Proposal for the 04 series of amendments to UN Regulation No. 51

Main body, Paragraph 1. amended as following:

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, Real Driving Additional Sound Emission Provisions (RD-ASEP) for vehicles of categories M1 and N1 referring to typical on road driving conditions including high accelerations and engine loads for urban and suburban traffic, except for highways situations.

Main body, introduction of new definitions in paragraph 2

2. Definitions

2.24. Table of symbols

2.24.1 Table of symbols for Annex 3 for the test method according Annex 3

Symbols listed under the paragraphs 2.2.1 up to 3.1.1 are general symbols used for both test methods described under paragraphs 3.1.2.1 and 3.1.2.2.

Symbols listed under the paragraphs 3.1.2.1 are used for the test method of vehicles of category M1, N1 and M2 ≤ 3.500 kg technically permissible maximum laden mass.

Symbols listed under the paragraphs 3.1.2.2 are used for the test method of vehicles of category M_2 > 3,500 kg technically permissible maximum laden mass, M_3, N_2, N_3.

Symbol	*Unit*	*Paragraph*	*Explanation*
m_{ro}	kg	2.2.1.	mass in running order; value to be reported and used for calculations to a precision of 10 kg
m_t	kg	2.2.1.	test mass of the vehicle; value to be reported and used for calculations to a precision of 10 kg
m_{target}	kg	2.2.1.	target mass of the vehicle
m_{xload}	kg	2.2.1.	extra loading
$m_{fa\ load\ unladen}$	kg	2.2.1.	front axle load in unladen condition
$m_{ra\ load\ unladen}$	kg	2.2.1.	rear axle load in unladen condition
$m_{unladen}$	kg	2.2.1.	unladen vehicle mass
$m_{ac\ ra\ max}$	kg	2.2.1.	Technically permissible maximum laden mass allowed for the rear axle as declared by the manufacturer

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

Symbol	*Unit*	*Paragraph*	*Explanation*
m_d	kg	2.2.1.	mass of driver
$m_{chassis\ M2M3}$	kg	2.2.1.	mass of the incomplete vehicle (M_2 or M_3)
$m_{xload\ M2M3}$	kg	2.2.1.	extra load to be added to the incomplete vehicle (M_2 or M_3) to reach the mass of the vehicle in running order as chosen by the manufacturer
$m_{fa\ load\ laden}$	kg	2.2.7.2.	front axle load in laden condition
$m_{ra\ load\ laden}$	kg	2.2.7.2.	rear axle load in laden condition
$m_{t\ (2\ axles\ virtual)}$	kg	2.2.7.4.	test mass of a virtual vehicle with two axles (4x2 or 4x4)
v_{rf}	—	2.2.7.4.	vehicle with more than two axles representing the vehicle family
$m_{unladen\ (2\ axles\ virtual)}$	kg	2.2.7.4.	unladen vehicle mass of the virtual vehicle with two axles
$m_{xload\ (2\ axles\ virtual)}$	kg	2.2.7.4.	extra loading for the virtual vehicle with two axles
$m_{ac\ ra\ max\ (chosen)}$	kg	2.2.7.4.	Technically permissible maximum laden mass allowed for the chosen rear axle as defined in paragraph 2.2.7.4. in Annex 3
AA'	—	3.1.1.	line perpendicular to vehicle travel which indicates beginning of zone in which to record sound pressure level during test
BB'	—	3.1.1.	line perpendicular to vehicle travel which is 10.00 m behind line PP'
CC'	—	3.1.1.	line of vehicle travel through test surface defined in ISO 10844
PP'	—	3.1.1.	line perpendicular to vehicle travel which indicates location of microphones
v_{test}	km/h	3.1.2.1.	vehicle test speed
PMR	—	3.1.2.1.1.	power-to-mass ratio index to be used for calculations; value to be reported and used for calculations to the first decimal place
P_n	kW	3.1.2.1.1.	rated total engine net power
l	m	3.1.2.1.2.	reference length; value to be reported and used for calculations to a precision of 0.01 m (1 cm)
l_{veh}	m	3.1.2.1.2.	length of vehicle; value to be reported and used for calculations to a precision of 0.01 m (1 cm)
$v_{AA'}$	km/h	3.1.2.1.2.	vehicle velocity when the reference point passes line AA' (see paragraph 2.11. for definition of reference point); value to be reported and used for calculations to the first decimal place

Symbol	*Unit*	*Paragraph*	*Explanation*
$v_{BB'}$	km/h	3.1.2.1.2.	vehicle velocity when the reference point or rear of the vehicle passes line BB' (see paragraph 2.11. for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{PP'}$	km/h	3.1.2.1.2.	vehicle velocity when the reference point passes line PP' (see paragraph 2.11. for definition of reference point)
$a_{wot\ test}$	m/s^2	3.1.2.1.2.1.	acceleration from AA' to BB'; value to be reported and used for calculations to the second decimal place
$a_{wot\ test,i}$	m/s^2	3.1.2.1.2.1.	acceleration achieved in a particular gear i; value to be reported and used for calculations to the second decimal place
l_{pa}	m	3.1.2.1.2.1.	point of depressing the accelerator before line AA'; value to be reported in full meter
$a_{wot\ test,\ PP\text{-}BB}$	m/s^2	3.1.2.1.2.2.	acceleration from PP' to BB'; value to be reported and used for calculations to the second decimal place
a_{urban}	m/s^2	3.1.2.1.2.3.	target acceleration representing urban traffic acceleration; value to be reported and used for calculations to the second decimal place
$a_{wot\ ref}$	m/s^2	3.1.2.1.2.4.	reference acceleration for the acceleration test; value to be reported and used for calculations to the second decimal place
k_P	—	3.1.2.1.3.	partial power factor; value to be reported and used for calculations to the second decimal place
$a_{wot\ i}$	m/s^2	3.1.2.1.4.1.	acceleration in gear ratio i; value to be reported and used for calculations to the second decimal place
$a_{wot\ (i+1)}$	m/s^2	3.1.2.1.4.1.	acceleration in gear ratio (i + 1); value to be reported and used for calculations to the second decimal place
gear ratio i	—	3.1.2.1.4.1.	gear ratio which provides an acceleration within the 5 per cent tolerance of the reference acceleration a_{wot_ref} or greater than the reference acceleration a_{wot_ref}
gear ratio i+1	—	3.1.2.1.4.1.	second of two gear ratios, with an acceleration lower than gear ratio i
gear ratio i+2, i+3, …	—	3.1.2.1.4.1.	gear ratios selectable for the pass-by test of Annex 3, if gear ratio i and gear ratio i+1 exceed an acceleration of 2.0 m/s^2
k	—	3.1.2.1.4.1.	gear ratio weighting factor; value to be reported and used for calculations to the second decimal place
$n_{BB'}$	1/min	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}
S	1/min	3.1.2.2.	rated engine rotational speed in revs per minute, synonymous with the engine rotational speed at maximum power

Symbol	*Unit*	*Paragraph*	*Explanation*
$n_{target\ BB'}$	1/min	3.1.2.2.1.1.(a)	target engine rotational speed of the vehicle when the reference point has to pass line BB' (see 2.11.2. for definition of reference point)
$v_{target\ BB'}$	km/h	3.1.2.2.1.1.(a)	target vehicle velocity when it is necessary that the reference point has to pass line BB' (see 2.11.2. for definition of reference point)
$v_{BB'\ gear\ I}$	km/h	3.1.2.2.1.1.(b)	target vehicle velocity when certain conditions are met
$v_{BB'\ gear\ i,\ i=1,2}$	km/h	3.1.2.2.1.1. (c)	target vehicle velocity when certain conditions are met
$gear_x$	-	3.1.2.2.1.1. (d)	first of two gear ratios used for testing of M_2 having a maximum authorized mass of more than 3 500 kg, M_3, N_2, and N_3 where certain criteria on test conditions are met
$gear_y$	-	3.1.2.2.1.1. (d)	second of two gear ratios used for testing of M_2 having a maximum authorized mass of more than 3,500 kg, M_3, N_2, and N_3 where certain criteria on test conditions are met
$v_{BB'x}$	km/h	3.1.2.2.1.1. (d)	target vehicle velocity when certain conditions are met
$v_{BB'y}$	km/h	3.1.2.2.1.1. (d)	target vehicle velocity when certain conditions are met
$v_{BB'1}$	km/h	3.1.2.2.1.2. (b)	target vehicle velocity when certain conditions are met
$v_{BB'2}$	km/h	3.1.2.2.1.2. (b)	target vehicle velocity when certain conditions are met
$n_{BB'i}$, i=1,2	1/min	3.1.2.2.1.2. (d)	engine rotational speed when the reference point passes BB' when certain conditions are met
$L_{crs\ i}$	dB(A)	3.1.3.1.	vehicle sound pressure level at constant speed test for gear i; value to be reported and used for calculations to the first decimal place
$L_{crs\ (i+1)}$	dB(A)	3.1.3.1.	vehicle sound pressure level at constant speed test for gear (i + 1); value to be reported and used for calculations to the first decimal place
$L_{crs\ rep}$	dB(A)	3.1.3.1.	reported vehicle sound pressure level at constant speed test; value to be reported and used for calculations to the first decimal place
$L_{wot\ i}$	dB(A)	3.1.3.1.	vehicle sound pressure level for the acceleration test for gear i; value to be reported and used for calculations to the first decimal place
$L_{wot\ (i+1)}$	dB(A)	3.1.3.1.	vehicle sound pressure level ~~at wide-open throttle~~ for the acceleration test for gear (i + 1); value to be reported and used for calculations to the first decimal place
$L_{wot\ rep}$	dB(A)	3.1.3.1.	reported vehicle sound pressure level ~~at wide-open throttle~~ for the acceleration test to be reported and used for calculations to the first decimal place
L_{urban}	dB(A)	3.1.3.1.	reported vehicle sound pressure level representing urban operation; value to be reported mathematically rounded to the nearest integer

