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Additional Sound Emission Provisions in the new European type approval method for exterior noise of road vehicles

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ABSTRACT

Within the framework of the United Nations ECE a new measurement method has been developed for the type approval of road vehicles with respect to their exterior noise emission. For passenger cars the operating conditions of the new test are changed significantly compared to the existing test. Also the ranking of noise sources has changed from predominantly propulsion noise to a significant amount of tyre/road noise. With this change a more effective reduction will be possible of the equivalent traffic noise as emitted during cruising on main streets.

Currently another new test method for passenger cars, called ASEP (Additional Sound Emission Provisions), is under development. This second new method covers a broader range of operating conditions, including worst case acceleration events. This method is designed to safeguard the achievements of the past in the area of single events and propulsion noise reduction. The combination of the two new test methods will enable more effective noise reduction of road vehicles.

With the current place holders for limit values the two new method may face a serious stringency issue. Vehicles may be allowed to become more noisy. To overcome this, the Netherlands has drafted an alternative ASEP method, which is also more design neutral.

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1. INTRODUCTION

A. Traffic noise and noise type approval

Traffic noise is an important health issue and the most cost-effective measures are those addressing the noise at source. Therefore in Europe requirements are set to the noise emission of newly produced vehicles by means of a type approval since 1970. Since the European Union is signatory to the UN/ECE 1958 agreement, the relevant document is the UN/ECE regulation R51 and the discussions on updates take place in Geneva under the umbrella of the UN/ECE Working Party on Noise (GRB).

During the past 4 decades the limits have been reduced regularly. Also the measurement method has been amended several times to stay tuned to the changing automotive technology. Especially for passenger cars some of the lowering of limits have been compensated by a changed measurement method. Therefore the effective lowering of limits is not as big as the bare figures may look like[1].

Nevertheless for trucks this approach has resulted in a significant reduction in environmental noise emission. For passenger cars the environmental noise reduction can be split in to two areas. For single events with high acceleration, where propulsion noise dominates, a significant reduction could be observed, especially for low frequent exhaust noise. For cruising conditions on main streets with low acceleration, where tyre/road noise dominates, no significant change could be observed[2]. For this reason separate noise requirements where set to tyres from 2001 onward.

B. New type approval method

In the same time frame GRB started a discussion to update the current R51(version R51.02) with a new measurement method. The existing method was believed not to be appropriate for future technologies anymore; for example:

- For manual gearboxes the method prescribes measurements in 2nd and 3rd gear. This is appropriate for nowadays five speed gearboxes, but technologies are changing to 6 or more gears or adaptive gear ratios;
- The method prescribes to fully depress the accelerator during the test, but nowadays the gas pedal is linked to the engine by means of an electronic control unit. Therefore a full throttle acceleration is not guaranteed anymore;
- The current method allows for qualifier tyres and focuses on an operating condition with high engine speeds where tyres are not very important. Modern vehicles however operate significant time at much lower engine speeds and tyres are in daily traffic an important noise source.

Therefore GRB introduced a new type approval method[3] which is currently known as method B in R51.02, but may in future become the new type approval method in R51.03. The new method is design neutral and performance based, as it requires to achieve a target acceleration at a prescribed test speed. In order to overcome any acceleration delay, pre-acceleration may be used. The gears to be used depend on the actual performance in relation to the target acceleration. Poorly performing vehicles will use lower gears and higher engine speeds than promptly performing vehicles, just like in real traffic. The method also simulates a partial throttle acceleration by mixing full throttle tests with cruise tests. The target acceleration is set such that the average engine speeds are reduced compared to the existing test. For traditional 5 speed manual gear boxes the new test may typically require testing in 3rd and 4th gear, while the current R51.02 test requires 2nd and 3rd gear.

Due to these changing operating conditions the measured noise levels of vehicles are reduced by 2 a 3 dB. Therefore the noise limits should be reduced by the same amount to get equivalent stringency. Place holders for limit values are:

- 72 (cars < 120 kW/t)
- 73 (cars 120-200 kW/t)
- 75 (cars > 200 kW/t
- 74 (delivery vans)

This proposal does not yet take into account any lowering of limits in order to enforce a further traffic noise reduction. The current monitoring programme with simultaneous measurements with method A and B will bring more data to set appropriate limit values for the new method.

2. ASEP

Due to the changing operation condition and noise source distribution, the new type approval method sets less tight demands on propulsion noise and worst case acceleration events. For some vehicles this would mean a significant liberty to increase the propulsion noise. In order to prevent a potential increase of propulsion noise and to safeguard the achievements of the past, GRB decided that a second measurement method had to be developed (for passenger cars and light duty vehicles under 3,5 tons only). This ASEP (Additional Sound Emission Provisions) should cover a wider range of the engine map, including the worst case acceleration events. A GRB informal group was installed under the chairmanship of this author and given the task to develop this method. By September 2009 this informal group will submit its final report[4] to GRB.

