

## **Proposals to clarify the provisions of Regulation No. 51, Revision 3, Annex 7**

The proposed amendments to the current Regulation are incorporated into the consolidated text and marked in bold for new or strikethrough for deleted characters.

### **I. Proposal**

#### **Annex 7**

#### **Measuring method to evaluate compliance with the Additional Sound Emission Provisions**

Only applicable for vehicles as specified in paragraph 6.2.3. of this Regulation

1. General

This annex describes a measuring 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. The test specified in Annex 3 shall be carried out on the same test track under conditions similar to those required in the tests prescribed in this annex.

2. Measuring method

2.1. Measuring instruments and condition of measurements

Unless otherwise specified, the measuring instruments, the conditions of the measurements and the condition of the vehicle are equivalent to those specified in Annex 3, paragraphs 1. and 2.

If the vehicle has different modes that affect sound emission, all modes shall comply with the requirements in this annex. In the case where the manufacturer has performed tests to prove to the approval authority compliance with the above requirements, the modes used during those tests shall be reported in a test report.

2.2. Method of testing

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 measured and evaluated.

2.3. Control range

Operation conditions are as follows:

Vehicle speed  $V_{AA\_ASEP}$ :  $v_{AA} \geq 20 \text{ km/h}$

Vehicle acceleration  $a_{WOT\_ASEP}$ :  $a_{WOT} \leq 5.0 \text{ m/s}^2$

Engine speed  $n_{BB\_ASEP}$ :  $n_{BB} \leq 2.0 * PMR^{-0.222} * S$  or

$n_{BB} \leq 0.9 * S$ , whichever is the lowest

Vehicle speed  $V_{BB\_ASEP}$ :

~~if  $n_{BB\_ASEP}$  is reached in one gear  $v_{BB} \leq 70 \text{ km/h}$~~

~~in all other cases  $v_{BB} \leq 80 \text{ km/h}$~~

~~If the vehicle, in the lowest valid gear, does not achieve the maximum engine speed below 70 km/h, the vehicle speed limit is 80 km/h~~

**if  $n_{BB\_ASEP}$  is reached in at least one valid gear below 80 km/h, the maximum vehicle speed is 70 km/h for all other valid gears  $v_{BB} \leq 70 \text{ km/h}$**

**if  $n_{BB\_ASEP}$  is not reached in any valid gear below 80 km/h, the maximum vehicle speed is 80 km/h for all valid gear  $v_{BB} \leq 80 \text{ km/h}$**

Valid gears

$\kappa \leq$  gear i as determined in Annex 3

Annex 3 gear selection	Annex 7 gear selection
Gear i, gear i+1	Gear ratio i, gear ratio i-1, ...
Gear i+1 or gear i+2,.. due to exceeding 2.0 m/s <sup>2</sup> on gear i	Gear ratio i, gear ratio i-1, ...
D range	D range

#### 2.4. Gear ratios

The ASEP requirements apply to every gear ratio  $\kappa$  that leads to test results within the control range as defined in paragraph 2.3. of this annex.

In case of vehicles with automatic transmissions, adaptive transmissions and CVT's tested with non-locked gear ratios, the test may include a gear ratio change to a lower range and a higher acceleration. A gear change to a higher range and a lower acceleration is not allowed. A gear shift which leads to a condition that is not in compliance with the boundary conditions shall be avoided. In such a case, it is permitted to establish and use electronic or mechanical devices, including alternate gear selector positions.

#### 2.5. Target conditions

The sound emission shall be measured in each valid gear ratio at the four test points as specified below. **For all test points the boundary conditions as specified in paragraph 2.3. shall be met.**

**The gear ratio is valid if all four points and the anchor point meet the specifications of paragraph 2.3.**

The first test point  $P_1$  is defined by using an entry speed  $v_{AA}$  of 20 km/h  $\pm 3$  km/h. If a stable acceleration condition cannot be achieved, the speed  $v_{AA}$  shall be increased in steps of 5 km/h until a stable acceleration is reached

**In case of non-locked automatic transmission where  $n_{BB\_ASEP}$  is exceeded during the test, the following measures shall be considered separately or together :**

