A Short Introduction to the

F/D-ASEP-Proposal

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ASEP serves two main purposes

- to complement the focus of Annex 3 (typical urban driving conditions at low revs) with much noisier and more disturbing (though less frequently occurring) urban driving conditions at higher revs

- to hinder cycle detection and cycle beating by introducing a broad control range in addition to the precisely defined control points of Annex 3

The F/D proposal is based on a simple noise model:

The noise model assumes that the total WOT-emission L_{wot} can be split (energetically) into two parts, the tire-road noise L_{tiro} and the propulsion noise L_{prop},

$$L_{wot} = L_{tiro} \oplus L_{prop}$$

where $\oplus$ refers to an energetic summation.

The tire-road noise L_{tiro} is modeled as a logarithmic function of the vehicle's velocity,

$$L_{tiro}(v) - L_{tiro}(v_{ref}) = \Gamma_v \times \log_{10}(v / v_{ref})$$

and the propulsion noise L_{prop} is modeled as a linear function of the engine speed

$$L_{prop}(n) - L_{prop}(n_{ref}) = \Gamma_n \times (n - n_{ref}).$$

Parameters to be measured or prescribed are:

- the reference velocity v_{ref}
- the constant of proportionality for the tire-road noise, Γ_v
- the reference engine speed n_{ref}
- the constant of proportionality for the propulsion noise, Γ_n
- an acoustic anchor point L_{ref}

Tire-road noise:

Reference velocity: The maximum noise level is reached somewhere between PP' and BB' at velocities somewhat higher than 50 km/h. For simplicity the reference velocity v_{ref} is set to 50 km/h for all vehicles.

Γ_v: This parameter varies from tire to tire typically between 30 and 40. To avoid detailed measurements Γ_v is set to the average slope in the data set, namely 34.

Propulsion noise:

Reference engine speed: No specific engine speed is prescribed for the Annex 3 tests. Rather the engine speed results from the gear ratios chosen to achieve the required acceleration at 50 km/h.
In deriving the acceleration requirement for Annex 3 from driving tests typical engine speeds were determined alongside. These are – by definition – consistent with the test conditions of Annex 3 and defined as

$$n_{ref} = n_o + (S - n_o) \times 2.2 \times PMR^{-0.43}$$

Propulsion noise:

Γ_n: There is no systematic difference in the slope of the propulsion noise with respect to the engine speed between Otto and Diesel engines. The slope is on average 4.5 dB(A) per 1000 rpm.

We propose to construct the ASEP limit curve with a slope of

[4] dB(A)/1000rpm for engine speeds below n_{ref}
[5] dB(A)/1000rpm for engine speeds above n_{ref}

Anchor point – Option 1:

The limit value LV applies to L_{urban} which is a weighted average of L_{wot} and L_{crs}. An anchor point can be calculated as the upper limit for WOT-measurements:

$$L_{ref} = (LV – k_p \times L_{crs,50}) / (1 – k_p)$$

$$\text{with } k_p = 1 – a_{urban}/a_{wot}$$

L_{ref} is defined such that L_{urban} does not exceed the limit value LV only if L_{wot} does not exceed L_{ref}.

Anchor point – Option 2:

The anchor point is set equal to the WOT emissions in gear i of Annex 3, $L_{wot,i}$, with a bonus proportional to the difference between the limit value and the test result of Annex 3:

$$L_{ref} = L_{wot,i} + [1] \times (LV - L_{urban})$$

Now we are ready to apply the F/D-noise model:

Tire-road noise

$$L_{tiro}(v) = L_{crs,50} + 34 \times \log_{10}(v/50)$$

Propulsion noise

$$L_{prop}(n) = L_{prop,ref} + \Gamma_n \times (n - n_{ref})$$

$$\text{with } L_{prop,ref} = L_{ref} \ominus L_{crs,50}$$

Total WOT-limit

$$L_{ASEP}(n,v) = L_{tire} \oplus L_{prop} + [0] \text{ dB}$$

Inaccuracies due to subtraction:

The reference propulsion noise is calculated by subtracting energetically the cruise-by-level from the WOT-level. To avoid problems the difference between $L_{prop,ref}$ and L_{crs} is set to a minimum of 2 dB. By applying this approximation only in the final equation the resulting error can be kept minimal.

Measurement effort:

In order not to burden the manufacturers with an undue work load for ASEP during type approval, we suggest to require a statement of compliance with the ASEP limit instead of specific ASEP-measurements.

Summary:

The proposed ASEP limit curve is simple to apply. For a given vehicle, no measurements in addition to those required for Annex 3 are needed to calculate the ASEP-limit curve and to perform ASEP-tests.

The limit curve forms an upper bound for all operating conditions in the control range as it was derived for WOT operation (i.e. the worst case).

By requiring only a statement of conformity with Annex 10 from the manufacturer no extra test load is associated with ASEP during type approval and COP.