

Additional Sound Emission Provisions

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This proposal for additional sound emission provisions is based on the Off cycle emission provisions proposal from 15.08.2004. This proposal was modified with respect to the discussions in the previous ASEP group meeting. The limit curve is now related to the wot test result of annex 3 instead of Lurban. Aim and rationale are almost the same as in the previous proposal.

Aim

Additional sound emission provisions are preventive requirements intended to also cover driving conditions of the vehicle in real traffic, which can be environmentally relevant concerning their sound emission and which differ from those during type approval.

The sound emission of the vehicle under normal driving conditions different from the conditions of the type approval test in Annex 3 shall not differ significantly from what can be expected from the type approval test result for this specific vehicle with regard to technical practicability.

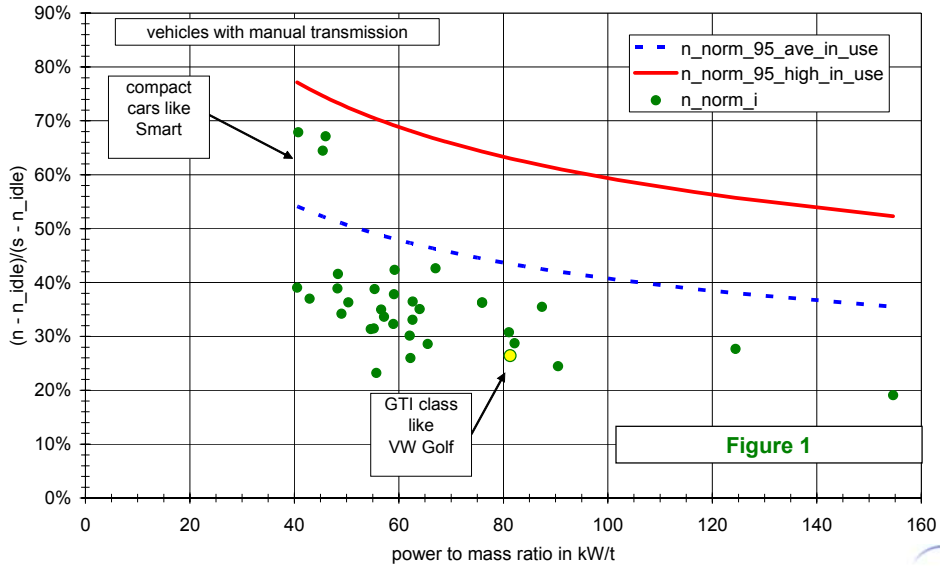
Rationale

The driving conditions of Annex 3 are intended to represent peak acceleration conditions (a_90) at 50 km/h and average engine speed values (n_50) in dense urban traffic under typical partial load operation of the engine. The corresponding sound level is quite well correlated with the Leq-contribution of the particular vehicle under test.

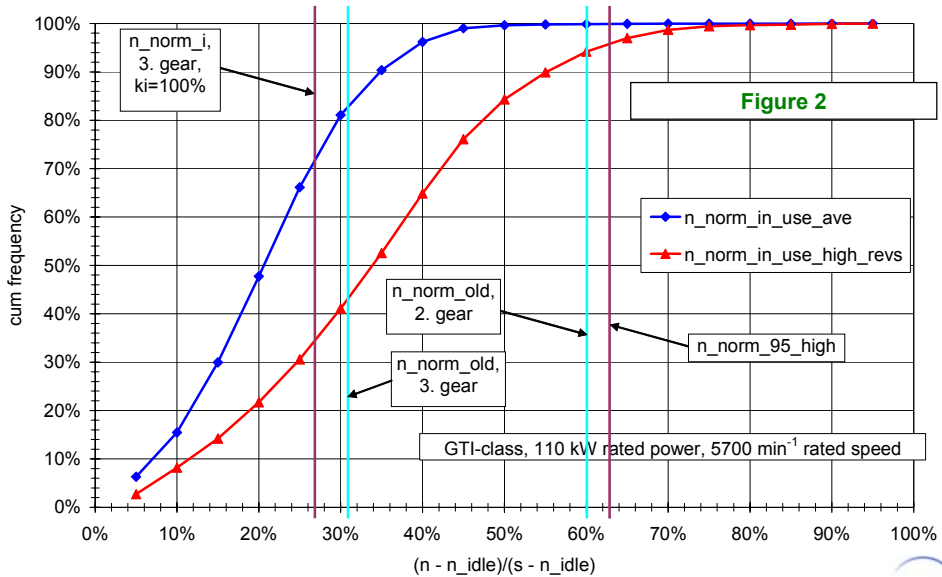
Since partial load acceleration cannot be practised in a reproducible way it is simulated by a combination of a WOT tests and a constant speed tests.

