

In case the engine speed deviates from the applicable target engine speed, the engine speed used for the test and the reason for the deviation shall be documented in the test report and at paragraph 2.2. of Appendix 1 to Annex 1.

3.2.5.3.2.2. Test procedure

The engine speed shall be gradually increased from idle to the target engine speed, not exceeding the tolerance band of ±3 per cent of the target engine speed, and held constant. Then the throttle control shall be rapidly released and the engine speed shall be returned to idle. The sound pressure level shall be measured during a period of operation consisting of a maintaining constant engine speed of 1 second and throughout the entire deceleration period. The maximum sound level meter reading during this period of operation, mathematically rounded to the first decimal place, is taken as the test value.

3.2.5.3.2.3. Test validation

The measurement shall be regarded as valid if the test engine speed does not deviate from the target engine speed by more than ±3 per cent for at least 1 second.

3.2.6. Results for sound emitted by stationary vehicles

3.2.6.1. Single test position (outlet)

For the vehicles equipped with one exhaust outlet or two or more exhaust outlets as specified in paragraph 3.2.5.3.1.3., the stationary sound of the vehicle shall be determined for one test position.

At least three measurements for a test position (outlet) shall be made.

The maximum A-weighted sound pressure level indicated during each of the three measurements shall be recorded to the first decimal place.

The first three valid consecutive measurement results, within 2 dB(A), allowing for the deletion of non-valid results (see paragraph 2.1. except the specifications of the test site), shall be used for the determination of the final result for the given measurement position.

The result for a test position (outlet) is the arithmetic average of the three valid measurements, mathematically rounded to the nearest integer value (e.g. 72.5 shall be noted as to 73 while 72.4 shall be noted as to 72).

3.2.6.2. Multiple test positions (outlets)

For vehicles equipped with multiple exhaust outlets as specified in paragraph 3.2.5.3.1.2., the stationary sound of the vehicle shall be determined for each test position, following the measurement and calculation principles above.

The reported sound pressure level shall be for the test position having the highest average sound pressure level.

3.2.6.3. Modes

If the vehicle has different modes according to the definition 2.25.1. the stationary sound of the vehicle shall be determined for each mode, following the measurement and calculation principles above.

The sound pressure level for each mode shall be reported according to 3.2.6.1. in case the vehicle has only a single test position (outlet) and according to 3.2.6.2. in case of multiple test positions (outlets).

3.2.7. Stationary sound pressure level representative for the vehicle type[3]

If the vehicle has only one mode and a single test position (outlet), the representative sound pressure level for the vehicle type is determined by the measurement result according to paragraph 3.2.6.1.

If the vehicle has only one mode but multiple test positions (outlets), the representative sound pressure level for the vehicle type is determined by the measurement result according to paragraph 3.2.6.2.

If the vehicle has multiple modes and one or more test positions (outlets), the representative sound pressure level for the vehicle type is determined by the measurement result according to paragraph 3.2.6.3. In the test report and paragraph 2.2. of Appendix 1 to Annex 1 the representative test result determined by the principles above and the name of the mode shall be documented for every mode. The representative sound pressure level for the vehicle type and its registration papers is the highest reported sound pressure level of all modes as documented in paragraph 2.2. of Appendix 1 to Annex 1.

4. Sound from the hybrid vehicle of categories M_1 in motion, where an internal combustion engine cannot operate when the vehicle is stationary (data reported to facilitate testing of the vehicle in use).

4.1. In order to facilitate in-use compliance test of hybrid vehicles – where an internal combustion engine cannot operate when the vehicle is stationary –, the following information relating to the sound-pressure level measurements carried out in accordance with paragraph 3.1. of Annex 3 for the motor vehicles in motion is referred to as in-use compliance reference data:

(a) Gear (i) or, for vehicles tested with non-locked gear ratios, the position of the gear selector chosen for the test;

(b) Position of the operating switch during measurement of the sound pressure level $L_{wot\ (i)}$ (if switch is fitted);

(c) The pre-acceleration length lPA in m;

(d) The average vehicle speed in km/h at the beginning of the full throttle acceleration for tests in gear (i); and

(e) The sound pressure level $L_{wot\ (i)}$ in dB(A) of the wide-open-throttle tests in gear (i), defined as the maximum of the two values resulting from

[3] See Figure 6 of Annex 3, Appendix

averaging the individual measurement results at each microphone position separately.

4.2. The in-use compliance reference data shall be entered in the type approval certificate as specified in paragraph 2.3. of the Addendum to the Communication form (Annex 1, Appendix 1).

Annex 3 – Appendix 1

Figure 1
Measuring positions for vehicles in motion

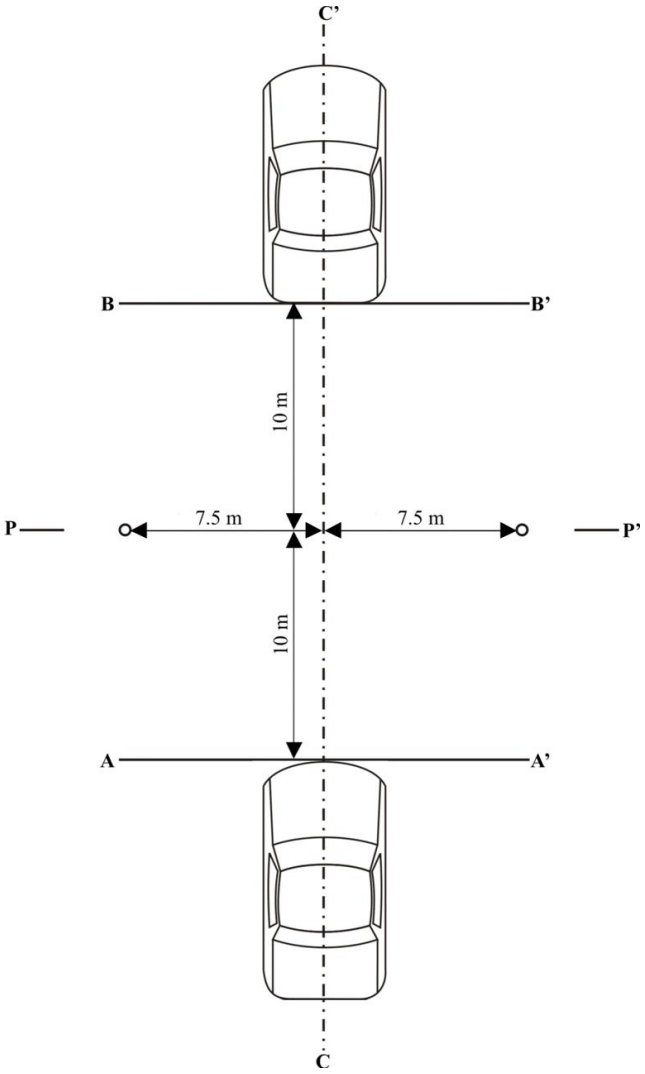
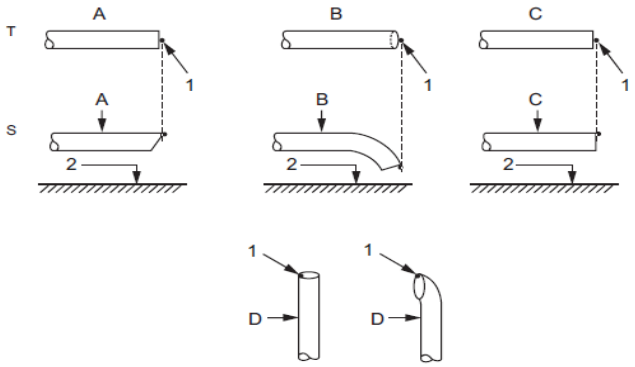


Figure 2

Reference point for measurement of sound emitted by stationary vehicles



Key

T top view
S side view

1 reference point
2 road surface

A mitered pipe
B bent down pipe
C straight pipe
D vertical pipe

Figure 3a

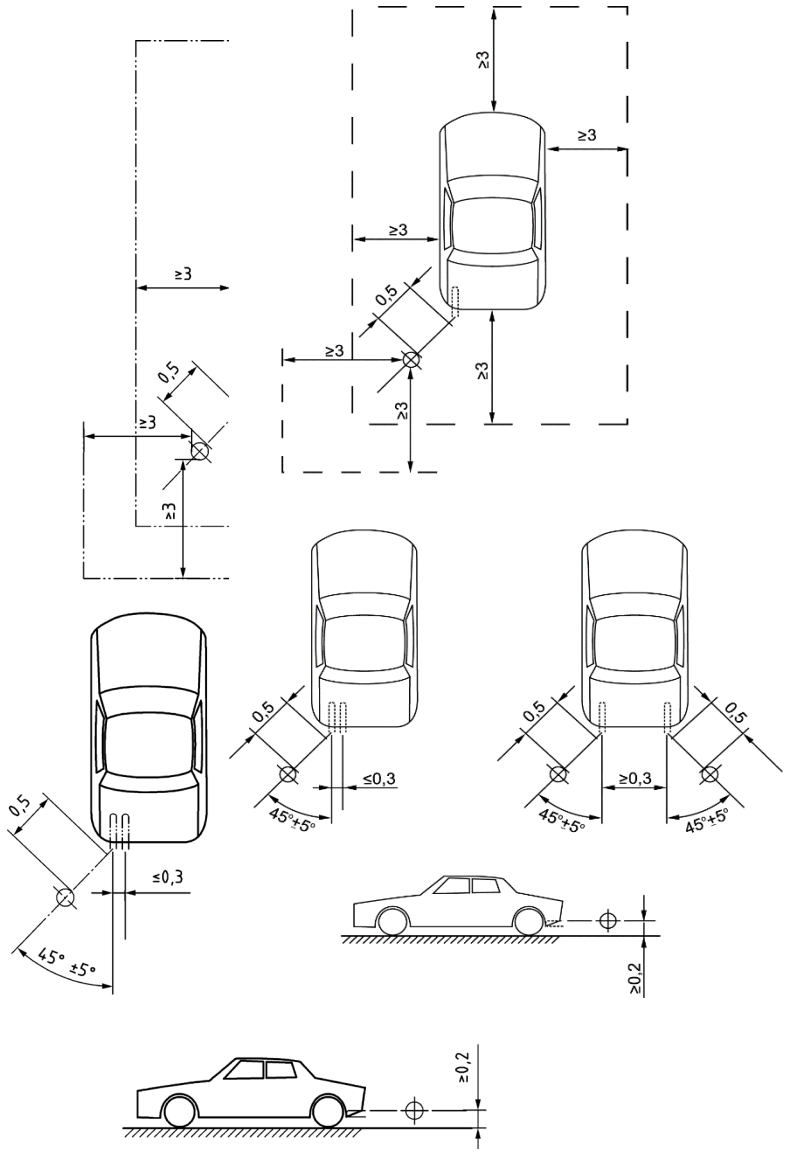


Figure 3b

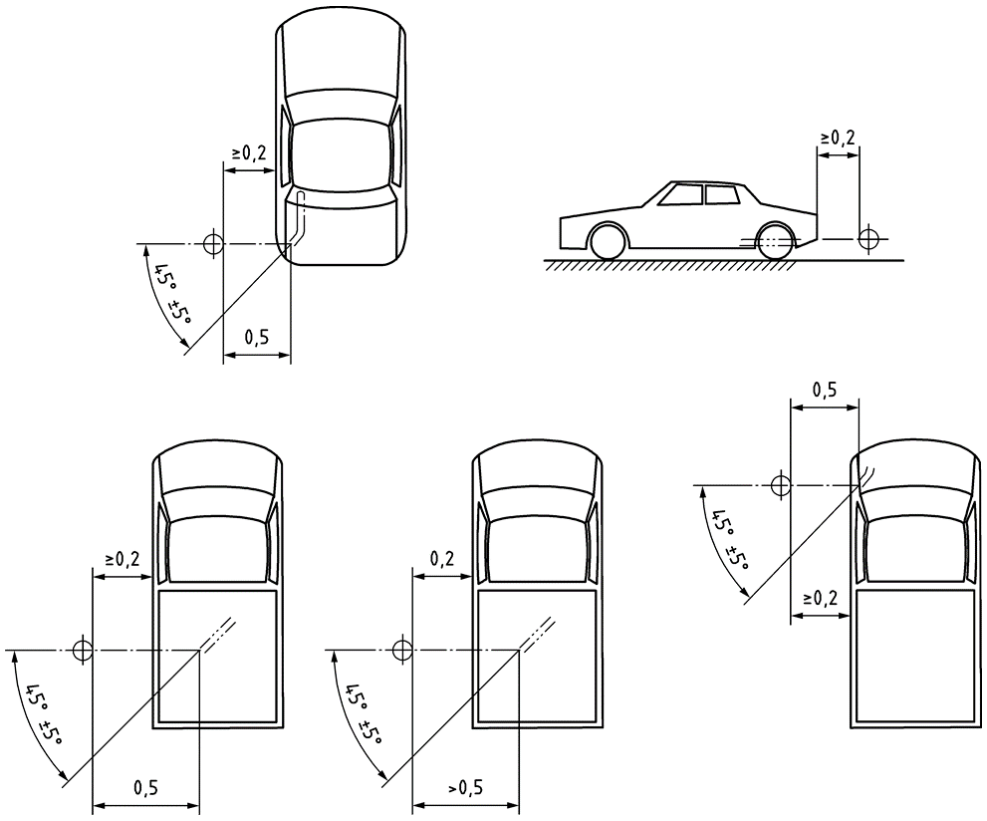


Figure 3c

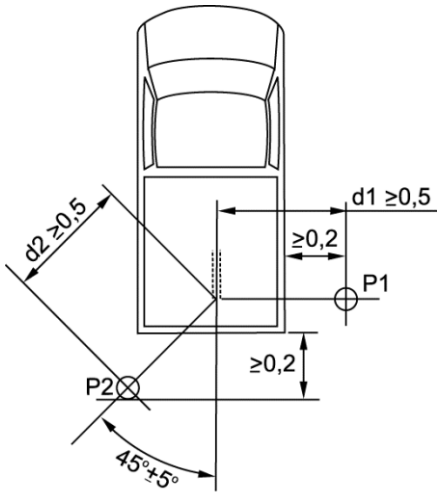


Figure 3d

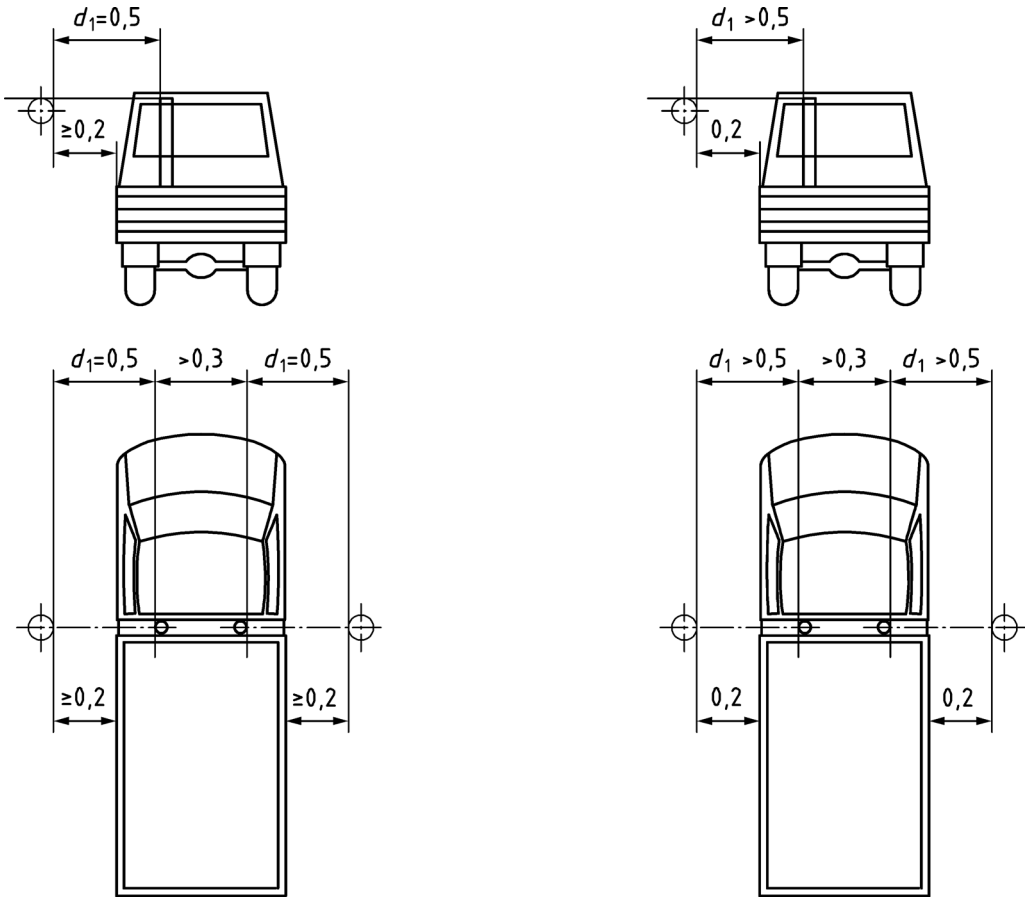


Figure 4a

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – L_{urban} computation

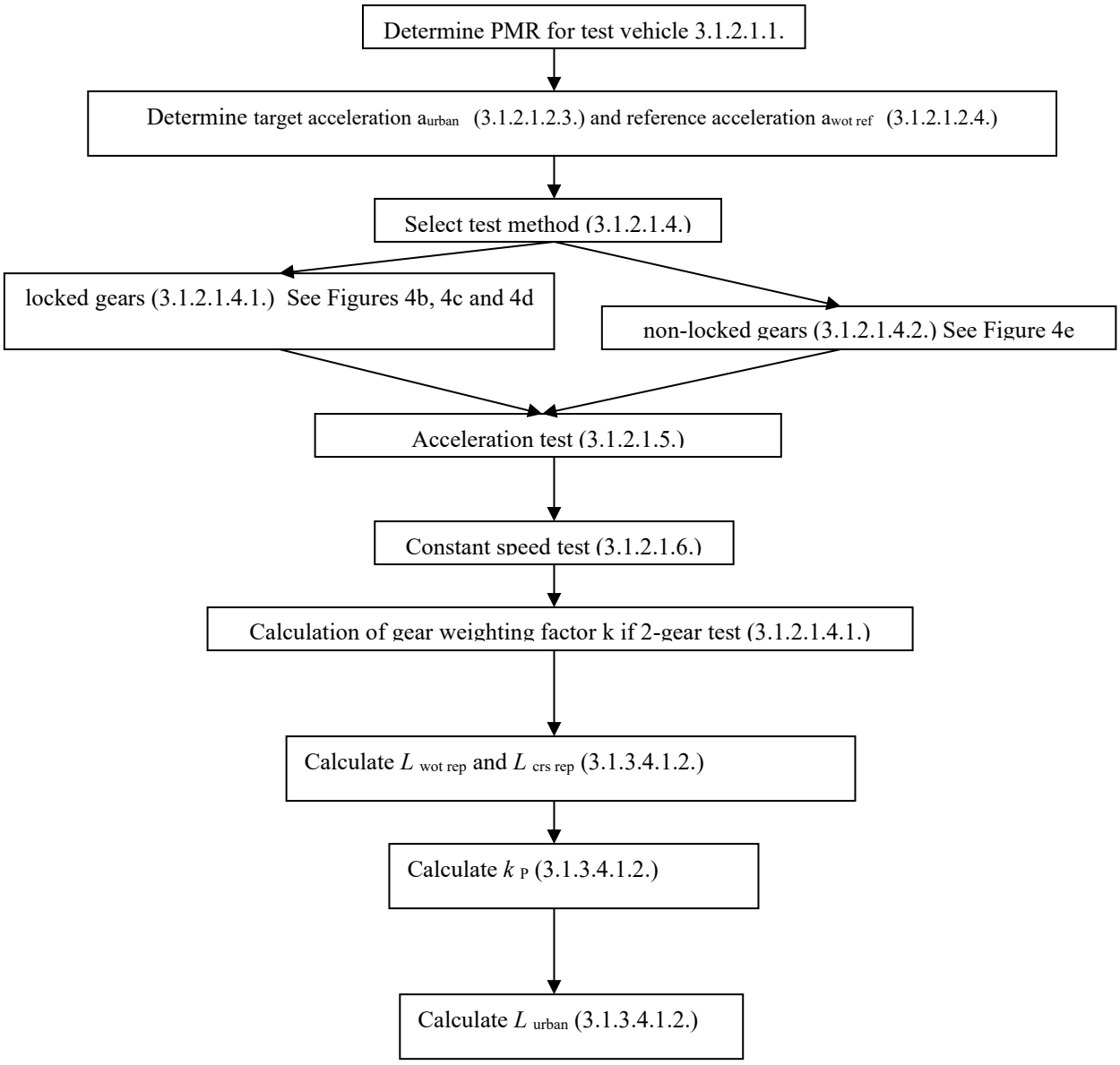


Figure 4b

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation - Gear selection using locked gear PART 1

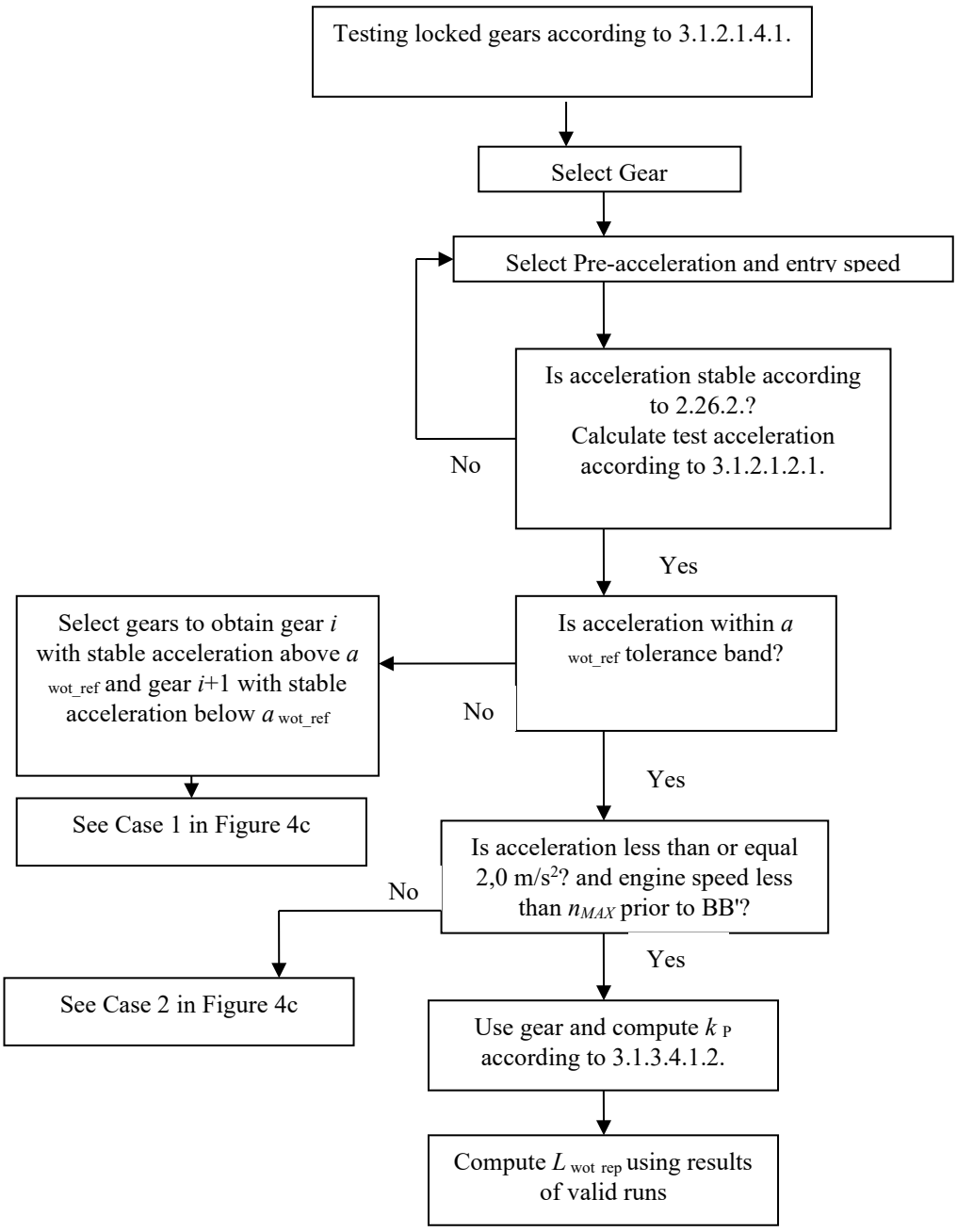


Figure 4c

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear selection using locked gear PART 2