- **provisions of 2.4**
- **increased speed in steps of 5 km/h**

**The test speed for the fourth test point  $P_4$  in any gear is defined by either :**

- **~~0.95~~  $n_{BB\_ASEP} \leq n_{BB\_4} \leq n_{BB\_ASEP}$  or**
- **$3 \text{ km/h} \leq V_{BB\_4} \leq V_{BB\_ASEP}$  with  $V_{BB\_ASEP}$  as defined in paragraph 2.3.**

The test speed other two test points are defined by the following formula:

Test Point  $P_j$ :  $v_{BB\_j} = v_{BB\_1} + ((j - 1) / 3) * (v_{BB\_4} - v_{BB\_1})$  for  $j = 2$  and  $3$  **with a tolerance of  $\pm 3 \text{ km/h}$**

Where:

$v_{BB\_1}$  = vehicle speed at BB' of test point  $P_1$

$v_{BB\_4}$  = vehicle speed at BB' of test point  $P_4$

~~Tolerance for  $v_{BB\_j}$ :  $\pm 3 \text{ km/h}$~~

~~For all test points the boundary conditions as specified in paragraph 2.3. shall be met.~~

## 2.6. Test of the vehicle

The path of the centreline of the vehicle shall follow line CC' as closely as possible throughout the entire test, starting from the approach **of the reference point according to paragraph 2.11 of the main body** to line AA' until the rear of the vehicle passes line BB'.

At line AA' the accelerator shall be fully depressed. To achieve a more stable acceleration or to avoid a down shift between line AA' and BB' pre-acceleration before line AA' may be used **according to the provisions of paragraphs 3.1.2.1.2.1 and 3.1.2.1.2.2.** The accelerator shall be kept in depressed condition until the rear of the vehicle reaches line BB'.

**Per test point, one single run is carried out.**

For every separate test run, the following parameters shall be determined and noted:

The maximum A-weighted sound pressure level of both sides of the vehicle, indicated during each passage of the vehicle between the two lines AA' and BB', shall be mathematically rounded to the first decimal place ( $L_{wot,kj}$ ). If a sound peak obviously out of character with the general sound pressure level is observed, the measurement shall be discarded. Left and right side may be measured simultaneously or separately. **For further processing the higher sound pressure level of both sides is to be used.**

The vehicle speed readings at AA', **PP'** and BB' shall be **rounded and** reported with the first significant digit after the decimal place. ( $v_{AA,kj}$ ;  $v_{PP,kj}$ ;  $v_{BB,kj}$ )

If applicable, the engine speed readings at AA' and BB' shall be reported as a full integer value ( $n_{AA,kj}$ ;  $n_{BB,kj}$ ).

The calculated acceleration shall be determined in accordance to the formula in paragraph 3.1.2.1.2. of Annex 3 and reported to the second digit after the decimal place ( $a_{wot,test,kj}$ ).

3. ~~Analysis of results~~ **Analysis Method 1: Slope-Assessment**

3.1. Determination of the anchor point for each gear ratio

The anchor point consists of the maximum sound level  $L_{wot,rep}$ , the reported engine speed  $n_{wot,i}$  and vehicle speed  $v_{wot,i}$  at BB' of gear ratio  $i$  of the acceleration test in Annex 3.

$L_{anchor,k} = L_{wot,Annex\ 3}$  is the higher sound pressure level of  $L_{wot,i}$  of left and right side.

$n_{anchor,k} = n_{BB,wot,Annex\ 3}$  is the average of  $n_{wot,i}$  of the 4 runs reported from annex 3 at line BB' of the acceleration test.

$v_{anchor,k} = v_{BB,wot,Annex\ 3}$  is the average of  $v_{wot,i}$  of the 4 runs reported from annex 3 at line BB' of the acceleration test

3.2. Slope of the regression line for each gear ratio

The sound measurements shall be evaluated as function of engine speed according to paragraph 3.2.1.

