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1958 Agreement:
Consideration of draft amendments to existing UN Regulations submitted by GRBP

Proposal for Supplement 7 to 03 series of amendments to UN Regulation No. 51 (Noise of M and N categories of vehicles)

Submitted by the Working Party on Noise and Tyres*

The text reproduced below was adopted by the Working Party on Noise and Tyres (GRBP) at its seventy-fourth and seventy-fifth sessions (ECE/TRANS/WP.29/GRBP/72, para. 5 and ECE/TRANS/WP.29/GRBP/73, paras. 4 to 9). It is based on ECE/TRANS/WP.29/GRBP/2021/22 as amended by para. 5 of ECE/TRANS/WP.29/GRBP/72, ECE/TRANS/WP.29/GRBP/2022/4 as amended by informal document GRBP-75-37, ECE/TRANS/WP.29/GRBP/2022/3 as amended by informal document GRBP-75-36 and para. 4 of ECE/TRANS/WP.29/GRBP/73, ECE/TRANS/WP.29/GRBP/2022/8 as amended by para. 6 of ECE/TRANS/WP.29/GRBP/73 and informal document GRBP-74-40 as amended by para. 9 of ECE/TRANS/WP.29/GRBP/73. It is submitted to the World Forum for Harmonization of Vehicle Regulations (WP.29) and to the Administrative Committee (AC.1) for consideration at their June 2022 sessions.

* In accordance with the programme of work of the Inland Transport Committee for 2022 as outlined in proposed programme budget for 2022 (A/76/6 (part V sect. 20) para 20.76), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

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Paragraph 1., add a new footnote 2 to read:

"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]"

Paragraph 2.8., amend to read:

2.8. "*Maximum net power, P_n*" means the engine power available for propulsion expressed in kW and measured dependent on the drive train concepts.

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”.

Paragraph 2.24., amend to read:

“2.24. Table of symbols

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
…	…	…	…	…
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

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

[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.

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
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)
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}
…	…	…	…	…
$n_{BB'}$	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)
…	…	…	…	…
L_{urban}	dB(A)	Annex 3	3.1.3.1.	reported vehicle sound pressure level representing urban operation; value to be reported mathematically rounded to the nearest integer
$L_{TR,\vartheta ref,(vTR,ref)}$	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/ride 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
$v_{TR,ref}$	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

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
$\vartheta_{crs,j}$	°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
$L_{crs,j,\vartheta ref}$	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/ride 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/ride 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/ride 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/ride side according to Annex 3 Appendix 3 taken from a database
a_{wot_ASEP}	m/s^2	Annex 7	2.3.	maximum required acceleration at wide-open-throttle

Symbol	*Unit*	*Annex*	*Paragraph*	*Explanation*
…	…	…	…	…

"

Paragraph 3.4., amend to read and insert a new *paragraph 3.4.2.* and add a new footnote:

"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[3] 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."

Paragraph 5. and its subparagraphs., amend to read:

"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 test results shall be communicated to the Type Approval Authority in the format according to the test report sheet of Appendix 5 in Annex 9.

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.

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

Paragraph 5.4., amend to read:

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;[4]

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.

Paragraph 6.1., amend to read:

"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.

6.1.2. 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."

Paragraph 6.2.2.2., amend to read:

6.2.2.2. For vehicle types designed for off-road[5] 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.

Paragraph 6.2.3., amend to read:

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).

…

[4] 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), ECE/TRANS/WP.29/78/Rev.6.

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

Paragraph 11.6., amend to read:

*"*11.6. Until 30 June 2025, 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. "

Paragraph 11.8., amend to read:

"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.*"*

Paragraph 12., amend to read and insert new subparagraphs 12.2. and 12.3.:

"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 3,

Paragraph 1.4., amend to read:

"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."

Paragraph 1.5., amend to read:

"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."

Paragraph 2.1.3., amend to read and structured by subparagraphs:

"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 1.2 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

"

Paragraph 2.2. and its subparagraphs, amend to read:

"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 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. 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. Tyres

2.2.3.4.1. 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.[6] The tyres 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

[6] 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 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.

and other sound control measures to produce tyre/road sound which does not influence the measurement result.

2.2.3.4.2. 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.

2.2.3.5. 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. 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. 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. 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."

Paragraph 3.1.1. amend to read:

"3.1.1. General conditions of test

For outdoor testing, two lines, AA' and BB', parallel to line PP' and situated respectively 10 m ± 0.05 m forward and 10 m ± 0.05 m 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 microphones 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'."

Paragraph 3.1.2.1.4., fourth indent, replace "Appendix 3, Figure 4a to Figure 4e" to read "Appendix 1, Figure 4a to Figure 4f".

Paragraph 3.1.2.1.4.1., amend to read:

"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/s², 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/s², 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 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 1 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."

Paragraph 3.1.2.1.4.2., amend to read:

"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.