This leads to engine speeds during the test that are lower than the peak values (n_95) used in urban traffic under normal conditions and significantly lower than the peak values under conditions requiring a high acceleration potential like filtering into a main street with dense, fast going traffic stream (n_95_high), see figures 1 and 2.

Norm. engine test speeds vs. in-use peak values



In-use norm. engine speeds vs test speeds



Approach

In order to define what can be expected from the type approval test result for a specific vehicle with regard to driving conditions of the vehicle in real traffic, which can be environmentally relevant concerning their sound emission and which differ from those during type approval, the following technical side conditions have to be considered:

- The additional sound emission provisions can be focussed on wide open throttle (wot) tests,
- An upper limit for the engine speed range environmentally relevant should be derived from in-use data as function of power to mass ratio to reflect real world driving,
- A specification of gear ratios for wot tests,
- A slope for the vehicle speed dependence of the sound emission at wot.

Approach

- The engine speed range up to n_{95_high} includes higher speeds than those tested in annex 3. In order to minimise the tyre/road contribution and to avoid too high vehicle speeds, lower gears than in annex 3 shall be used. Since the 1. gear cannot be used for reproducibility reasons, the 2. gear shall be used for vehicles with manual transmission. To be consistent with Annex 3, the D-range shall be used for vehicles with automatic transmission.
- In order to find a representative limit curve for the wot sound emission between 25 and 70 km/h, the measurement results of 36 M1 vehicles and more than 10 N1 vehicles were approximated as functions of vehicle speed.

Limit curve for engine speeds

- The n_{95_high} curve of the previous figure can be used to specify the upper engine speed limit. This curve is defined by the following formula:

$$2.26 * pmr^{-0.29},$$

pmr is the ratio between rated power and kerb mass + 75 kg, expressed in kW/t

- This curve is related to the engine speed where the max. sound level occurs. For wot tests it is better to specify an engine speed at BB'. For a sample of 64 vehicles the ratio between the engine speed at BB' and at max sound level occurrence was analysed for wot acceleration tests. The rounded average value was 1.15. Consequently, the $n_{norm_95_high}$ curve was multiplied by 1.15, in order to specify a curve for $n_{norm_max_BB'}$. $n_{norm_max_BB'}$ shall be limited to 90%.

Limit curve for wot emissions

- It would be not sufficient to specify one limit curve for each category, because it would allow vehicles with a low test result for annex 3 to be much louder in the additional sound emission provision area than one would expect from the annex 3 result.
- Therefore it is proposed to link the upper limit curve to the test result of annex 3. Since annex 10 deals with wot results, it would be consequent to use the wot result of annex 3.
- In order to find an appropriate link between the limit curve of annex 10 and the test result of annex 3, the latter were compared with the wot results in different gears or gear ranges between 25 km/h and 70 km/h for 36 vehicles.
- A limit curve was then derived from the analysis complying with the following side conditions:
 - ✓ The wot sound level at 50 km/h should not be more than 5 dB(A) higher than L_{wot_ref} of annex 3,
 - ✓ The slope of the limit curve should be an average slope for the 2. gear,
 - ✓ The difference between the limit curve and L_{wot_ref} of annex 10 should not exceed 7 dB(A) at any speed up to 70 km/h.

Limit curve for wot emissions

This lead to the following formula for the limit curve:

$$L_{\text{limit}} = 0,3 * (v - 50 \text{ km/h}) + L_{\text{wot_ref}} + 5 \text{ dB(A)}, \text{ if } 25 \text{ km/h} \leq v < 56,7 \text{ km/h}$$

$$= L_{\text{wot_ref}} + 7 \text{ dB(A)}, \text{ if } 56,7 \text{ km/h} \leq v \leq 70 \text{ km/h}$$

With v at PP'

and $n_{\text{norm_BB}}' \leq 2.6 * \text{pmr}^{-0.29}$, but not more than 90%

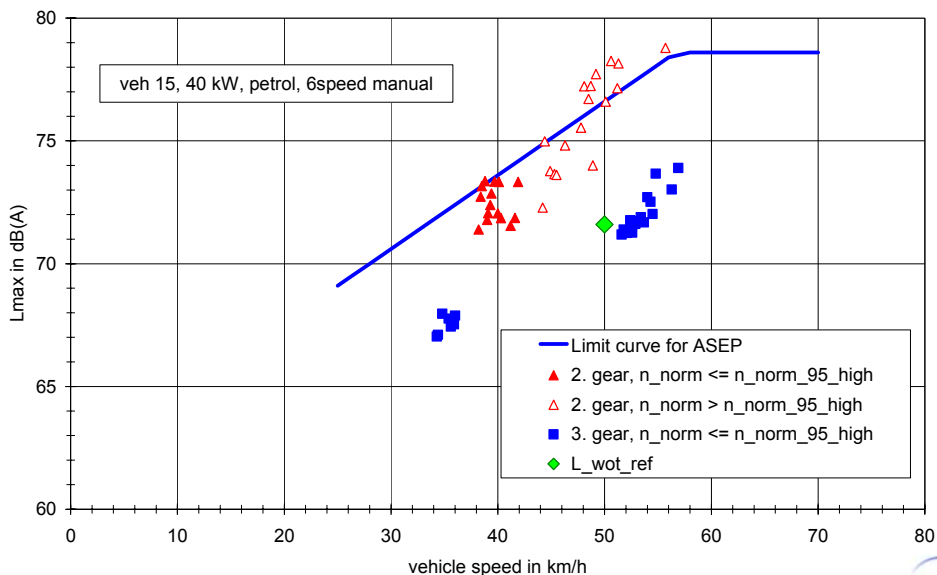
pmr is the ratio between rated power and kerb mass + 75 kg, expressed in kW/t,