3.2.1. Calculation of the slope of the regression line for each gear ratio

The linear regression line is calculated using the anchor point and the four correlated additional measurements.

$$Slope_k = \frac{\sum_{j=1}^5 (n_j - \bar{n})(L_j - \bar{L})}{\sum_{j=1}^5 (n_j - \bar{n})^2} \quad (\text{in dB(A)/1,000 min}^{-1})$$

$$\text{With } \bar{L} = \frac{1}{5} \sum_{j=1}^5 L_j \quad \text{and} \quad \bar{n} = \frac{1}{5} \sum_{j=1}^5 n_j ;$$

where  $n_j$  = engine speed measured at line BB'

3.2.2. Slope of the regression line for each gear ratio

The  $slope_k$  of a particular gear for the further calculation is the derived result of the calculation in paragraph 3.2.1. rounded to the first decimal place, but not higher than 5 dB(A)/1,000 min<sup>-1</sup>.

**In case of non-locked automatic transmission, if  $slope_k < 0$ , the selected transmission setup is not valid.**

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3.3. Calculation of the linear sound level increase expected for each measurement

The sound level  $L_{ASEP,\kappa,j}$  for measurement point  $j$  and gear **ratio**  $\kappa$  shall be calculated using the engine speeds measured for each measurement point, using the slope specified in paragraph 3.2. above to the specific anchor point for each gear ratio.

For  $n_{BB,\kappa,j} \leq n_{anchor,\kappa}$ :

$$L_{ASEP,\kappa,j} = L_{anchor,\kappa} + (\text{Slope}_{\kappa} - Y) * (n_{BB,\kappa,j} - n_{anchor,\kappa}) / 1,000$$

For  $n_{BB,\kappa,j} > n_{anchor,\kappa}$ :

$$L_{ASEP,\kappa,j} = L_{anchor,\kappa} + (\text{Slope}_{\kappa} + Y) * (n_{BB,\kappa,j} - n_{anchor,\kappa}) / 1,000$$

Where  $Y = 1$

3.4. Samples

On request of the type approval authority two additional runs within the boundary conditions according to paragraph 2.3. of this annex shall be carried out.

4. ~~Interpretation of results~~ **Slope-Assessment- Specifications**

Every individual sound measurement shall be evaluated.

The sound level of every specified measurement point shall not exceed the limits given below:

$$L_{\kappa,j} \leq L_{ASEP,\kappa,j} + X$$

With:

$X = 3 \text{ dB(A)}$  for vehicle with a non-lockable automatic transmission or non-lockable CVT

$X = 2 \text{ dB(A)} + \text{limit value} - L_{urban}$  of Annex 3 for all other vehicles

If the measured sound level at a point exceeds the limit, two additional measurements at the same point shall be carried out to verify the measurement uncertainty. The vehicle is still in compliance with ASEP, if the average of the three valid measurements at this specific point fulfils the specification.

5. Reference sound assessment

5.1. **General**

**The reference sound can be obtained by simulation or from direct measurement. The result of one assessment method has to comply with the specification of 5.4.**

5.1.1 **Conditions for simulation**

**For simulation, the** ~~The~~ reference sound is assessed at a single point in one discrete gear, simulating an acceleration condition ~~starting with an entry speed at  $v_{aa}$  equal to 50 km/h and assuming an exit speed at  $v_{bb}$  equal to 61 km/h. The sound compliance at this point can either be~~ **is** calculated using the results of paragraph 3.2.2. ~~and the specification below or be evaluated by direct measurement using the gear as specified below~~

If the result of 3.2.2 is not available for the gear specified in 5.2, the slope of the missing gear can be determined according to paragraphs 2.5, 3.1 and 3.2.

#### 5.1.2 Conditions for direct measurement

For direct measurement, the reference sound is assessed at a single run in an acceleration condition started at line AA as specified in 2.6. The gear shall be as specified in 5.2 for vehicles tested in locked position or in D for vehicles tested in non-locked position.

The target test speed  $v_{aa}$  is equal to 50 km/h  $\pm$  1 km/h unless  $v_{bb}$  exceeds 61 km/h.

If  $v_{bb}$  exceeds 61 km/h, the target test speed  $v_{bb}$  shall be set to 61 km/h  $\pm$  1 km/h. The entry speed shall be adjusted to achieve the target test speed.