If possible, the manufacturer shall take measures to avoid an acceleration value a_{wot_test} greater than 2.0 m/s^2.

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

Table 1 in Appendix 1 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}."

Paragraph 3.1.2.1.4.3., fifth indent, replace "Appendix to Annex 3" to read "Appendix 1 to Annex 3".

Paragraph 3.1.2.1.6., amend to read:

"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 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."

Paragraph 3.1.2.2.1.2., fifth indent, replace "Appendix to Annex 3" to read "Appendix 1 to Annex 3".

Paragraph 3.1.3. and its subparagraphs, amend to read:

"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 weighting factor k_P gives the part power factor 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:

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

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."

Paragraph 3.2.3., amend to read:

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

Paragraph 3.2.3., amend to read:

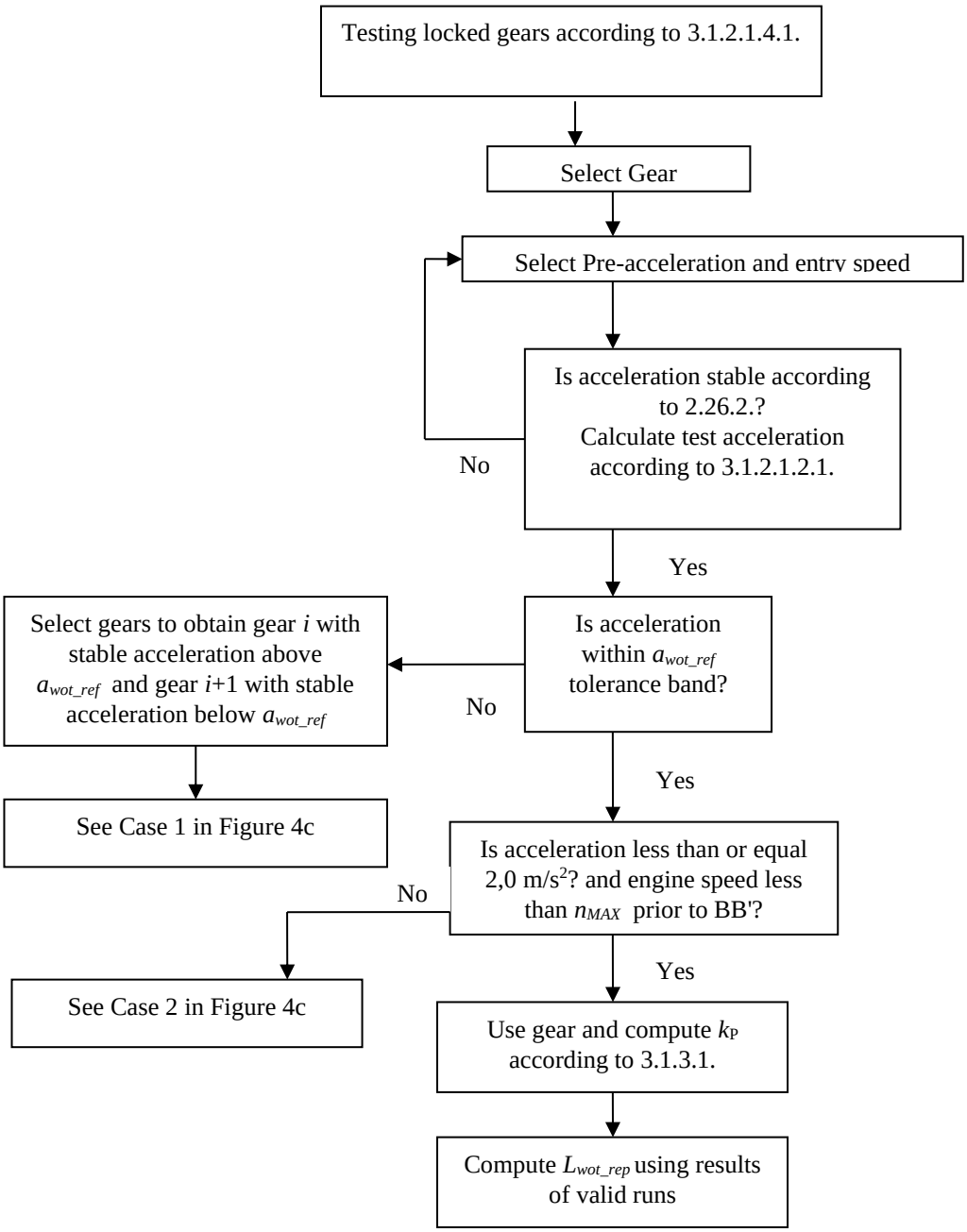
3.2.5.3. Measuring of noise in proximity to the exhaust (see Appendix 1 of Annex 3, Figure 3a)

Annex 3, Appendix, renumber as Appendix 1.