2.24.2 Table of symbols for Annex 7

Symbol	*Unit*	*Paragraph*	*Explanation*
a_{wot_ASEP}	m/s^2	2.3.	maximum required acceleration
κ	—	2.3.	gears to be tested under "Additional Sound Emission Provisions" (ASEP)
n_{BB_ASEP}	1/min	2.3.	maximum test engine speed; value to be reported and used for calculations to a precision of 10 min-1
$v_{AA'\_ASEP}$	km/h	2.3.	Target vehicle velocity for test point P1 of the assessment method according paragraph 2.4
$v_{BB'\_ASEP}$	km/h	2.3.	Target vehicle velocity for test point P4 of the assessment method according paragraph 2.4
P_j	—	2.4.	test point(s) under ASEP
j	—	2.4.	index for the test points under ASEP
$v_{BB'\_j}$	km/h	2.4.	vehicle test speed at BB' for a particular ASEP test point
$a_{wot,test,\ \kappa j}$	m/s^2	2.5.	acceleration achieved in gear κ and at test point j
$L_{wot,\kappa j}$	dB(A)	2.5.	sound pressure level measured for a gear κ and at a test point j; value to be reported and used for calculations to the first decimal place
$n_{BB',\kappa j}$	1/min	2.5.	vehicle test engine speed at BB' for a gear κ and at test point j
$v_{AA',\kappa j}$	km/h	2.5.	vehicle test speed at AA' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
$v_{BB',\kappa j}$	km/h	2.5.	vehicle test speed at BB' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
$v_{PP',\kappa j}$	km/h	2.5.	vehicle test speed at PP' for a gear κ and at test point j; value to be reported and used for calculations to the first decimal place
L_{anchor}	dB(A)	3.1.	reported vehicle sound pressure level for gear ratio i from Annex 3; value to be reported and used for calculations to the first decimal place
n_{anchor}	1/min	3.1.	reported vehicle engine speed for gear ratio i from Annex 3
v_{anchor}	km/h	3.1.	reported vehicle test speed for gear ratio i at BB' from Annex 3; value to be reported and used for calculations to the first decimal place
$L_{\kappa j}$	dB(A)	3.5.	sound pressure level measured for a gear κ and at a test point j; value to be reported and used for calculations to the first decimal place
k_{P_ASEP}	—	4.2.1.	partial power factor determined for the L_{urban} principle of ASEP

Symbol	*Unit*	*Paragraph*	*Explanation*
L_{wot_ASEP}	dB(A)	4.2.1.	vehicle sound pressure level measured for the L_{urban} principle of ASEP; value to be reported and used for calculations to the first decimal place
L_{urban_ASEP}	dB(A)	4.2.1.	Estimated urban sound pressure level determined for the L_{urban} principle of ASEP; value to be reported and used for calculations to the first decimal place
$L_{urban\_measured\_ASEP}$	dB(A)	4.2.1.	interim result for calculation of ΔL_{urban_ASEP}; value to be reported and used for calculations to the first decimal place
$L_{urban\_normalized}$	dB(A)	4.2.1.	interim result for calculation of ΔL_{urban_ASEP}; value to be reported and used for calculations to the first decimal place
ΔL_{urban_ASEP}	dB(A)	4.2.1.	estimated deviation from urban sound pressure level; value to be reported to the first decimal place
α	—	5.2	gear to be determined for the reference sound assessment according to the type of transmission
L_{ref}	dB(A)	5.3.	reference sound pressure level for reference sound assessment; value to be reported and used for calculations to the first decimal place
n_{ref_κ}	1/min	5.3.	reference engine speed for reference sound assessment
v_{ref}	km/h	5.3.	reference vehicle test speed for reference sound assessment
$n_{BB'\_ref}$	1/min	5.3.	Reference vehicle test engine speed for reference sound assessment
$v_{BB'\_ref}$	km/h	5.3.	reference vehicle test speed for reference sound assessment*

2.29. "*Exhaust silencing system with variable geometry*" means a silencing system, not including pressure charging, containing one or more active, passive, or self-actuated moving parts or devices.

These parts or devices will cause a change of the gas flow through the exhaust silencing system and result in a change of the sound reduction performance, by opening or closing one or more valves in the exhaust gas flow as a function of varying driving or engine conditions (rpm, load, speed, etc.).

Active devices mean actuators, controlled by any means.

Passive or self-actuated devices mean units controlled e.g. by exhaust flow.

2.30. "*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.

2.31. "*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…).

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

Insert new paragraphs 2.33., 2.34. and 2.35.,

"2.3.3. "Electronic Control System" means a combination of units, designed to co-operate in the production of the stated vehicle control function by electronic data processing. Such systems, often controlled by software, are built from discrete functional

components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, electro-pneumatic or electro-hydraulic elements. "The System", referred to herein, is the one for which type approval is being sought.

2.3.4. "Software" means the part of an Electronic Control System that consists of digital data and instructions."

2.3.5. "Rx Software Identification Number (RXSWIN)" means a dedicated identifier, defined by the vehicle manufacturer, representing information about the type approval relevant software of the Electronic Control System contributing to the UN Regulation No. 51.04 type approval relevant characteristics of the vehicle.

Main body, Paragraph 6.1.2. amended as following:

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.

Main body, Paragraph 6.2.1.1. amended as following:

6.2.1.1. The sound made by the vehicle type submitted for approval shall be measured either indoors or outdoors by the methods described in Annex 3 and Annex 7 to this Regulation. The specific conditions for indoor testing are provided in Annex 8 to this Regulation. The results of the outdoor and indoor tests are deemed equivalent.

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

In addition, the sound shall be measured on the stationary[3] vehicle; in the case of a vehicle where an internal combustion engine cannot operate when the vehicle is stationary, the emitted sound shall only be measured in motion. In the case of a hybrid electrical vehicle of category M_1 where an internal combustion engine cannot operate when the vehicle is stationary, the emitted sound shall be measured according to Annex 3, paragraph 4.

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

Main body, Paragraph 6.2.3. amended as following:

6.2.3. Real Driving Additional Sound Emission Provisions

The Real Driving Additional Sound Emission Provisions (RD-ASEP) apply 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.

6.2.3.1. Exemptions

Notwithstanding the requirements above, vehicles equipped with an ICE for propulsion, inclusive HEV are exempted from RD-ASEP, if their exhaust silencing systems have no variable geometries,

- and the vehicle has no sound enhancement systems, or
- a sound enhancement system is fitted to the vehicle solely for the purpose of fulfilling the provisions of UN Regulation No. 138.01, and the sound emitting device does not emit a sound pressure level of more than 75 dB(A)[2] under any operation conditions exceeding the specification range of UN Regulation No. R138.01.

  Manufacturer shall demonstrate compliance to the 75dB(A) by using the test set up according to UN Regulation No. R138.01 Annex 3 paragraph 3.3.2.2. by using the control range of RD-ASEP described in Annex 7 paragraph 3.3.

Notwithstanding the requirements above, vehicles which have no ICE for propulsion are exempted from RD-ASEP, if

- the vehicle does not have any sound enhancement system, or
- a sound enhancement system is fitted to the vehicle solely for the purpose of fulfilling the provisions of UN Regulation No. 138.01, and the sound emitting device does not emit a sound pressure level of more than 75 dB(A) under any operation conditions exceeding the specification range of UN Regulation No. R138.01.

  Manufacturer shall demonstrate compliance to the 75dB(A) by using the test set up according to UN Regulation No. R138.01 Annex 3 paragraph 3.3.2.2. by using the control range of RD-ASEP described in Annex 7 paragraph 3.3.

6.2.3.2. Specifications

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

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

6.2.3.2.3. Regardless of the specifications above, the sound emissions of the vehicle under other driving conditions not subject to the measuring conditions of the Annex 3 and Annex 7, shall not deviate from the evaluation principles outlined by Annex 7 in a significant manner.

6.2.**3.3**. Provisions against manipulation

6.2.**3.3**.1. Software manipulation

6.2.3.3.1.1. Requirements for software identification

For the purpose of ensuring the software of the System can be identified, an RXSWIN may be implemented by the vehicle manufacturer.