#### 5.2. The determination of gear $\kappa$ is as follows:

$\kappa = 3$  for all manual transmission and for automatic transmission **tested in locked position** with up to 5 gears;

$\kappa = 4$  for automatic transmission **tested in locked position** with 6 or more gears.

If no discrete gears are available, e.g. for non-lockable automatic transmissions or non-lockable CVTs, the gear ratio for further calculation shall be determined from the acceleration test result in Annex 3 using the reported engine speed and vehicle speed at line BB'.

### 5.3 Data-processing for simulation assessment

#### 5.3.1 Determination of reference engine speed $n_{ref\_k}$

The reference engine speed,  $n_{ref\_k}$ , shall be calculated using the gear ratio of gear  $\kappa$  at the reference speed of  $v_{ref} = 61$  km/h.

#### 5.3.2 Calculation of $L_{ref}$

$$L_{ref} = L_{anchor\_k} + Slope_{\kappa} * (n_{ref\_k} - n_{anchor\_k}) / 1,000$$

### 5.4 Specifications

$L_{ref}$  shall be less than or equal to 76 dB(A).

For vehicles fitted with a manual **transmission gear-box** having more than four forward gears and equipped with an engine developing a rated maximum net power greater than 140 kW (according to Regulation No. 85) and having a maximum-power/maximum-mass ratio greater than 75,  $L_{ref}$  shall be less than or equal to 79 dB(A).

For vehicles fitted with an automatic **transmission gear-box** having more than four forward gears and equipped with an engine developing a rated maximum net power greater than 140 kW (according to Regulation No. 85) and having a maximum-power/maximum-mass ratio greater than 75,  $L_{ref}$  shall be less than or equal to 78 dB(A).

6. ~~Evaluation of ASEP using the principle of  $L_{urban}$~~  **Analysis Method 2:  
Lurban Assessment**

6.1. General

This evaluation procedure is an alternative selected by the vehicle manufacturer to the procedure described in paragraph 3. of this annex and is applicable for all vehicle technologies. It is the responsibility of the vehicle manufacturer to determine the correct manner of testing. Unless otherwise specified, all testing and calculation shall be as specified in Annex 3 to this Regulation.

**The measuring method is defined in paragraph 2. Each testing point shall be evaluated individually.**

6.2. Calculation of  $L_{urban\_ASEP}$

**6.2.1 Data-processing**

From any  $L_{wot\_ASEP}$  as measured according to this annex,  $L_{urban\_ASEP}$  shall be calculated as follows:

(a) Calculate  $a_{wot\_test\_ASEP}$  using acceleration calculation from paragraph 3.1.2.1.2.1. or 3.1.2.1.2.2. of Annex 3 to this Regulation, as applicable;

(b) Determine the vehicle speed ( $v_{BB\_ASEP}$ ) at BB during the  $L_{wot\_ASEP}$  test;

(c) Calculate  $k_{P\_ASEP}$  as follows:

$$k_{P\_ASEP} = 1 - (a_{urban} / a_{wot\_test\_ASEP})$$

Test results where  $a_{wot\_test\_ASEP}$  are less than  $a_{urban}$  shall be disregarded.

(d) Calculate  $L_{urban\_measured\_ASEP}$  as follows:

$$L_{urban\_measured\_ASEP} = L_{wot\_ASEP} \cdot k_{P\_ASEP} * (L_{wot\_ASEP} - L_{crs})$$

For further calculation, use the  $L_{urban}$  from Annex 3 to this Regulation without rounding, including the digit after the decimal (xx.x).