Annex 3, Appendix 1 (renumbered), Figure 4b, amend to read:

"Figure 4b

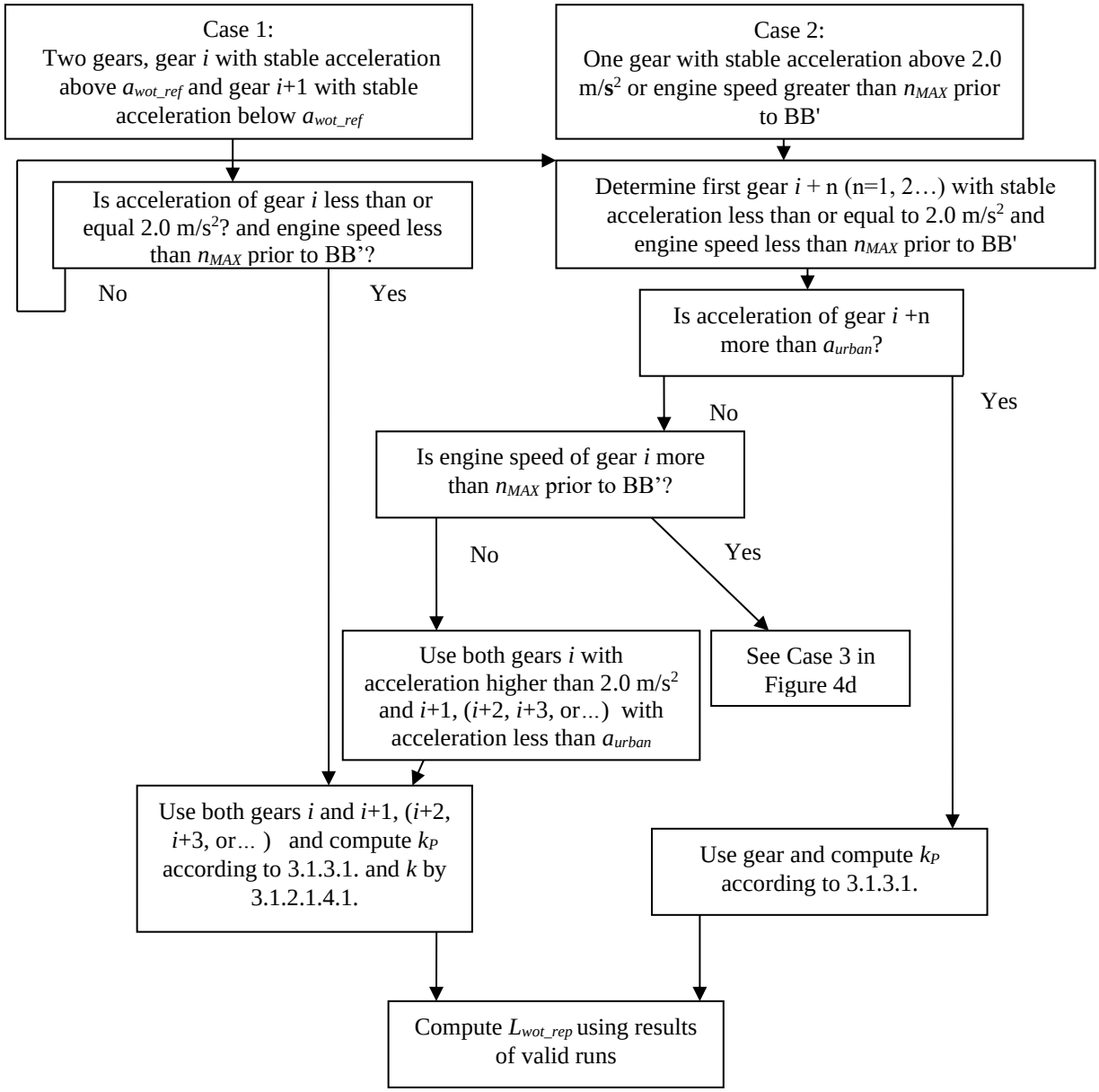
Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation - Gear selection using locked gear PART 1



Annex 3 – Appendix 1 (renumbered), Figure 4c, amend to read:

"Figure 4c

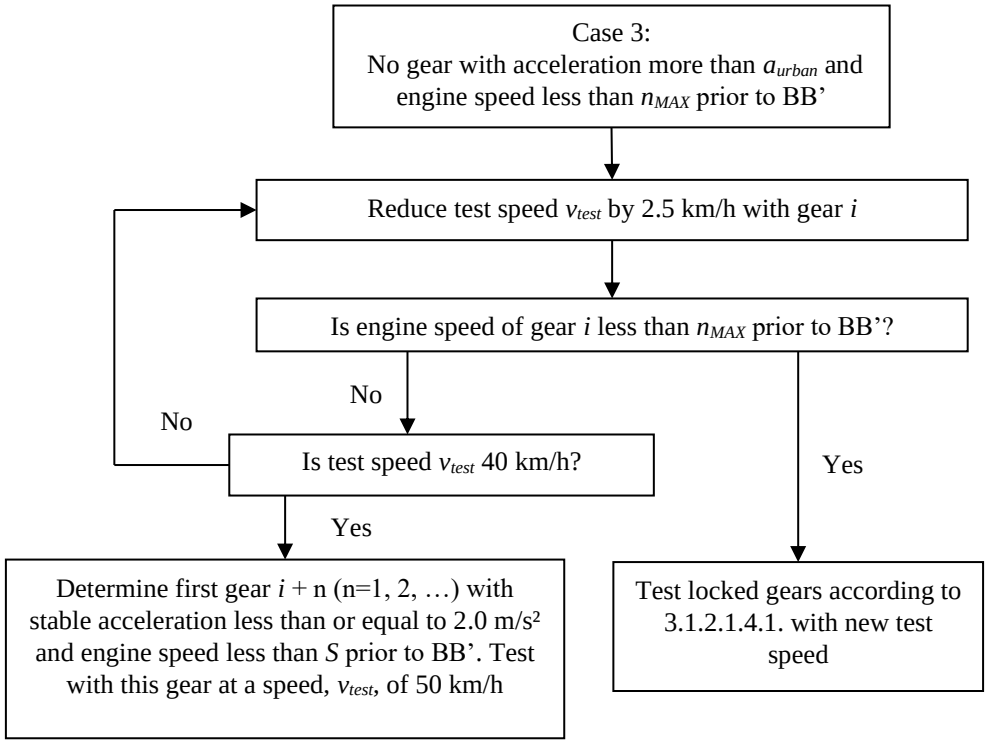
Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear selection using locked gear PART 2



Annex 3 – Appendix 1 (renumbered), Figure 4d, amend to read:

"Figure 4d

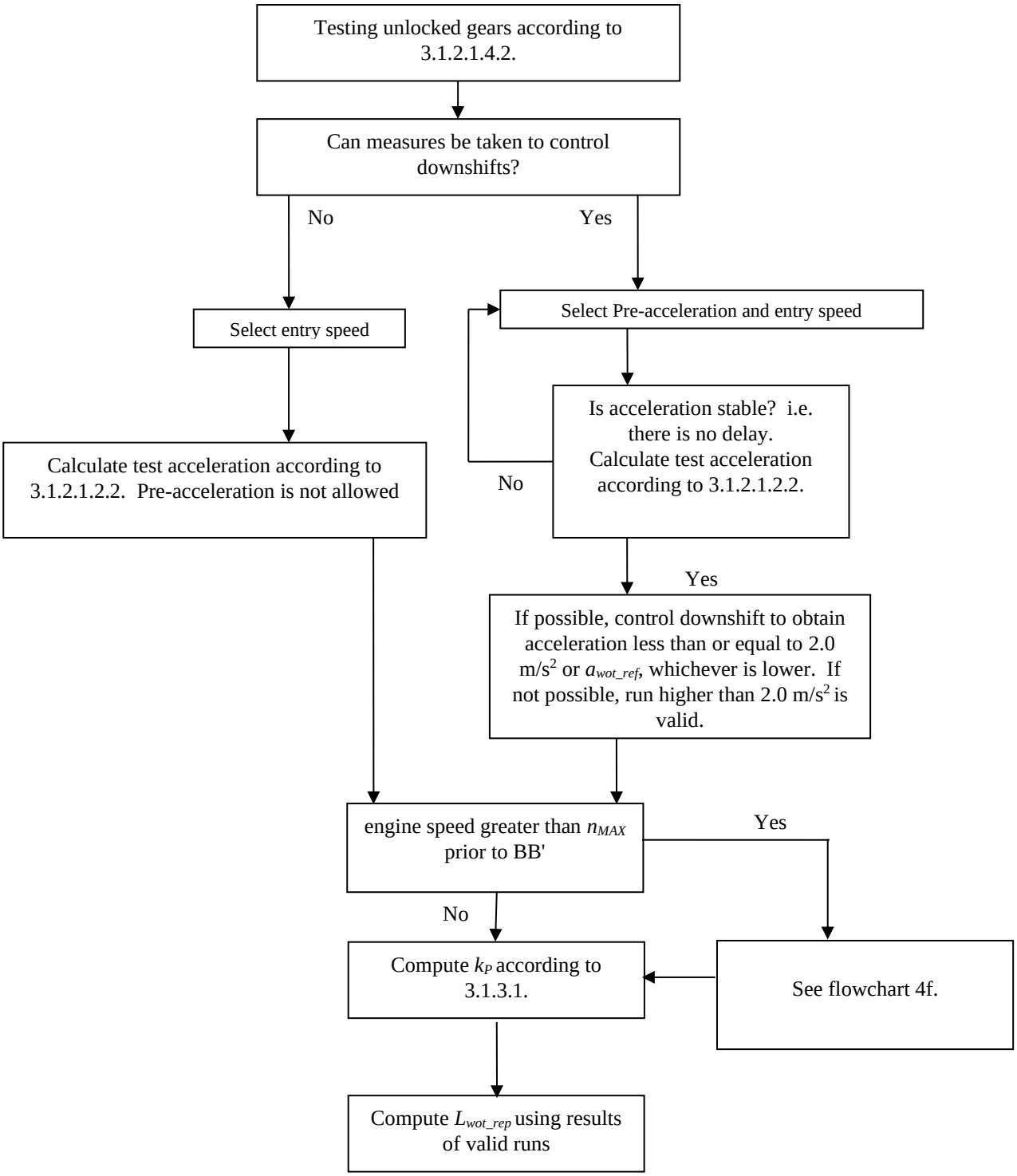
Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear selection using locked gear PART 3