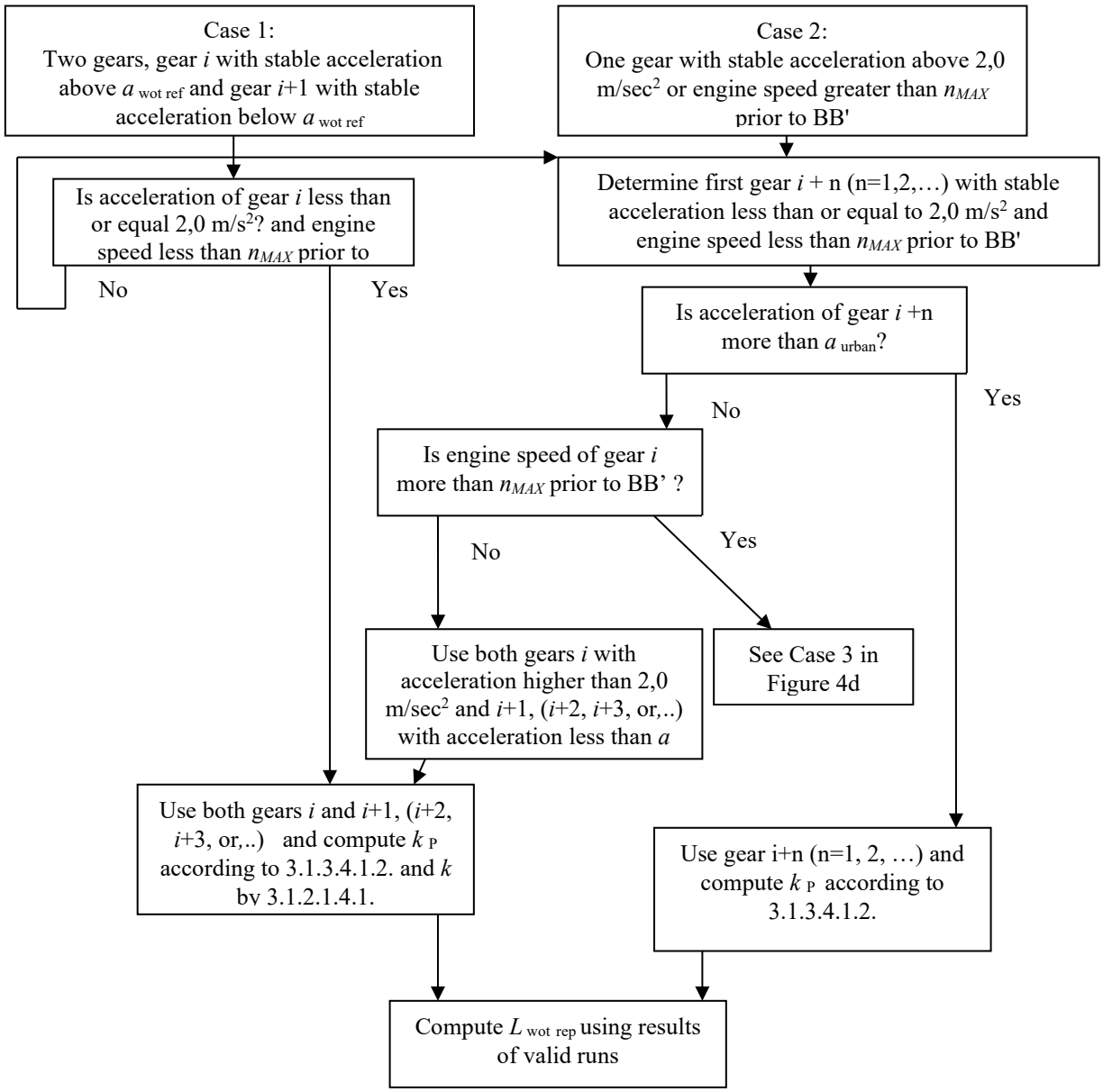


Figure 4d

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear selection using locked gear PART 3

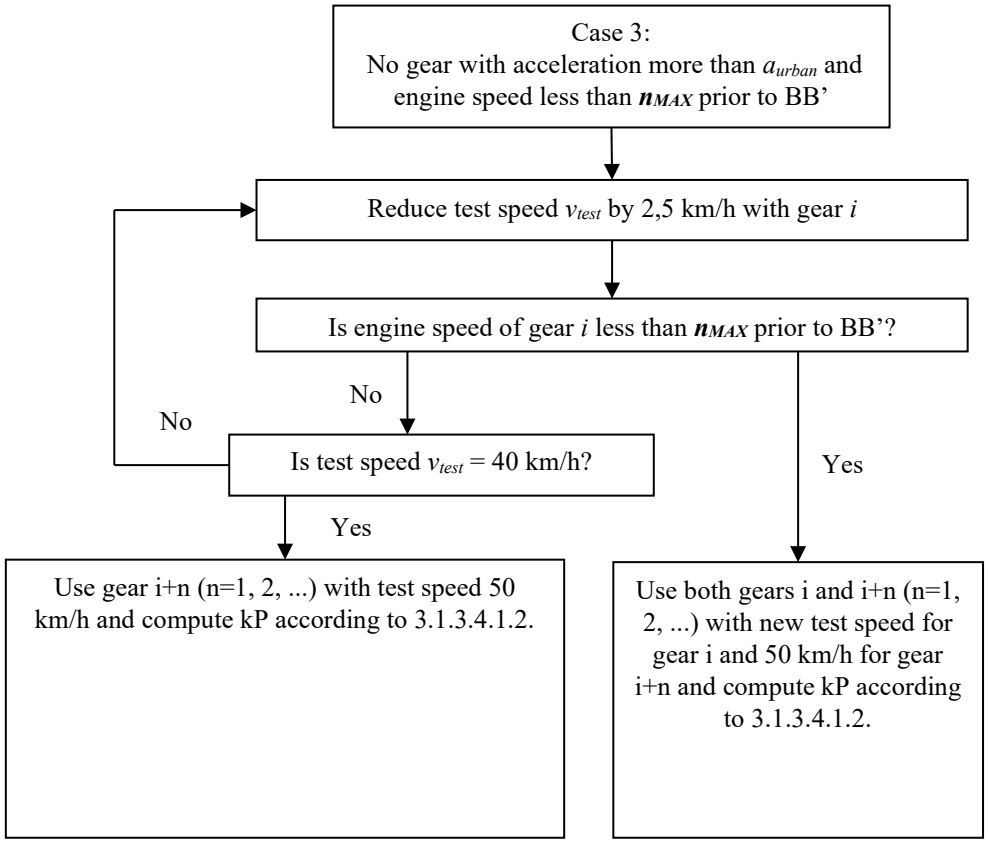


Figure 4e

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear Selection using non-locked gears

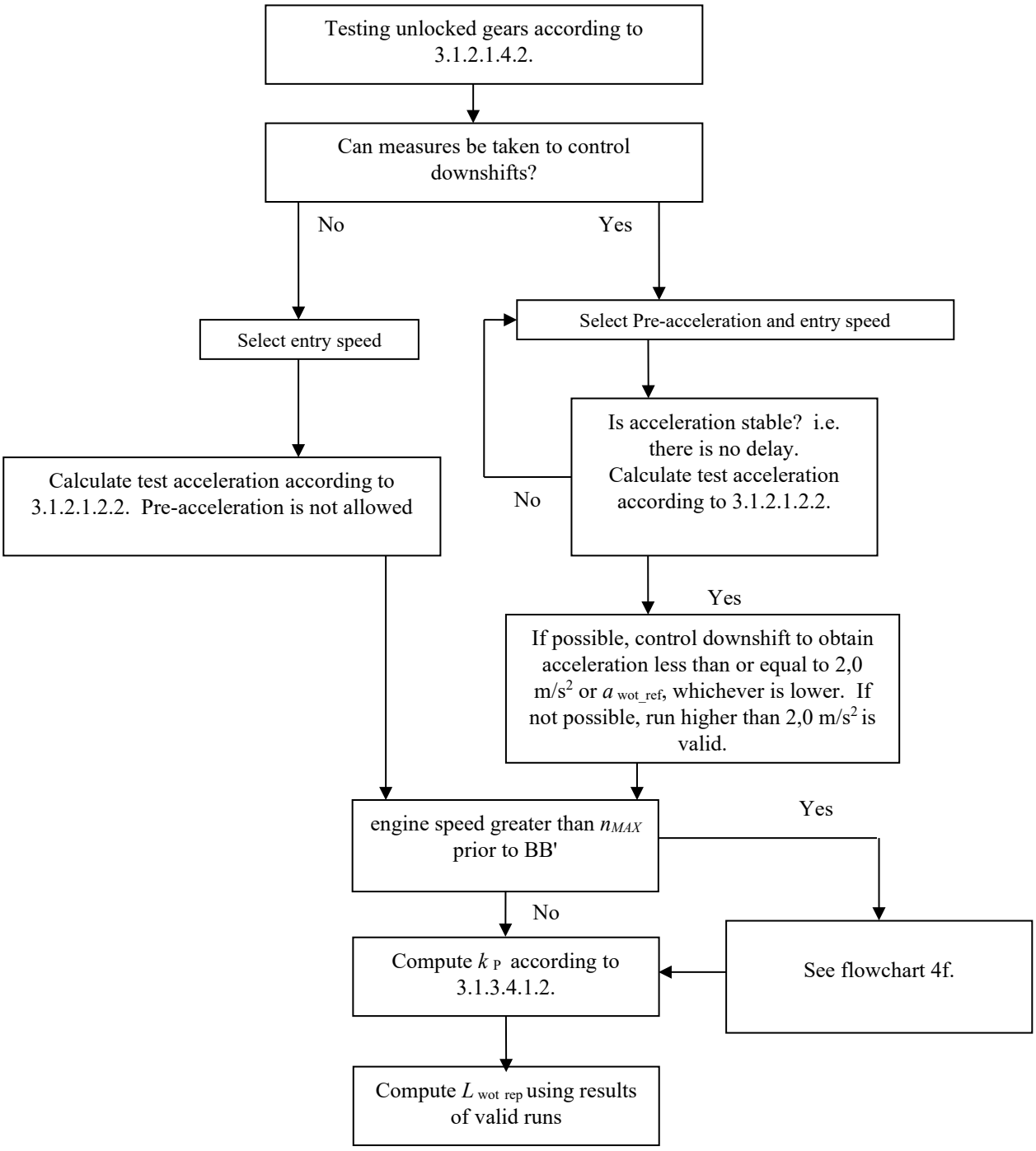


Figure 4f

Flowchart for vehicles tested according to paragraph 3.1.2.1.4.2. of Annex 3 to this Regulation – Gear Selection using non-locked gears

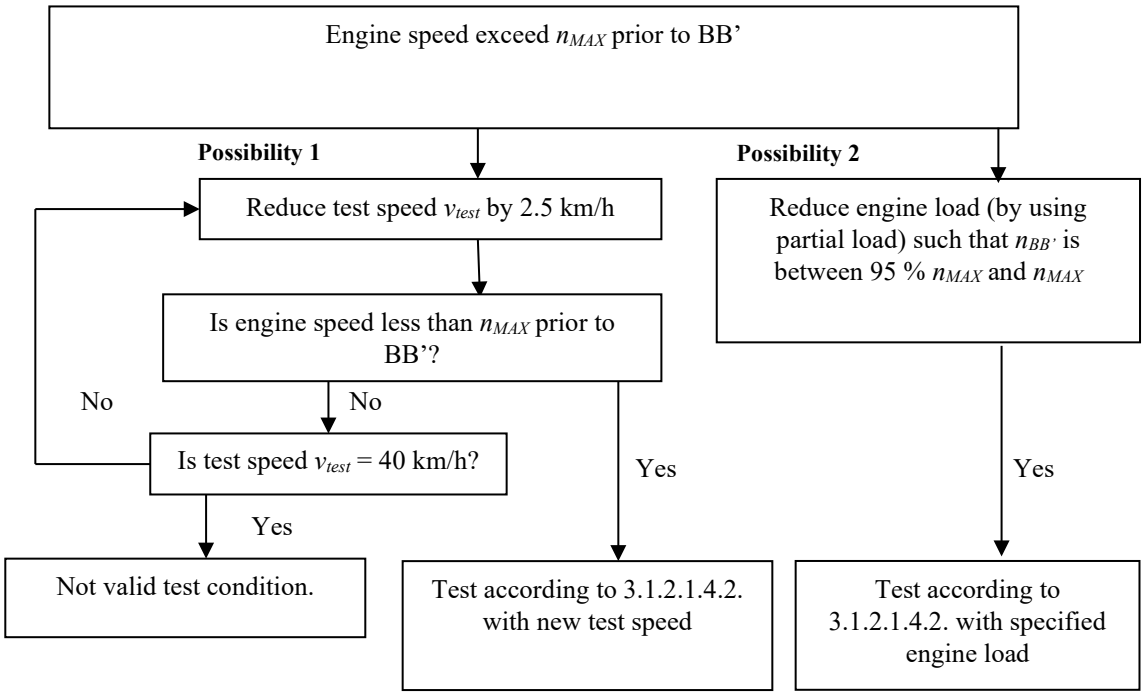


Figure 5a*

Flowchart for vehicles tested according to paragraph 3.1.2.2. of Annex 3 to this Regulation – Test in locked gears

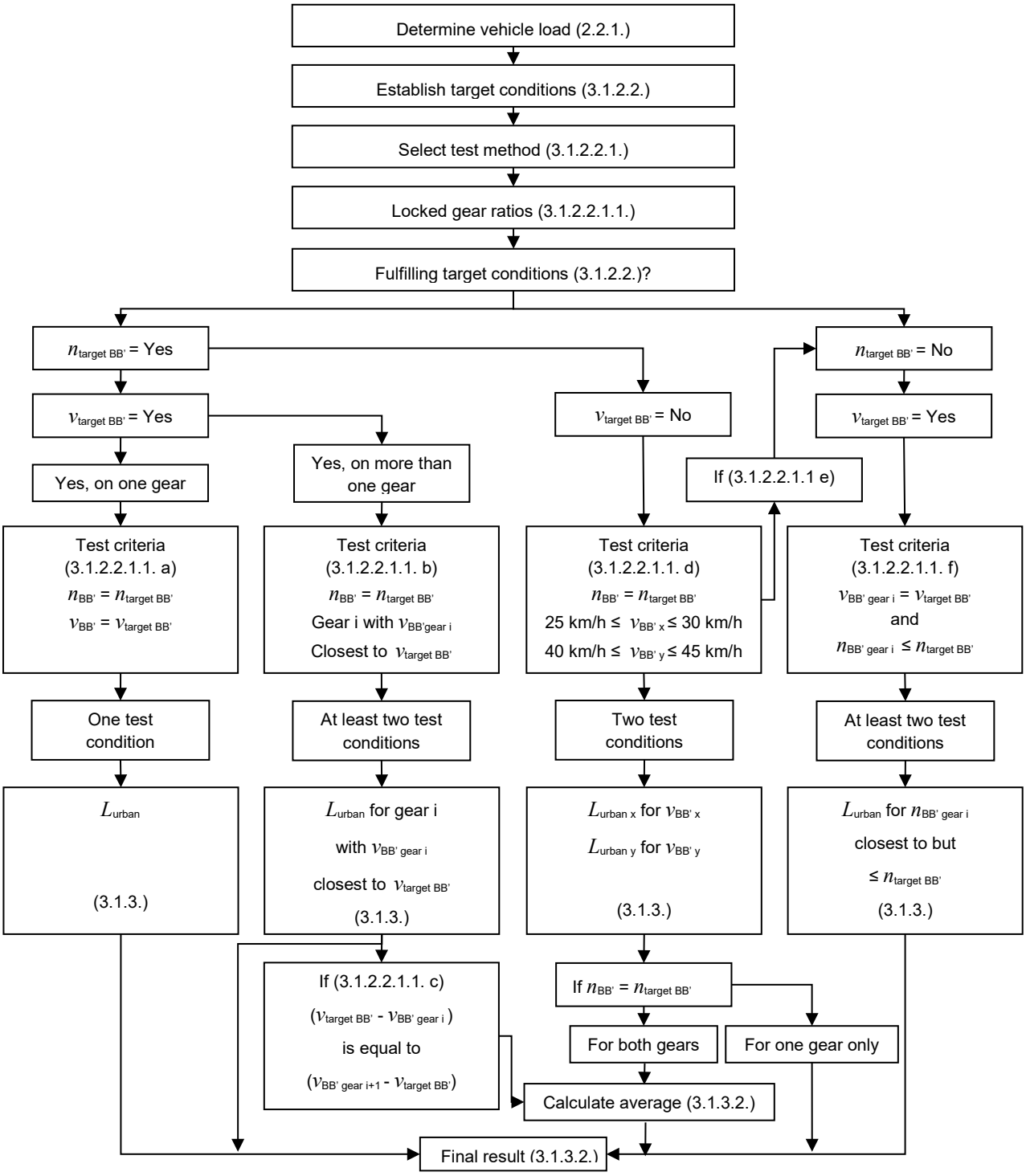


Figure 5b*

Flowchart for vehicles tested according to paragraph 3.1.2.2. of Annex 3 to this Regulation – Test in non-locked gears PART 1

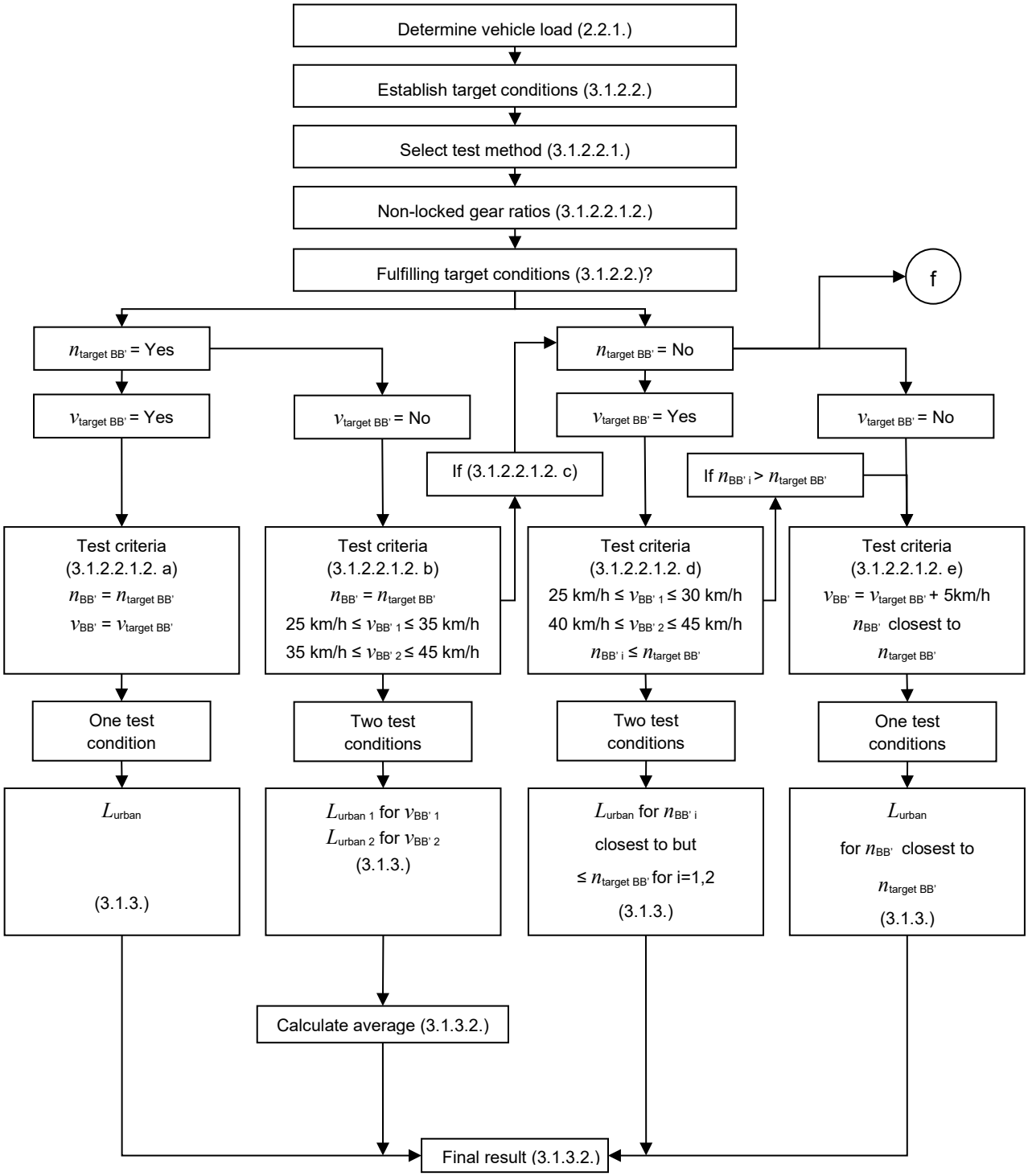


Figure 5c*

Flowchart for vehicles tested according to paragraph 3.1.2.2. of Annex 3 to this Regulation – Test in non-locked gears PART 2

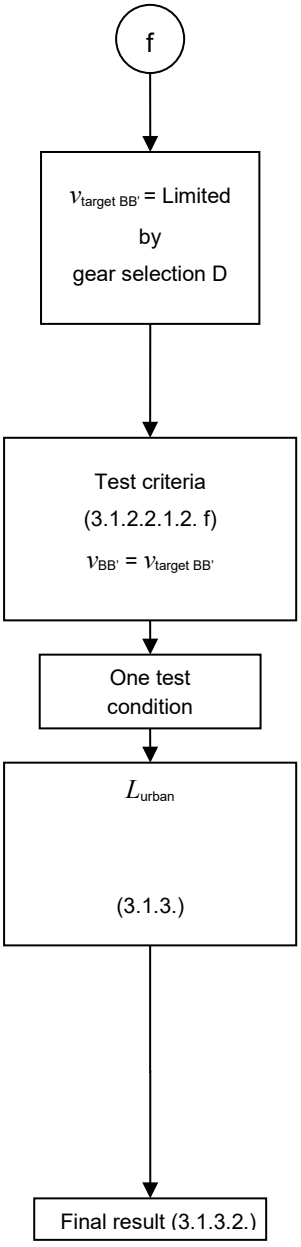
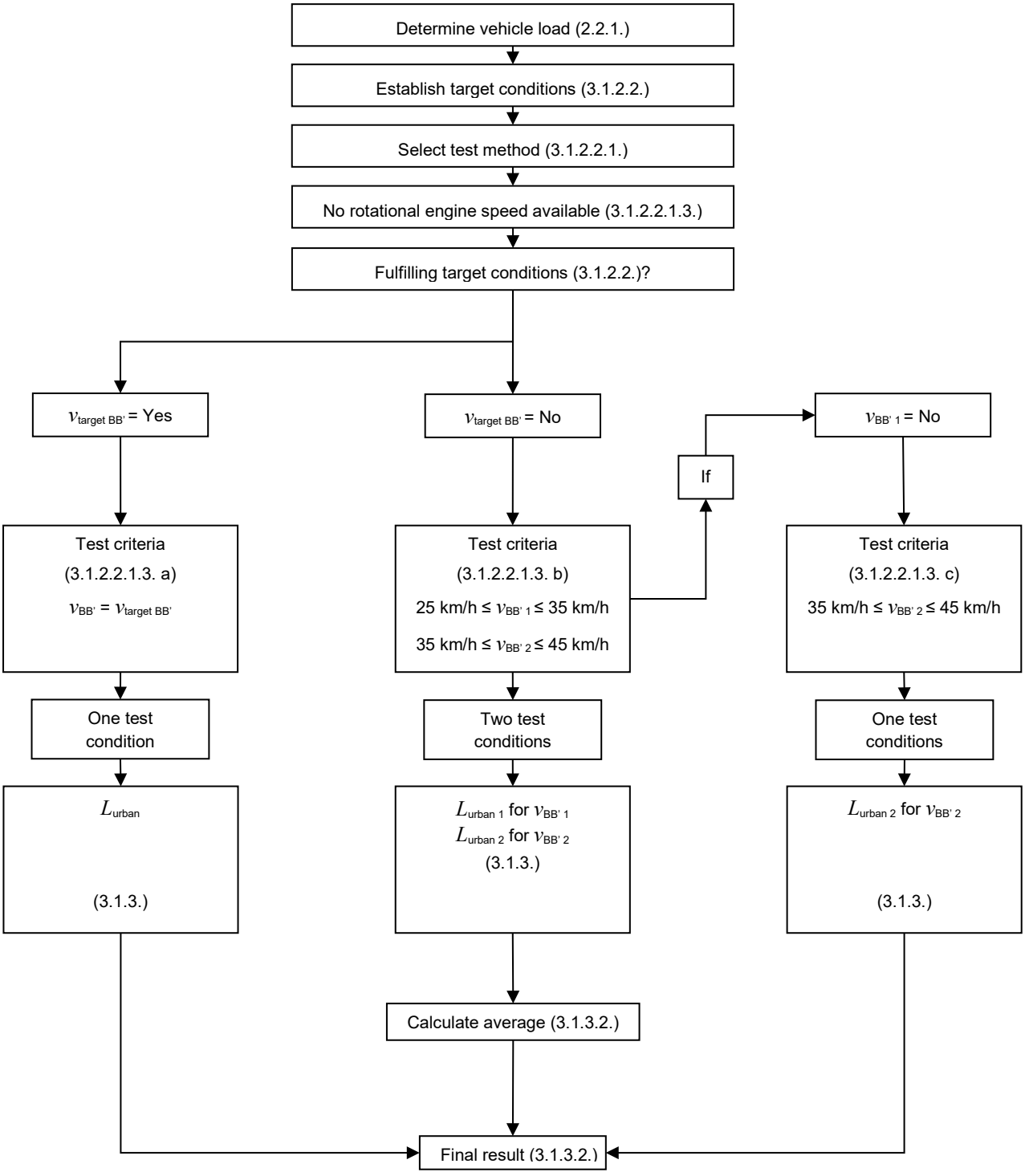


Figure 5d*

Flowchart for vehicles tested according to paragraph 3.1.2.2. of Annex 3 to this Regulation – Test for no- combustion engine speed available



Note:

* Broaden the window for the target vehicle speed $v_{target\ BB'}$ for vehicles of category M_2>3,500 kg technically permissible maximum laden mass and for vehicles of category N_2, M_3 and N_3.