A. Multiple measurements in a range of valid operation conditions

The ASEP will cover a wider range of operation conditions around that of the type approval method. It will explore if the noise emission around the type approval point does not deviate too much from what could be expected from the type approval value. Therefore the noise emission as function of engine speed is investigated and has to comply with certain limits.

Measurements are only valid within the following range of operating conditions

- Vehicle speed: $20 \leq v \leq 80$ km/h
- Acceleration $a \leq 4$ m/s2
- Engine speed $n \leq 2{,}0 * pmr^{-0{,}222} * s$ and $n \leq 0{,}9 * s$

In which

- pmr = the power to mass ratio in kW/t and
- s = the rated engine speed.

This range of operating conditions is thought to cover 99% of all the urban driving conditions, including normal driving, single events and hectically driving. The ASEP range is complementary to the operating condition of the type approval, since the type approval focuses on normal driving behaviour on main streets.

In any valid gear ratio 4 equally spaced measurements shall be taken in order to cover the entire engine speed range. 2 additional random point checks can be taken optionally.

B. Noise limit curve as function of engine speed

All these noise measurements shall comply with the limit curve as function of engine speed, which is based on the following elements:

1. anchor point; the anchor point comes from the type approval test result;
2. bonus for silent vehicles; the noise level of the anchor point is increased with the difference between the type approval limit and the type approval test result; this will allow silent vehicles to pass ASEP easily;
3. margin for random variations; the noise level of the anchor point is also increased with a margin of [Z] dB, as allowance for random variations in individual measurements;
4. slope; the slope of the limit curve as function of engine speed is maximised to [X] dB/1000 rpm;
5. edging; the difference in the slope below and above the engine speed of the anchor point is set to [Y] dB/1000 rpm.

The coefficients X, Y and Z determine the stringency of ASEP. The GRB informal group has not given any advice on the these coefficients, since they are part of a political discussion. During the discussion in the informal group the following range of place holders are mentioned.

Slope X = 4 a 7 dB/1000 rpm
Edging Y = 0 a 2 dB/1000 rpm
Margin Z = 0 a 3 dB

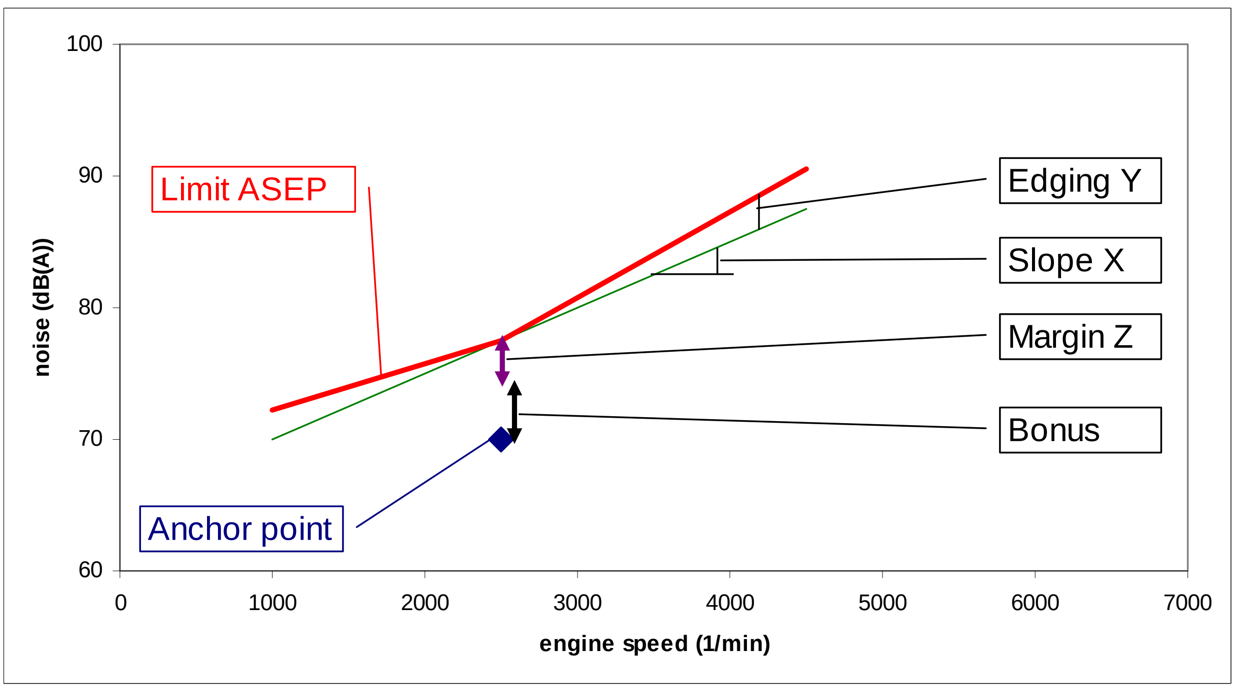

Figure 1: ASEP proposal of the GRBIG; sketch of the limit curve and the different coefficients which determine the stringency.