6.2.3.3.1.2. If the manufacturer implements an RXSWIN the following shall apply:

6.2.3.3.1.2.1. The vehicle manufacturer shall have a valid approval according to UN Regulation No. 156.

6.2.3.3.1.2.2. The vehicle manufacturer shall provide the following information in the communication form of this Regulation:

- the RXSWIN
- how to read the RXSWIN or software version(s) in case the RXSWIN is not held on the vehicle

[2] See footnote 3 in paragraph 6.2.7 of UN Regulation No. 138.01 "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."

6.2.3.3.1.2.3. The vehicle manufacturer may provide in the communication form of this Regulation a list of the relevant parameters that will allow the identification of those vehicles that can be updated with the software represented by the RXSWIN. The information provided shall be declared by the vehicle manufacturer and may not be verified by an Approval Authority.

[6.2.3.3.1.3. The vehicle manufacturer may obtain a new vehicle approval for the purpose of differentiating software versions intended to be used on vehicles already registered in the market from the software versions that are used on new vehicles. This may cover the situations where type approval regulations are updated or hardware changes are made to vehicles in series production. In agreement with the testing agency duplication of tests shall be avoided where possible.]

6.2.3.3.2. Hardware manipulation

All exhaust silencing systems shall be designed, constructed and assembled in a way that does not easily permit removal of baffles, exit-cones and other parts whose primary function is as part of the silencing/expansion chambers. It also applies to control units for active systems and to components like exhaust or intake flaps, or to vacuum tubes controlling the flaps, whose removal for purposes of maintenance, repair, or replacement is only possible by special tools and expertise.

Main body, paragraph 8, amend to read,

8. Conformity of production

8.1 The conformity of production procedures shall comply with those set out in the Agreement, Schedule 1 (E/ECE/TRANS/505/Rev.3).

8.2. Control procedures carried out by the manufacturer for conformity of production according to paragraph 2.3 of Schedule 1 of the Agreement (see 8.1 above) shall at least comply with the requirements of Annex 6 to this Regulation.

8.3 Whenever measurements on Conformity of Production according to paragraph 3. of Schedule 1 of the Agreement (see 8.1 above) or other authority initiated measurements dedicated to evaluate the conformity of the vehicle with regard to this Regulation are carried out, the setup of the vehicle and the assessment methods as established during type approval shall be taken as reference for the conformity assessment

Notwithstanding this provision, the requirements of 6.2.1.1 remain valid.

Main body, paragraph 11, amend to read,

11. Transitional provisions

11.1. As from the official date of entry into force of the 04 series of amendments to this Regulation, no Contracting Party applying this Regulation shall refuse to grant or refuse to accept type-approvals under this Regulation as amended by the 04 series of amendments.

[further transitional provisions to be completed]

ANNEX 3

Annex 3, Paragraph 3.1.1. amended as following:

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.

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.

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'.

Annex 3, Paragraph 3.1.2.1.2.4. amended as following:

3.1.2.1.2.4. Reference acceleration

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

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

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

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

Annex 3, Paragraph 3.1.2.1.3. amended as following:

3.1.2.1.3. Partial power factor k_P

The partial power factor k_P (see paragraph 3.1.3.1.) is used for the weighted combination of the test results of the acceleration test and the constant speed test for vehicles of category M_1 and N_1 and $M_2 \leq 3{,}500$ kg technically permissible maximum laden mass

In cases other than a single gear test, $a_{wot\ ref}$ shall be used instead of $a_{wot\ test}$ (see paragraph 3.1.3.1.).

Regardless of the achieved acceleration, the minimum contribution of the constant speed test result shall always be at least 10 per cent.

Annex 3, Paragraph 3.1.2.1.4.1. amended as following:

3.1.2.1.4. Gear ratio selection

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

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

The vehicle transmission, gear, or gear ratio may be controlled by electronic or mechanical measures for prevention of kick-down.

Note: We propose the following understanding for gear and gear ratio:

- ***gear: we talk about gears, when the transmission has a clear discrete number of selectable gears as it is the case for manual transmissions and automatic transmissions and automated manual transmissions.***
- ***Gear ratio: we talk about gear ratios, especially in junction with CVTs where any gear ratio may be available.***
- ***A CVT might have predefined by soft- or hardware discrete gears, but could provide as well more gear ratios by external control measures.***

We suggest to rework definition 2.18 accordingly, especially to clarify:

- The gear ratio is defined by the formula below:
- $v_{1000rpm} = 60 \times \frac{U_T}{i_{GEAR} \times i_{FINAL}}$

Where U_T is the dynamic (see ETRO handbook) tyre diameter

i_{GEAR} is the gear ratio of the discrete selected gear

i_{FINAL} is the gear ratio of the drive shaft gear

Appendix 3, Figure 4a to Figure 4e, give gear selection criteria and test run criteria for categories M_1 and M_2 having a technically permissible maximum laden mass not exceeding 3.500 kg and for category N_1, in a flowchart form as an aid to test operation.

Annex 3, Paragraph 3.1.2.1.4.1. amended as following:

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

The following conditions for selection of gear ratios are possible:

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

(b) If none of the gear ratios give the required acceleration, then choose a gear ratio i, with an acceleration higher and a gear ratio i+1, with an acceleration lower than the reference acceleration. If the acceleration value in gear ratio i does not exceed 2.0 m/s^2, use both gear ratios for the test. The weighting ratio in relation to the reference acceleration $a_{wot\ ref}$ is calculated by:

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

(c) If the acceleration value of gear ratio i exceeds 2.0 m/s^2, the first gear ratio shall be used that gives an acceleration below 2.0 m/s^2 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/s^2. 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 the maximum engine speed $n_{BB',max}$ is exceeded in a gear ratio i before the vehicle passes BB' the next higher gear i+1 shall be used. If the next higher gear i+1 results in an acceleration below a_{urban}, the vehicle test speed, v_{test}, in the gear ratio i shall be reduced by 2.5 km/h and the gear ratio selection shall proceed as specified by the options given in this paragraph. In no case shall the vehicle test speed be reduced below 40 km/h.

If the maximum engine speed $n_{BB',max}$ 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 $n_{BB',max}$ is given by the formula below:

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

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

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

Annex 3, Paragraph 3.1.2.1.4.1. amended as following:

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 ~~used~~ representative ~~in~~ 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

- 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}.
- a test engine speed exceeding $n_{BB',max}$.
    - 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
    - The engine load is reduced to avoid a downshift to a gear ratio, where $n_{BB',max}$ is exceeded.

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

If possible, the manufacturer shall take measures to avoid an engine speed higher than $n_{BB',max}$.

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

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

Annex 3, Paragraph 3.1.2.1.6. amended as following:

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.

Annex 3, Paragraph 3.1.2.1.3. amended as following:

3.1.3.1. Vehicles of categories M_1, N_1 and $M_2 \leq 3{,}500$ kg technically permissible maximum laden mass

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

$L_{wot\ rep} = L_{wot\ (i+1)} + k * (L_{wot(i)} - L_{wot\ (i+1)})$

$L_{crs\ rep} = L_{crs(i+1)} + k * (L_{crs\ (i)} - L_{crs\ (i+1)})$

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

In the case of a single gear ratio test the values are the test result of each test.

The final result is calculated by combining $L_{wot\ rep}$ 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 k_P is less than 0.1 or where $a_{wot\ test}$ is less than a_{urban}:

$k_P = 0.1$

ANNEX 6

Annex 6, Paragraph 2.1. amended as following:

2. Testing procedure

The test site and measuring instruments shall be those as described in Annex 3.

2.1. The vehicle(s) under test shall be subjected to the test for measurement of sound of vehicle in motion as described in paragraph 3.1. of Annex 3.

The vehicle(s) under test shall be subjected to the test for measurement of RD-ASEP according to Annex 7 and paragraph 2.3 of this Annex unless the vehicle is exempted from RD-ASEP.

For vehicles of category M_1, N_1 and $M_2 \leq 3{,}500$ kg technically permissible maximum laden mass,

- 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 shall be used, provided this information are available from the type approval test report for the applicable vehicle variant of the family. If not, this information shall be or determined anew. The test report shall document which way of data processing was selected.
- the test mass m_t of the vehicle shall be between $0.90\ m_{ro} \leq m_t \leq 1.20\ m_{ro}$.

Annex 6, Paragraph 2.3. amended as following:

2.3. Additional Sound Emission Provisions (ASEP)

The vehicle manufacturer shall assess the compliance with ASEP by an appropriate evaluation (for example, but not limited to, part checks) or may perform the test described in Annex 7.

The vehicle CoP test of Annex 7 shall be randomised over the whole control range of RD-ASEP and shall be at least 3 runs and not more than 5 runs.

3. Sampling and evaluation of the results

One vehicle shall be chosen and subjected to the tests set out in point 2. If the sound level of the vehicle tested does not exceed by more than 1 dB(A) the limit values specified in paragraphs 6.2.2. and 6.2.3. of this regulation, and, where appropriate, paragraph 3. of Annex 5, the vehicle type shall be considered to conform to the requirements of this Regulation.

If one of the test results does not fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation two more vehicles of the same type shall be tested pursuant to paragraph 2. above.