(e) Calculate  $L_{urban\_normalized}$  as follows:

$$L_{urban\_normalized} = L_{urban\_measured\_ASEP} - L_{urban}$$

(f) Calculate  $L_{urban\_ASEP}$  as follows:

$$L_{urban\_ASEP} = L_{urban\_normalized} - (0.15 * (V_{BB\_ASEP} - 50))$$

~~(g)~~ —

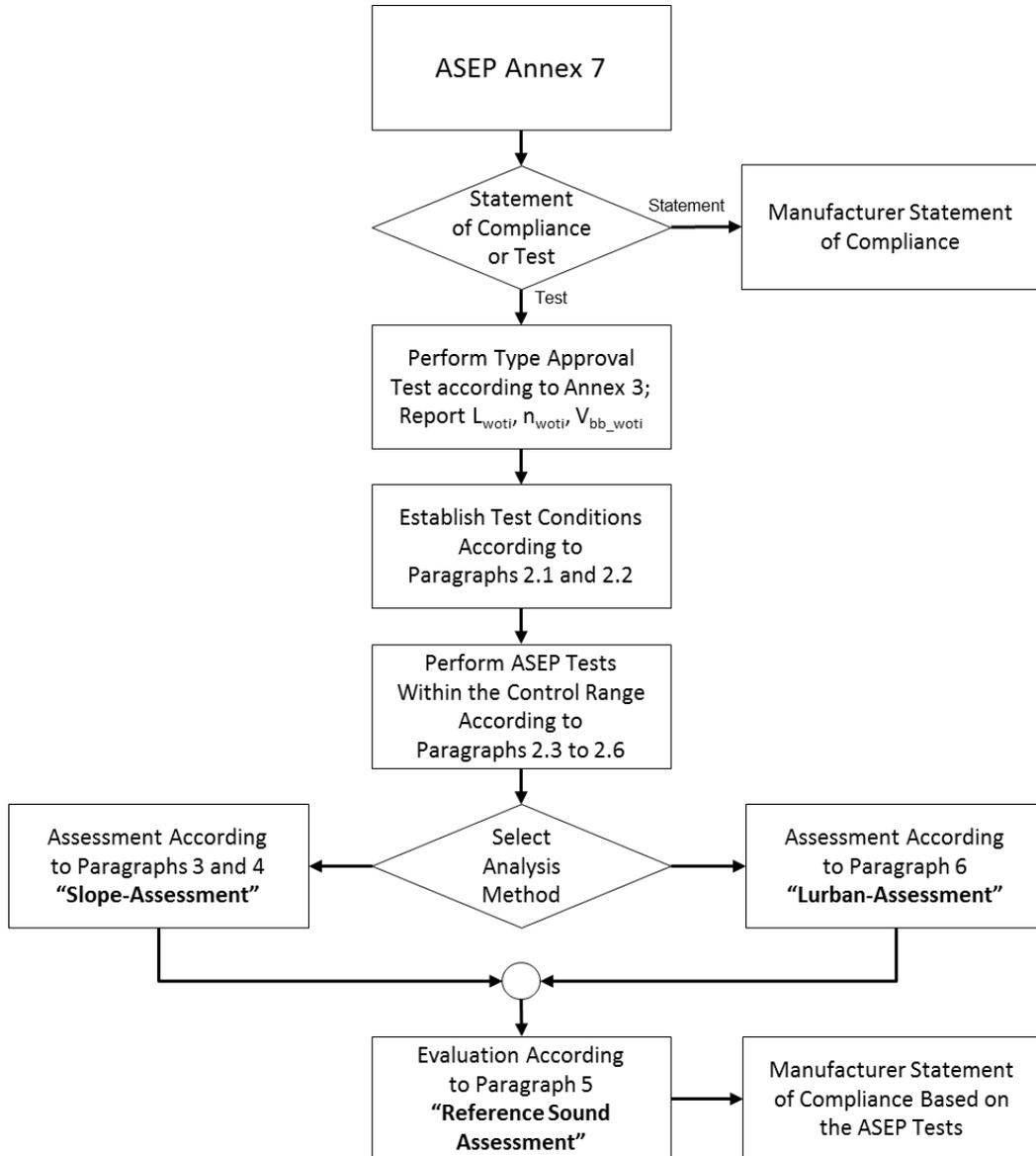
**6.2.2 Specifications**

Compliance with limits:

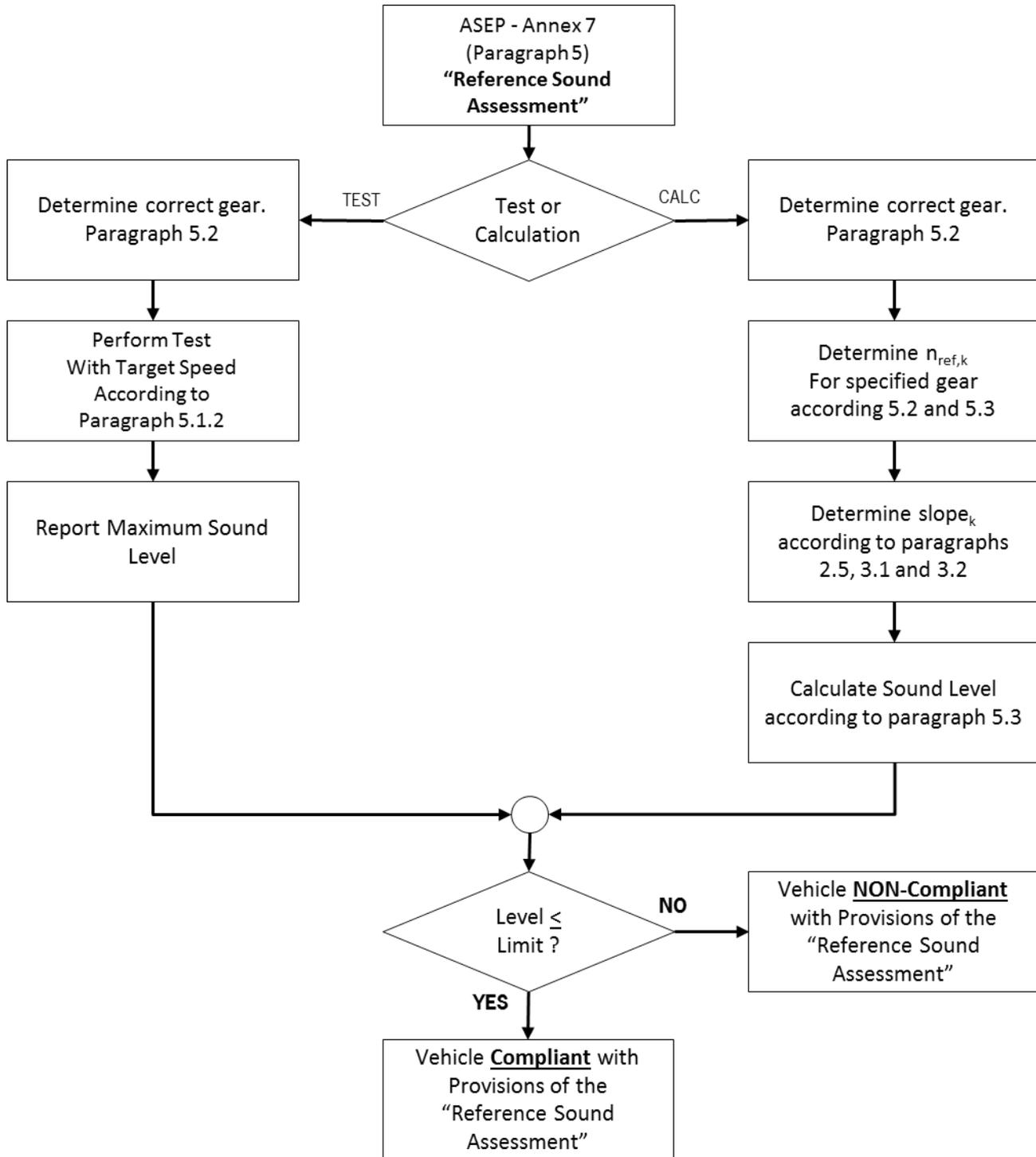
$L_{urban\_ASEP}$  shall be less than or equal to 3.0 dB(A).