"

Annex 3 – Appendix 1 (renumbered), Figure 4e, amend to read:

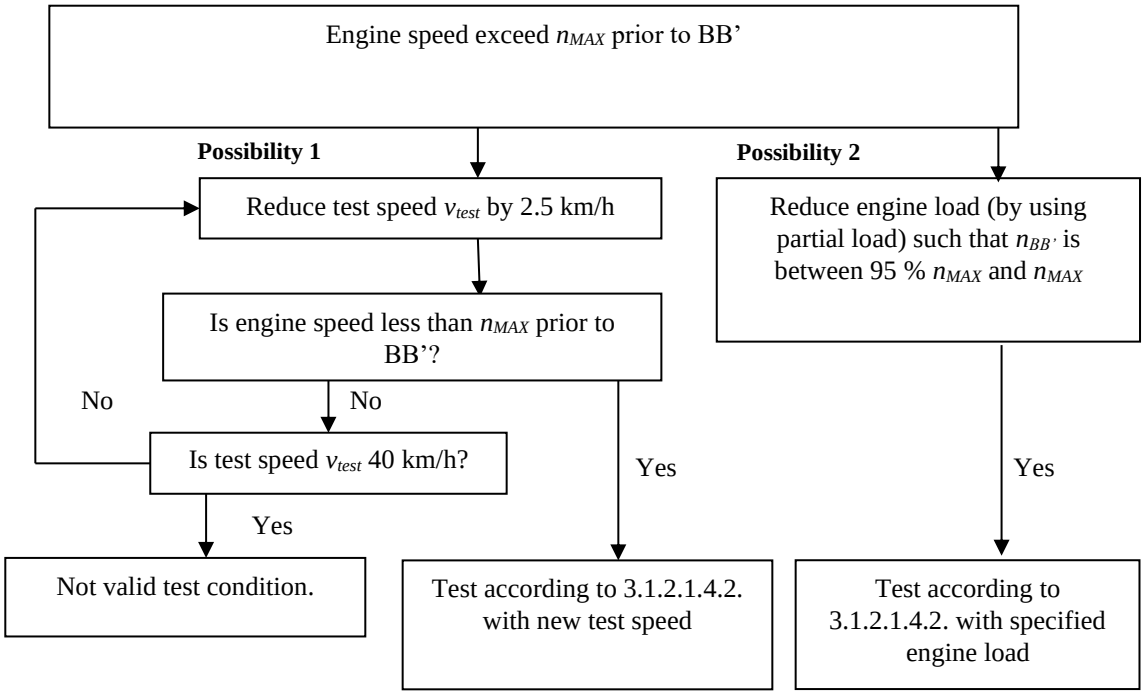
"Figure 4e
Flowchart for vehicles tested according to paragraph 3.1.2.1. of Annex 3 to this Regulation – Gear Selection using non-locked gears



Annex 3 – Appendix 1 (renumbered), add a new *Figure 4f*, to read:

"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



Annex 3, add a new Appendix 2 to read:

"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 7d)

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

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

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 $L_{TR,wot,j,\vartheta_{wot}}$ is greater than $L_{wot,j}$ the power train component $L_{PT,wot,j}$ is determined by