If the test results for the second and the third vehicle fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation, the vehicle is considered in compliance with regard to the COP.

If one of the test results of the second or third vehicle does not fulfil the COP requirements of this annex and of paragraph 8. of the main body of this Regulation the vehicle type shall be considered not to conform to the requirements of this Regulation and the manufacturer shall take the necessary measures to re-establish the conformity.

ANNEX 7

Measuring method to evaluate compliance with the Real Driving Additional Sound Emission Provisions (RD-ASEP)

This annex is applicable to vehicles as specified in paragraph 6.2.3. of this Regulation.

1. General

Any vehicle operating conditions within the control range, as specified in paragraph 2.3. of Annex 7 are typical on road driving conditions and are covered by RD-ASEP.

Any electric sound enhancement system for the purpose of the exterior sound emission shall operate as designed during the type-approval test and not be interfered with.

2. Facilities

Due to limitations of test facilities and in respect of safety, not every test condition may be safely performed on every test facility.

Notwithstanding such restrictions, the type approval shall be granted on these test facilities, however the vehicle has to comply to all provisions of this Annex 7. In these cases, the vehicle manufacturer shall explain to the satisfaction of the authority present at type approval that the vehicle fulfils the requirements which could not be tested due to the restriction of the test facility.

Tests for Annex 7 may be carried out on different test facilities[3] 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.

3. Measurement method

3.1. 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.

3.2. 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.

3.3. 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 (vxa)	0 m²/s³	35 m²/s³
Gear	ANY for forward driving	
Mode	ANY	

[3] Tests for Annex 3 and Annex 7 may be carried out on different test facilities if documentation exists that demonstrates that the differences in sound performance are neglectable.

In any operation condition, the engine speed of a vehicle, which can be propelled with an ICE operating, is limited to 80% of S.

3.4. 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%].

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 2.26.1. 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]

(to be revised after refinement of the sound model)

The operation conditions and test results shall be entered into the test report sheet according to the table of the Appendix 3 to this Annex.

The first operation condition shall be selected according to the principles outlined in paragraph 3.6.1. of the Appendix 1 to determine the maximum reference acceleration $a_{MAX,REF}$.

3.5. Test of the vehicle

3.5.1. 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.

3.5.2. Non-locked transmissions

In case of non-locked transmission conditions, the test may include a gear ratio change to a lower range and a higher acceleration under accelerated conditions.

A gear ratio 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.

3.5.3. 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, ~~either measured simultaneously or separately~~ shall be measured and shall be mathematically rounded to the first decimal place ($L_{wot,кj}$). *(symbol to be checked)*
- The vehicle speed readings at lines AA' and PP’, when the vehicle reference point passes these lines, shall be rounded and reported with the first significant digit after the decimal place ($v_{AA,кj}$; $v_{PP,кj}$). *(symbols to be checked)*
- 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 ($v_{BB,кj}$). *(symbols to be checked)*
- If applicable, the engine speed readings at line AA’ and BB' ~~and the maximum engine speed between line AA’ and line BB’ + 20 m~~ shall be rounded to 10 min^{-1} and reported ($n_{AA,кj}$ $n_{BB,кj}$). *(symbol to be checked)*

All measured values shall be entered into the test report sheet according to the table of Appendix 3 of this Annex.

3.5.4. Calculated values

All calculated values shall be entered into the test report sheet according to the table of Appendix 3 of this Annex.

3.5.4.1. Acceleration a

The accelerations shall be calculated between lines PP’ to BB’, in accordance to 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 ($a_{wot,test,кj}$) as results. *(symbol to be checked)*

3.5.4.2. Performance vxa

The performance shall be 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.

3.5.4.3. Expected sound pressure level L_{EXP}

For the calculation of the expected sound pressure level, the measured values according to paragraph 3.5.3. and calculated values according to paragraphs 3.5.4.1.

and 3.5.4.2. shall be used. All calculations are done according to Appendix 1 to this Annex.

4. Compliance assessment

4.1. Case 1

The compliance of the vehicle is acceptable if the measured sound pressure levels of all valid runs are lower than or equal to the expected sound pressure levels of paragraph 3.5.4.3. ***(rounded to integer needed or not → to be decided later)***

$L_{TEST} \leq L_{EXP,TEST}$

4.2. Case 2

If not more than [two] valid runs of the specified runs exceed the expected sound pressure level of paragraph 3.5.4.3. by not more than [2] dB(A) the compliance of the vehicle is acceptable.

4.3. Case 3

If more than [two] valid runs of the specified runs exceed the expected sound pressure level of paragraph 3.5.4.3. then the vehicle is non-compliant with RD-ASEP.

4.4. Case 4

No valid run shall exceed the expected sound pressure level of paragraph 3.5.4.3. by more than [2 dB(A)]. If this is the case, the vehicle is non-compliant with RD-ASEP.

Annex 7 - APPENDIX 1 – Sound Expectation Model

Aspect of partial load driven by acceleration test (Supplements 4 & 5) needs to be considered for the ASEP model

1. General

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 estimation 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. Engine speed is not requested for Annex 3. However, for the purpose of Annex 7 it needs to be measured.

The parameters to be reported from the acceleration test are:

- The sound pressure level $L_{WOT,REP}$ 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 the acceleration test has been carried out under partial load according to the measures 3.1 or 3.2 described in table 1 to the Appendix of Annex 3.
- The vehicle speed $v_{BB,WOT,REP}$ when the rear of the vehicle passes line BB', rounded to the first decimal.
- The engine speed $n_{BB,WOT,REP}$ when the rear of the vehicle passes line BB', rounded to 10 min^{-1}.

The parameters to be reported from the constant speed test are:

- The sound pressure level $L_{CRS,REP}$ 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 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 $v_{BB,CRS}$, rounded to the first decimal.
- The engine speed $n_{BB,CRS,REP}$ 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 the Appendix 2 to this Annex.

2.3.1. Discrete Determination of the factor x

On request of the manufacturer the x – factor may be determined by discrete coast-down measurement to determine $L_{REF,TR}$ directly, according to the calculation

principles of UN R117 for a vehicle speed of 50 km/h. Rounding and correction for measurement uncertainty shall not apply.

[➔ Temperature correction: see work of IWG MU]

2.4. Calculate the Reference Tyre/Rolling Sound Level $L_{REF,TR}$

$$L_{REF,TR} = 10 \times LOG(x * 10^{0.1 L_{CRS,REP}})$$

2.5. Calculate the Reference Power Train Mechanics Sound Level $L_{REF,PT}$

$$L_{REF,PT} = 10 \times LOG((1-x) * 10^{0.1\, L_{CRS,REP}})$$

2.6. Calculate the Reference Dynamic Sound Level $L_{REF,DYN}$

$$L_{REF,DYN} = L_{REF,PT} - 15$$

2.7. Determine the Vehicle Dynamic Delta Sound Level ΔL_{DYN}

If the arithmetic sound level difference between the reported acceleration sound level $L_{WOT,REP}$ and the reported constant speed sound level $L_{CRS,REP}$ is at least 1.1 dB or higher, the vehicle dynamic delta sound level ΔL_{DYN} is calculated by

$$\Delta L_{DYN} = 10 \times LOG(10^{0.1\, L_{WOT,REP}} - 10^{0.1\, L_{REF,TR,ADJ}} - 10^{0.1 L_{REF,PT,ADJ}}) - L_{REF,DYN}$$

with

$$L_{REF,TR,ADJ} = \theta_{TR,LO} * LOG(\frac{v_{BB,WOT,REP}}{50}) + L_{REF,TR}$$

$$L_{REF,PT,ADJ} = \theta_{PT,LO} * LOG\left(\frac{(n_{BB,WOT,REP} + n_{SHIFT,PT})}{(n_{BB,CRS,REP} + n_{SHIFT,PT})}\right) + L_{REF,PT}$$

If the arithmetic sound level difference between the reported acceleration sound level $L_{WOT,REP}$ and the reported constant speed sound level $L_{CRS,REP}$ is less than 1,1 dB, the vehicle dynamic delta sound level ΔL_{DYN} is set to 10 dB(A).

$$\Delta L_{DYN} = 10\, dB(A)$$

2.8. For a better understanding on the procedure, guidance is provided by the flowchart 2 in the Appendix 4 to Annex 7.

2.9. Having established the sound estimation 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 3.4 and 3.5 of Annex 7.

3. Calculation of the expected sound level $L_{EXP,TEST}$

3.1. For each single test run performed, for the purpose of Annex 7, an expected sound level $L_{EXP,TEST}$ shall be calculated.

The flowchart 3 in the Appendix 4 to Annex 7 provides guidance through the necessary calculation steps provided by the following paragraphs.

3.2. Necessary input data for the sound model are taken from the pass-by measurement according to paragraph 3.5.1. of Annex 7

3.2.1. For the calculation of the expected sound level the parameters listed in paragraphs 3.5.3. and 3.5.4.1 and 3.5.4.2 are needed.