The target vehicle velocity $v_{target\ BB'}$ is defined as $v_{target\ BB'}$ = 35 km/h ± 5 km/h which results in a window for the velocity $v_{BB'}$, when the reference point passes line BB', from 30 km/h to 40 km/h. If the target vehicle velocity $v_{target\ BB'}$ is changed into two target vehicle velocities, a lower and a higher one, the following is meant: The lower target vehicle velocity is defined as the target vehicle velocity $v_{target\ BB'}$ reduced by 5 km/h ($v_{target\ BB'}$ - 5 km/h) which results in a window for the velocity $v_{BB'\ 1}$, when the reference point passes line BB', from 25 km/h to 35 km/h.

25 km/h ≤ $v_{BB'1}$ ≤ 35 km/h.

The higher target vehicle velocity is defined as the target vehicle velocity $v_{target\ BB'}$ increased by 5 km/h ($v_{target\ BB'}$ + 5 km/h) which results in a window for the velocity $v_{BB'2}$, when the reference point passes line BB', from 35 km/h to 45 km/h.

35 km/h ≤ $v_{BB'2}$ ≤ 45 km/h.

Figure 6
Flowchart for measurement and data processing of stationary sound according to paragraph 3.2.

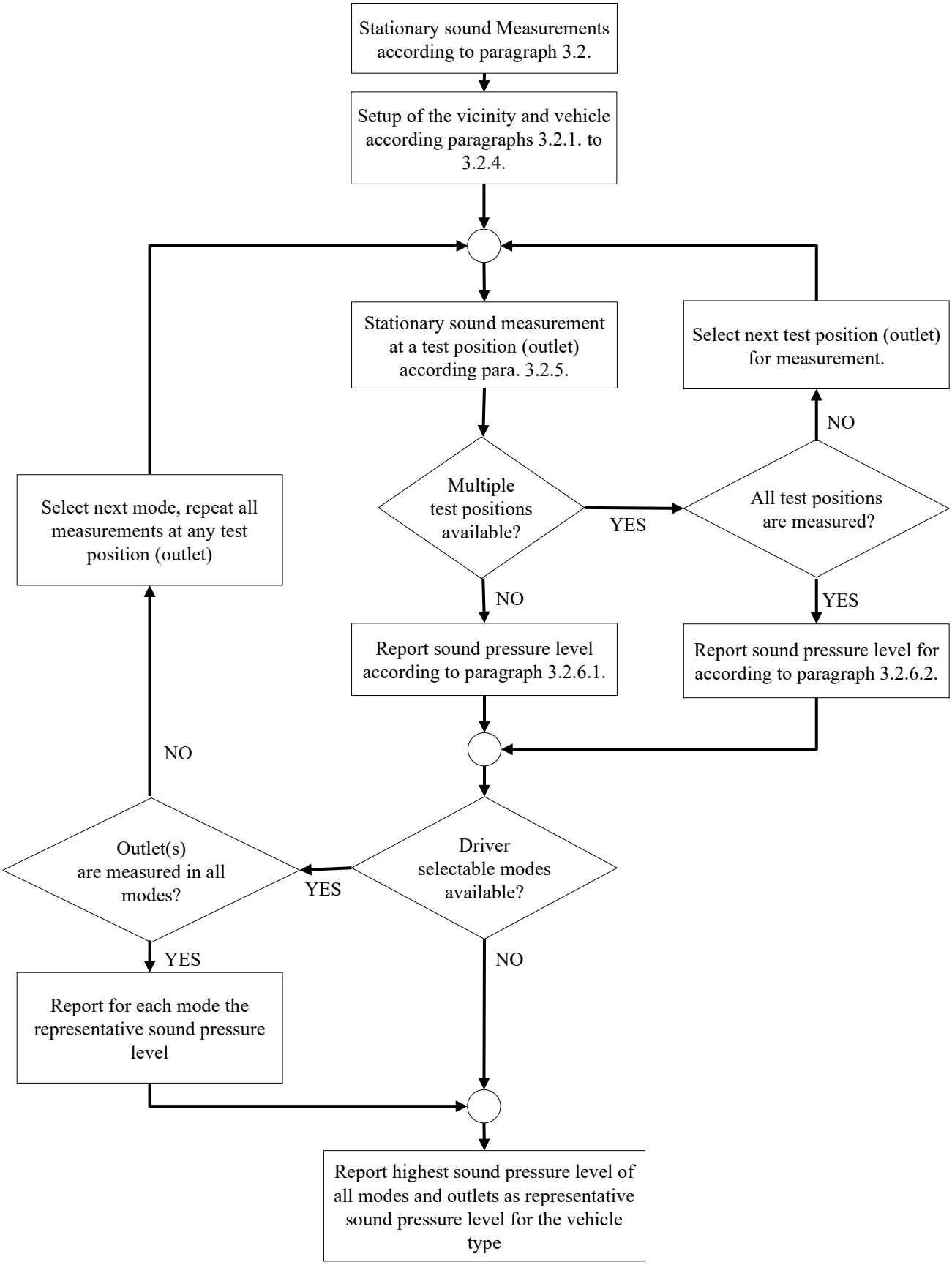


Table 1
Examples for Devices and Measures to Enable a Vehicle Tested within the Acceleration Boundaries

No.	*Impact*	*Sub No.*	*Measure*	*Additional Requirements*
1	Lock of a discrete gear ratio	1*	A discrete gear ratio can be locked by the driver	none
		2	A discrete gear ratio is available onboard, but is not available to the driver. Locking can be activated by the manufacturer with an onboard (hidden) function or with an external device	none
2	Controlled gear shift management: Applicable to transmissions which cannot be locked, or where no locked gear provides a valid test result	1*	Kickdown is deactivated	none
		2	Gear shift change(s) can happen during the test, gear shift is controlled by activation of an internal function or external device	Acceleration** shall be between a_{urban} and $a_{wot,ref}$, not exceeding 2.0 m/s².
3	Defined partial load driving****	1	Acceleration is limited by a mechanical device	Defined acceleration** shall be between a_{urban} and $a_{wot,ref}$, not exceeding 2.0 m/s². For ASEP**, the anchor point parameter are calculated by: $L_{anchor} = (L_{test} - k_p * L_{crs}) / (1-k_p)$ with $k_P = 1-a_{test}/a_{wot,ref}$ and $a_{wot,ref}$ according to 3.1.2.1.2.4. but not higher than 2.0 m/s² $n_{anchor} = n_{bb,test} * 3.6 / v_{bb,test} * (a_{wot,ref}*(20+2*l)+192,9)^{0,5}$
		2	External Programming for partial load acceleration***)	
4	Mixed Solution (Mode): This measure will be a mix of the above solutions combined in a specific mode	1*	Mode is available onboard and can be selected by the driver	none
		2	Mode is available onboard and can only be activated by the manufacturer with a hidden function or an external device	none
		3	Mode is not available onboard, an external software overrides the internal software	Acceleration** shall be between a_{urban} and $a_{wot,ref}$, not exceeding 2.0 m/s².

* Comment: This is a standard situation, already covered by the Regulation text.

** Applicable to vehicles of category M_1, N_1 and $M_2 \leq 3{,}500$ kg.

*** Partial load shall be achieved by simulation of the travel restriction of the accelerator. It is not allowed to interfere with the engine control management.

**** Applicable to vehicles of categories M_1, N_1 and $M_2 \leq 3{,}500$ kg, for the further calculation of L_{urban} in Annex 3 the sound level measured under partial load shall replace the sound level under wide open throttle. The achieved acceleration under partial load during the test shall be used for the calculation of the part power factor k_P instead of $a_{wot\ ref}$.

The test procedure and the data processing follow the same principle. Although it is tested in partial load, symbols x_{wot} (e.g. L_{wot}, a_{wot}, …) shall be used.

Annex 3 – Appendix 2

Correction for the tyre rolling sound component of pass-by sound measurements

1. Scope of the correction

This Appendix contains provisions on the correction for the tyre rolling sound component of pass-by sound measurements of Annex 3 and applies to vehicles of categories M_1 and N_1, and for vehicles of category M_2 having a maximum authorized mass not exceeding 3,500 kg.

2. General (see the flowcharts in this Appendix 2, Figure 7a to Figure 7c)

This Appendix provides correction for temperature and test track dependent on the tyre category and purpose.

For the correction, tyre rolling sound reference values are needed. Tyre rolling sound measurements shall be carried out according to the test procedure of Appendix 3 to Annex 3 of this regulation.

2.1. These measurements might be carried out during the type approval of a vehicle type (Case 1 as described in paragraph 3. of this appendix) or be performed as an independent test to be used for type approval tests of different vehicle types (Case 2 as described in paragraph 4. of this appendix).

For the further processing of data, the following tyre rolling sound reference information shall be available from the test according to Appendix 3 to Annex 3:

(a) The tyre rolling sound $L_{TR,9ref}$ separately for the left and the right side of the vehicle

(b) The slope of the tyre rolling sound slp_{ref} separately for the left and for the right side of the vehicle

(c) The reference speed $v_{TR,ref}$ to which these sound levels are assigned. If tyre rolling sound measurements are directly carried out in junction with the pass-by measurements, the reference speed $v_{TR,ref}$ shall be determined in a way to be equal to the vehicle test speed v_{crs} and v_{wot}.

2.2. The test results for each gear as determined according to Annex 3 paragraphs 3.1.2.1.4., test condition (acceleration or constant speed) and per vehicle side, are subject to the temperature correction.

2.3. For simplicity, the formula below uses the index x as place holder for the applicable gear ratio(s) i or i+n. No index is introduced for left and right side, but all calculations shall be done separately for left and right side of the vehicle.

2.4. If tests are carried out at air temperatures below 5 °C according to paragraph 2.1.3. of Annex 3, the temperature correction is applicable down to an air temperature of 0 °C. For any tests carried out at air temperatures below 0°C, the temperature correction shall be calculated with 0 °C, regardless of the measured air temperature.

3. Case 1

The temperature correction is based on tyre rolling sound measurements carried in junction with pass-by tests according to Annex 3.

3.1. Tyre Rolling Sound Reference

The rolling sound of the tyre $L_{TR,\vartheta_{ref},v_{TR,ref}}$ and the tyre sound level slope slp_{ref} for left and right side of the vehicle shall be determined for a reference vehicle speed $v_{TR,ref}$ at the reference temperature ϑ_{ref} according to Appendix 3 to Annex 3.

3.2. Temperature correction for constant speed test results

3.2.1. The reference speed shall be identical to the reference test speed of the constant speed test v_{crs} determined in Annex 3. In most cases this will be 50 km/h. If the tyre reference speed $v_{TR,ref}$, differs from v_{crs}, adjust the tyre rolling sound per vehicle side to the test speed v_{crs} by:

$$L_{TR,crs,j,\vartheta_{ref}} = L_{TR,\vartheta_{ref},v_{TR,ref}} + slp_{ref} \times \lg \frac{v_{crs}}{v_{TR,ref}}$$

3.2.2. For each valid pass-by test run j under constant speed the following values per gear are available from the measurements according to Annex 3 paragraph 3.1.2.1.:

(a) the reported sound levels $L_{crs,j}$,

(b) the vehicle speed $v_{crs,PP',j}$, and

(c) the air temperature $\vartheta_{crs,j}$.

3.2.3. For each individual test run (gear, condition and vehicle side), a tyre rolling sound reference shall be calculated for the applicable air temperature $\vartheta_{crs,j}$.

$$L_{TR,crs,j,\vartheta crs} = L_{TR,crs,j,\vartheta_{ref}} + K_1 \times \lg\left(\frac{\vartheta_{ref} + K_2}{\vartheta_{crs,j} + K_2}\right)$$

where ϑ_{ref} = 20 °C and
K_1 = 3.4 for C_1 and C_2 tyres and
K_2 = 3.0 for C_1 tyres and
K_2 = 15.0 for C_2 tyres

3.2.4. For each gear, run and vehicle side under constant speed extract the power train component $L_{PT,crs,j}$ from the test result $L_{crs,j}$, by calculation.

$$L_{PT,crs,j} = 10 \times \lg\left(10^{0.1 \times L_{crs,j}} - 10^{0.1 \times L_{TR,crs,j,\vartheta crs}}\right)$$

In case that $L_{TR,crs,\vartheta_{crs}}$ is greater than $L_{crs,j}$ the power train component $L_{PT,crs,j}$ is determined by

$$L_{PT,crs,j} = 10 \times \lg\left(0.01 \times 10^{0.1 \times L_{crs,j}}\right)$$

with $L_{TR,crs,j,\vartheta crs}$ redefined as

$$L_{TR,crs,j,\vartheta crs} = 10 \times \lg(0.99 \times 10^{0.1 \times Lcrs,j})$$

The redefined $L_{TR,crs,j,\vartheta crs}$ shall then be subjected to temperature correction in 3.2.3 to obtain the corresponding $L_{TR,crs,j,\vartheta ref}$."

3.2.5. Calculate per gear, run and vehicle side the air temperature adjusted constant speed test result $L_{crs,j,\vartheta_{ref}}$ using the temperature normalized tyre rolling sound $L_{TR,\vartheta_{ref}}$ calculated by

$$L_{crs,j,\vartheta_{ref}} = 10 \times \lg\left(10^{0.1 \times L_{PT,crs,j}} + 10^{0.1 \times L_{TR,crs,j,\vartheta_{ref}}}\right)$$

3.3. Temperature correction for acceleration test results

3.3.1. For each gear, run and vehicle side, adjust the tyre rolling sound to the speed condition of the acceleration test

$$L_{TR,wot,j,\vartheta_{ref}} = L_{TR,\vartheta_{ref},v_{TR,ref}} + slp_{ref} \times \lg\left(0.5 \times \left(v_{BB',wot} + v_{PP',wot}\right)/v_{TR,ref}\right)$$

3.3.2. For each valid pass-by test run under acceleration the following values per gear are available from the measurements according to Annex 3 paragraph 3.1.2.1.:

(a) the reported sound levels $L_{wot,j,}$

(b) the vehicle speeds $v_{wot,PP',j}$ and $v_{wot,BB',j}$, and

(c) the air temperature $\vartheta_{wot,j.}$

3.3.3. For each individual test run (gear, condition and vehicle side), a tyre rolling sound reference shall be calculated for the applicable air temperature or $\vartheta_{wot,j}$.

$$L_{TR,wot,j,\vartheta_{wot}} = L_{TR,wot,j,\vartheta_{ref}} + K_1 \times \lg\left(\frac{\vartheta_{ref} + K_2}{\vartheta_{wot,j} + K_2}\right)$$

where ϑ_{ref} = 20 °C and
K_1 = 3.4 for C_1 and C_2 tyres and
K_2 = 3.0 for C_1 tyres and
K_2 = 15.0 for C_2 tyres

3.3.4. For each gear, run and vehicle side extract the power train component $L_{PT,wot,j}$ from the reported acceleration test $L_{wot,j}$, by calculation.

$$L_{PT,wot,j} = 10 \times \lg\left(10^{0.1 \times L_{wot,j}} - 10^{0.1 \times L_{TR,wot,j,\vartheta_{wot}}}\right)$$

In case that

$$10^{0.1 \times L_{TR,wot,j,\vartheta_{wot}}} \geq 0.99 \times 10^{0.1 \times L_{wot,j}}$$

the power train component $L_{PT,wot,j}$ is determined by

$$L_{PT,wot,j} = 10 \times \lg\left(0.01 \times 10^{0.1 \times L_{wot,j}}\right)$$

with $L_{TR,wot,j,\vartheta_{wot}}$ redefined as

$$L_{TR,wot,j,\vartheta_{wot}} = 10 \times \lg(0.99 \times 10^{0.1 \times L_{wot,j}})$$

The redefined $L_{TR,wot,j,\vartheta_{wot}}$ shall then be subjected to temperature correction in ~~3.2.3~~ **3.3.3.** to obtain the corresponding $L_{TR,wot,j,\vartheta_{ref}}$

3.3.5. Calculate per gear the acceleration test result $L_{wot,j,\vartheta_{ref}}$

$$L_{wot,j,\vartheta_{ref}} = 10 \times \lg\left(10^{0.1 \times L_{PT,wot,j}} + 10^{0.1 \times L_{TR,wot,j,\vartheta_{ref}}}\right)$$

3.4. Proceed to calculate L_{urban} using the temperature normalized sound pressure levels $L_{crs,j,\vartheta_{ref}}$ and $L_{wot,j,\vartheta_{ref}}$ according to the procedure of Annex 3 paragraph 3.1.3.4.1.2.

4. Case 2

The temperature correction based on tyre rolling sound measurements that have been performed independent from the pass-by tests subject to the temperature correction.

Case 2 is applicable, when pass-by tests carried out according to Annex 3 shall be compared with already existing results – e.g., from type approval, that have been performed under a different temperature condition and on a different test track.

4.1. The necessary information on tyre rolling sound representative for the tyre used on the vehicle is available from former type approval tests or have been

carried out separately according to Appendix 3 to Annex 3 of this UN Regulation. The essential information is provided by the test report of that Appendix and is:

(a) the tyre rolling sound $L_{TR,DB,\vartheta_{ref}}$ at the reference temperature ϑ_{ref},

(b) the reference vehicle speed $v_{TR,DB,ref}$, and

(c) the tyre rolling sound slope $slp_{DB,ref}$.

4.2. Determine the tyre rolling sound for the vehicle according to Case 1 above and extract the power train relevant components $L_{PT,crs,j}$ and $L_{PT,wot,j}$ for each gear and run accordingly.

4.3. Temperature correction for constant speed test results

4.3.1. The reference speed shall be identical to the reference test speed of the constant speed test v_{test} determined in Annex 3. In most cases this will be 50 km/h. If the tyre reference speed $v_{TR,DB,ref}$ differs from v_{crs}, adjust the tyre rolling sound per vehicle side to the test speed v_{crs} by:

$$L_{TR,DB,crs,j,\vartheta_{ref}} = L_{TR,DB,\vartheta_{ref}} + slp_{DB,ref} \times \lg\left(v_{crs,j}/v_{TR,DB,ref}\right)$$

4.3.2. For each gear, test run and vehicle side, calculate the air temperature and test track adjusted constant speed test results $L_{crs,j,\vartheta_{ref}}$ by

$$L_{crs,j,\vartheta_{ref}} = 10 \times \lg\left(10^{0.1\times L_{PT,crs,j}} + 10^{0.1\times L_{TR,DB,crs,j,\vartheta_{ref}}}\right)$$

4.4. Temperature correction for acceleration test results

4.4.1. For each gear, test run and vehicle side, adjust the tyre rolling sound $L_{TR,DB,\vartheta_{ref}}$ to the speed condition of the acceleration test

$$L_{TR,DB,wot,j,\vartheta_{ref}} = L_{TR,DB,\vartheta_{ref}} + slp_{DB,ref} \times \lg\left(0.5 \times \left(v_{BB',wot,j} + v_{PP',wot,j}\right)/v_{TR,DB,ref}\right)$$

4.4.2. For each gear, test run and vehicle side, calculate the acceleration test result $L_{wot,j,\vartheta_{ref}}$ by

$$L_{wot,j,\vartheta_{ref}} = 10 \times \lg\left(10^{0.1\times L_{PT,wot,j}} + 10^{0.1\times L_{TR,DB,wot,j,\vartheta_{ref}}}\right)$$

4.5. Proceed to calculate L_{urban} with the temperature normalized sound pressure levels $L_{crs,j,\vartheta_{ref}}$ and $L_{wot,j,\vartheta_{ref}}$ according to the procedure of Annex 3 paragraph 3.1.3.4.1.2.