3. STRINGENCY ISSUE

A. Comparison of ASEP with existing method

During the development of the ASEP method, the GRB informal group has carried out some analysis on the stringency of the new method in comparison to the existing method[5,6]. Assuming the type approval limit values as given in chapter 1 and one of the proposals for X,Y and Z ASEP coefficients, the new method would allow most vehicles to become significantly noisier compared to the existing method (some vehicles more than 10 dB(A), see fig 2 left).
Both a reduction of type approval limit values as well as a set of tight ASEP coefficients are necessary to come to a comparable stringency with the existing method (see fig 2 right).
As this is only a statistical analysis on a dBase of 140 vehicles, a more detailed analysis is necessary which vehicles will fail the new method with which set of ASEP coefficients. One of the next challenges is to make a list of vehicles which are a concern to the environmental noise emission and should be traced with the new method.

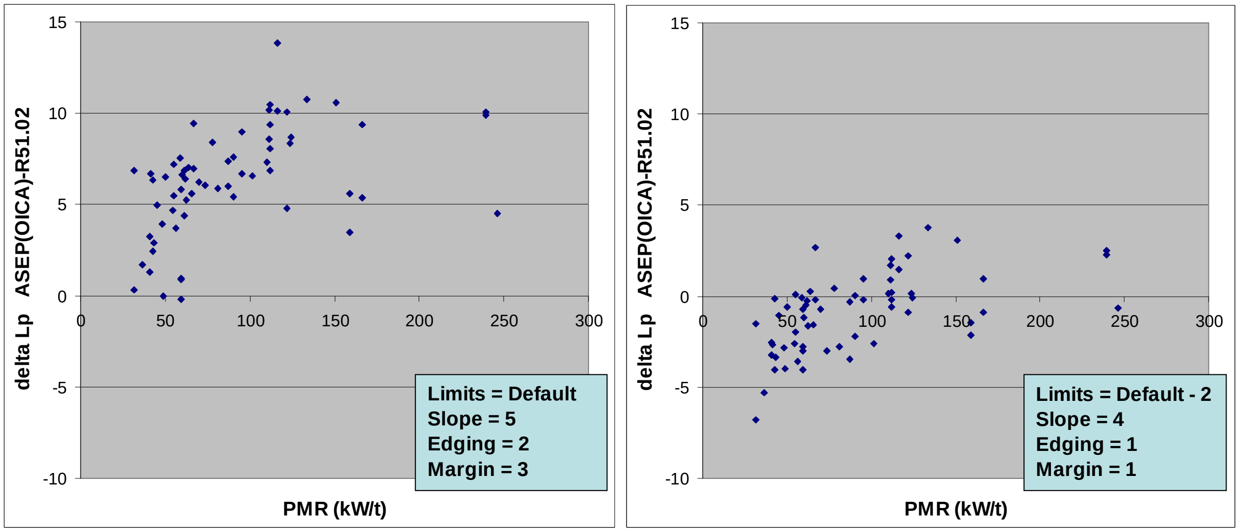

Figure 2: Stringency of the new test method compared to the existing R51.02. Depicted is the allowance to increase the noise emission at the R51.02 operating condition as a function of PMR; left with default limits and ASEP coefficients resulting in significant allowance, right with tighter values resulting in on average equal stringency.

B. Alternative design neutral ASEP method

As the stringency issue is not solved yet and may be a serious threat to the acceptance of the new method, the Netherlands has drafted an alternative ASEP method, which is based on a different philosophy and may therefore be easier accepted. While the above described ASEP method is based on a certain design and the acceptable noise increase as function of engine speed, the Netherlands approach is in its basis design independent en sets an environmentally acceptable noise level which is not to be exceeded within the ASEP range of operating conditions.

More in detail the Netherlands ASEP proposal is based on the following elements:

1. an anchor point (determined from the type approval measurements);
2. a not to exceed point (the noise level of the NTE point consists of the type approval limit value plus a delta of [Y] dB; the engine speed of the NTE point is the maximum valid engine speed within the ASEP control range in that gear);

3. above the anchor point: a straight line between the anchor point and the not to exceed point;
4. below the anchor point: a line with a fixed slope of [Z] dB/1000 rpm;
5. a bonus for silent vehicles;
6. a margin of [X] dB (to allow for uncertainty of single measurements).