In addition, the gear ratio i_{TEST}, expressed in km/h per 1000 min^{-1} and calculated by the formula below, rounded to the second decimal

$$i_{TEST} = v_{BB',TEST} / n_{BB',TEST} \times 1000$$

The transmission ratio i of the first operation condition according to paragraph 3.6.1 is defined a reference transmission ratio i_{REF}.

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 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}.

$$n_{BB',TEST} = \left(v_{BB',TEST}/30\right) \times 1000$$

3.2.3. Virtual engine speed for hybrid electric vehicles (parallel HEV)

Hybrid electric vehicle may have been tested in Annex 3 partly or fully in electric condition. For evaluation according 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
An engine speed information is available for both test results.

3.2.3.1.2. Correction of sound pressure level
No correction 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
An engine speed information is available for the acceleration test result. For the constant speed test, the engine speed is calculated with the lowest transmission gear ratio that can be engaged at the target speed of the vehicle v_{test} as selected for the constant speed test in Annex 3.

3.2.3.2.2. Correction of sound pressure level
No correction is applied to the acceleration test result. The corrected cruise test result $L_{CRS,REP'}$ is determined by

$$L_{CRS,REP'} = L_{CRS,REP} + 0.5\ dB$$

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
An engine speed information is available for the constant speed test.

The engine speed for the acceleration test is calculated with the lowest transmission gear ratio that provides an acceleration when the internal combustion engine and the electric propulsion power are operational greater than the reference acceleration $a_{WOT,REF}$ or an acceleration not exceeding 2.0 m/s², whichever is lower.

3.2.3.3.2. Correction of sound pressure level
No correction is applied to the constant speed test result.

The sound pressure level for the acceleration test is determined by

$$L_{WOT,REP'} = \left(Limit - k_P \times L_{CRS,REP}\right)/(1 - k_P)$$

where Limit is the applicable limit for this vehicle type and k_P is the determined k_P-factor from the Annex 3 test.

3.2.3.4. Case 4 – Internal combustion engine neither operational during the acceleration test nor during the constant speed test

3.2.3.4.1. Assignment of engine speed

The engine speed for the constant speed test is calculated with the lowest transmission gear ratio that can be engaged at the target speed of the vehicle v_{test} as selected for the constant speed test in Annex 3.

The engine speed for the acceleration test is calculated with the lowest transmission gear ratio that provides an acceleration when the internal combustion engine and the electric propulsion power is operational greater than the reference acceleration $a_{WOT,REF}$ or an acceleration not exceeding 2.0 m/s², whichever is lower.

3.2.3.4.2. Correction of sound pressure level

The sound pressure level for the constant speed test is determined by

$$L_{CRS,REP'} = L_{CRS,REP} + 0.5\ dB$$

The sound pressure level for the acceleration test is determined by

$$L_{WOT,REP'} = \left(Limit - k_P \times L_{CRS,REP'}\right)/(1 - k_P)$$

where Limit is the applicable limit for this vehicle type and k_P is the determined k_P-factor from the Annex 3 test.

3.2.4 Virtual engine speed for hybrid electric vehicle (series HEV)

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

An engine speed information is available for both test results.

3.2.4.1.2. Correction of sound pressure level

No correction 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

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. For the acceleration test, an engine speed information is available in the test result.

3.2.4.2.2. Correction of sound pressure level

No correction is applied to the acceleration test result. The corrected cruise test result $L_{CRS,REP'}$ is determined by

$$L_{CRS,REP'} = L_{CRS,REP} + 0.5\ dB$$

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

An engine speed information is available for the constant speed test.

The engine speed for the acceleration test is calculated with a virtual uniform gear ratio of [20] km/h per 1000 min^{-1}.

3.2.4.3.2. Correction of sound pressure level

No correction is applied to the constant speed test result.

The sound pressure level for the acceleration test is determined by

$$L_{WOT,REP'} = \left(Limit - k_P \times L_{CRS,REP}\right)/(1 - k_P)$$

where Limit is the applicable limit for this vehicle type and k_P is the determined k_P-factor from the Annex 3 test.

3.2.4.4. Case 4 – Internal combustion engine neither operational during the acceleration test nor during the constant speed test

3.2.4.4.1. Assignment of engine speed

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.

The engine speed for the acceleration test is calculated with a virtual uniform gear ratio of [20] km/h per 1000 min^{-1}.

3.2.4.4.2. Correction of sound pressure level

The sound pressure level for the constant speed test is determined by

$$L_{CRS,REP'} = L_{CRS,REP} + 0.5\ dB$$

The sound pressure level for the acceleration test is determined by

$$L_{WOT,REP'} = \left(Limit - k_P \times L_{CRS,REP'}\right)/(1 - k_P)$$

where Limit is the applicable limit for this vehicle type and k_P is the determined k_P-factor from the Annex 3 test.

3.3. 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 50 km/h, $L_{TR,EXP}$ is calculated by

$$L_{TR,EXP} = \theta_{TR,LO} \times \log\left(v_{BB,TEST}/v_{BB,CRS}\right) + L_{REF,TR} \text{ with } \theta_{TR,LO} = [20]$$

For vehicle speeds $v_{BB,TEST}$ exceeding 50 km/h, $L_{TR,EXP}$ is calculated by

$$L_{TR,EXP} = \theta_{TR,HI} \times \log\left(v_{BB,TEST}/v_{BB,CRS}\right) + L_{REF,TR} \text{ with } \theta_{TR,HI} = [40]$$

3.4. Calculation of expected power train mechanics sound component $L_{PT,EXP}$

The expected power train base mechanic 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 $n_{BB,CRS,REP}$, $L_{PT,EXP}$ is calculated by

$$L_{PT,EXP} = \theta_{PT,LO} \times \log\left(\left(n_{BB,TEST} + n_{SHIFT}\right)/\left(n_{BB,CRS,REP} + n_{SHIFT}\right)\right) + L_{REF,PT}$$

with

$$\theta_{PT.LO} = [60]$$

$$n_{SHIFT,PT} = [5000]$$

For vehicle speeds $v_{BB,TEST}$ exceeding 50 km/h, $L_{PT,EXP}$ is calculated by

$$L_{PT,EXP} = \theta_{PT,HI} \times \log\left(\left(n_{BB,TEST} + n_{SHIFT}\right)/\left(n_{BB,CRS,REP} + n_{SHIFT}\right)\right) + L_{REF,PT}$$

with

$$\theta_{PT,HI} = [115]$$

$n_{SHIFT,PT} = [5000]$

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 $n_{BB,WOT,REP}$, $L_{DYN,EXP}$ is calculated by

$$L_{DYN,EXP} = \theta_{DYN,LO} \times \log\left(\left(n_{BB,TEST} + n_{SHIFT}\right)/\left(n_{BB,WOT,REP} + n_{SHIFT}\right)\right) + L_{REF,DYN}$$

with

$\theta_{DYN.LO} = [50]$

$n_{SHIFT,PT} = [5000]$

For vehicle speeds $v_{BB,TEST}$ exceeding 50 km/h, $L_{DYN,EXP}$ is calculated by

$$L_{DYN,EXP} = \theta_{DYN,HI} \times \log\left(\left(n_{BB,TEST} + n_{SHIFT}\right)/\left(n_{BB,CRS,REP} + n_{SHIFT}\right)\right) + L_{REF,DYN}$$

with

$\theta_{DYN,HI} = [105]$

$n_{SHIFT,PT} = [5000]$

3.6. Calculation of expected dynamic delta sound component $\Delta L_{DYN,EXP}$

3.6.1. Determination of the maximum reference acceleration $a_{MAX,REF}$

3.6.1.1. The reference acceleration $a_{MAX,REF}$ is the maximum acceleration performance determined in a low gear under full load condition following the recommendations below:

A test run shall be performed in a gear ratio and at a vehicle entry speed such, that the vehicle engine speed $n_{BB'}$ is between the 50% of S and 80% of S.

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 3.5.4.1. of Annex 7.

3.6.2. Calculation of the load portion $LOAD_{TEST}$ achieved during the test run

The load portion as fractal of the maximum load is calculated based on the achieved acceleration a_{TEST}, relative to the reference acceleration $a_{MAX,i}$ with the formula below

$$LOAD_{TEST} = a_{TEST}/a_{MAX,i}$$

with

$$a_{MAX,i} = \frac{i_{GEAR}}{i_{REF}} \times a_{MAX,REF}$$

3.6.3. Performance related calculations

3.6.3.1. Calculation of the performance va_{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

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

3.6.3.2. Calculation of the dynamic performance component $\Delta L_{DYN,va}$

The dynamic performance component of the vehicle dynamic sound is calculated based on the achieved performance va_{TEST} relative to a reference performance.

If the achieved performance does not exceed the reference performance va_{REF} according to the parameter coefficient table 1, the dynamic performance component $\Delta L_{DYN,va}$ is equal zero.