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

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

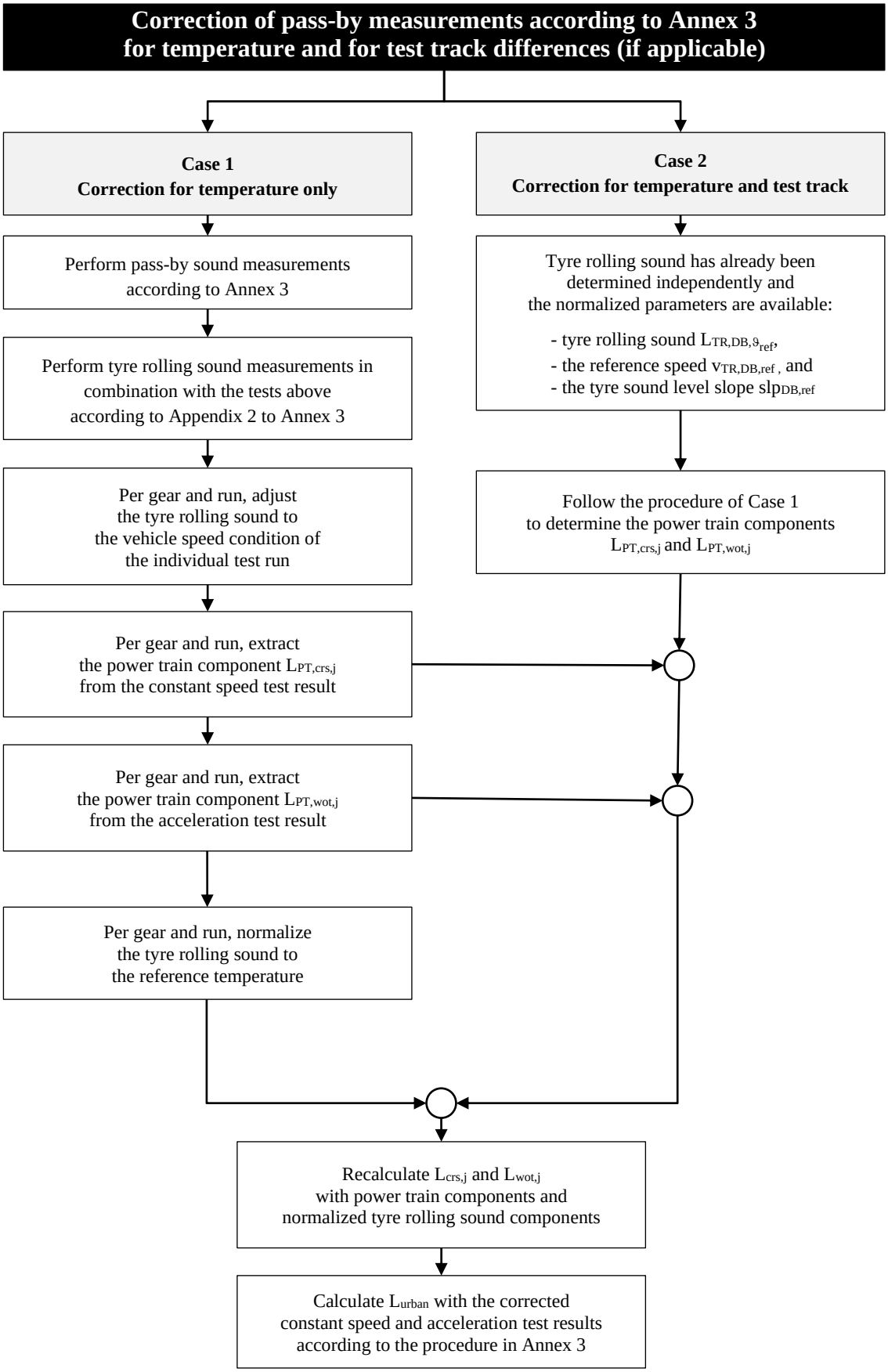