Figure 7a

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Correction of pass-by measurements for temperature and if applicable for test track differences

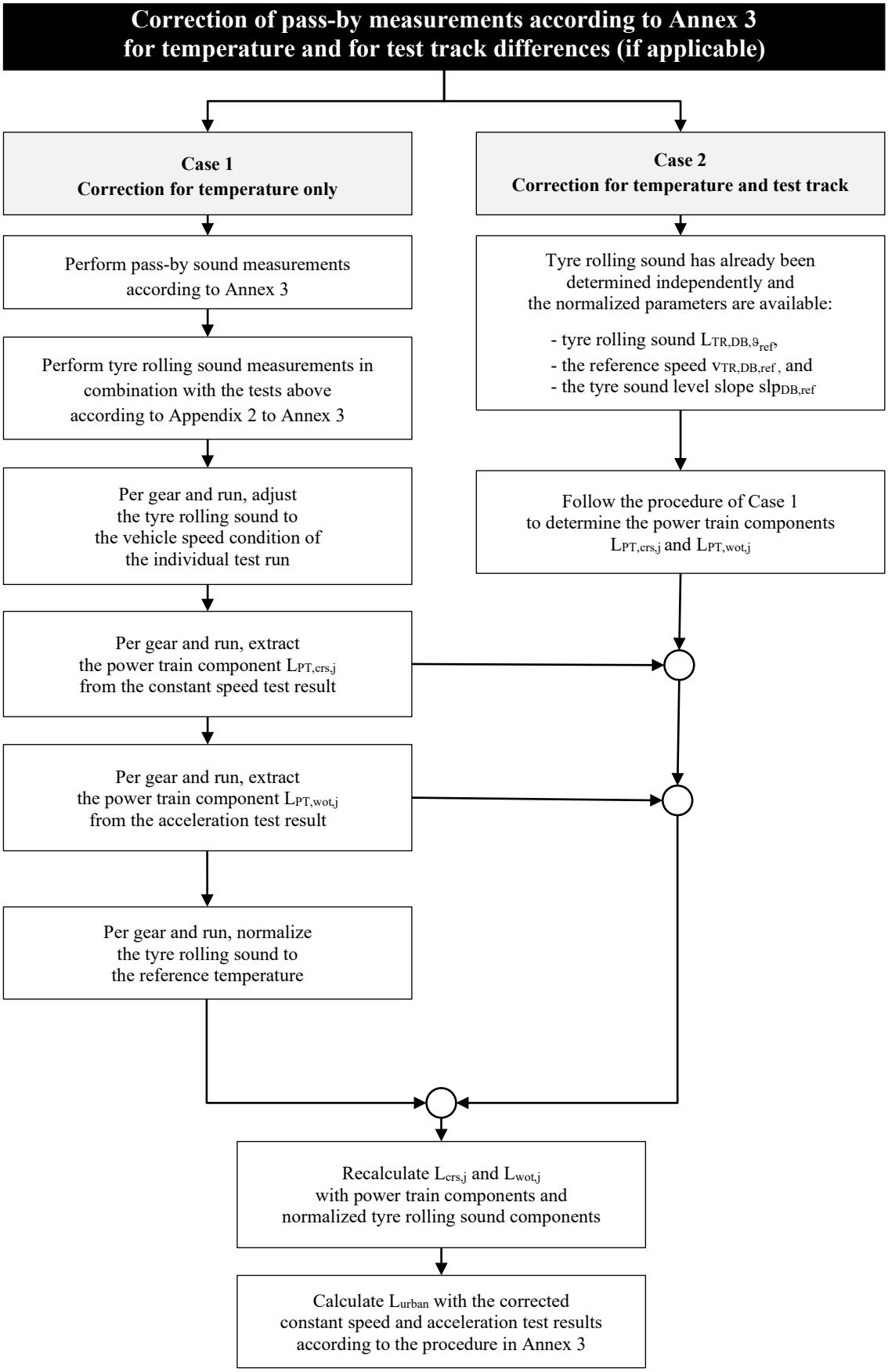

Correction of pass-by measurements according to Annex 3 for temperature and for test track differences (if applicable)
Case 1
Correction for temperature only
Case 2
Correction for temperature and test track
Perform pass-by sound measurements according to Annex 3
Perform tyre rolling sound measurements in combination with the tests above according to Appendix 2 to Annex 3
Per gear and run, adjust the tyre rolling sound to the vehicle speed condition of the individual test run
Per gear and run, extract the power train component $L_{PT,crs,j}$ from the constant speed test result
Per gear and run, extract the power train component $L_{PT,wot,j}$ from the acceleration test result
Per gear and run, normalize the tyre rolling sound to the reference temperature
Tyre rolling sound has already been determined independently and the normalized parameters are available:
- tyre rolling sound $L_{TR,DB,\vartheta_{ref}}$,
- the reference speed $v_{TR,DB,ref}$, and
- the tyre sound level slope $slp_{DB,ref}$
Follow the procedure of Case 1 to determine the power train components $L_{PT,crs,j}$ and $L_{PT,wot,j}$
Recalculate $L_{crs,j}$ and $L_{wot,j}$ with power train components and normalized tyre rolling sound components
Calculate L_{urban} with the corrected constant speed and acceleration test results according to the procedure in Annex 3

Figure 7b

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Temperature Correction for Tyre Rolling Sound Components Case 1

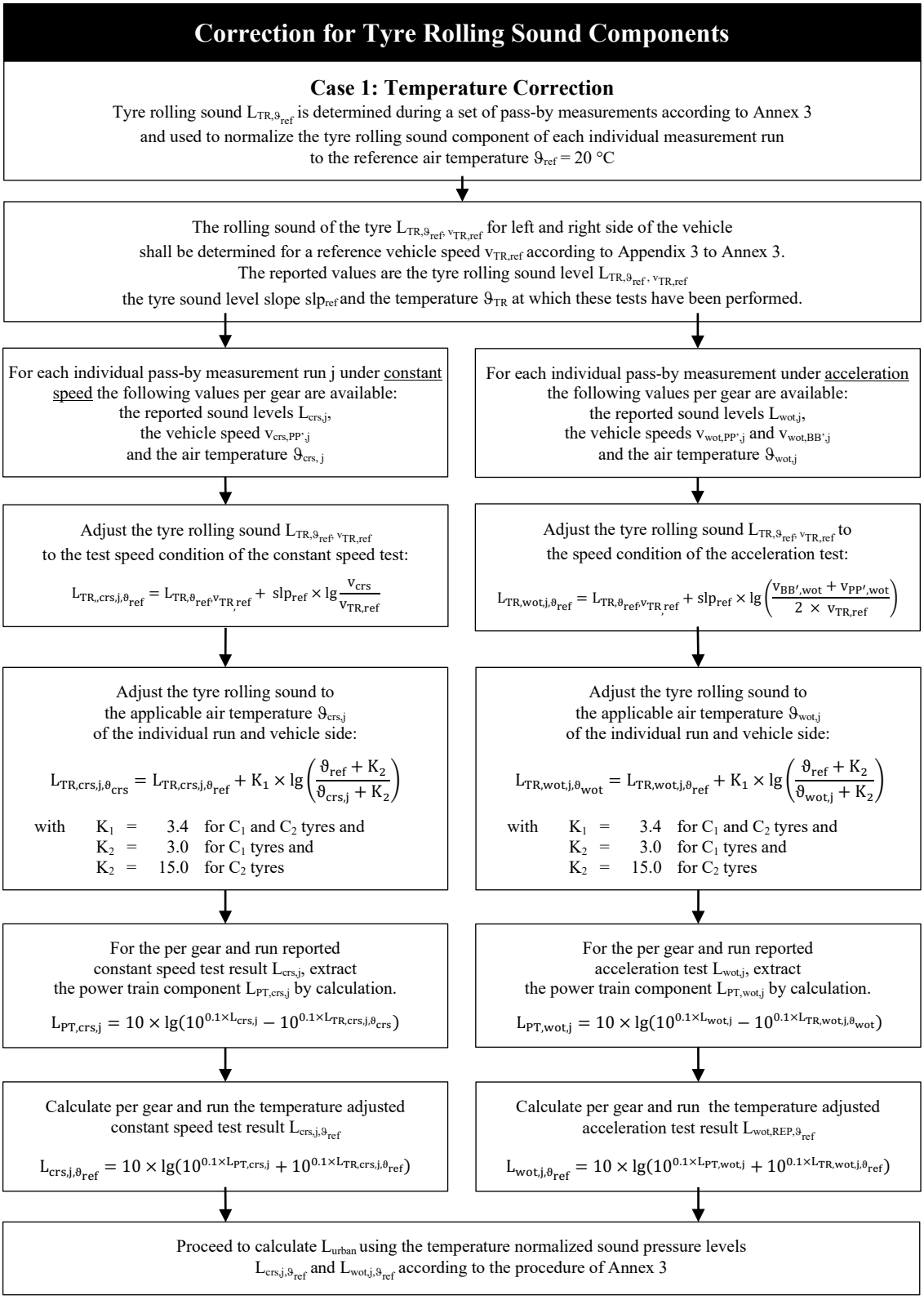
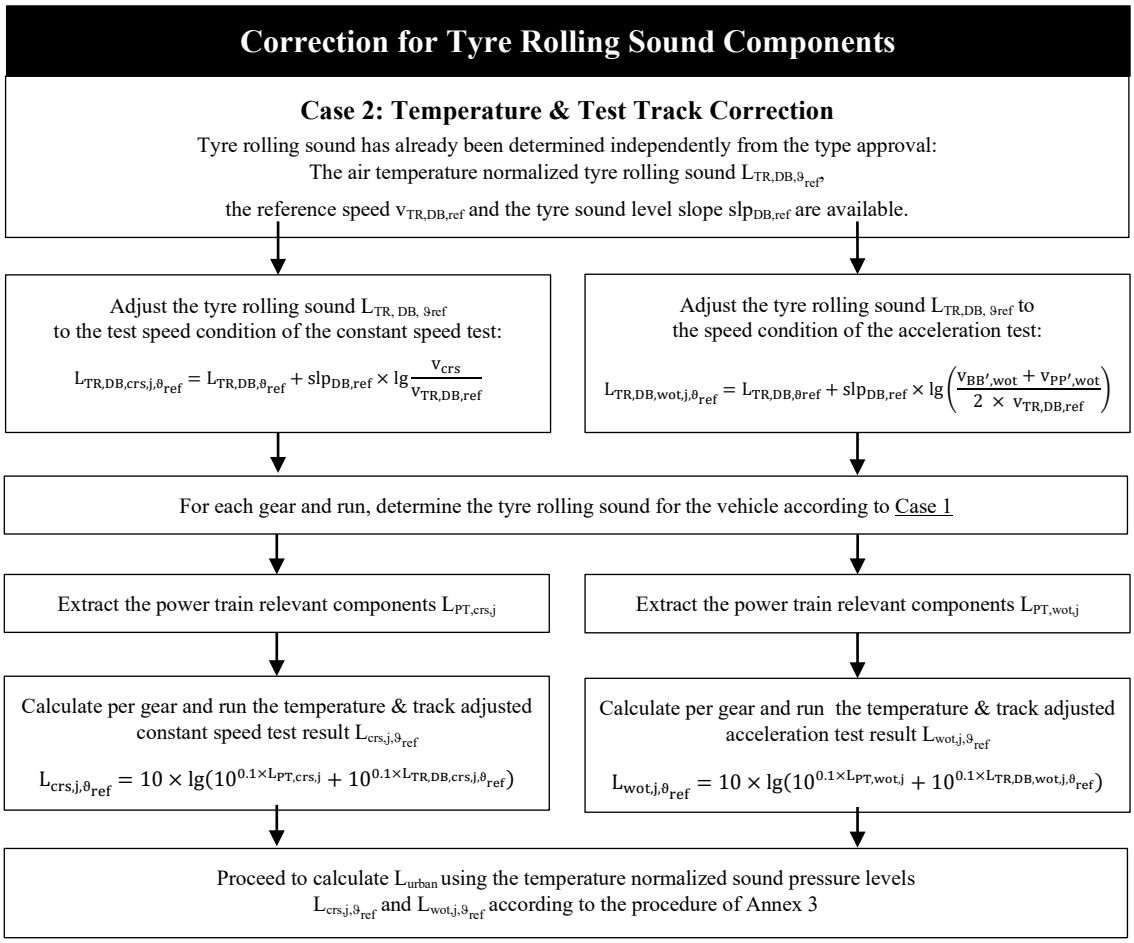


Figure 7c

Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Temperature/Test Track Correction for Tyre Rolling Sound Components Case 2



Annex 3 – Appendix 3

Coast-by test method for measuring tyre-rolling sound emission

1. Measuring instruments

Unless otherwise specified, the measuring instruments shall comply with the provisions of Annex 3 of this UN Regulation.

1.1. Meteorological equipment

Unless otherwise specified, the meteorological equipment shall comply with the provisions of Annex 3 of this UN Regulation.

2. Conditions of measurement

2.1. Test site

The test site shall comply with the provisions of Annex 3 of this UN Regulation.

2.2. Meteorological conditions

Tests carried out on request of the manufacturer at temperatures below 5° C shall be accepted as well, however temperature correction to be applied is limited to a minimum air temperature of 0 °C. See paragraph 2 of Appendix 2 to Annex 3 of this Regulation as well.

2.3. Ambient noise

The background noise provisions shall be in line with Annex 3 of this UN Regulation.

2.4. Test vehicle requirements

2.4.1. General

The test vehicle shall be either

(a) the vehicle directly used for tests according to Annex 3 of this UN Regulation. In this case, the requirements of paragraphs 2.4.2. to 2.4.4. inclusive the subparagraphs do not apply. The vehicle shall comply with the specifications of Annex 3 of this UN Regulation, or

(b) a motor vehicle compliant with the provisions of paragraphs 2.4.2. to 2.4.4.

2.4.2. Vehicle load

The vehicle shall be loaded such as to comply with the test tyre loads as specified in paragraph 2.5.2. below.

2.4.3. Wheelbase

The wheelbase between the first and the second axles fitted with the test tyres shall for Class C_1 be less than 3.50 m and for Class C_2 tyres be less than 5 m.

2.4.4. Measures to minimize vehicle influence on sound level measurements

The test vehicle shall be suitable for vehicles to which this tyre will be fitted, this is fulfilled, if the vehicle has been cross-checked to the vehicle type to which the tyres are dedicated with regard to the design criteria below:

2.4.4.1. Requirements:

(a) Spray suppression flaps or another extra device to suppress spray;

(b) Retention of elements in the immediate vicinity of the rims and tyres, which may screen the emitted sound;

(c) Wheel alignment (toe in, camber and caster) shall be in full accordance with the vehicle manufacturer's recommendations;

(d) Sound absorbing material in the wheel housings or under the underbody;

(e) Ground clearance: if available, the body level shall be adjusted to a comparable ground clearance as applicable for the vehicle type.

2.4.4.2. Recommendations to avoid parasitic noise:

(a) During testing it should be ascertained that brakes are not poorly released, causing brake noise;

(b) It should be ascertained that electric cooling fans are not operating;

(c) Windows and sliding roof of the vehicle shall be closed during testing.

2.5. Tyres

2.5.1. General

Four tyres shall be fitted on the test vehicle to be representative for the tyre configuration as it will be used for the type approval of a vehicle. Tyres with special fitting requirements shall be tested in accordance with these requirements (e.g., rotation direction). The tyres shall have a minimum tread depth of 80%.

New tyres shall be "run-in" prior to testing to remove compound nodules or other tyre pattern characteristics resulting from the moulding process. This will normally require the equivalent of about 100 km of normal use on the road.

Tyres are to be tested on rims specified by the vehicle manufacturer.

2.5.2. Tyre loads

2.5.2.1. If the test vehicle is a vehicle subject to tests according to Annex 3 according to this UN Regulation, the provisions on the tyre loads below do not apply.

2.5.2.2. In other cases, the loads on the tyres shall be representative for the vehicle to which these tyres are dedicated with a tolerance +/- 20% not exceeding 90% of the maximum tyre load.

2.5.3. Tyre inflation pressure

2.5.3.1. If the test vehicle is a vehicle subject to type approval according to this Regulation, the tyre inflation pressure shall be according to paragraph 2.2.2. of Annex 3.

2.5.3.2. In other cases, the tyre pressure shall be adjusted according to the manufacturer’s specification for the tyre load as selected according to paragraph 2.5.2.2. above.

2.5.4. Preparations prior to testing

Prior to testing tyres shall be warmed up by running under test conditions for at least 10 min to allow the rubber compound to warm-up.

3. Method of testing

3.1. General conditions

For all measurements the vehicle shall be driven in a straight line over the measuring section (AA' to BB') in such a way that the median longitudinal plane of the vehicle is as close as possible to the line CC'.

When the front end of the test vehicle has reached the line AA' the vehicle shall be brought to coast-down by full release of the acceleration pedal. If applicable, the influence of the power train noise shall be minimized, e.g. the driver shall have put the gear selector to neutral position and switched off the engine. If abnormal noise (e.g. ventilator, self-ignition) is emitted by the test vehicle during the measurement, the test shall be disregarded.

As an alternative test method, the acceleration pedal may be positioned such to maintain a constant speed between line AA' with an accuracy of +/- 1 km/h. The procedure is recommended especially for electric vehicles when a release of the acceleration pedal would result is a forced deceleration (recuperation) with higher negative torque on the tyre.

3.2. Nature and number of measurements

The maximum sound level expressed in A-weighted decibels (dB(A)) shall be measured simultaneously for the left and right side of the vehicle and be reported to the first decimal place as the vehicle is coasting between lines AA' and BB' (front end of the vehicle on line AA', rear end of the vehicle on line BB').

For each pass-by measurement n the vehicle speeds $v_{PP',n}$ shall be reported, when the reference point of the vehicle (see definition 2.11) passes the lines PP'. In case of a test vehicle according 2.4.1. (b) test might be needed at various reference points, if the tyre configuration shall be used on vehicles with different reference points. The vehicles speeds shall be mathematically rounded to the first decimal place.

At least six measurements shall be made on each side of the test vehicle approximately equally spaced over the speed range specified in paragraph 3.3. below.

3.3. Test speed range

The test vehicle speeds shall be within the range from 40 km/h to 60 km/h.

4. Interpretation of results

The measurement shall be invalid if an abnormal discrepancy between the values is recorded (see background noise and measurement reading provisions of annex 3).

4.1. Determination of test result

Reference speed $v_{TR,ref}$ used to determine the final result will be 50 km/h, unless the reference speed is reduced during the type approval test according to the provisions of paragraph 3.1.2.1.4.1. (d) of Annex 3 of this UN Regulation.

4.2. Temperature correction

Each test result $L_{TR,i}$ shall be normalized to the air temperature ϑ_{ref} by applying a temperature correction, according to the following:

$$L_{TR,i,\vartheta_{ref}} = L_{TR,i,\vartheta_{TR}} + K_1 \times \lg\left(\frac{\vartheta_{TR,i} + K_2}{\vartheta_{ref} + K_2}\right)$$

where ϑ_{ref} = 20 °C and
$\vartheta_{TR,i}$ = the measured air temperature per run i and
K_1 = 3.4 for C_1 and C_2 tyres and
K_2 = 3.0 for C_1 tyres and
K_2 = 15.0 for C_2 tyres.

4.3. Regression analysis of rolling sound measurements

The tyre-road rolling sound level $L_{TR,\vartheta_{ref},v_{TR,ref}}$ is determined by a regression analysis for each vehicle side separately according to:

$$L_{TR,\vartheta_{ref},v_{TR,ref}} = \overline{L} - slp_{ref} \times \overline{v}$$

where $\overline{L}$ is the mean value of the rolling sound levels L_i, measured in dB(A):

$$\overline{L} = \frac{1}{n}\sum_{i=1}^{n} L_{TR,i,\vartheta_{ref}}$$

n is the measurement number ($n \geq 6$),
$\overline{v}$ is the mean value of logarithms of speeds v_i:

$$\overline{v} = \frac{1}{n}\sum_{i=1}^{n} v_i$$

with $v_i = \lg \frac{v_i}{v_{TR,ref}}$

slp_{ref} is the slope of the regression line in dB(A):

$$slp_{ref} = \frac{\sum_{i=1}^{n}(v_i - \overline{v})\left(L_{TR,i,\vartheta_{ref}} - \overline{L}\right)}{\sum_{i=1}^{n}(v_i - \overline{v})^2}$$

4.4. The final result $L_{TR,\vartheta_{ref},v_{TR,ref}}$ for the reference speed $v_{TR,ref}$ and the slope slp_{ref} of the regression line shall be reported per vehicle side to the first decimal place.

5. Test report

5.1. Authority present during the tests: .....

5.1.1. Name and address of applicant: .....

5.1.2. Test report No.: .....

5.1.3. Date of test: .....

5.1.4. Location of test track: .....

5.1.4.1. Date of track certification to ISO 10844:2021*: .....

** Delete what does not apply according to the transitional provisions in this Regulation.*

5.1.4.2. Issued by: .....

5.1.4.3. Method of certification: .....

5.1.5. Test vehicle

5.1.5.1. Vehicle used for tyre testing (strike trough what is not applicable):

type approval vehicle / tyre test vehicle

5.1.5.2. In case of a type approval vehicle

5.1.5.2.1. Type description: .....

5.1.5.3. In case of a tyre test vehicle

5.1.5.3.1. Make, model, year, modifications, etc.: .....

5.1.5.3.2. Test vehicle wheelbase: ..... mm

5.1.6. Tyre Information

5.1.6.1. Manufacturer and Brand Name or Trade description: .....

5.1.6.2. Tyre Class: .....

5.1.6.3. Category of use: (M_1, N_1 or $N_2 < 3.5$ t) .....

5.1.6.4. Tyre test details (front/rear axle): .....

5.1.6.5. Tyre size designation: .....

5.1.6.6. Tyre service description: .....

5.1.6.7. Reference inflation pressure: ..... kPa

5.1.7. Reported values

5.1.7.1. Tyre Rolling Sound Level $L_{TR,\vartheta_{ref},v_{TR,ref}}$ (left/right side of the vehicle): ..dB(A)

5.1.7.2. Reference speed $v_{TR,ref}$ according to paragraph 4.1:.....km/h

5.1.7.3. Regression slopes slp_{ref} (left/right side of the vehicle): .....dB(A)/log(v)

5.1.8. Comments (if any): .....

5.1.9. Date: .....

5.1.9.1. Signature:

Annex 4

Exhaust silencing systems containing acoustically absorbing fibrous materials

1. General

Sound absorbing fibrous materials may be used in silencing systems or components thereof only if

(a) The exhaust gas is not in contact with the fibrous materials; or if

(b) The silencing system or components thereof are of the same design family as systems or components for which it has been proven, in the course of type approval process in accordance with the requirements of this regulation for another vehicle-type, that they are not subject to deterioration.

Unless one of these conditions is fulfilled, the complete silencing system or components thereof shall be submitted to a conventional conditioning using one of three installations and procedures described below, or - on request of the manufacturer - by removing the fibrous materials from the silencer.

1.1. Continuous road operation for 10,000 km

1.1.1. 50 ± 20 per cent of this operation shall consist of urban driving and the remaining operation shall be long-distance runs at high speed; continuous road operation may be replaced by a corresponding test-track programme.

1.1.2. The two speed regimes shall be alternated at least twice.

1.1.3. The complete test programme shall include a minimum of 10 breaks of at least three hours duration in order to reproduce the effects of cooling and any condensation which may occur.

1.2. Conditioning on a test bench

1.2.1. Using standard parts and observing the vehicle manufacturer's instructions, the silencing system or components thereof shall be fitted to the vehicle referred to in paragraph 3.3. of this Regulation or the engine referred to in paragraph 3.4. of this Regulation. In the former case the vehicle shall be mounted on a roller dynamometer. In the second case, the engine shall be coupled to a dynamometer.

1.2.2. The test shall be conducted in six six-hour periods with a break of at least 12 hours between each period in order to reproduce the effects of cooling any condensation which may occur.

1.2.3. During each six-hour period, the engine shall be run, under the following conditions:

(a) Five minutes at idling speed;

(b) One-hour sequence under 1/4 load at 3/4 of rated maximum speed (S);

(c) One-hour sequence under 1/2 load at 3/4 of rated maximum speed (S);

(d) 10-minute sequence under full load at 3/4 of rated maximum speed (S);

(e) 15-minute sequence under 1/2 load at rated maximum speed (S);

(f) 30-minute sequence under 1/4 load at rated maximum speed (S).

Each period shall comprise two sequenced sets of the six above-mentioned conditions in consecutive order from (a) to (f).

1.2.4. During the test, the silencing system or components thereof shall not be cooled by a forced draught simulating normal airflow around the vehicle. Nevertheless, at the request of the manufacturer, the silencing system or components thereof may be cooled in order not to exceed the temperature recorded at its inlet when the vehicle is running at maximum speed.

1.3. Conditioning by pulsation

1.3.1. The silencing system or components thereof shall be fitted to the vehicle referred to in paragraph 3.3. of this Regulation or the engine referred to in paragraph 3.4. of this Regulation. In the former case the vehicle shall be mounted on a roller dynamometer.

In the second case, the engine shall be mounted on a dynamometer. The test apparatus, a detailed diagram of which is shown in Figure 1 of the appendix to this annex shall be fitted at the outlet of the silencing system. Any other apparatus providing equivalent results is acceptable.