$$n_{\text{norm}} = (n - n_{\text{idle}}) / (s - n_{\text{idle}}),$$

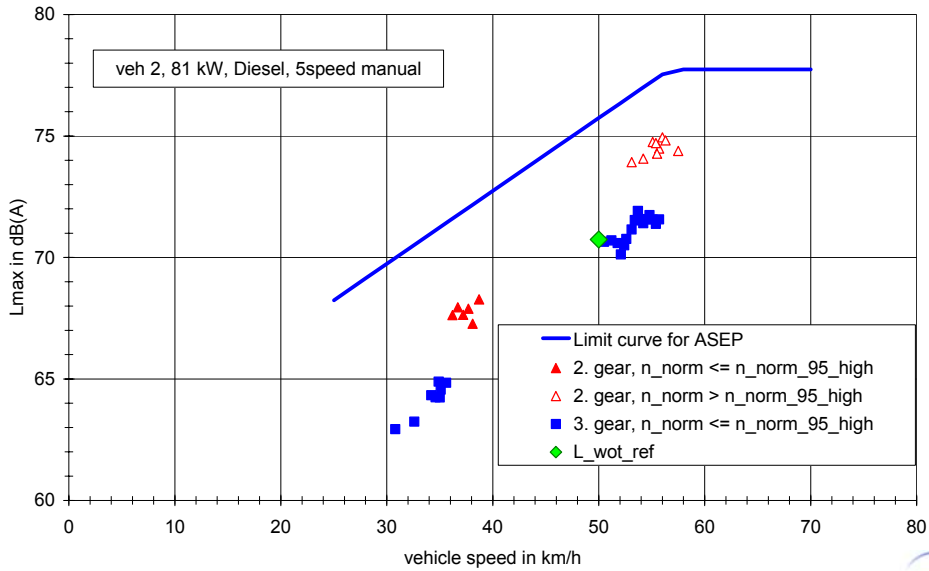
n is the engine speed, s is rated engine speed, n_{idle} is idling speed, all in min^{-1}

The following figures show some measurement results together with the above defined limit curve.

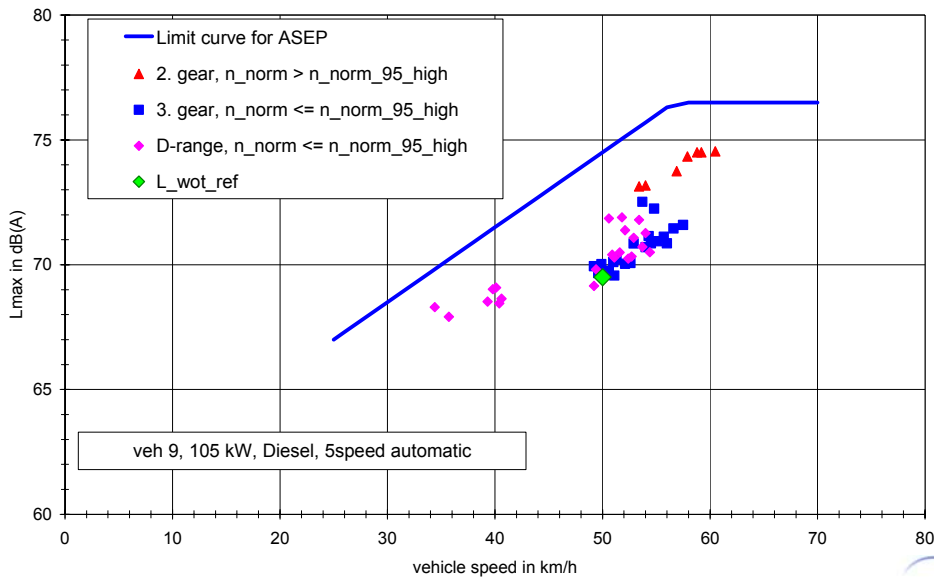
measurement results and ASEP limit curve



measurement results and ASEP limit curve



measurement results and ASEP limit curve



measurement results and ASEP limit curve