If the achieved performance exceeds the reference performance, the dynamic performance component $\Delta L_{DYN,va}$ is calculated by

$$\Delta L_{DYN,va} = \beta \times \log\left(\frac{va_{TEST}}{va_{REF}}\right)$$

with β = [16]

The maximum dynamic performance component $\Delta L_{DYN,va}$ is limited to 8 dB(A)

3.6.3.3. Aggregation of dynamic sound components

The final dynamic delta sound component $\Delta L_{DYN,EXP}$ dynamic is calculated by

$$\Delta L_{DYN,EXP} = \left(\Delta L_{DYN} + \Delta L_{DYN,va}\right) \times (1 - \alpha/(LOAD_{TEST} + \alpha))/(1 - \alpha)$$

with

$$\alpha = [0,111]$$

3.7. Calculation of the expected sound level $L_{TEST,EXP}$

The calculation results of the paragraphs 3.3. to 3.6. 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

$$L_{TEST,EXP} = 10 \times \log\left(10^{0,1\times L_{TR,EXP}} + 10^{0,1\times L_{PT,EXP}} + 10^{0,1\times\left(L_{DYN,EXP}+\Delta L_{DYN,EXP}\right)}\right) + 2dB(A)$$

3.8. Proceed with the compliance assessment according to paragraph 4 of Annex 7

Annex 8

Indoor testing

1. Documentation for indoor application

Documentation shall include:

(a) Validation of facility, e.g. free field propagation, dyno and air handling background noise level, dyno dynamic performance, software.

(b) Procedures to be applied for indoor testing, e.g. dyno and software set-up, loading and tie-down, air-handling and vehicle's temperature management.

(c) Coast down and tyre sound level data used for calculation of dynamometer load coefficients and tyre sound data used for determination of final reported results.

(d) Test results on a representative selection of the manufacturer's production to demonstrate that indoor testing delivers comparable results as outdoor testing within acceptable accuracy.

2. Vehicle tested indoor using Variant A for Annex 3

Indoor pass-by test is simulated by measurement of power train sound on the dynamometer and energetical addition of the tyre/road sound (measured separately on an outdoor test track).

2.1. General

This method is a combination of indoor testing (power train sound) and outdoor testing (tyre/road sound). It is not necessary to repeat the measurement of the tyre/road sound every time a vehicle is tested. The data of several tyres can be stored in a database and a matching data set from the database can then be used for the test.

2.2. Power train sound

It shall be ensured that there is no remaining tyre/road sound affecting the measurements. In any case it shall be ensured that the remaining tyre/road sound shall be at least 10 dB below the maximum A-weighted sound pressure level produced by the vehicle under test. If this condition cannot be fulfilled, a correction shall be carried out. This correction procedure is described in ISO 362-3:2016 or later Annex B, paragraph B.6.

The vehicle shall be measured according to the operating condition specified in paragraphs 3.1.2.1. or 3.1.2.2. of Annex 3 of this Regulation.

2.3. Tyre/road sound

The measurements of the tyre/road sound shall be performed on a test track as described paragraph 2.1.1. of Annex 3 of this Regulation. The evaluation of tyre/road sound consists of two procedures, namely:

(a) Evaluation of free rolling sound;

(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 2.5 of this Annex.

2.4. Calculation of the total vehicle sound

The total vehicle sound is the energetical sum of tyre/road sound and power train sound. This calculation shall be carried out for each single run as describe in ISO 362-3.2016 or later, paragraph 10.2.4.

2.5 Procedure for measurement, evaluation, and calculation of tyre/road sound when using variant A

All conditions for evaluation of tyre/road sound, free rolling sound, and torque influence are described in ISO 362-3:2016 or later, Annex B.

3. Vehicle tested indoor for Annex7

3.1. General

The use of indoor testing for Annex 7 may not require tire/road data gathered on an outdoor track.

3.2 Measurement method

The vehicle shall be measured according to paragraph 3. of Annex 7 of this Regulation.

3.3 Compliance assessment

The compliance of the vehicle shall be followed in paragraph 4. of Annex 7 of this Regulation.

3.4 Determination of reference data

The necessary reference data to establish the sound estimation model are taken from the pass-by and from the cruise-by test of one gear of the Annex 3 tests.

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.

These reference data shall be measured in the same indoor facility as measurement of paragraph 3.2 in this Annex.

4. Adjustment of room dimensions

To cater for the smaller size test rooms, the maximum levels shall be evaluated with caution though to avoid missing them according to ISO 362-3:2016, Annex E."

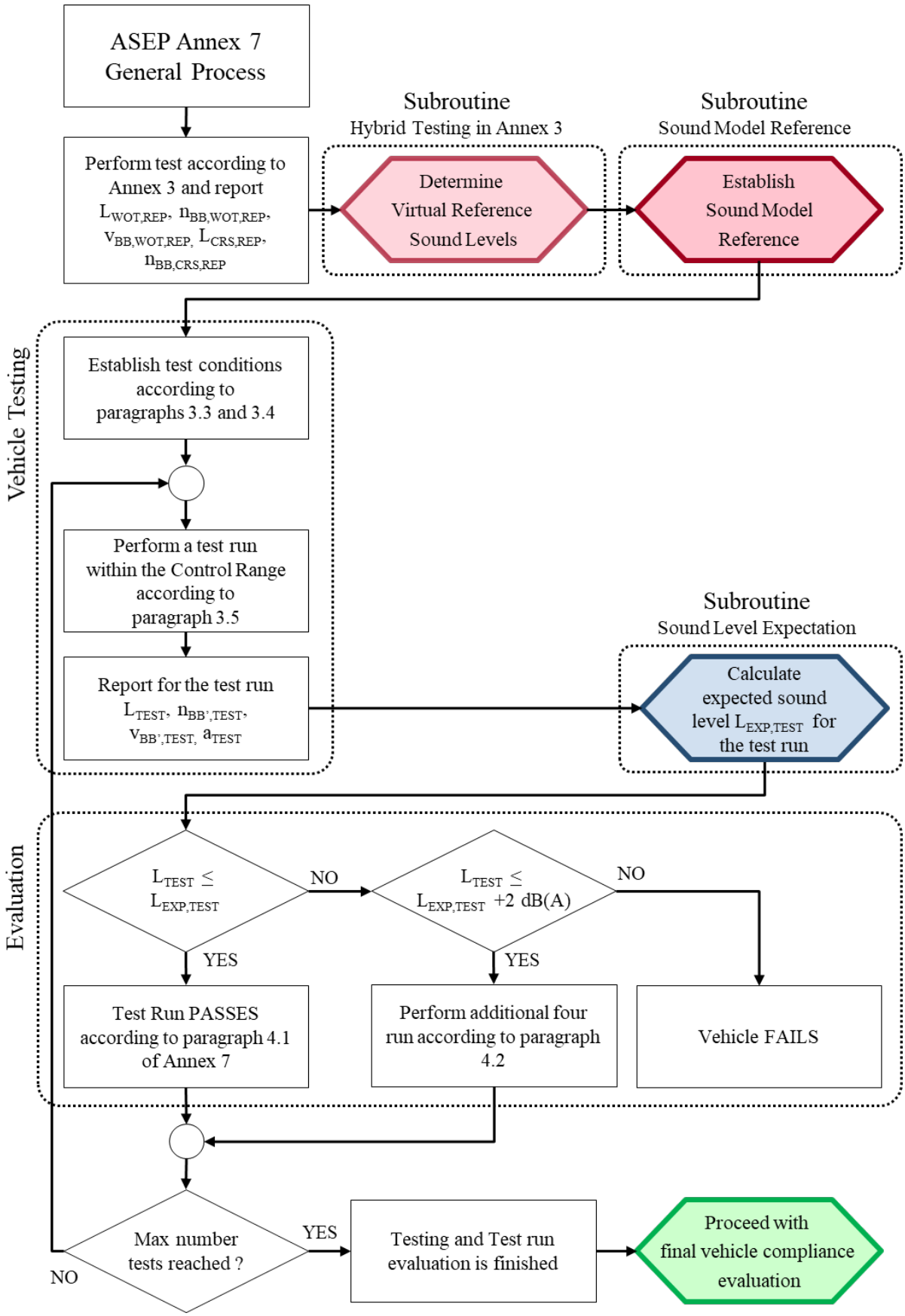
ANNEX 7 – APPENDIX 2 ***[to be completed]***