## Annex 7 – Appendix

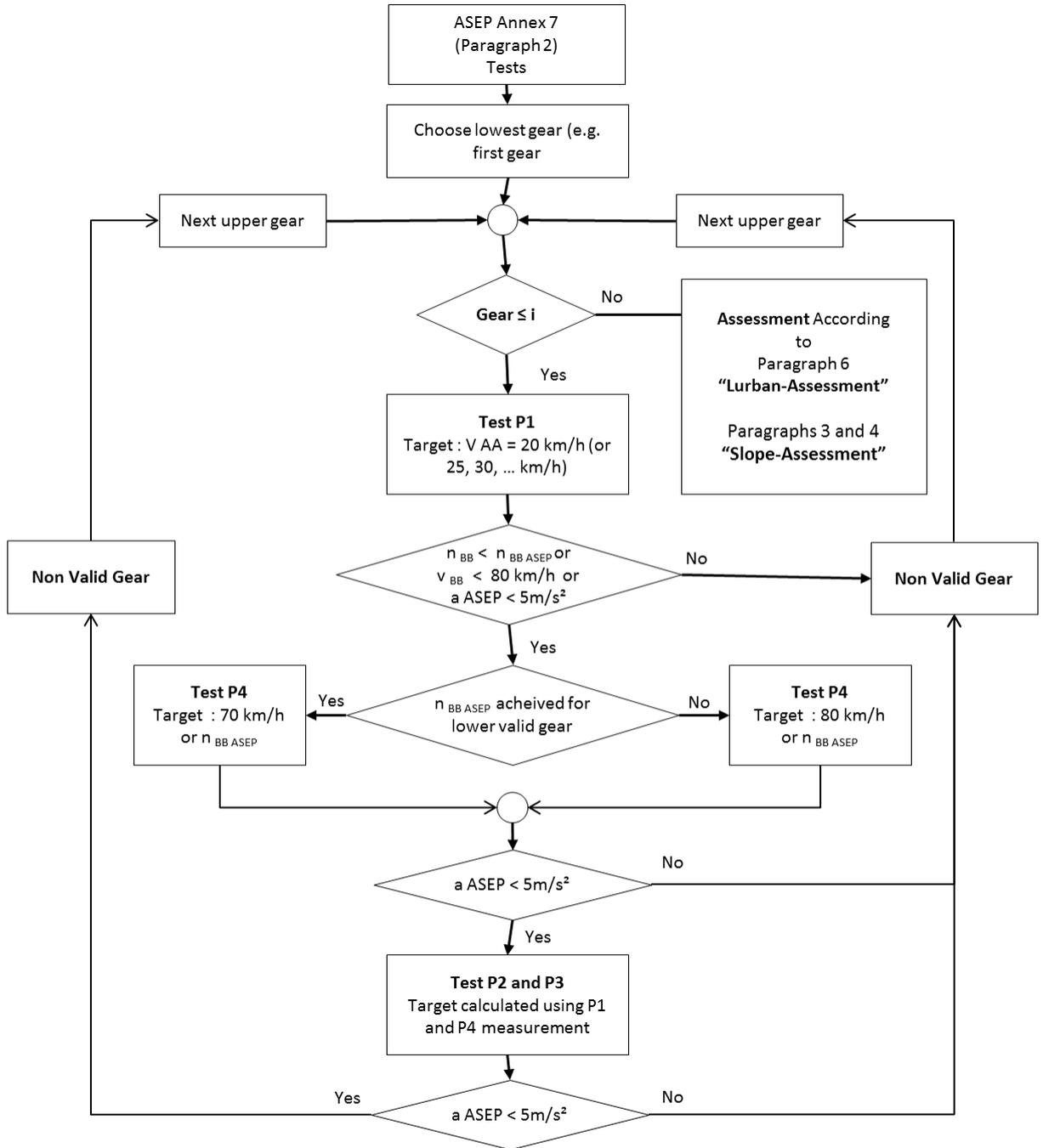
Figure 1 : Flowchart for the assessment concept for ASEP according to Annex 7



**Figure 2 : Flowchart for the vehicle sound assessment according to Annex 7 Paragraph 5 “Reference Sound Assessment”**



**Figure 3 : Flowchart for the determination of the individual test points Pj according to paragraph 2.**



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## **II. Justification**

There are several possibilities of misunderstanding and confusions which may induce different interpretations on application.