Figure 7b

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

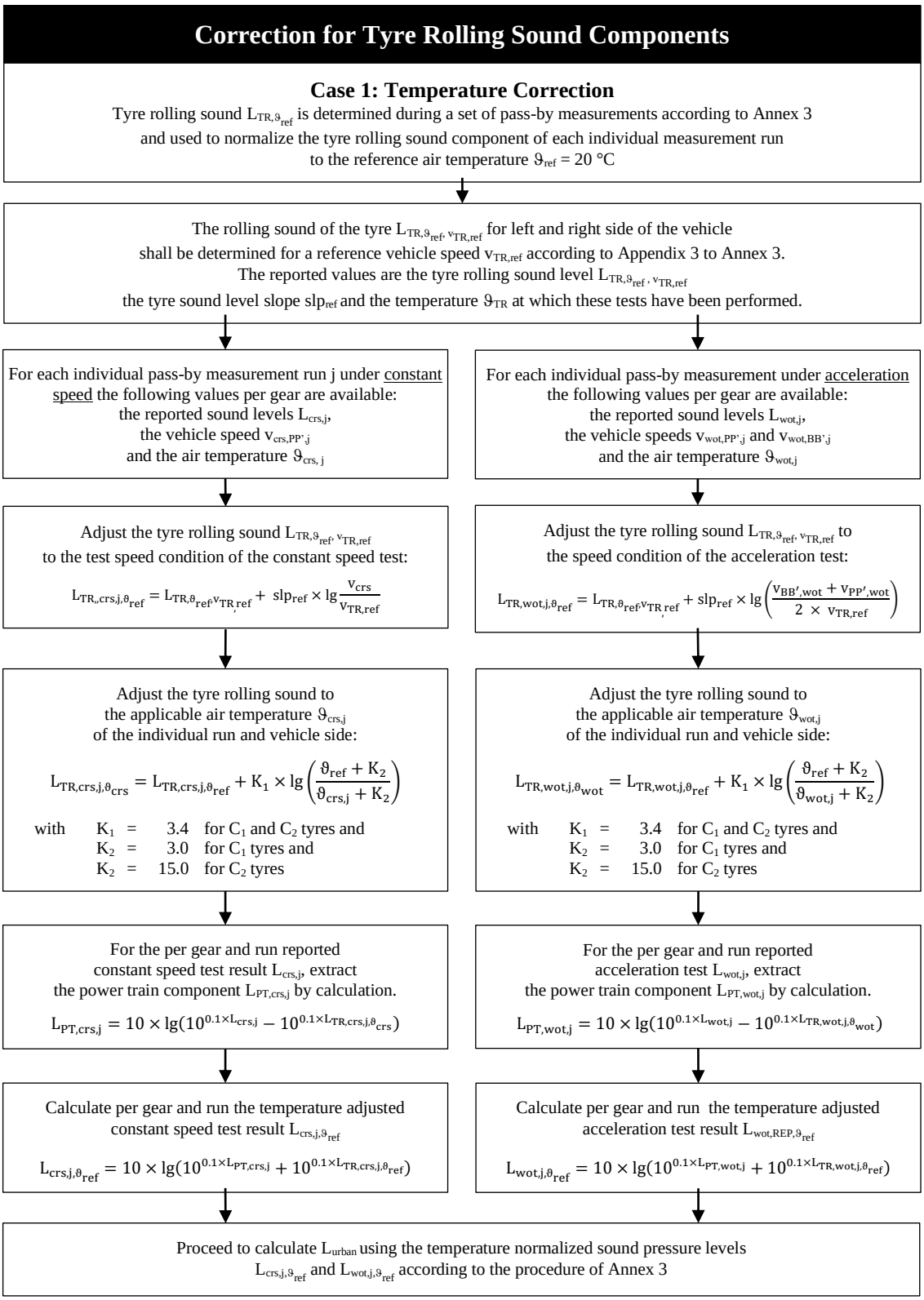
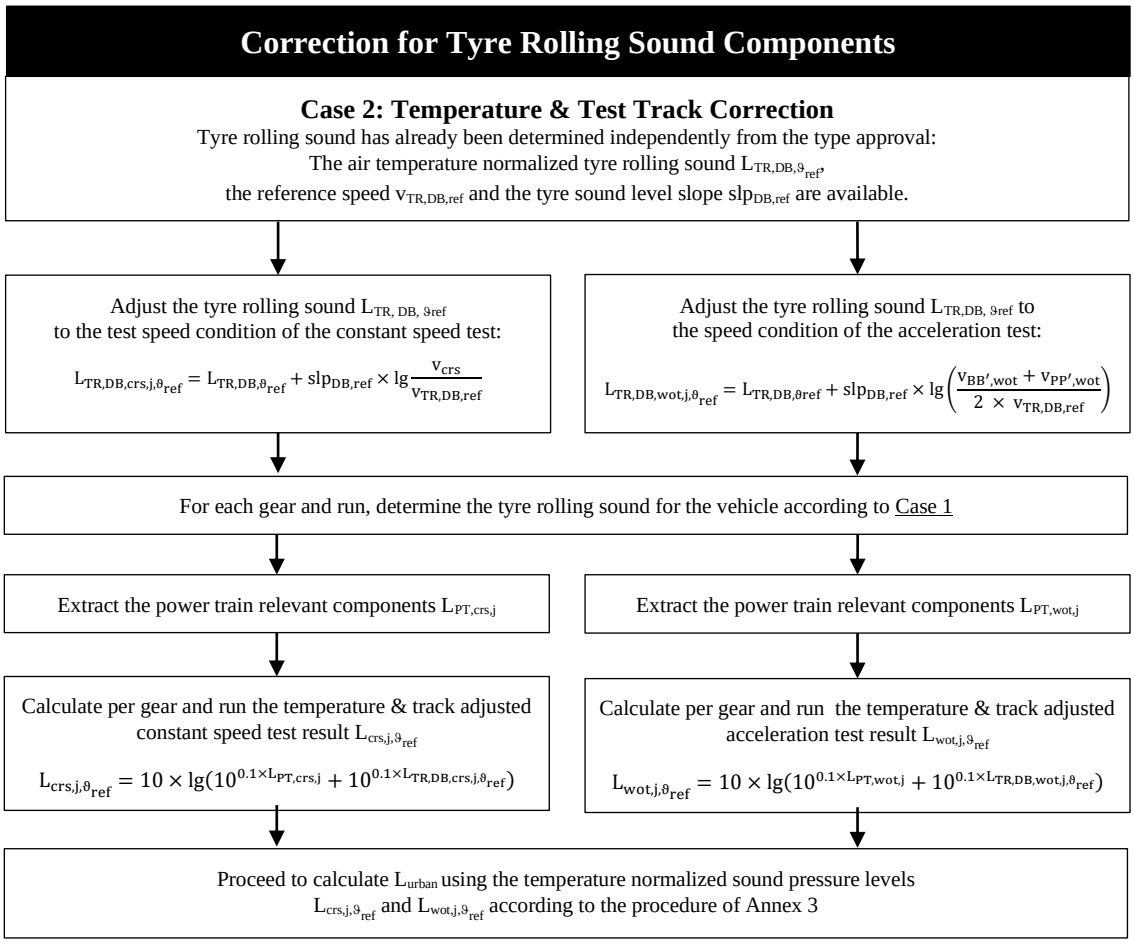