1.3.2. The test apparatus shall be adjusted in such a way that the exhaust-gas flow is alternatively interrupted and re-established by the quick-action valve for 2,500 cycles.

1.3.3. The valve shall open when the exhaust-gas back pressure, measured at least 100 mm downstream of the intake flange, reaches a value of between 35 and 40 kPa. It shall close when this pressure does not differ by more than 10 per cent from its stabilized value with the valve open.

1.3.4. The time-delay switch shall be set for the duration of gas exhaust resulting from the provisions laid down in paragraph 1.3.3. above.

1.3.5. Engine speed shall be 75 per cent of the rated engine speed (S) at which the engine develops rated maximum net power.

1.3.6. The power indicated by the dynamometer shall be 50 per cent of the full-throttle power measured at 75 per cent of rated engine speed (S).

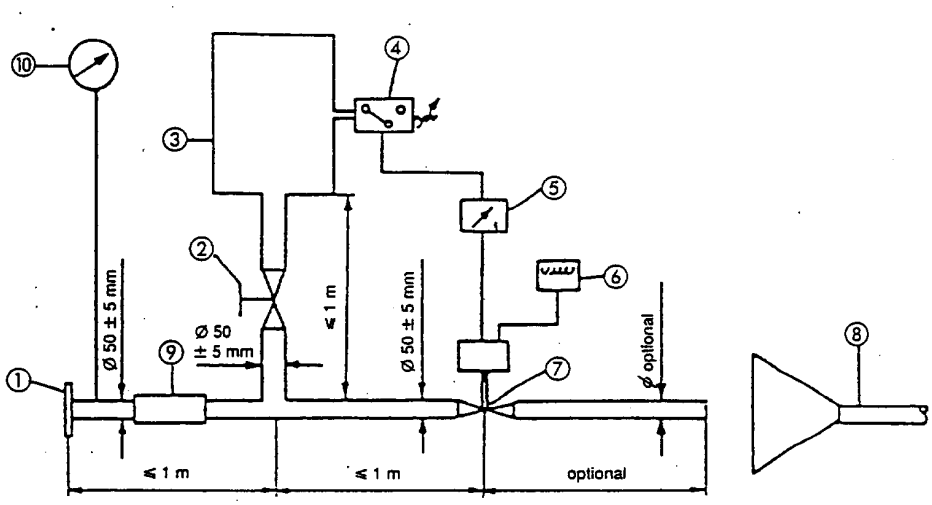
1.3.7. Any drain holes shall be closed off during the test.

1.3.8. The entire test shall be completed within 48 hours.

If necessary, one cooling period will be observed after each hour.

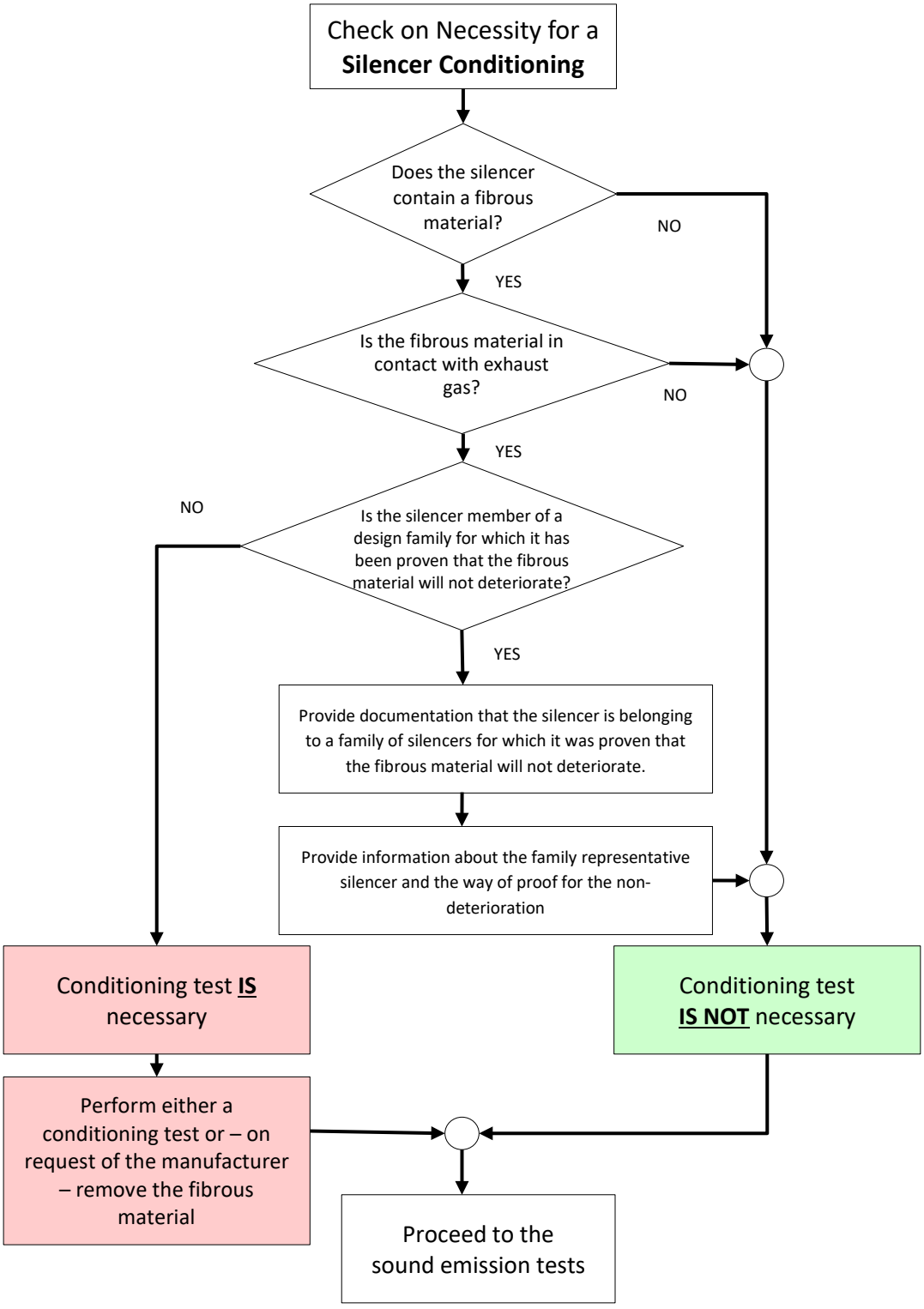
Annex 4 - Appendix

Figure 1
Test apparatus for conditioning by pulsation



1. Inlet flange or sleeve for connection to the rear of the test exhaust system.
2. Hand-operated regulating valve.
3. Compensating reservoir with a maximum capacity of 40 l and a filling time of not less than one second.
4. Pressure switch with an operating range of 0.05 to 2.5 bar.
5. Time delay switch.
6. Pulse counter.
7. Quick-acting valve, such as exhaust brake valve 60 mm in diameter, operated by a pneumatic cylinder with an output of 120 N at 4 bar. The response time, both when opening and closing, shall not exceed 0.5 second.
8. Exhaust gas evacuation.
9. Flexible pipe.
10. Pressure gauge.

Figure 2: Flowchart for the check on the necessity for a silencer conditioning test



Annex 5

Compressed air noise

1. Method of measurement

   The measurement is performed at microphone positions 2 and 6 according to Figure 1, with the vehicle stationary. The highest A-weighted sound level is registered during venting the pressure regulator and during ventilating after the use of both the service and parking brakes.

   The noise during venting the pressure regulator is measured with the engine at idling speed. The ventilating noise is registered while operating the service and parking brakes; before each measurement, the air-compressor unit has to be brought up to the highest permissible operating pressure, and then the engine switched off.

2. Evaluation of the results

   For all microphone positions two measurements are taken. In order to compensate for inaccuracies of the measuring equipment, the meter reading is reduced by 1 dB(A), and the reduced value is taken as the result of measurement. The results are taken as valid if the difference between the measurements at one microphone position does not exceed 2 dB(A). The highest value measured is taken as the result. If this value exceeds the sound limit by 1 dB(A), two additional measurements are to be taken at the corresponding microphone position.

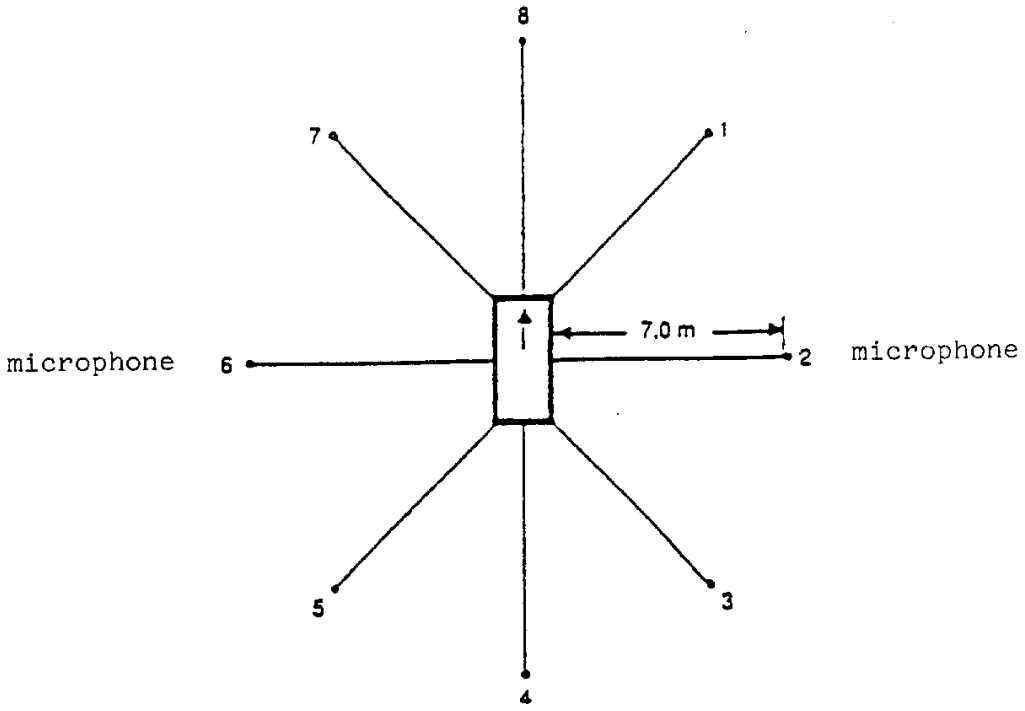
   In this case, three out of the four results of measurement obtained at this position have to comply with the sound limit.

3. Limiting value

   The sound level shall not exceed the limit of 72 dB(A).

Annex 5 - Appendix

Figure 1
Microphone positions for measurement of compressed air noise



The measurement is performed at the stationary vehicle according to Figure 1, using two microphone positions at a distance of 7 m from the contour of the vehicles, and at 1.2 m above ground.

Annex 6

Checks on conformity of production

1. General

These requirements are consistent with the test for checking Conformity of Production (COP) according to paragraph 8. of this Regulation.

2. Testing procedure

The test site and measuring instruments shall be those as described in Annex 3.

2.1. The vehicle(s) under test shall be subjected to the test for measurement of sound of vehicle in motion as described in paragraph 3.1. of Annex 3.

For vehicles of category M_1, N_1 and for vehicles of category M_2 having a maximum authorized mass not exceeding 3,500 kg,

(a) the same mode, gear(s)/gear ratio(s), gear weighting factor k and partial power factor k_P as determined during the type approval process may be used, provided this information is available from the type approval test report for the applicable vehicle variant of the family. If not, this information shall be determined anew. The test report shall document which way of data processing was selected;

(b) the test mass m_t of the vehicle shall be between $0.9m_{ro} \leq m_t \leq 1.2m_{ro}$.

Notwithstanding the provisions of paragraph 2.2.3.4.2. on tyre conditioning for testing, manufacturer may use a simplified conditioning according to the vehicle manufacturers specification to avoid excessive use of the tyres during the conditioning.

2.2. Compressed air noise

Vehicles having maximum mass exceeding 2,800 kg and equipped with compressed air systems shall be subjected to an additional test for measurement of the compressed air noise as described in paragraph 1. of Annex 5.

2.3. Additional Sound Emission Provisions (ASEP)

The vehicle manufacturer shall assess the compliance with ASEP by an appropriate evaluation (for example, but not limited to, part checks) or may perform the test described in Annex 7.

3. Sampling and evaluation of the results

One vehicle shall be chosen and subjected to the tests set out in point 2. If the sound level of the vehicle tested does not exceed by more than 1 dB(A) the limit value specified in paragraph 6.2.2. of this Regulation, and, where appropriate, paragraph 3. of Annex 5, the vehicle type shall be considered to conform to the requirements of this Regulation.

If one of the test results does not fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation two more vehicles of the same type shall be tested pursuant to paragraph 2. above.

If the test results for the second and the third vehicle fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation, the vehicle is considered in compliance with regard to the COP.

If one of the test results of the second or third vehicle does not fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation the vehicle type shall be considered not to conform to the requirements of this Regulation and the manufacturer shall take the necessary measures to re-establish the conformity.

Annex 7

Measurement method to evaluate compliance with the Additional Sound Emission Provisions

Only applicable for vehicles as specified in paragraph 6.2.3. of this Regulation

1. General (see the flowchart in Appendix 2, Figure 1)

This annex describes a measurement method to evaluate compliance of the vehicle with the additional sound emission provisions (ASEP) conforming to paragraph 6.2.3. of this Regulation.

It is not mandatory to perform actual tests when applying for type-approval. The manufacturer shall sign the declaration of compliance set out in Appendix 1. The approval authority may ask for additional information about the declaration of compliance and carry out the tests described below.

The procedure set out in this annex requires the performance of a test in accordance with Annex 3.

If the tests according to Annex 7 are carried out in the course of type approval, all tests either for Annex 3 and for Annex 7 shall be carried out on the same test track and under similar environmental conditions.[33]

If Annex 7 tests are carried out when type approval has already been granted, e.g. during tests for conformity of production or for in-use compliance, the tests in motion specified in Annex 3 shall be carried out with the same mode, gear(s)/gear ratio(s), gear weighting factor k and partial power factor k_P as determined during the type approval process.

The test results of Annex 3 shall be used within Annex 7 without any temperature correction.

2. Measurement method (see the flowchart in Appendix 2, Figure 3)

2.1. Measurement instruments and condition of measurements

Unless otherwise specified, the measurement instruments, the conditions of the measurements and the condition of the vehicle are equivalent to those specified in Annex 3, paragraphs 1. and 2.

If the vehicle has different modes which affect sound emission, all modes shall comply with the requirements in this annex. In the case where the manufacturer has performed tests to prove to the approval authority compliance with the above requirements, the modes used during those tests shall be reported in a test report.

2.2. Method of testing

[33] Measurements for Annex 7 for a particular vehicle type may be carried out on a different test tracks or under different environmental conditions, each according to the provisions of this Regulation, if the test results of the lower gear used for the calculation of L_{urban} in Annex 3 and representing the anchor point, do not differ by more the +/- 1.0 dB from the test results at the time when the tests according to Annex 3 have been carried out.

Unless otherwise specified, the conditions and procedures of Annex 3 shall be used. For the purpose of this annex, one run per test condition is measured and evaluated.

2.3. Control range

The ASEP requirements apply to every gear ratio κ that leads to test results within the control range as defined below.

Vehicle speed $V_{AA'\_ASEP}$: $v_{AA'} \geq 20$ km/h

Vehicle acceleration a_{WOT_ASEP}: $a_{WOT} \leq 5.0$ m/s^2

Engine speed $n_{BB'\_ASEP}$ $n_{BB'} \leq 2.0 * PMR^{-0.222} * S$ or

$n_{BB'} \leq 0.9 * S$, whichever is the lowest

Vehicle speed V_{BB_ASEP}:

If the vehicle, in the lowest valid gear does not achieve the maximum engine speed $n_{BB'\_ASEP}$ below 70 km/h, increase the vehicle speed in that gear to reach the maximum engine speed $n_{BB'\_ASEP}$, but not beyond 80 km/h.

For any other gear, the maximum vehicle speed is 70 km/h.

For vehicles tested in non-locked transmission conditions, the maximum vehicle speed is 80 km/h.

Gears $\kappa \leq$ gear i as determined in Annex 3

Transmission conditions:

Annex 3 gear selection	*Annex 7 gear selection*
Locked	$Gear_i$, $gear_{i-1}$,…
Non-locked	Non-locked

2.4. Target conditions

The sound emission shall be measured in each valid gear ratio at the four test points as specified below. For all test points the boundary conditions as specified in paragraph 2.3. shall be met.

The gear ratio is valid if all four points and the anchor point meet the specifications of paragraph 2.3. above. Any gear ratio for which this criteria is not fulfilled is invalid and not analysed further.

The first test point P_1 is defined by using an entry speed $v_{AA,\kappa 1}$ of 20 km/h ≤ $v_{AA,\kappa 1}$ < 20 km/h + 3 km/h.

For P_1, if a stable acceleration condition according to the definition of 2.26.1 cannot be achieved, the speed $v_{AA,\kappa 1}$ shall be increased in steps of 5 km/h until a stable acceleration is reached.

For all points, stable acceleration condition according to the definition of 2.26.3. shall be verified by comparing the acceleration $a_{wot\_test,AA\text{-}BB}$ calculated between line AA' and line BB' with the acceleration $a_{wot\_test,PP\text{-}BB}$ calculated between line PP' and BB'.

If the ratio $a_{wot\_test,PP\text{-}BB}$ / $a_{wot\_test,AA\text{-}BB}$ does not exceed or is equal to 1,20, then proceed with the acceleration calculation between line AA' and Line BB'.

If the ratio $a_{wot\_test,PP\text{-}BB}$ / $a_{wot\_test,AA\text{-}BB}$ does exceed 1,20, then proceed with the acceleration calculation between line PP' and line BB'.

In case of non-locked transmission conditions where n_{BB_ASEP} is exceeded during the test, the following measures shall be considered separately or together:

- provisions of paragraph 2.5.1.
- increased speed in steps of 5 km/h.

The test speed for the fourth test point P_4 in any gear is defined by either

- $0.95 \times n_{BB\_ASEP} \leq n_{BB,\kappa4} \leq n_{BB\_ASEP}$ or

v_{BB_ASEP} - 3 km/h $\leq V_{BB,\kappa4} \leq V_{BB\_ASEP}$ with V_{BB_ASEP} as defined in paragraph 2.3. The test speed for the other two test points is defined by the following formula:

Test Point P_j: $v_{BB,\kappa j} = v_{BB,\kappa1} + ((j - 1) / 3) * (v_{BB,\kappa4} - v_{BB,\kappa1})$ for j = 2 and 3 with a tolerance of ±3 km/h

Where:

$v_{BB,\kappa1}$ = vehicle speed at BB' of test point P_1

$v_{BB,\kappa4}$ = vehicle speed at BB' of test point P_4

2.5. Test of the vehicle

2.5.1. The path of the centreline of the vehicle shall follow line CC' as closely as possible throughout the entire test, starting from the approach of the reference point according to definition 2.11. of the main body to line AA' until the rear of the vehicle passes line BB'.

At line AA' the accelerator shall be fully depressed. To achieve a more stable acceleration according definition 2.26.2. or to avoid a down shift between line AA' and BB' pre-acceleration before line AA' may be used according to the provisions of paragraphs 3.1.2.1.2.1. and 3.1.2.1.2.2. of Annex 3. The accelerator shall be kept in depressed condition until the rear of the vehicle reaches line BB'.

In case of non-locked transmission conditions, the test may include a gear ratio change to a lower range and a higher acceleration. A gear change to a higher range and a lower acceleration is not allowed.

If possible, the manufacturer shall take measures to avoid that a gearshift leads to a condition not in compliance with the boundary conditions. For that, it is permitted to establish and use electronic or mechanical devices, such as alternate gear selector positions. If no such measures can be applied, the rationale shall be provided and documented in the technical report.

Table 1 in Appendix 1 to Annex 3 provides examples for valid measures to control the downshift of gears. Any measure used by manufacturer for the above-mentioned purposes shall be documented in the test report.

2.5.2. Measurements reading:

Per test point, one single run is carried out.

For every separate test run, the following parameters shall be determined and noted:

The maximum A-weighted sound pressure level of both sides of the vehicle, indicated during each passage of the vehicle according to paragraph 3.1.2.1.5. of Annex 3, shall be mathematically rounded to the first decimal place ($L_{wot,\kappa j}$). If a sound peak obviously out of character with the general sound pressure level is observed, the measurement shall be discarded. Left and right side may be measured simultaneously or separately. For further processing, the higher sound pressure level of both sides shall be used.

The vehicle speed readings at AA', PP' and BB' shall be rounded and reported with the first significant digit after the decimal place. ($v_{AA,\kappa j}$; $v_{PP,\kappa j}$; $v_{BB,\kappa j}$)

If applicable, the engine speed readings at BB' shall be reported as a full integer value ($n_{BB,\kappa j}$).

2.5.3. The calculated acceleration shall be determined in accordance to the formula in paragraph 3.1.2.1.2. of Annex 3 and reported to the second digit after the decimal place ($a_{wot,test,\kappa j}$).

3. Analysis method 1: Slope-Assessment

3.1. Determination of the anchor point

The anchor point is the same for each gear ratio κ falling under the control range according to paragraph 2.3. The parameters for the anchor point are taken from the acceleration test of Annex 3 as follows:

In the case the test has been carried out with two gear ratios:

L_{anchor} is the higher sound pressure level of $L_{wot,(i)}$ of left and right side of gear ratio i;

n_{anchor} is the average of $n_{BB,wot}$ of the 4 runs of gear ratio i reported from Annex 3;

In the case the test has been carried out in a single gear:

L_{anchor} is the higher sound pressure level of L_{wot} of left and right side of gear ratio selected for the test;

n_{anchor} is the average of $n_{BB,wot}$ of the 4 runs of gear ratio selected for the test reported from Annex 3;

3.2. Slope of the regression line for each gear ratio κ

The sound measurements shall be evaluated as function of engine speed according to paragraph 3.2.1.

3.2.1. Calculation of the slope of the regression line for each gear ratio κ

The linear regression line is calculated using the anchor point and the four correlated additional measurements with the results for engine speeds and sound levels as reported under 2.5.2. of this annex.

$$Slope_k = \frac{\sum_{j=1}^{5}(n_j - \overline{n})(L_j - \overline{L})}{\sum_{j=1}^{5}(n_j - \overline{n})^2} \text{ (in dB(A)/1,000 min}^{-1}\text{)}$$

$$\text{With} \quad \overline{L} = \frac{1}{5}\sum_{j=1}^{5} L_j \quad \text{and} \quad \overline{n} = \frac{1}{5}\sum_{j=1}^{5} n_j \ ;$$

Where n_j = engine speed measured at line BB'

3.2.2. Slope of the regression line for each gear ratio κ

The $slope_\kappa$ of a particular gear for the further calculation is the derived result of the calculation in paragraph 3.2.1. rounded to the first decimal place, but not higher than 5 dB(A)/1,000 min^{-1}.

In case of non-locked conditions, if $Slope_\kappa < 0$, the selected transmission setup is not valid. In that case the L_{urban}-Assessment as specified in paragraph 4. shall be applied.

3.3. Calculation of the linear sound level increase expected for each measurement

The sound level $L_{ASEP,\kappa j}$ for measurement point j and gear ratio κ shall be calculated using the engine speeds measured for each measurement point, using the slope specified in paragraph 3.2. above to the specific anchor point for each gear ratio.

For $n_{BB\_\kappa,j} \leq n_{anchor}$: $L_{ASEP\_\kappa,j} = L_{anchor} + (Slope_\kappa - Y) * (n_{BB\_\kappa,j} - n_{anchor}) / 1{,}000$

For $n_{BB\_\kappa,j} > n_{anchor}$: $L_{ASEP\_\kappa,j} = L_{anchor} + (Slope_\kappa + Y) * (n_{BB\_\kappa,j} - n_{anchor}) / 1{,}000$

Where Y= 1

3.4. Additional Samples

On request of the type approval authority, two additional runs within the boundary conditions according to paragraph 2.3. of this annex shall be carried out.