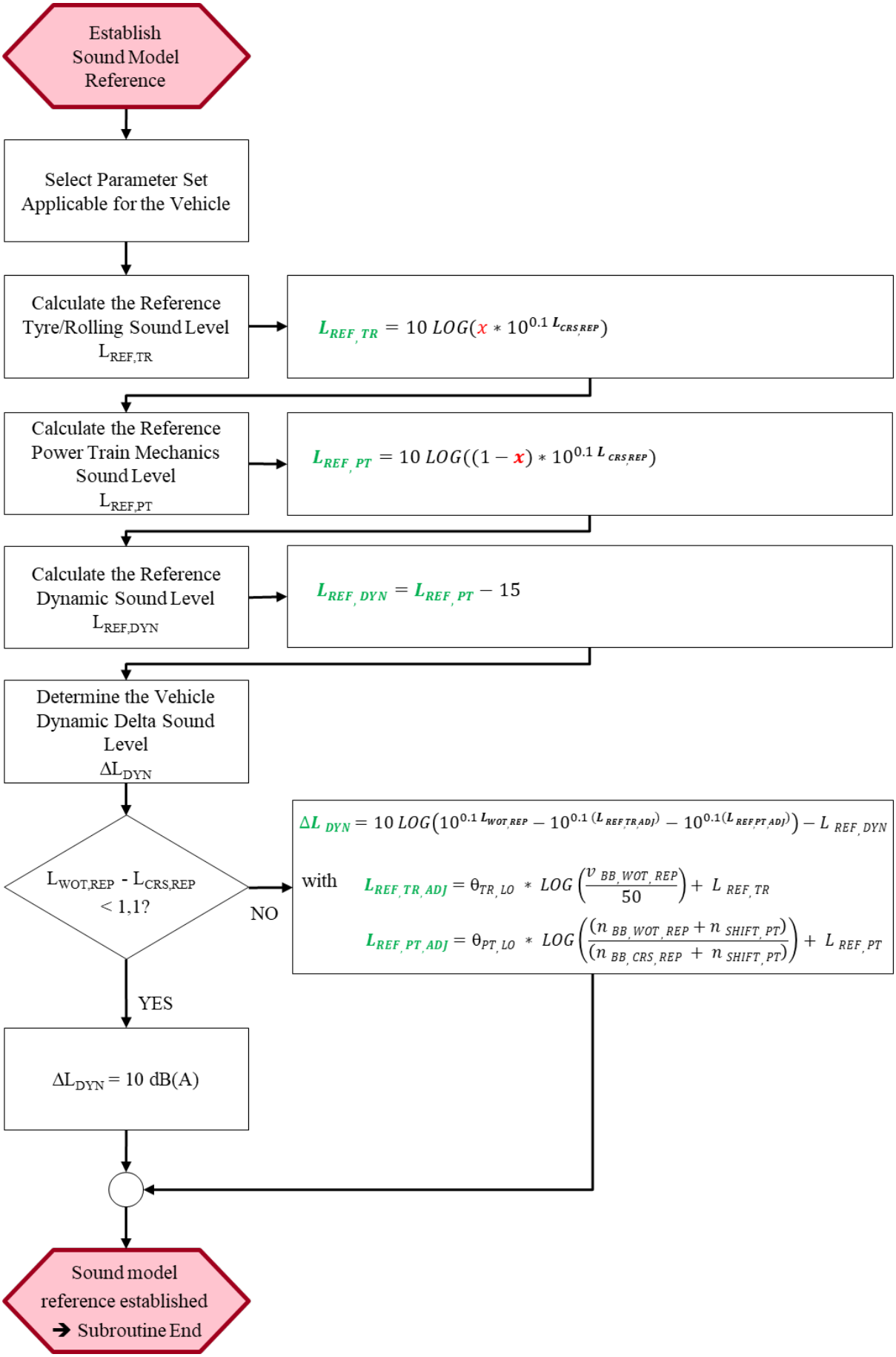
			M1		
Parameter	**Symbol**	**Unit**	**ICE**	**PEV**	**HEV**
Reference Vehicle Speed	v_{REF}	km/h	50	50	50
Tyre Rolling Sound Energy Fraction of Annex 3 Cruise Test $L_{CRS,REP}$	x	%	90	98	90
T/R Sound Slope ≤ 50 km/h	$\theta_{TR,LO}$	dB/log(v/v_{ref})	20	20	20
T/R Sound Slope > 50 km/h	$\theta_{TR,HI}$	dB/log(v/v_{ref})	40	40	40
P/T Sound Slope ≤ $n_{BB,CRS,REP}$	$\theta_{PT,LO}$	dB/Log(n/n_{ref})	60	60	60
P/T Sound Slope > $n_{BB,CRS,REP}$	$\theta_{PT,HI}$	dB/Log(n/n_{ref})	115	115	115
Form Factor for the logarithm function of the meachanic sound model	$n_{SHIFT,PT}$	rpm	5000	5000	5000
Dynamic Sound Slope ≤ $n_{BB,WOT,REP}$	$\theta_{DYN,LO}$	dB/Log(n/n_{ref})	50	50	50
Dynamic Sound Slope > $n_{BB,WOT,REP}$	$\theta_{DYN,HI}$	dB/Log(n/n_{ref})	105	105	105
Form Factor for the logarithm function of the dynamic sound model	$n_{SHIFT,DYN}$	rpm	5000	5000	5000
Reference Performance	va_{REF}	m^2/s^3	28	28	28
Dynamic $v_x a$ Factor b	β	dB(A)	16	16	16
Partial Load Form Factor a	α	---	0,111	0,111	0,111

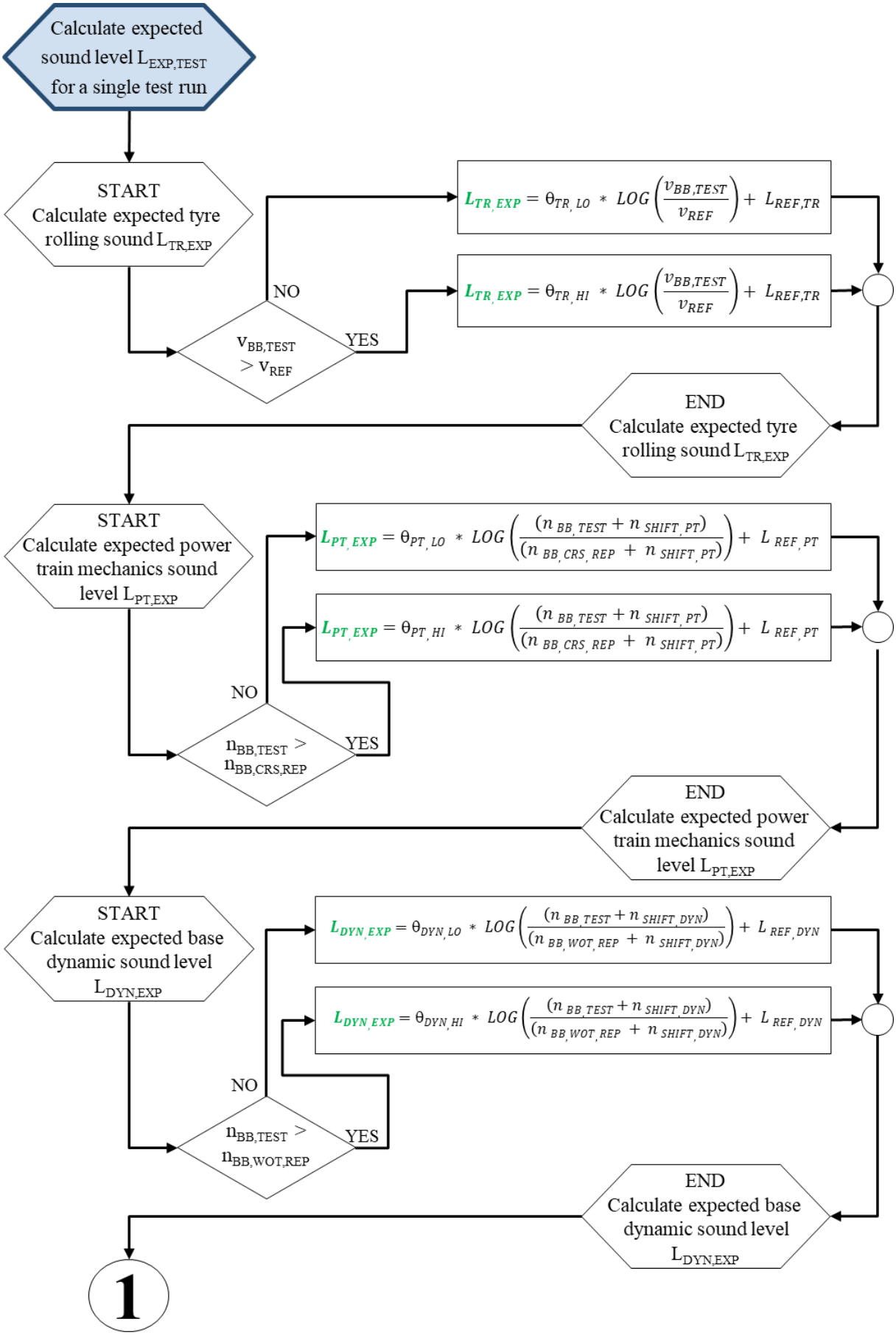
ANNEX 7 - APPENDIX 3 – Test report sheet (example) *[to be completed]*