Figure 7c

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, add a new Appendix 3 to read:

“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 ride 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 10844:2014: .....

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 6,

Paragraph 2.1., amend to read:

“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 and 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 $0.90m_{ro} \leq m_t \leq 1.20m_{ro}$.

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."

Annex 7,

Title, amend to read:

"Measurement method to evaluate compliance with the Additional Sound Emission Provisions"

Paragraph 1., amend to read

"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 same test track and under similar environmental conditions.[7]

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."

Paragraph 2.5.1., last indent, replace "Appendix to Annex 3" to read "Appendix 1 to Annex 3".

Annex 8,

Introduction, amend to read:

"Indoor testing

Indoor testing is only for Annex 3 and Annex 7 measurements.

1. Documentation for indoor application

…"

Paragraph 2.3., amend to read:

"2.3. Tyre/road sound

[7] Measurements for Annex 7 for a particular vehicle type may be carried out on 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.

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."

Insert a new Annex 9, to read:

"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 vehicles of categories M_1 and N_1 equipped with:

- an internal combustion engine (ICE) for propulsion of the vehicle, or
- any other propulsion technology fitted with an exterior 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) [8] 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

[8] 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."

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.

2.3. "*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…).

2.4. "*Performance*" means the product of acceleration and vehicle speed as quantity of the achieved vehicle performance.

2.5. "*Power trains*" 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[9] 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[10] 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/s²	4 m/s²
Performance	0 m²/s³	35 m²/s³
Gear	ANY for forward driving	

[9] Facilities may provide restriction for safety reasons, such as for vehicle speed.

[10] 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.

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 L_{REF_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 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 3.8. 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

$$\kappa_{TEST} = v_{BB'\_TEST}/n_{BB'\_TEST} \times 1000$$

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

$L_{ACC\_ANCHOR\prime} = \left(Limit - k_P \times L_{CRS\_ANCHOR}\right)/(1 - k_P)$

Formula 3.2.4.4.2 No.1

$n_{CRS\_ANCHOR} = (v_{TEST}/30) \times 1000$

Formula 3.2.4.4.2 No.2

$n_{CRS\_ANCHOR} = (v_{TEST}/30) \times 1000$

Formula 3.2.4.4.3 No.1

$L_{CRS\_ANCHOR\prime} = L_{CRS\_ANCHOR} + 0.5\ dB(A)$

Formula 3.2.4.4.3 No.2

$L_{ACC\_ANCHOR\prime} = \left(Limit - k_P \times L_{CRS\_ANCHOR\prime}\right)/(1 - k_P)$

Formula 3.2.5.1.

$L_{CRS\_ANCHOR\prime} = L_{ACC\_ANCHOR} - 1.1\ dB(A)$

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

$L_{PT_{EXP}} = \theta_{PT_{HI}} \times \lg\left(\left(n_{BB'_{TEST}} + n_{SHIFT_{PT}}\right)/\left(n_{BB'_{CRS_{ANCHOR}}} + n_{SHIFT_{PT}}\right)\right) + L_{REF_{PT}}$

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.

$$v{\cdot}a_{TEST} = \frac{v_{BB'\text{-}TEST}}{3{,}6} \times a_{TEST} \quad [m^2/s^3]$$

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.

$$\Delta L_{DYN\_EXP} = \left(\Delta L_{DYN} + \Delta L_{DYN\_v{\cdot}a}\right) \times (1 - \alpha_1/(LOAD_{TEST} + \alpha_2))/\left(1 - \alpha_1/(1 + \alpha_2)\right) + 0.3$$

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 3.8.

$$L_{TEST\_EXP} = 10 \times \lg\left(10^{0.1 \times L_{TR\_EXP}} + 10^{0.1 \times L_{PT\_EXP}} + 10^{0.1 \times \left(L_{DYN\_EXP} + \Delta L_{DYN\_EXP}\right)}\right) + \Delta L_{AVAS} + 2dB(A)$$

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·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																			
5																			

Compliance of the test results to Annex 9: YES/NO

Number Case of compliance according to paragraph 4 of Annex 9:

"