The ASEP coefficients X, Y and Z again determine the stringency. The following placeholders are proposed:

X = 2 dB
Y = 8 dB
Z = 3 dB/1000 rpm

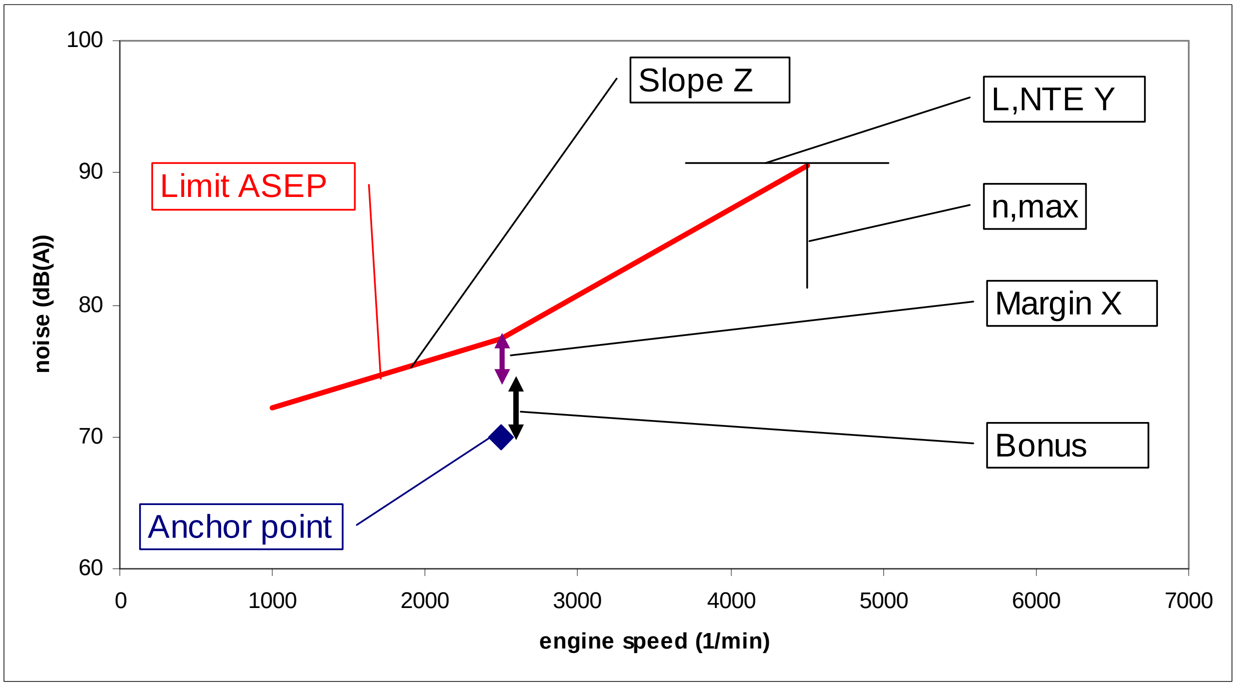

Figure 3: ASEP proposal of the Netherlands; sketch of the limit curve and the different coefficients which determine the stringency.

The ASEP control range is thought to remain identical to the proposal as given in chapter 2. Currently both the limit curve and the control range are based on engine speed as most relevant parameter of the current technologies. If necessary the engine speed could be replaced easily in the Netherlands proposal by a design neutral parameter like propulsion power or a combination of vehicle speed and acceleration.

A first analysis shows that this proposal gives a stringency which is comparable to the stricter variants of the slope based ASEP proposal above. In combination with a 2 dB(A) reduction of the type approval limit values this proposal gives on average a comparable stringency with the existing R51.02 method.
The big difference however is that the allowable noise increase within the ASEP control range is now based on a design neutral environmental demand rather than a design dependent demand.

4. CONCLUSIONS

The current UN/ECE R51 type approval test for the exterior noise emission of road vehicles is thought to be replaced by a combination of two tests: a new type approval test and an ASEP test. The stringency of the proposal as currently discussed in UN/ECE GRB is dependent on the type approval limit values and the ASEP coefficients and yet to be discussed. With the current placeholders, the new method allows most vehicles to become significantly more noisy compared to the existing method. Tighter limit values and ASEP coefficients are necessary, but the question arises if this system will pick out those vehicles which are environmentally relevant. The Netherlands has introduced an alternative ASEP proposal which is design neutral and prescribes a NTE; a noise level which is not to be exceed within the ASEP control range. Inherently the environmental relevance of the vehicles which are picked out with this method can not be questioned.

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