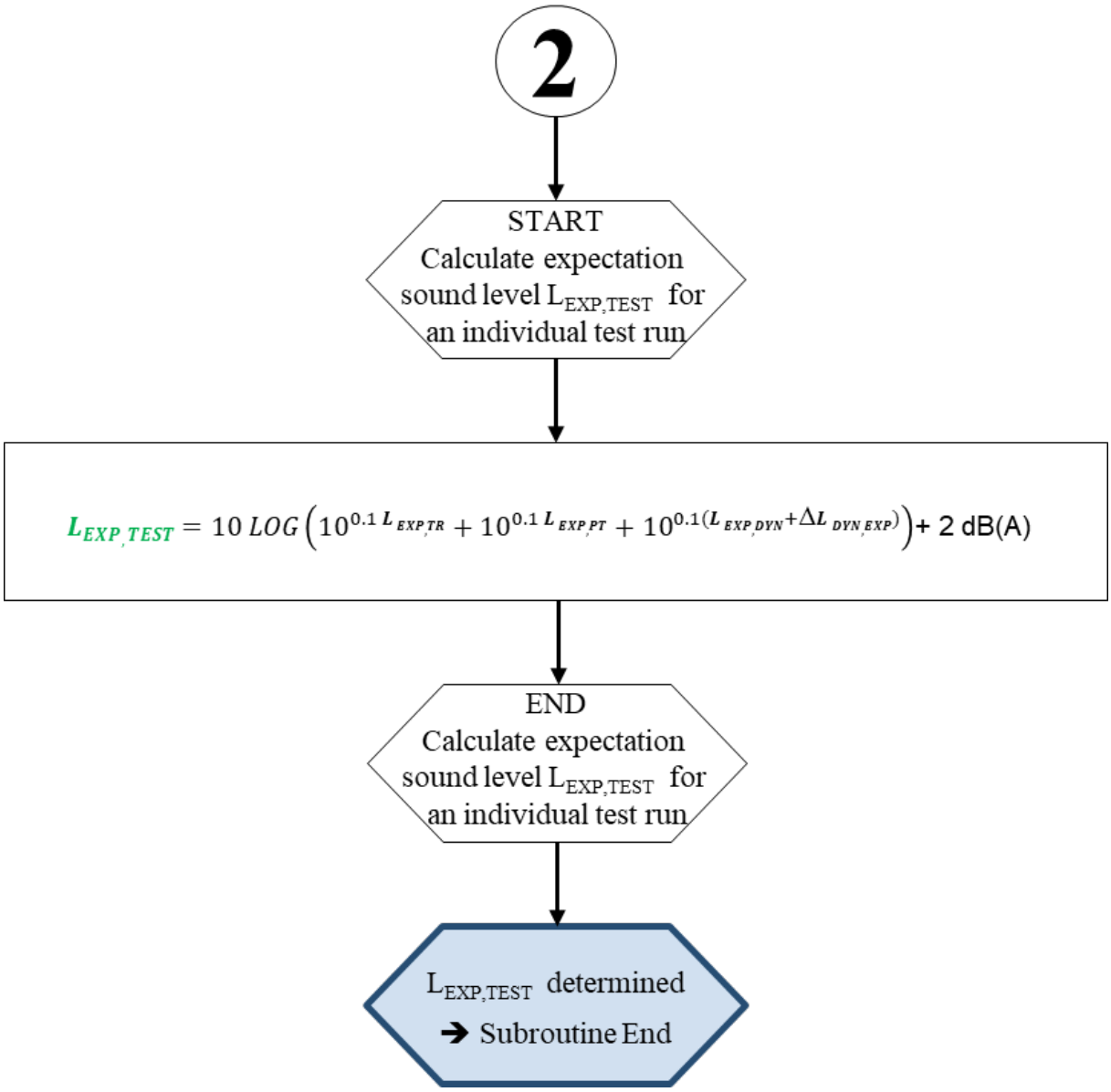
Run	Target Conditions																		Conformity	
	Gear Selector Position	Driver Selectable Mode (if applicable)	Target Entry Speed	Accelerator Position (% depression)	Entry Speed	Microphone Speed	Exit Speed	Max Engine Speed	Exit Engine Speed	Maximum SPL Left Side	Maximum SPL Right Side	Maximum SPL Left/Right Side	Validity Check (Operation Condition within control range?)	Run comment	Acceleration PP'-BB'	transmission ratio i_{GEAR}	Vehicle Performance	Expected Sound Pressure Level	$L_{TEST} \leq L_{EXP,TEST}$	$L_{TEST} \leq L_{EXP,TEST} + [2]$ dB(A)
Nr	Gear/Nr.		$v_{AA',TAR}$	$\%_{PED}$	$v_{AA',TEST}$	$v_{PP',TEST}$	$v_{BB',TEST}$	n_{MAX}	$n_{BB',TEST}$	L_{TEST}	L_{TEST}	L_{TEST}	"VALID" or VOID		$a_{PP',BB'}$		va	$L_{EXP,TEST}$	Type in "X" where applicable	
			km/h	%	km/h	km/h	km/h	1/min	1/min	dB(A)	dB(A)	dB(A)			m/s²		m²/s³	dB(A)		
Mandatory Runs According Table 2 of Annex 7																				
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
Additional Runs According Paragraph 4.2 of Annex 7																				
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				

ANNEX 7 - APPENDIX 4 –FLOWCHART




Establish Sound Model Reference
Select Parameter Set Applicable for the Vehicle
Calculate the Reference Tyre/Rolling Sound Level $L_{REF,TR}$
$L_{REF,TR} = 10\,LOG(x * 10^{0.1\,L_{CRS,REP}})$
Calculate the Reference Power Train Mechanics Sound Level $L_{REF,PT}$
$L_{REF,PT} = 10\,LOG((1-x) * 10^{0.1\,L_{CRS,REP}})$
Calculate the Reference Dynamic Sound Level $L_{REF,DYN}$
$L_{REF,DYN} = L_{REF,PT} - 15$
Determine the Vehicle Dynamic Delta Sound Level ΔL_{DYN}
$L_{WOT,REP}$ - $L_{CRS,REP}$ < 1,1?
NO
$\Delta L_{DYN} = 10\,LOG\left(10^{0.1\,L_{WOT,REP}} - 10^{0.1\,(L_{REF,TR,ADJ})} - 10^{0.1(L_{REF,PT,ADJ})}\right) - L_{REF,DYN}$
with
$L_{REF,TR,ADJ} = \theta_{TR,LO} * LOG\left(\frac{v_{BB,WOT,REP}}{50}\right) + L_{REF,TR}$
$L_{REF,PT,ADJ} = \theta_{PT,LO} * LOG\left(\frac{(n_{BB,WOT,REP} + n_{SHIFT,PT})}{(n_{BB,CRS,REP} + n_{SHIFT,PT})}\right) + L_{REF,PT}$
YES
ΔL_{DYN} = 10 dB(A)
Sound model reference established
➔ Subroutine End


Calculate expected sound level $L_{EXP,TEST}$ for a single test run
START Calculate expected tyre rolling sound $L_{TR,EXP}$
$v_{BB,TEST} > v_{REF}$
NO
YES
$L_{TR,EXP} = \theta_{TR,LO} * LOG\left(\frac{v_{BB,TEST}}{v_{REF}}\right) + L_{REF,TR}$
$L_{TR,EXP} = \theta_{TR,HI} * LOG\left(\frac{v_{BB,TEST}}{v_{REF}}\right) + L_{REF,TR}$
END Calculate expected tyre rolling sound $L_{TR,EXP}$
START Calculate expected power train mechanics sound level $L_{PT,EXP}$
$n_{BB,TEST} > n_{BB,CRS,REP}$
NO
YES
$L_{PT,EXP} = \theta_{PT,LO} * LOG\left(\frac{(n_{BB,TEST} + n_{SHIFT,PT})}{(n_{BB,CRS,REP} + n_{SHIFT,PT})}\right) + L_{REF,PT}$
$L_{PT,EXP} = \theta_{PT,HI} * LOG\left(\frac{(n_{BB,TEST} + n_{SHIFT,PT})}{(n_{BB,CRS,REP} + n_{SHIFT,PT})}\right) + L_{REF,PT}$
END Calculate expected power train mechanics sound level $L_{PT,EXP}$
START Calculate expected base dynamic sound level $L_{DYN,EXP}$
$n_{BB,TEST} > n_{BB,WOT,REP}$
NO
YES
$L_{DYN,EXP} = \theta_{DYN,LO} * LOG\left(\frac{(n_{BB,TEST} + n_{SHIFT,DYN})}{(n_{BB,WOT,REP} + n_{SHIFT,DYN})}\right) + L_{REF,DYN}$
$L_{DYN,EXP} = \theta_{DYN,HI} * LOG\left(\frac{(n_{BB,TEST} + n_{SHIFT,DYN})}{(n_{BB,WOT,REP} + n_{SHIFT,DYN})}\right) + L_{REF,DYN}$
END Calculate expected base dynamic sound level $L_{DYN,EXP}$
1


2
START
Calculate expectation sound level $L_{EXP,TEST}$ for an individual test run
$L_{EXP,TEST} = 10\ LOG\left(10^{0.1\ L_{EXP,TR}} + 10^{0.1\ L_{EXP,PT}} + 10^{0.1(L_{EXP,DYN}+\Delta L_{DYN,EXP})}\right)$ + 2 dB(A)
END
Calculate expectation sound level $L_{EXP,TEST}$ for an individual test run
$L_{EXP,TEST}$ determined
➔ Subroutine End

Redefinition of the Annex 3 sound pressure level test results for Hybrid Vehicles