3.5. Specifications

Every individual sound measurement shall be evaluated.

The sound level of every specified measurement point shall not exceed the limits given below:

$L_{\kappa j} \leq L_{ASEP\_\kappa.j} + x$

With:

$x = 3$ dB(A) + limit value[34] - L_{urban} for vehicle tested with non-locked transmission conditions

[34] As applicable for the approved type of vehicle

x = 2 dB(A) + limit value[35] - L_{urban} of Annex 3 for all other vehicles

If the measured sound level at a point exceeds the limit, two additional measurements at the same point shall be carried out to verify the measurement uncertainty. The vehicle is still in compliance with ASEP, if the average of the three valid measurements at this specific point fulfils the specification.

4. Analysis method 2: L_{urban} Assessment

4.1. General

This evaluation procedure is an alternative selected by the vehicle manufacturer to the procedure described in paragraph 3. of this annex and is applicable for all vehicle technologies. It is the responsibility of the vehicle manufacturer to determine the correct manner of testing. Unless otherwise specified, all testing and calculation shall be as specified in Annex 3 to this Regulation.

The measurement method is defined in paragraph 2. Each testing point shall be evaluated individually.

4.2. Calculation of ΔL_{urban_ASEP}

4.2.1. Data-processing

From any L_{wot_ASEP} as measured according to this annex, ΔL_{urban_ASEP} shall be calculated as follows:

(a) Calculate $a_{wot\_test\_ASEP}$ using acceleration calculation from paragraph 3.1.2.1.2.1. or 3.1.2.1.2.2. of Annex 3 to this Regulation, as applicable;

(b) Determine the vehicle speed (v_{BB_ASEP}) at BB during the L_{wot_ASEP} test;

(c) Calculate k_{P_ASEP} as follows:

$k_{P\_ASEP} = 1 - (a_{urban} / a_{wot\_test\_ASEP})$

Test results where $a_{wot\_test\_ASEP}$ are less than a_{urban} shall be disregarded.

(d) Calculate $L_{urban\_measured\_ASEP}$ as follows:

$L_{urban\_measured\_ASEP} = L_{wot\_ASEP} - k_{P\_ASEP} * (L_{wot\_ASEP} - L_{\_crs\ rep})$

For further calculation, use the L_{urban} from Annex 3 to this Regulation without rounding, including the digit after the decimal (xx.x).

(e) Calculate $L_{urban\_normalized}$ to normalize the speed from v_{BB_ASEP} to 50 km/h as follows:

$L_{urban\_normalized} = L_{urban\_measured\_ASEP} - (0.15 * (V_{\_BB\_ASEP} - 50))$

(f) Calculate the deviation ΔL_{urban_ASEP} relative to L_{urban} as follows:

$\Delta L_{urban\_ASEP} = L_{urban\_normalized} - L_{urban}$ –4.2.2. Specifications

Compliance with limits:

ΔL_{urban_ASEP} shall be less than or equal to 3.0 dB(A) + limit value[36] - L_{urban}5. Reference sound assessment (see the flowchart in Appendix 2, Figure 2)

5.1. General

[35] As applicable for the approved type of vehicle

[36] As applicable for the approved type of vehicle

The reference sound can be obtained by simulation or from direct measurement. The result of one assessment method has to comply with the specification of paragraph 5.4.

5.1.1. Simulation method[37]

For simulation, the reference sound is assessed at a single point in one discrete gear, simulating an acceleration condition assuming an exit speed $v_{BB'}$ equal to 61 km/h. The sound compliance is calculated using the slope results of paragraph 3.2.2.

If the result of slope of 3.2.2. is not available for the gear specified in paragraph 5.2, this slope of the missing gear can be determined according to paragraphs 2.4., 3.1. and 3.2.

5.1.2. Direct measurement method

For direct measurement, the reference sound is assessed at a single run in an acceleration condition started at line AA' as specified in paragraph 2.5. The gear shall be as specified in paragraph 5.2. for vehicles tested in locked condition or in a gear selected position for normal driving as specified by the manufacturer for vehicles tested in non-locked condition.

The target test speed v_{AA} is equal to 50 km/h ± 1 km/h unless v_{BB} exceeds 61 km/h.

If v_{BB} exceeds 61 km/h, the target test speed v_{BB} shall be set to 61 km/h ± 1 km/h. The entry speed shall be adjusted to achieve the target test speed.

5.2. The determination of gear α is as follows:

- α = 3 for manual transmission and for automatic transmission tested in locked position with up to 5 gears;

- α = 4 for manual transmission and for automatic transmission tested in locked position with 6 or more gears. If the acceleration calculated from AA to BB + vehicle length in gear 4 exceeds 1.9 m/s², the first higher gear α > 4 with an acceleration lower than or equal to 1.9 m/s² shall be chosen. If there is no gear with an acceleration less than or equal to 1.9 m/s² available, the highest available gear shall be chosen.For vehicles tested under non-locked condition , the gear ratio for further calculation shall be determined from the acceleration test result in Annex 3

For vehicles tested under non-locked condition, the gear ratio for further calculation shall be determined from the acceleration test result in Annex 3 using the reported engine speed and vehicle speed at line BB'.

5.3. Data-processing for simulation assessment5.3.1. Determination of reference engine speed $n_{BB'\_ref\_\alpha}$

The reference engine speed, $n_{BB'\_ref\_\alpha}$ shall be calculated using the gear ratio of gear α at the reference speed of $v_{BB'\_ref}$ = 61 km/h.

5.3.2. Calculation of L_{ref}

$$L_{ref} = L_{anchor} + Slope_{\alpha} * (n_{BB'\_ref\_\alpha} - n_{anchor}) / 1{,}000$$

[37] Simulation may not always be applicable as the test result of Annex 3 and the elaborated slopes according to paragraph 3. of Annex 7 might not provide consistent data for the simulation. In that case, it is recommended to carry out direct measurements.

5.4. Specifications

For vehicles of category M_1, L_{ref} shall be less than or equal to 76 dB(A).

For vehicles of category M_1 fitted with a manual transmission having more than four forward gears and equipped with an engine developing a rated maximum net power greater than 140 kW (according to Regulation No. 85) and having a maximum-power/maximum-mass ratio greater than 75, L_{ref} shall be less than or equal to 79 dB(A).

For vehicles of category M_1 fitted with an automatic transmission having more than four forward gears and equipped with an engine developing a rated maximum net power greater than 140 kW (according to Regulation No. 85) and having a maximum-power/maximum-mass ratio greater than 75, L_{ref} shall be less than or equal to 78 dB(A).

For vehicles of category N_1 with a technically permissible maximum laden mass below 2,000 kg, L_{ref} shall be less than or equal to 78 dB(A).

For vehicles of category N_1 with a technically permissible maximum laden mass above 2,000 kg and below 3,500 kg, L_{ref} shall be less than or equal to 79 dB(A).

For vehicles of category M_1 and N_1 equipped with a compression-ignition and direct injection internal combustion engine, the sound level shall be increased by 1 dB(A).

For vehicles of category M_1 and N_1 designed for off-road use and with a technically permissible maximum laden mass above 2 tonnes, the sound level shall be increased by 1 dB(A) if they are equipped with an engine having a rated maximum net power of less than 150 kW (according to UN Regulation No. 85) or by 2 dB(A) if they are equipped with an engine having a rate maximum net power of 150 kW (according to UN Regulation No. 85) or higher.

Annex 7 – Appendix 1

Statement of compliance with the additional sound emission provisions

(Maximum format: A4 (210 x 297 mm))

..... (Name of manufacturer) attests that vehicles of this type ..... (type with regard to its sound emission pursuant to Regulation No. 51) comply with the requirements of paragraph 6.2.3. of Regulation No. 51.

..... (Name of manufacturer) makes this statement in good faith, after having performed an appropriate evaluation of the sound emission performance of the vehicles.

Date: .....

Name of authorized representative: .....

Signature of authorized representative: .....

Annex 7 – Appendix 2

Figure 1
Flowchart for the assessment concept for ASEP according to Annex 7

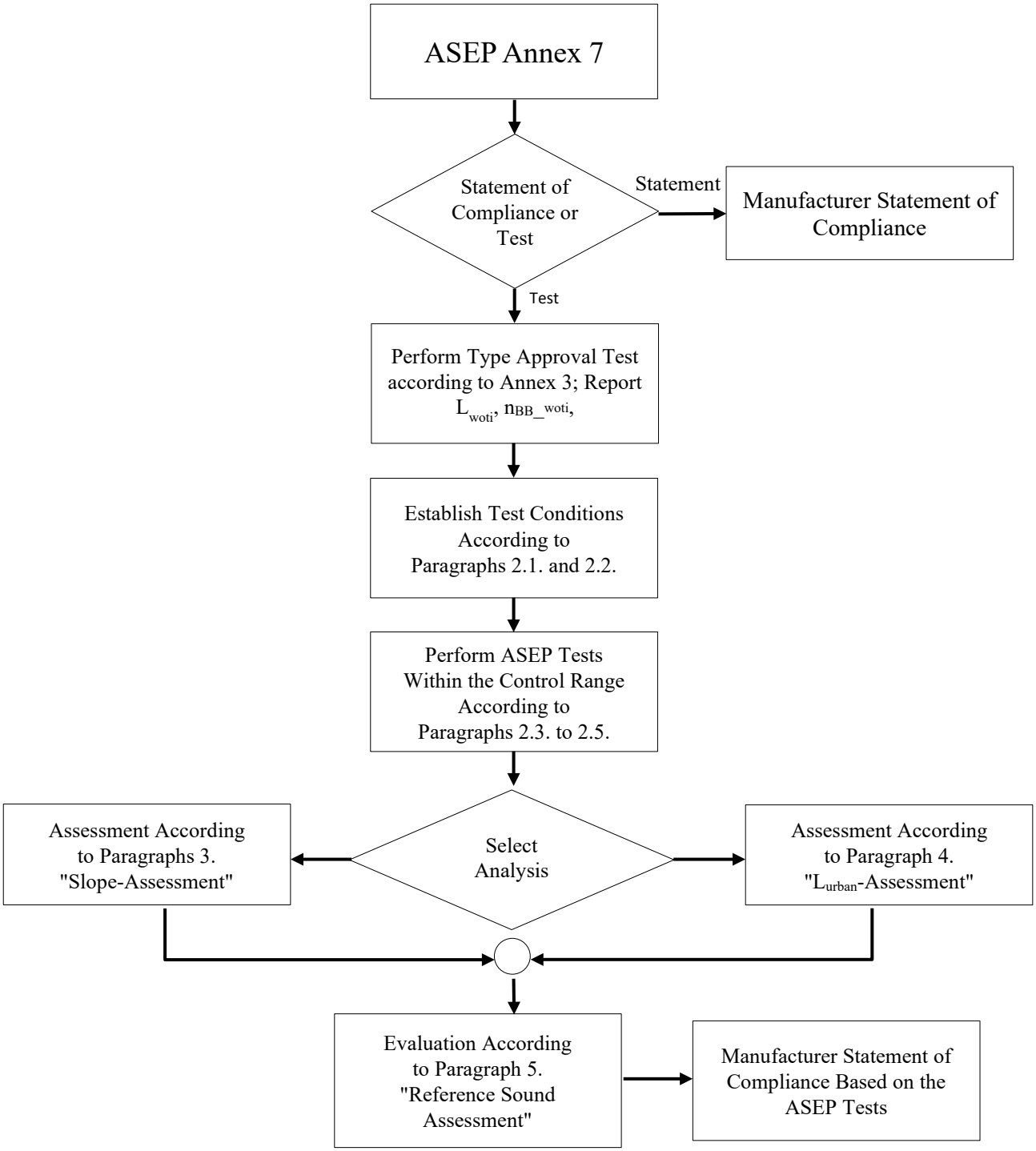


Figure 2
Flowchart for the vehicle sound assessment according to Annex 7, paragraph 5. "Reference sound assessment"

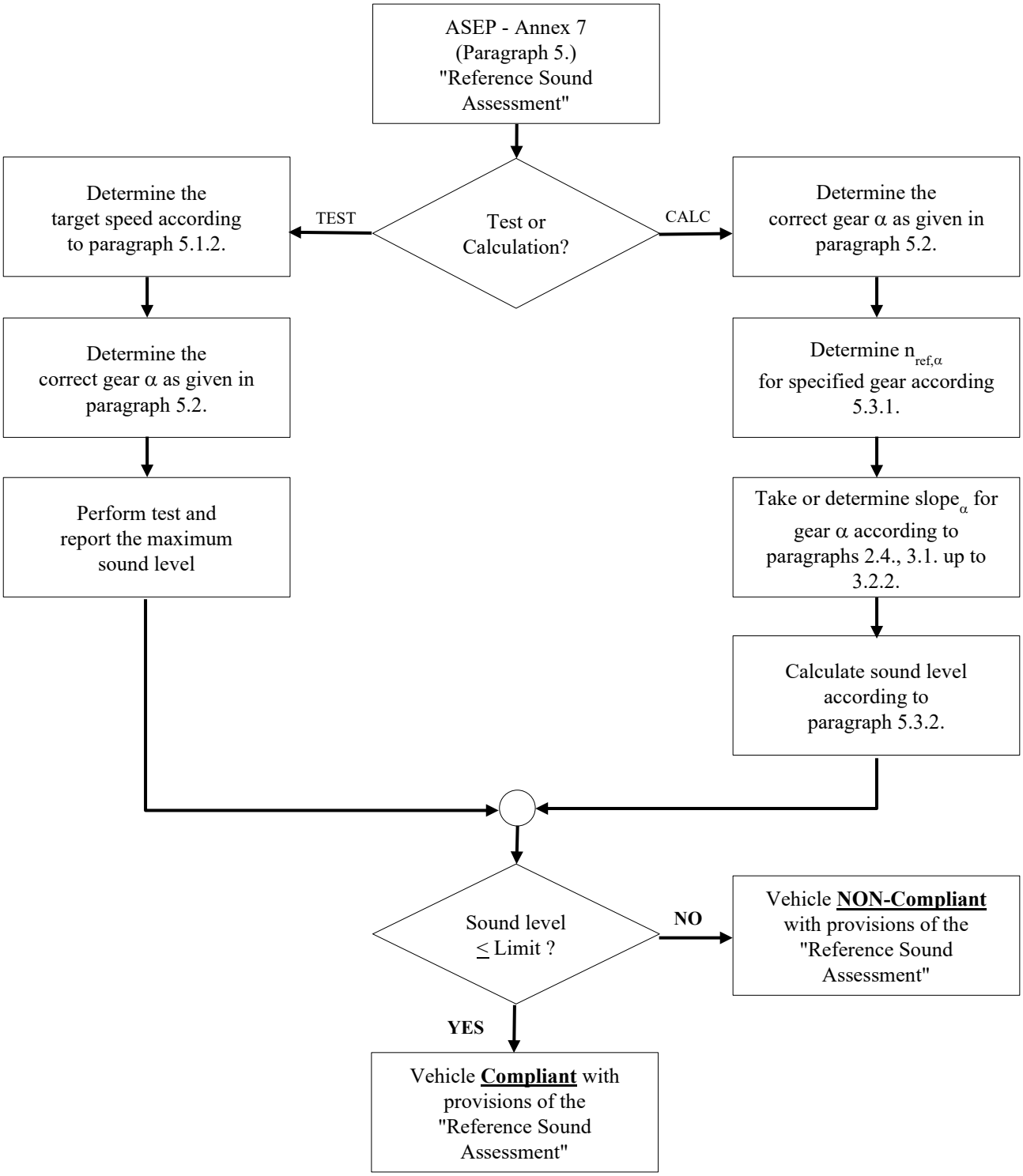
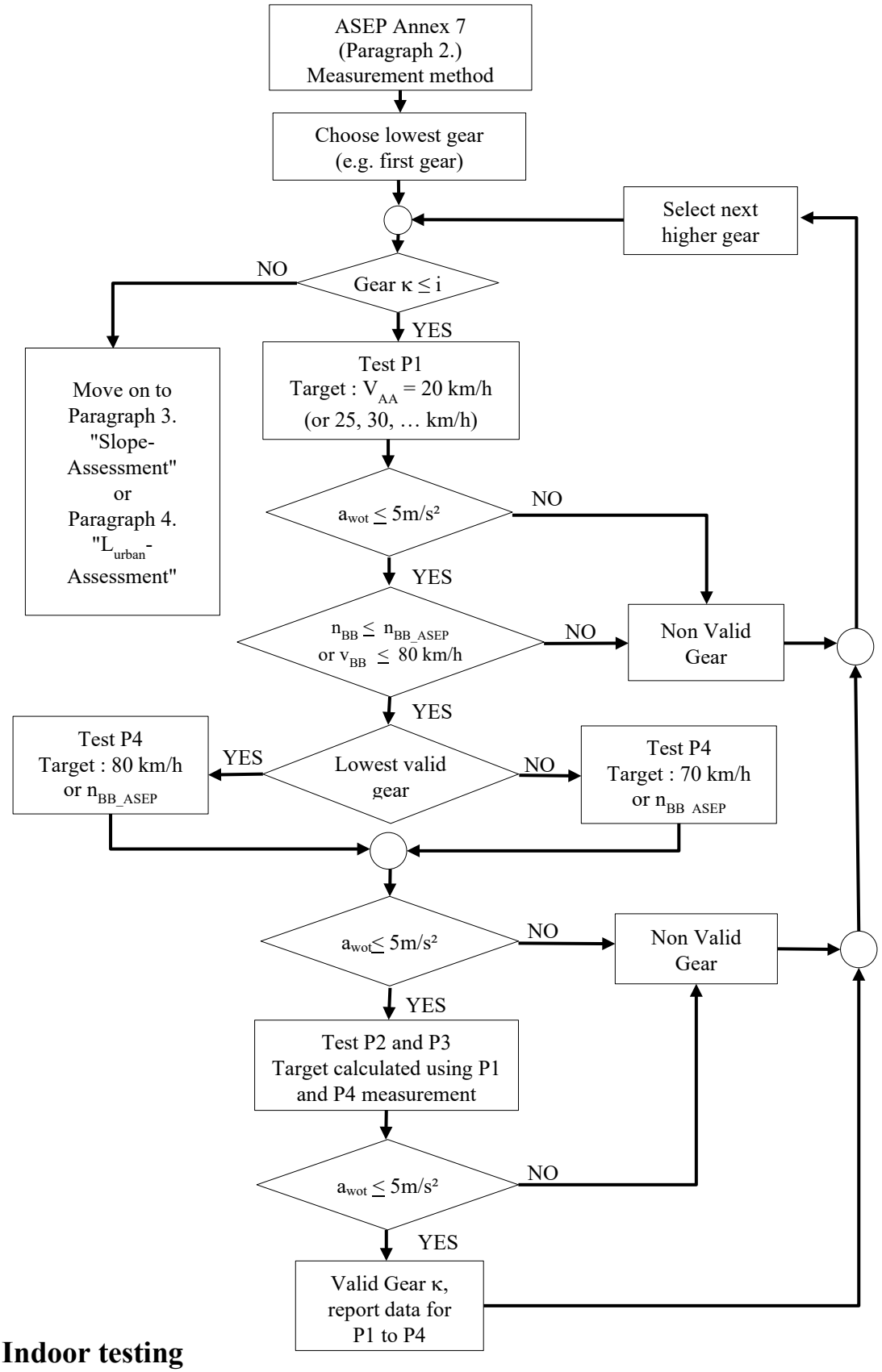

ASEP - Annex 7
(Paragraph 5.)
"Reference Sound
Assessment"
Test or
Calculation?
TEST
CALC
Determine the
target speed according
to paragraph 5.1.2.
Determine the
correct gear α as given in
paragraph 5.2.
Perform test and
report the maximum
sound level
Determine the
correct gear α as given in
paragraph 5.2.
Determine n ref,α
for specified gear according
5.3.1.
Take or determine slope α for
gear α according to
paragraphs 2.4., 3.1. up to
3.2.2.
Calculate sound level
according to
paragraph 5.3.2.
Sound level
≤ Limit ?
NO
YES
Vehicle NON-Compliant
with provisions of the
"Reference Sound
Assessment"
Vehicle Compliant with
provisions of the
"Reference Sound
Assessment"

Figure 3
Flowchart for the determination of the individual test points P_j according to Annex 7, paragraph 2. "Measurement method"



Annex 8

Indoor testing

Indoor testing is only for Annex 3 and Annex 7 measurements.

1. Documentation for indoor application

Documentation shall include:

(a) Validation of facility, e.g. free field propagation, dyno and air handling background noise level, dyno dynamic performance, software.
(b) Procedures to be applied for indoor testing, e.g. dyno and software set-up, loading and tie-down, air-handling and vehicle's temperature management.
(c) Coast down and tyre sound level data used for calculation of dynamometer load coefficients and tyre sound data used for determination of final reported results.
(d) Test results on a representative selection of the manufacturer's production to demonstrate that indoor testing delivers comparable results as outdoor testing within acceptable accuracy.

2. Vehicle tested indoor using Variant A

Indoor pass-by test is simulated by measurement of power train sound on the dynamometer and energetical addition of the tyre/road sound (measured separately on an outdoor test track).

2.1. General

This method is a combination of indoor testing (power train sound) and outdoor testing (tyre/road sound). It is not necessary to repeat the measurement of the tyre/road sound every time a vehicle is tested. The data of several tyres can be stored in a database and a matching data set from the database can then be used for the test.

2.2. Power train sound

It shall be ensured that there is no remaining tyre/road sound affecting the measurements. In any case it shall be ensured that the remaining tyre/road sound shall be at least 10 dB below the maximum A-weighted sound pressure level produced by the vehicle under test. If this condition cannot be fulfilled, a correction shall be carried out. This correction procedure is described in ISO 362-3:2016 Annex B, paragraph B.6.

The vehicle shall be measured according to the operating condition specified in paragraphs 3.1.2.1. or 3.1.2.2. of Annex 3 of this Regulation.

2.3. Tyre/road sound

The measurements of the tyre/road sound shall be performed on a test track as described paragraph 2.1.1. of Annex 3 of this Regulation. The evaluation of tyre/road sound consists of two procedures, namely:

(a) Evaluation of free rolling sound as described in Appendix 3 of Annex 3;

(b) Evaluation of tyre/road sound including torque influence which can be derived from a) by a simplified method.

All conditions for evaluation of tyre/road sound shall be done according to paragraph 3. of this Annex.

2.4. Calculation of the total vehicle sound

The total vehicle sound is the energetical sum of tyre/road sound and power train sound. This calculation shall be carried out for each single run as describe in ISO 362-3.2016, paragraph 10.2.4.

3. Procedure for measurement, evaluation, and calculation of tyre/road sound when using variant A

All conditions for evaluation of tyre/road sound, free rolling sound, and torque influence are described in ISO 362-3:2016, Annex B.

4. Adjustment of room dimensions

To cater for the smaller size test rooms, the maximum levels shall be evaluated with caution though to avoid missing them according to ISO 362-3:2016, Annex E.

Annex 9

Measurement method to evaluate compliance with the Real Driving Additional Sound Emission Provisions (RD-ASEP)

1. General

The Real Driving Additional Sound Emission Provisions (RD-ASEP) apply ~~only~~ to all vehicles of categories M_1 and N_1 **with the exception of those listed in point 6.2.3.**~~equipped with:~~

~~- an internal combustion engine (ICE) for propulsion of the vehicle, or~~

~~- any other propulsion technology fitted with an 6.2.3exterior sound enhancement system.~~

1.1. Notwithstanding the provisions of Annex 7, paragraph 1., section 4 inclusive its footnote, tests according to Annex 9 done in the course of type approval shall be witnessed by the Authority present during the tests.

Tests shall be carried out on the same test track and under similar environmental conditions subject to the limitations in paragraph 3.3.

1.2. ~~Exemptions~~

~~Notwithstanding the requirements above, vehicles which have no ICE for propulsion are exempted from RD-ASEP, if a sound enhancement system is fitted to the vehicle solely for the purpose of fulfilling the provisions of UN Regulation No. 138, and the sound emitting device (AVAS) does not emit a sound pressure level of more than 75 dB(A)[38] under any operation conditions exceeding the specification range of UN Regulation No.138.~~

1.3. All symbols' abbreviations and acronyms used in this Annex are listed and defined in Appendix 3 to this Annex.

1.4. All formulas used in this Annex and Appendix 1 are listed in Appendix 4 to this Annex.

2. Definitions

2.1. "*Exhaust silencing system with variable geometry*" means a silencing system, not including pressure charging, containing one or more active, passive, or self-actuated moving parts or devices.

These parts or devices will cause a change of the gas flow through the exhaust silencing system and result in a change of the sound reduction performance, by opening or closing one or more valves in the exhaust gas flow as a function of varying driving or engine conditions (engine speed, load, vehicle speed, etc.).

Active devices mean actuators, controlled by any means.

Passive or self-actuated devices mean units controlled by exhaust flow.

2.2. ~~"*Exterior sound enhancement system*" means a system that is installed to a vehicle for producing exterior sound, such as but not limited to sound actuators, either integrated into an exhaust silencing system or mounted as an individual unit.~~

[38] See footnote 4 in paragraph 6.2.8. of UN Regulation No. 138 "The maximum overall sound pressure level of 75 dB(A) measured at a distance of 2 m is corresponding to the overall sound pressure level of 66 dB(A) measured at a distance of 7,5 m."

2.2. "*Deceleration*" means the vehicle deceleration stipulated by the release of the acceleration control unit only, without any driver applied braking (service brake, retarder, parking brake, etc…).

2.3. "*Performance*" means the product of acceleration and vehicle speed as quantity of the achieved vehicle performance.

2.4. "~~*Power trains*~~ ***Powertrain***" means a propulsion system as combination of the energy storage system, the energy supply system and the powertrain according to the UN Mutual Resolution No. 2 (for example PEV, HEV, FCHEV).

3. Facilities

3.1. Due to spatial limitations of test facilities[39] not every test condition may be performed on every test facility.

3.2. Notwithstanding such restrictions, the RD-ASEP tests shall be done on these test facilities.

3.3. Tests for Annex 9 may be carried out on different test facilities[40] in case of facility limitation(s). However, it is recommended to carry out all tests on one test facility and under similar environmental conditions to reduce measurement uncertainties.

4. Measurement method

4.1. Measurement instruments and condition of measurements

Unless otherwise specified, the measurement instruments, the conditions of the measurements and the condition of the vehicle are equivalent to those specified in Annex 3, paragraphs 1. and 2.

4.2. Method of testing

Unless otherwise specified, the conditions and procedures of Annex 3, paragraphs 3.1. to 3.1.2.1.2.2. shall be used. For the purpose of this Annex, single test runs are performed and evaluated.

4.3. Control range

A measurement for RD-ASEP is valid, if all parameters are within the specifications of the table below during the test run between lines AA' and BB'.

Parameter	*Minimum*	*Maximum*
Vehicle Speed	> 0 km/h at line AA'	100 km/h at line BB'
Acceleration	0 m/s^2	4 m/s^2
Performance	0 m^2/s^3	35 m^2/s^3

[39] Facilities may provide restriction for safety reasons, such as for vehicle speed.

[40] Tests for Annex 3, Annex 7, and Annex 9 may be carried out on different test facilities if documentation exists that demonstrates that the differences in sound performance are neglectable.

Parameter	*Minimum*	*Maximum*
Gear	ANY for forward driving	
Mode	ANY	

In any operation condition, the engine speed of a vehicle, which can be propelled with an ICE operating, is limited to 80% of S.

4.4. Target operation conditions

The target operation condition for a single test run is randomly selected by the authority present during the tests carried out for type approval.

The operation condition during measurements per run is defined by

- the gear selector position,
- the vehicle mode,
- the vehicle entry speed at line AA', and
- the percentage of accelerator depression, either for constant speed or in steps of 25 % acceleration depression.

The manufacturer may establish a mechanical or electronic device to enable the requested percentage of accelerator depression.

The requested accelerator depression shall be achieved during the test with a tolerance of ± 10 % of full range.

The requested vehicle speed at AA' shall be achieved during the test with a tolerance of ± 3 km/h.

If under the chosen operation condition, a stable acceleration according to paragraph 2.26.1. of the main body cannot be enabled, the authority present during the test shall decide how to modify the operation condition (e.g. different gear selector position, speed, acceleration, driving mode).

The chosen operation condition shall result in a run within the control range. Each operation condition shall differ substantially from the test conditions of Annex 3 and all other operation conditions already chosen for this type approval already carried out under this Annex. For vehicles with a combustion engine for propulsion, the operating conditions shall be chosen to differ substantially in engine speed.

The number of operation conditions per vehicle in total is dependent on the vehicles technology and provided by the table below.

	D-Range	*M (locked)*
Automatic Transmissions (lockable)	5	10
Automatic Transmissions (non-lockable)	15	n.a.(*)
Vehicles with only one gear	15	n.a.(*)
Manual Transmissions	n.a.(*)	15

(*) Not applicable

The operation conditions and test results shall be entered into the test report sheet according to the table of the Appendix 5 to this Annex.

4.5. Test of the vehicle

4.5.1. The path of the centerline of the vehicle shall follow line CC' as closely as possible throughout the entire test, starting from the approach of the reference point according to definition in paragraph 2.11. of the main body to line AA' until the rear of the vehicle passes line BB' + 20 m.

The accelerator shall be positioned such to achieve the requested operation condition for this run latest when the reference point of the vehicle reaches line AA'. The accelerator shall be kept in its position until the rear of the vehicle passes line BB'. The accelerator shall then be fully released between BB' and BB'+ 5 m and kept in this released position until the rear of the vehicle passes the line BB'+20 m.

4.5.2. Non-locked transmissions

In case of non-locked transmission conditions, the test may include a gear change to a lower range and a higher acceleration under accelerated conditions.

A gear change to a higher range could occur under cruise and low load acceleration conditions. Such upshifts shall be avoided. The authority present during the test shall modify operation conditions so that these upshifts are avoided between AA' and BB'.

In the approach to line AA', the vehicle shall be driven in a way to allow the transmission to stabilize the gear.

4.5.3. Measurement readings

Per operation condition, one test run is carried out.

If a measurement within the control range is invalid due to background noise disturbances, wind gusts or other reasons, the measurement shall be discarded and repeated.

For every test run, the following parameters shall be determined and noted:

- The maximum A-weighted sound pressure level of both sides of the vehicle, indicated during each passage of the vehicle between the two lines AA' and BB' + 20 m, shall be measured and shall be mathematically rounded to the first decimal place (L_{TEST}).

  If a sound peak obviously out of character with the general sound pressure level is observed, the measurement shall be discarded.

  For further processing, the higher sound pressure level of both sides shall be used.

- The vehicle speed reading at lines BB', when the rear end of the vehicle passes this line, shall be rounded and reported with the first significant digit after the decimal place ($v_{BB'\_TEST}$).

- If applicable, the engine speed readings at line AA' and BB' shall be rounded to 10 min^{-1} and reported ($n_{AA'\_TEST}$; $n_{BB'\_TEST}$).

All measured values shall be entered into the test report sheet according to the table of Appendix 5 to this Annex.

4.5.4. Calculated values

All calculated values shall be entered into the test report sheet according to the table of Appendix 5 to this Annex.

4.5.4.1. Acceleration a

The accelerations shall be calculated between lines PP' to BB', in accordance with the formula provided in paragraph 3.1.2.1.2.2. of Annex 3 and be reported to the second digit after the decimal place (a_{TEST}) as results.

4.5.4.2. Performance $v \cdot a$

The performance shall be calculated from the reported vehicle speed at line BB' and the acceleration result from paragraph 4.5.4.1. and rounded to the first digit after the decimal place.

4.5.4.3. Expected sound pressure level L_{TEST_EXP}

For the calculation of the expected sound pressure level per test run, the measured values according to paragraph 4.5.3. and calculated values according to paragraphs 4.5.4.1. and 4.5.4.2. shall be used. All calculations are done according to Appendix 1 to this Annex.

5. Compliance assessment

5.1. Case 1

The compliance of the vehicle is acceptable if the measured sound pressure levels of all valid test runs are lower than or equal to the expected sound pressure levels of paragraph 4.5.4.3.

$L_{TEST} \leq L_{TEST\_EXP}$

5.2. Case 2

If not more than two valid runs of the specified runs exceed the expected sound pressure level of paragraph 4.5.4.3. by not more than 2 dB the compliance of the vehicle is acceptable.

5.3. Case 3

If more than two valid runs of the specified runs exceed the expected sound pressure level of paragraph 4.5.4.3. then the vehicle is non-compliant with RD-ASEP.

5.4. Case 4

If one or more valid runs exceed the expected sound pressure level of paragraph 4.5.4.3. by more than 2 dB, the vehicle is non-compliant with RD-ASEP.

5.5 The case of compliance according to this paragraph 5 and the final result (compliance yes/no) have to be mentioned in the Test report of Appendix 5 to this Annex 9.

Annex 9 – Appendix 1

Sound Expectation Model

1. General

All the formulas and values coming from Annex 3 are identified with a suffix of '$_{ANCHOR}$' in the symbols.

For example, v_{TEST_ANCHOR} in Annex 9 is equal to v_{TEST} from Annex 3.

2. Extraction of parameters from measurements according to Annex 3

2.1. The procedure set out in this Annex requires the performance of tests in accordance with Annex 3.

2.2. Determination of reference data from Annex 3:

2.2.1. The necessary reference data to establish the sound expectation model are taken from the pass-by and from the cruise-by test of one gear of the Annex 3 tests.

2.2.1.1. In the case the test has been carried out with two gear ratios, the reported parameters for gear i shall be selected. In the case the test has been carried out in a single gear, the reported parameters for this single gear shall be selected.

2.2.1.2. The parameters taken from Annex 3 tests are in all cases the arithmetic average of the four valid runs as determined by the measurements in Annex 3. All values shall be taken over without any temperature or test track correction. The engine speed is not requested for Annex 3. However, for the purpose of Annex 9 it needs to be measured.

The parameters to be reported from the acceleration test are:

- The sound pressure level L_{ACC_ANCHOR} which is the higher value of the measured sound pressure levels of the left and right side of the vehicle, rounded to the first decimal. If applicable, the value shall be corrected according to Table 1 of the Appendix 1 to Annex 3, measures No. 3, sub Nos. 1 or 2.
- The vehicle speed $v_{BB'\_ACC\_ANCHOR}$ when the rear of the vehicle passes line BB', rounded to the first decimal.
- The engine speed $n_{BB'\_ACC\_ANCHOR}$ when the rear of the vehicle passes line BB', rounded to 10 min^{-1}. If applicable, the value shall be corrected according to Table 1 of the Appendix 1 to Annex 3, measures No. 3, sub Nos. 1 or 2.

The parameters to be reported from the constant speed test are:

- The sound pressure level L_{CRS_ANCHOR} which is the higher value of the measured sound pressure levels of the left and right side of the vehicle, rounded to the first decimal.
- The reference vehicle speed v_{TEST} is 50 km/h, unless the vehicle was tested in Annex 3 at a different vehicle speed. In this case use the reported vehicle speed $v_{BB'\_CRS\_ANCHOR}$, rounded to the first decimal.
- The engine speed $n_{BB'\_CRS\_ANCHOR}$ when the rear of the vehicle passes line BB', rounded to 10 min^{-1}.

2.3. Selection of parameter coefficients

The necessary coefficients are dependent on the vehicle design and listed in the table in Appendix 2 to this Annex.

2.3.1. Discrete Determination of the factor x

On request of the manufacturer the factor x may be determined by discrete coast-down measurement to determine LREF_TR directly, according to Appendix 3 of Annex 3 to this Regulation for the reference vehicle speed. Rounding and temperature correction shall not apply.

2.4. Calculate the Reference Tyre/Rolling Sound Level L_{REF_TR}

(Formula 2.4. of Appendix 4)

2.5. Calculate the Reference Power Train Mechanics Sound Level L_{REF_PT}

(Formula 2.5. of Appendix 4)

2.6. Calculate the Reference Dynamic Sound Level L_{REF_DYN}

(Formula 2.6. of Appendix 4)

2.7. Determine the Vehicle Dynamic Delta Sound Level ΔL_{DYN}

If the arithmetic sound level difference between the reported acceleration sound level L_{ACC_ANCHOR} and the reported constant speed sound level L_{CRS_ANCHOR} is at least 1.1 dB(A) or higher, the vehicle dynamic delta sound level ΔL_{DYN} is calculated by

(Formula 2.7. No.1 of Appendix 4, in junction with Formulas 2.7 Nos. 2 and 3 of Appendix 4)

If the arithmetic sound level difference between the reported acceleration sound level L_{ACC_ANCHOR} and the reported constant speed sound level L_{CRS_ANCHOR} is less than 1,1 dB, the vehicle dynamic delta sound level ΔL_{DYN} is set to 10 dB.

$\Delta L_{DYN} = 10$ dB

In cases where the arithmetic sum of sound energy adjusted reference tyres rolling sound $L_{REF\_TR\_ADJ}$ and the adjusted reference power train $L_{REF\_PT\_ADJ}$ is equal or greater than the sound energy of the anchor point L_{ACC_ANCHOR}, the vehicle dynamic delta sound level ΔL_{DYN} is set to 10 dB:

If

$10^{0.1x\,L_{REF\_TR\_ADJ}} + 10^{0.1xL_{REF\_PT\_ADJ}} \geq 10^{0.1x\,L_{ACC\_ANCHOR}}$

then $\Delta L_{DYN} = 10$ dB

2.8. Having established the sound expectation model for a given vehicle based on its particular pass-by test results according to Annex 3 of this Regulation, proceed to the single point evaluation for each test run performed according to paragraphs 4.4. and 4.5. of Annex 9.

3. Calculation of the expected sound level L_{TEST_EXP}

3.1. For each single test run, performed for the purpose of Annex 9, an expected sound level L_{TEST_EXP} shall be calculated.

3.2. Necessary input data for the sound model are taken from the pass-by measurement according to paragraph 4.5.1. of Annex 9.

3.2.1. For the calculation of the expected sound level the parameters listed in paragraphs 4.5.3. and 4.5.4.1. and 4.5.4.2. of Annex 9 are needed.

In addition, the vehicle speed to engine speed ratio κ_{TEST} of the test run shall be determined, expressed in km/h per 1000 min^{-1} and calculated by the formula below, rounded to the second decimal
(Formula 3.2.1. of Appendix 4)

3.2.2. Virtual engine speed for vehicles without internal combustion engine

When testing vehicles without an internal combustion engine for direct forward propulsion, an engine speed information will not be available. In such

cases the engine speed is simulated on the basis of the measured vehicle speed $v_{BB'\_TEST}$ by using a virtual uniform gear ratio of 30 km/h per 1000 min^{-1}.
(Formula 3.2.2. of Appendix 4)

3.2.3. Virtual engine speed for hybrid electric vehicles

In case that an internal combustion engine is mechanically coupled with drive axle whenever internal combustion engine is operating, this paragraph shall be applied.
In case of the other HEV systems, paragraph 3.2.4. shall be used.
Hybrid electric vehicle may have been tested in Annex 3 partly or fully in electric condition. For evaluation according to RD-ASEP, engine speeds and, if applicable corrected sound pressure levels, will have to be assigned to the cruise and the acceleration test.

3.2.3.1. Case 1 – Internal combustion engine is operational during acceleration test and constant speed test:

3.2.3.1.1. Assignment of engine speed

For the acceleration test and the constant speed test, use the engine speed information from the test result of Annex 3.

3.2.3.1.2. Adjustment of sound pressure level

No adjustment is applied.

3.2.3.2. Case 2 – Internal combustion engine is operational during acceleration test but not during the constant speed test:

3.2.3.2.1. Assignment of engine speed

For the acceleration test, use the engine speed information from the test result of Annex 3.
For the constant speed test, determine the highest gear in which the vehicle can drive at the target speed of the vehicle v_{TEST} (usually 50 km/h) as selected for the constant speed test in Annex 3. Calculate the engine speed with the gear ratio of that gear.

3.2.3.2.2. Adjustment of sound pressure level

No adjustment is applied to the acceleration test result.
The adjusted cruise test result $L_{CRS\_ANCHOR'}$ is determined by
(Formula 3.2.3.2.2. of Appendix 4)

3.2.3.3. Case 3 – Internal combustion engine is operational during constant speed test but not during the acceleration test

3.2.3.3.1. Assignment of engine speed

For the constant speed, use the engine speed information from the test result of Annex 3.

For the acceleration test, determine the highest gear that provides an acceleration greater than the reference acceleration a_{ACC_REF} but not exceeding 2.0 m/s^2. Calculate the engine speed with the gear ratio of that gear.

3.2.3.3.2. Adjustment of sound pressure level

No adjustment is applied to the constant speed test result.

The adjusted sound pressure level for the acceleration test is determined by
(Formula 3.2.3.3.2. of Appendix 4)
where *Limit* is the applicable limit value for this vehicle type according to paragraph 6.2.2. of the main body and k_P is the determined k_P-factor from the Annex 3 test.

3.2.3.4. Case 4 – Internal combustion engine does neither operate during the acceleration test nor the constant speed test

3.2.3.4.1. Assignment of engine speed

For the constant speed test, determine the highest gear in which the vehicle can drive at the target speed of the vehicle v_{TEST} (usually 50 km/h) as selected for the constant speed test in Annex 3. Calculate the engine speed with the gear ratio of that gear.
For the acceleration test, determine the highest gear that provides an acceleration greater than the reference acceleration a_{ACC_REF} but not exceeding 2.0 m/s². Calculate the engine speed with the gear ratio of that gear.

3.2.3.4.2. Adjustment of sound pressure level

The adjusted sound pressure level for the constant speed test is
(Formula 3.2.3.4.2. No.1 of Appendix 4)
The adjusted sound pressure level for the acceleration test is
(Formula 3.2.3.4.2. No.2 of Appendix 4)
where *Limit* is the applicable limit for this vehicle type according to paragraph 6.2.2. of the main body and k_P is the determined k_P-factor from the Annex 3 test.

3.2.4. Virtual engine speed for hybrid electric vehicle the other system than paragraph 3.2.3.

3.2.4.1. Case 1 – Internal combustion engine is operational during acceleration test and constant speed test

3.2.4.1.1. Assignment of engine speed

For the acceleration test and the constant speed test, use the engine speed information from the test result of Annex 3.

3.2.4.1.2. Adjustment of sound pressure level

No adjustment is applied

3.2.4.2. Case 2 – Internal combustion engine is operational during acceleration test but not during the constant speed test

3.2.4.2.1. Assignment of engine speed

For the acceleration test, use the engine speed information from the test result of Annex 3.

For the constant speed test, determine a virtual uniform gear ratio of 30 km/h per 1000 min^{-1} at the target speed of the vehicle v_{TEST} as selected for the constant speed test in Annex 3. Calculate the engine speed with the gear ratio of that gear.

3.2.4.2.2. Adjustment of sound pressure level

No adjustment is applied to the acceleration test result.
The adjusted cruise test result $L_{CRS\_ANCHOR'}$ is determined by
(Formula 3.2.4.2.2. of Appendix 4)

3.2.4.3. Case 3 – Internal combustion engine is operational during constant speed test but not during the acceleration test

3.2.4.3.1. Assignment of engine speed
For the constant speed, use the engine speed information from the test result of Annex 3.
For the acceleration test, determine a virtual uniform vehicle speed to engine speed ratio of 20 km/h per 1000 min^{-1}. Calculate the engine speed with the vehicle speed $v_{BB'\_ACC\_ANCHOR}$.
(Formula 3.2.4.3.1. of Appendix 4)

3.2.4.3.2. Adjustment of sound pressure level
No adjustment is applied to the constant speed test result.

The sound pressure level for the acceleration test is determined by
(Formula 3.2.4.3.2. of Appendix 4)

where *Limit* is the applicable limit for this vehicle type according to paragraph 6.2.2. of the main body and k_P is the determined k_P-factor from the Annex 3 test.

3.2.4.4. Case 4 – Internal combustion engine is neither operational during the acceleration test nor during the constant speed test

3.2.4.4.2. Assignment of engine speed

For the constant speed test, determine a virtual uniform vehicle speed to engine speed ratio of 30 km/h per 1000 min^{-1} at the target speed of the vehicle v_{TEST} as selected for the constant speed test in Annex 3. Calculate the engine speed with the vehicle speed.
(Formula 3.2.4.4.2. No. 1 of Appendix 4)
For the acceleration test, determine a virtual uniform vehicle speed to engine speed ratio of 20 km/h per 1000 min^{-1}. Calculate the engine speed with the vehicle speed
(Formula 3.2.4.4.2. No. 2 of Appendix 4)

3.2.4.4.3. Adjustment of sound pressure level

The adjusted sound pressure level for the constant speed test is
(Formula 3.2.4.4.3. No. 1 of Appendix 4)
The adjusted sound pressure level for the acceleration test is
(Formula 3.2.4.4.3. No. 2 of Appendix 4)
where *Limit* is the applicable limit for this vehicle type and k_P is the determined k_P-factor from the Annex 3 test.

3.2.5. Virtual constant speed test for PMR < 25
A vehicle having a PMR lower than 25 is tested in Annex 3 without constant speed test. For the purpose of RD-ASEP a constant speed test result has to be assigned in Annex 9.

3.2.5.1. The virtual constant speed test result $L_{CRS\_ANCHOR'}$ is determined by

(Formula 3.2.5.1. of Appendix 4)

3.2.5.2 Assignment of engine speed

3.2.5.2.1. Annex 3 acceleration test done in locked gear
For the acceleration test, use the engine speed information from the test result of Annex 3.

If an engine speed information is not available for the acceleration test result (e.g. EV or HEV), the engine speed for the acceleration test is calculated by the formula below:

(Formula 3.2.5.2.1. No.1 of Appendix 4)
For the constant speed test, the engine speed is calculated with the parameters determined above for the acceleration test with the formula below:
(Formula 3.2.5.2.1. No.2 of Appendix 4)
For constant speed test, depending on the situation different cases using internal combustion engine and/or electric engine, use the formulas of paragraph 3.2.4.

3.2.5.2.2. Annex 3 acceleration test done in non-locked gear or one gear

The engine speed for the constant speed test is calculated with a virtual uniform gear ratio of 30 km/h per 1000 min^{-1} at the target speed of the vehicle v_{TEST} as selected for the constant speed test in Annex 3.

(Formula 3.2.5.2.2. of Appendix 4)

3.3. Calculation of expected tyre rolling sound component L_{TR_EXP}

The expected tyre rolling sound component L_{TR_EXP} is calculated dependent on the achieved vehicle speed $v_{BB'\_TEST}$ during the test.
For vehicles speeds up to and inclusive v_{TEST}, L_{TR_EXP} is calculated by
(Formula 3.3. No.1 of Appendix 4)
For vehicle speeds $v_{BB'\,TEST}$ exceeding v_{TEST}, $L_{TR\,EXP}$ is calculated by

(Formula 3.3. No.2 of Appendix 4)
The parameters θ_{TR_LO} and θ_{TR_HI} are taken from the parameter table as applicable for the vehicle.

3.4. Calculation of expected power train mechanical sound component L_{PT_EXP}

The expected power train base mechanical sound component L_{PT_EXP} is calculated dependent on the achieved engine speed $n_{BB'\_TEST}$ during the test.
For engine speeds up to and inclusive $n_{BB'\_CRS\_ANCHOR}$, L_{PT_EXP} is calculated by
(Formula 3.4. No.1 of Appendix 4)

For engine speeds exceeding $n_{BB'\_CRS\_ANCHOR}$, L_{PT_EXP} is calculated by

(Formula 3.4. No.2 of Appendix 4)

The parameters θ_{PT_LO},θ_{PT_HI} and n_{SHIFT_PT} are taken from the parameter table as applicable for the vehicle.

3.5. Calculation of expected base dynamic sound component L_{DYN_EXP}

The expected base dynamic sound component L_{DYN_EXP} is calculated dependent on the achieved engine speed $n_{BB'\_TEST}$ during the test.
For engine speeds up to and inclusive $n_{BB'\_ACC\_ANCHOR}$, L_{DYN_EXP} is calculated by
(Formula 3.5. No.1 of Appendix 4)
For engine speeds exceeding $n_{BB'ACC\,ANCHOR}$, L_{DYN_EXP} is calculated by
(Formula 3.5. No.2 of Appendix 4)
The parameters θ_{DYN_LO}, θ_{DYN_HI} and n_{SHIFT_DYN} are taken from the parameter table as applicable for the vehicle.

3.6. Calculation of expected dynamic delta sound component ΔL_{DYN_EXP}

3.6.1. Determination of the maximum reference acceleration a_{MAX_REF}

3.6.1.1. The maximum reference acceleration a_{MAX_REF} is the maximum acceleration performance determined in a low gear under full load condition.

A test run not part of the RD-ASEP assessment shall be performed to determine the maximum acceleration performance a_{MAX_REF} of the vehicle. This value will be used in the model to determine the load achieved during a RD-ASEP test run.
This test run is recommended to be carried out in a gear ratio and at a vehicle entry speed such, that the vehicle engine speed $n_{BB'\_TEST}$ is between the 50% of S and 80% of S. The acceleration a_{TEST} and the performance $v{\cdot}a_{TEST}$ may exceed the control range during this test.
This operation condition is determined by the vehicle manufacturer in agreement with the authority present during the test.
The acceleration a_{MAX_REF} is calculated according to the provisions of paragraph 4.5.4.1. of Annex 9.
The vehicle speed to engine speed ratio κ_{TEST} of this operation condition is defined as the reference vehicle speed to the engine speed ratio κ_{REF}. For calculation, see paragraph 3.2.1. of this Appendix.

3.6.2. Calculation of the partial load $LOAD_{TEST}$ achieved during the test run

The partial load normalized with the maximum load is calculated based on the achieved acceleration a_{TEST}, relative to the reference acceleration a_{MAX_i} with the formula below
(Formula 3.6.2. of Appendix 4)

3.6.3. Performance related calculations

3.6.3.1. Calculation of the performance $v{\cdot}a_{TEST}$

The performance achieved during the test is calculated from the achieved acceleration expressed in m/s² and the vehicle speed expressed in km/h by
(*Formula 3.6.3.1. of Appendix 4)*

3.6.3.2. Calculation of the dynamic performance component $\Delta L_{DYN\_v{\cdot}a}$

The dynamic performance component of the vehicle dynamic sound is calculated based on the achieved performance $v \cdot a_{TEST}$ relative to the achieved performances from Annex 3 Type-approval acceleration test.
(Formula 3.6.3.2. No.1 of Appendix 4)
If the achieved performance does not exceed the reference performance $v \cdot a_{ANCHOR}$, the dynamic performance component $\Delta L_{DYN\_v \cdot a}$ is equal zero.
If the achieved performance exceeds the reference performance, the dynamic performance component $\Delta L_{DYN\_v \cdot a}$ is calculated by
(Formula 3.6.3.2. No.2 of Appendix 4)
The parameter β is taken from the parameter table as applicable for the vehicle.
The maximum dynamic performance component $\Delta L_{DYN\_v \cdot a}$ is limited to 10 dB.

3.6.3.3. Aggregation of dynamic sound components

The final dynamic delta sound component ΔL_{DYN_EXP} dynamic is calculated by
(Formula 3.6.3.3. of Appendix 4)
The parameters α_1 and α_2 are taken from the parameter table as applicable for the vehicle.

3.7. For vehicles falling under the scope of UN Regulation No. 138 equipped with a sound system covering the specification range of UN Regulation No. 138, **the expected AVAS sound $L_{AVAS\text{-}EXP}$ is one of the dynamic sound components considered in the global aggregation of sounds.** ~~a tolerance ΔL_{AVAS} on the RD ASEP model is applied to ensure compatibility with the maximum permissible sound level emitted by the AVAS according to UN Regulation No.138.~~

~~For the vehicle speed range up to v_{REF} of Annex 3 of this UN Regulation, the additional tolerance is dependent on the achieved vehicle speed v_{TEST} during the RD ASEP test.~~
~~*(Formula 3.7. of Appendix 4)*~~
~~For vehicle speeds $v_{BB'\_TEST}$ exceeding v_{TEST}, no additional tolerance is applied, ΔL_{AVAS} is set to zero in that case.~~

3.8. Calculation of the expected sound level L_{TEST_EXP}

The calculation results of the paragraphs 3.3. to 3.7. are used to calculate the expected sound level for an individual run to be compared with the measured maximum sound pressure level, by the following formula
(Formula 3.~~7~~8. of Appendix 4)

3.9. Proceed with the compliance assessment according to paragraph 5. of Annex 9.

Annex 9 – Appendix 2

Parameter Table for the Sound Expectation Model

The table below provides the necessary parameters for establishing the sound expectation model of Annex 9 Appendix 1. The parameters to be selected depend on the propulsion technology.

- Column A: ICE
- Column B: BEV, FCEV
- Column C: HEV

				M1/N1		
Model Part	*Parameter*	*Symbol*	*Unit*	*A*	*B*	*C*
SOUND FROM TYRE ROLLING SOUND UNDER NO LOAD	Reference Vehicle Speed (as reported from Annex 3)	v_{TEST}	km/h	50 (min.40)	50 (min.40)	50 (min.40)
	Tyre Rolling Sound Energy Fraction of Annex 3 Cruise Test L_{CRS_ANCHOR}	x	%	90 or measure	95	90 or measure
	Tyre Rolling Sound Slope $\leq v_{TEST}$	θ_{TR_LO}	dB	20	20	20
	Tyre Rolling Sound Slope $> v_{TEST}$	θ_{TR_HI}	dB	40	40	40
SOUND FROM THE MECHANICAL SYSTEM UNDER NO LOAD	Power Train Sound Slope $\leq n_{BB'\_CRS'\_ANCHOR}$	θ_{PT_LO}	dB	60	60	60
	Power Train Sound Slope $> n_{BB'\_CRS'\_ANCHOR}$	θ_{PT_HI}	dB	115	85	115
	Form Factor for the logarithm function of the mechanical sound model	n_{SHIFT_PT}	1/min	5000	5000	5000
SOUND FROM DYNAMICS SYSTEM UNDER LOAD	Dynamic Sound Slope $\leq n_{BB'\_ACC\_ANCHOR}$	θ_{DYN_LO}	dB	50	50	50
	Dynamic Sound Slope $> n_{BB'\_ACC\_ANCHOR}$	θ_{DYN_HI}	dB	105	75	105
	Form Factor for the logarithm function of the dynamic sound model	n_{SHIFT_DYN}	1/min	5000	5000	5000
SOUND FROM DYNAMICS SYSTEM UNDER EXTENDED PERFORMANCE v·a	Dynamic v·a Factor β	β	dB(A)	8	8	8
	Partial Load Form Factor α_1	α_1	---	0.17	0.17	0.17
	Partial Load Form Factor α_2	α_2	---	0.40	0.40	0.40

Annex 9 – Appendix 3

Symbols, Abbreviations and Acronyms

Annex 9			
Symbol	***Unit***	***Paragraph***	***Explanation***
a_{MAX_REF}	m/s^2	3.4.	maximum reference acceleration as determined in a low gear under full load condition.
L_{TEST}	dB(A)	3.5.3.	sound pressure level measured for any target operation condition; value to be reported and used for calculations to the first decimal place
$v_{AA'\_TEST}$	km/h	3.5.3.	vehicle speed measured for target operation condition when the reference point passes line AA'; value to be reported and used for calculations to the first decimal place
$v_{PP'\_TEST}$	km/h	3.5.3.	vehicle speed measured for target operation condition when the reference point passes line PP; value to be reported and used for calculations to the first decimal place
$v_{BB'\_TEST}$	km/h	3.5.3.	vehicle speed measured for target operation condition when the rear end of the vehicle passes line BB'; value to be reported and used for calculations to the first decimal place
$n_{AA'\_TEST}$	1/min	3.5.3.	engine speed measured for target operation condition when the reference point of the vehicle passes line AA'; value to be reported and used for calculations to a precision of 10 min^{-1}
$n_{BB'\_TEST}$	1/min	3.5.3.	engine speed measured for target operation condition when the rear end of the vehicle passes line BB'; value to be reported and used for calculations to a precision of 10 min^{-1}
a_{TEST}	m/s^2	3.5.4.1.	acceleration from PP' to BB'; value to be reported and used for calculations to the second decimal place
$v \cdot a_{TEST}$	m^2/s^3	3.5.4.2.	performance calculated from the reported vehicle speed at line BB' in meters per second and the acceleration result from paragraph 3.5.4.1. and rounded to the first digit after the decimal place.
L_{EXP}	dB(A)	3.5.4.3.	the expected sound pressure level for a discrete test run
Annex 9 - Appendix 1			
L_{ACC_ANCHOR}	dB(A)	2.2.1.2.	vehicle sound pressure level for the acceleration test to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to the first decimal place
$v_{BB'\_ACC\_ANCHOR}$	km/h	2.2.1.2.	vehicle speed value when the rear of the vehicle passes line BB' for the acceleration test to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to the first decimal place
$n_{BB'\_ACC\_ANCHOR}$	1/min	2.2.1.2.	engine speed value when the rear of the vehicle passes line BB' for the acceleration test to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to a precision of 10 min^{-1}
L_{CRS_ANCHOR}	dB(A)	2.2.1.2.	vehicle sound pressure level at constant speed test; value to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to the first decimal place

$v_{BB'\_CRS\_ANCHOR}$	km/h	2.2.1.2.	vehicle speed value when the rear of the vehicle passes line BB' for the constant speed test to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to the first decimal place
$n_{BB'\_CRS\_ANCHOR}$	1/min	2.2.1.2.	engine speed value when the rear of the vehicle passes line BB' for the constant speed test to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to a precision of 10 min^{-1}
x	-	2.3.1.	energy contribution ratio of tyre/rolling sound level at L_{CRS_ANCHOR}
L_{REF_TR}	dB(A)	2.3.1.	calculated Reference Tyre Rolling Sound Level
L_{REF_PT}	dB(A)	2.5.	calculated Reference Power Train Mechanics Sound Level
L_{REF_DYN}	dB(A)	2.6.	calculated Reference Dynamic Sound Level
ΔL_{DYN}	dB(A)	2.7.	Vehicle Dynamic Delta Sound Level
$L_{REF\_TR\_ADJ}$	dB(A)	2.7.	Tyre Rolling Sound Level with adjusted vehicle speed for ΔL_{DYN} calculation
$L_{REF\_PT\_ADJ}$	dB(A)	2.7.	Power Train Mechanical Sound Level with adjusted engine speed for ΔL_{DYN} calculation
θ_{TR_LO}	dB(A)	2.7.	sound slope for tyre rolling sound when vehicle speed is not greater than the reference speed
θ_{PT_LO}	dB(A)	2.7.	sound slope for Power Train Sound when vehicle engine speed is not greater than $n_{BB'\_CRS'\_ANCHOR}$
n_{SHIFT_PT}	1/min	2.7.	constant (shifting factor) for the regression curve of the mechanic sound model
k_{TEST}	km/h·min	3.2.1.	vehicle speed to engine speed ratio under "Real Driving Additional Sound Emission Provisions" (RD-ASEP) as expressed in km/h per 1000 min-1 during a test run, rounded to the second decimal
k_{REF}	km/h·min	3.2.1.	Reference vehicle speed to engine speed ratio defined in paragraph 3.6.1.
$L_{CRS\_ANCHOR'}$	dB(A)	3.2.3.2.2.	corrected cruise test result for HEV
$L_{ACC\_ANCHOR'}$	dB(A)	3.2.3.3.2.	corrected acceleration test result for HEV
Limit	dB(A)	3.2.3.3.2.	sound level limits in the table of paragraph 6.2.2. of main body to this Regulation for the valid phase
L_{TR_EXP}	dB(A)	3.3.	expected tyre rolling sound
q_{TR_HI}	dB(A)	3.3.	sound slope for tyre rolling sound when vehicle speed is greater than the reference speed
L_{PT_EXP}	dB(A)	3.4.	expected power train mechanics sound
θ_{PT_HI}	dB(A)	3.4.	sound slope for Power Train Mechanics Sound when vehicle engine speed is exceeding $n_{BB'\_CRS'\_ANCHOR}$
L_{DYN_EXP}	dB(A)	3.5.	expected base dynamic sound
θ_{DYN_LO}	dB(A)	3.5.	sound slope for Dynamic Sound when vehicle engine speed is not greater than $n_{BB'\_ACC'\_ANCHOR}$
θ_{DYN_HI}	dB(A)	3.5.	sound slope for Dynamic Sound when vehicle engine speed is exceeding $n_{BB'\_ACC'\_ANCHOR}$
ΔL_{DYN_EXP}	dB	3.6.	expected dynamic delta sound
$LOAD_{TEST}$		3.6.2.	load achieved during the test run

a_{MAX_κ}	m/s^2	3.6.2.	Maximum acceleration in gear κ
$\Delta L_{DYN\_v\times a}$	dB	3.6.3.2.	dynamic performance component calculated based on the achieved performance $v \cdot a_{TEST}$ relative to a reference performance.
β		3.6.3.2.	coefficient for calculating dynamic performance component
$v \cdot a_{ANCHOR}$	m^2/s^3	3.6.3.2.	performance value to be reported from Annex3 with the tested gear in single-gear test or the lower tested gear in two-gear test and used for calculations to the first decimal place
a_1		3.6.3.3.	coefficient for calculating dynamic sound components
a_2		3.6.3.3.	coefficient for calculating dynamic sound components

Annex 9 – Appendix 4

Formulas

Formula 2.4

$$L_{REF\_TR} = 10 \times lg(x \times 10^{0.1 \times L_{CRS\_ANCHOR}})$$

Formula 2.5

$$L_{REF\_PT} = 10 \times lg((1 - x) \times 10^{0.1 \times L_{CRS\_ANCHOR}})$$

Formula 2.6

$$L_{REF\_DYN} = L_{REF\_PT} - 15\ dB(A)$$

Formula 2.7 No.1

$$\Delta L_{DYN} = 10 \times lg(10^{0.1 \times L_{ACC\_ANCHOR}} - 10^{0.1 \times L_{REF\_TR\_ADJ}} - 10^{0.1 \times L_{REF\_PT\_ADJ}}) - L_{REF\_DYN}$$

Formula 2.7 No.2

$$L_{REF\_TR\_ADJ} = \theta_{TR\_LO} \times lg(\frac{v_{BB'\_ACC\_ANCHOR}}{v_{TEST}}) + L_{REF\_TR}$$

Formula 2.7 No.3

$$L_{REF\_PT\_ADJ} = \theta_{PT\_LO} \times lg\left(\frac{(n_{BB'\_ACC\_ANCHOR} + n_{SHIFT\_PT})}{(n_{BB'\_CRS\_ANCHOR} + n_{SHIFT\_PT})}\right) + L_{REF\_PT}$$

Formula 3.2.1

$$L_{REF\_PT\_ADJ} = \theta_{PT\_LO} \times lg\left(\frac{(n_{BB'\_ACC\_ANCHOR} + n_{SHIFT\_PT})}{(n_{BB'\_CRS\_ANCHOR} + n_{SHIFT\_PT})}\right) + L_{REF\_PT}$$

Formula 3.2.2.

$$n_{BB'\_TEST} = \left(v_{BB'\_TEST}/30\right) \times 1000$$

Formula 3.2.3.2.2.

$$L_{CRS\_ANCHOR,} = L_{CRS\_ANCHOR} + 0.5\ dB(A)$$

Formula 3.2.3.3.2.

$$L_{ACC\_ANCHOR,} = \left(Limit - k_P \times L_{CRS\_ANCHOR}\right)/(1 - k_P)$$

Formula 3.2.3.4.2 No.1

$$L_{CRS\_ANCHOR,} = L_{CRS\_ANCHOR} + 0.5\ dB(A)$$

Formula 3.2.3.4.2 No.2

$$L_{ACC\_ANCHOR,} = \left(Limit - k_P \times L_{CRS\_ANCHOR,}\right)/(1 - k_P)$$

Formula 3.2.4.2.2

$$L_{CRS\_ANCHOR,} = L_{CRS\_ANCHOR} + 0.5\ dB(A)$$

Formula 3.2.4.3.1.

$$n_{ACC\_ANCHOR} = \left(v_{BB,\_ANCHOR}/20\right) \times 1000$$

Formula 3.2.4.3.2

$$L_{ACC\_ANCHOR,} = \left(Limit - k_P \times L_{CRS\_ANCHOR}\right)/(1 - k_P)$$

Formula 3.2.4.4.2 No.1

$$n_{CRS\_ANCHOR} = (v_{TEST}/30) \times 1000$$

Formula 3.2.4.4.2 No.2

$$n_{ACC\_ANCHOR} = (v_{TEST}/20) \times 1000$$

Formula 3.2.4.4.3 No.1

$$L_{CRS\_ANCHOR,} = L_{CRS\_ANCHOR} + 0.5\ dB(A)$$

Formula 3.2.4.4.3 No.2

$$L_{ACC\_ANCHOR,} = \left(Limit - k_P \times L_{CRS\_ANCHOR,}\right)/(1 - k_P)$$

Formula 3.2.5.1.

$$L_{CRS\_ANCHOR'} = L_{ACC\_ANCHOR} - 1.1\ dB(A)$$

Formula 3.2.5.2.1 No.1

$$n_{BB'\_ACC\_ANCHOR} = \frac{v_{BB'\_ACC\_ANCHOR}}{20} \times 1000$$

Formula 3.2.5.2.1 No.2

$$n_{BB'\_CRS\_ANCHOR} = \frac{v_{TEST}}{v_{BB'\_ACC\_ANCHOR}} \times n_{BB'\_ACC\_ANCHOR}$$

Formula 3.2.5.2.2.

$$n_{BB'\_CRS\_ANCHOR} = \frac{v_{TEST}}{30} \times 1000$$

Formula 3.3. No.1

$$L_{TR\_EXP} = \theta_{TR\_LO} \times \lg\left(v_{BB'\_TEST}/v_{TEST}\right) + L_{REF\_TR}$$

Formula 3.3. No.2

$$L_{TR\_EXP} = \theta_{TR\_HI} \times \lg\left(v_{BB'\_TEST}/v_{TEST}\right) + L_{REF\_TR}$$

Formula 3.4. No.1

$$L_{PT\_EXP} = \theta_{PT\_LO} \times \lg\left(\left(n_{BB'\_TEST} + n_{SHIFT\_PT}\right)/\left(n_{BB'\_CRS\_ANCHOR} + n_{SHIFT\_PT}\right)\right) + L_{REF\_PT}$$

Formula 3.4. No.2

$$L_{PT\_EXP} = \theta_{PT\_HI} \times lg((n_{BB'\_TEST} + n_{SHIFT\_PT}) / (n_{BB'\_CRS\_ANCHOR} + n_{SHIFT\_PT})) + L_{REF\_PT}$$

Formula 3.5. No.1

$$L_{DYN\_EXP} = \theta_{DYN\_LO} \times \lg\left(\left(n_{BB'\_TEST} + n_{SHIFT\_DYN}\right)/\left(n_{BB'\_ACC\_ANCHOR} + n_{SHIFT\_DYN}\right)\right) + L_{REF\_DYN}$$

Formula 3.5. No.2

$$L_{DYN\_EXP} = \theta_{DYN\_HI} \times \lg\left(\left(n_{BB'\_TEST} + n_{SHIFT\_DYN}\right)/\left(n_{BB'\_ACC\_ANCHOR} + n_{SHIFT\_DYN}\right)\right) + L_{REF\_DYN}$$

Formula 3.6.2. $LOAD_{TEST} = a_{TEST}/a_{MAX\,i}$

where $a_{MAX\_i} = \frac{\kappa_{REF}}{\kappa_{TEST}} \times a_{MAX\_REF}$

Formula 3.6.3.1.

$v{\cdot}a_{TEST} = \frac{v_{BB'\text{-}TEST}}{3{,}6} \times a_{TEST}$ [m²/s³]

Formula 3.6.3.2. No.1

$$v{\cdot}a_{ANCHOR} = v_{BB'\_ACC\_ANCHOR}/3.6 \times a_{ACC\_ANCHOR}$$

Formula 3.6.3.2. No. 2

$$\Delta L_{DYN\_v{\cdot}a} = \beta \times \lg\left(\frac{v{\cdot}a_{TEST}}{v{\cdot}a_{ANCHOR}}\right)$$

Formula 3.6.3.3.

$$\Delta L_{DYN\_EXP} = \left(\Delta L_{DYN} + \Delta L_{DYN\_v{\cdot}a}\right) \times \left(1 - \alpha_1/(LOAD_{TEST} + \alpha_2)\right)/\left(1 - \alpha_1/(1 + \alpha_2)\right) + 0.3$$

~~Formula 3.7.~~

~~$$\Delta L_{AVAS} = \left(L_{ACC\_ANCHOR} - 58\right) \times \left(1 - \left(v_{BB'\_TEST}/v_{TEST}\right)^{0.75}\right)$$~~

Formula 3.7~~8~~.

$$L_{TEST\_EXP} = 10 \times \lg\left(10^{0.1 \times L_{TR\_EXP}} + 10^{0.1 \times L_{PT\_EXP}} + 10^{0.1 \times \left(L_{DYN\_EXP} + \Delta L_{DYN\_EXP}\right)} \mathbf{+ 10^{0.1 \times L_{AVAS\_EXP}}}\right) \text{~~+ } \Delta L_{AVAS} + 2dB(A)$$

Annex 9 – Appendix 5 Test report sheet

Test Report for Pass-by Sound Measurements According to UN R51.03 Annex 9

Parameter from Annex 3 as specified by Paragraph 2.2. of Appendix 1 to Annex 9							
Refer gear (index)		L_{ACC_ANCHOR}	[dB(A)]		L_{CRS_ANCHOR}	[dB(A)]	
Refer gear (number)		$v_{BB'\_ACC\_ANCHOR}$	[km/h]		$v_{BB'\_CRS\_ANCHOR} = v_{REF}$	[km/h]	
		$n_{BB'\_ACC\_ANCHOR}$	[rpm]		$n_{BB'\_CRS\_ANCHOR}$	[rpm]	
		a_{ACC_ANCHOR}	[m/s²]				

Model Parameters	
Parameter Set	A/B/C
Ref gear ratio	
Ref acceleration	

	Target Condition				Measured Values												Conformity		
Run	Gear Selector Position	Selected Mode	Vehicle Speed $v_{AA'}$	Accelerator Position (%pedal depression)	Start Point Acceleration (pre-acceleration length)	Vehicle Speeds			Engine Speed at line BB'	Maximum Sound Pressure Level Left Side	Maximum Sound Pressure Level Right Side	Run Valid with Control Range	Comments	Acceleration between PP'-BB'	Vehicle Performance	Expected Sound Pressure Level	$L_{TEST} < L_{EXP}$	$L_{TEST} < L_{EXP}$ + tolerance	$L_{TEST} > L_{EXP}$ + tolerance
Nr	Gear/Nr.				l	$v_{AA'}$	$v_{PP'}$	$v_{BB'}$	$n_{BB'}$	L_{LEFT}	L_{RIGHT}	Yes/No		a_{TEST}	$v \cdot a$	L_{EXP}	Cross X if applicable	Cross X if applicable	Cross X if applicable
			km/h	%	m	km/h	km/h	km/h	1/min	dB(A)	dB(A)			m/s²	m²/s³	dB(A)			
Test Runs																			
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
Additional Runs																			
1																			
2																			
3																			
4																			

Compliance of the test results to Annex 9: YES/NO **Number Case of compliance according to paragraph 4 of Annex 9:**