



Functional noise specifications for purchasing green low noise vehicles

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It is expected that the municipalities want to purchase green vehicles because of their noise benefits and not only because of their low chemical emissions. It is therefore a need to develop a universal functional noise specification to be included in green car purchase specification.

Five different noise classes (A, B, C, D and E) covering the whole range in exterior noise from passenger cars according to ISO 362:2007 have been developed. Noise class A is the quietest class, while E is the noisiest. The proposal is that a passenger car has to fulfil noise class A or B, in order to be considered as an environmentally friendly car regarding exterior noise. The proposed noise limit in this study is expected to be included in the purchase specification of green passenger cars. This noise specification will help the buyer to ensure that their cars are environmentally friendly with respect to noise and not only regarding chemical emissions.

The proposed testing method (ECE R51, method B) during type approval has been used by manufactures since 2007 and is therefore already a well-known noise testing method. However, some small changes in the full acceleration test may be needed when testing hybrid and electric passenger cars in order to include all relevant noise sources in an adequate way.

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1 INTRODUCTION

A multitude of city administrations throughout Europe has decided to invest in environmentally friendly vehicles. E.g. in Stockholm there is several on-going projects targeting at the use of environmentally friendly vehicles in cities. By decision of the Mayor of Stockholm, all vehicles paid and used by the City of Stockholm shall be of the environmental friendly type. It is expected that the municipalities want to purchase vehicles because of their noise benefits. The definition of environmental vehicles has up to now only included chemical emissions as criteria and not noise. The objective of this study is therefore to develop a universal functional noise specification to be included in green car purchase specification. This will help the buyer to ensure that their car is environmentally friendly also with respect to noise.

2 TESTING METHODS FOR EXTERIOR NOISE TYPE APPROVAL

A universal and functional noise specification for green vehicle purchase requires a proper noise testing method that considers the actual driving conditions and provides the basis to evaluate new propulsion technologies like hybrid and pure electric vehicles.

2.1 ECE Regulation 51, method A

The current noise Regulation No 51 (R51) of the Economic Commission for Europe (ECE) has been in force since 1970 (Directive 70/157/EC) with several amendments since then. The measurement method is based on ISO 362:1998 and seeks to measure the highest noise levels produced in urban traffic with a focus on driveline noise, i.e. so called full acceleration tests (or full throttle acceleration) in urban areas. Therefore, the test method is based on a full throttle acceleration test starting from 50 km/h or less, depending on the vehicle category.

Since the technical design of vehicles has changed significantly over the last decade, the correlation between the test conditions for type approval and the conditions for normal urban driving has gradually decreased. New test conditions were therefore required to be more representative of normal urban driving behavior in order to affect noise exposure in urban areas more efficiently.

The regulated limit has been strongly reduced since the start in 1970, see Figure 1. However, almost no noise level decrease has been seen in real urban traffic. Note that the limit value for passenger cars is 74 dBA.

2.2 ECE Regulation 51, method B

The new ECE R51 method, based on ISO 362:2007, was prepared by WG42, a joint workgroup of ISO TC43/SC1 "Noise" and ISO TC22 "Road vehicles" and amended by WP29 in 2007 to be implemented in Directive 2007/34/EC. Development and evaluation were notably carried out in 2004 for technical accuracy and practical considerations by over 180 vehicles included in a first monitoring test program. In 2007/2008 the European Commission launched a new monitoring procedure for 2 years application in order to establish new limit values to be applied for the new test method B. During that time, the noise tests during type approval were measured according to the current method A as well as the new method B.

The measurement procedure in method B is based on an estimation of partial throttle operation at 50 km/h for light vehicles (M1, N1 and M2<3.5t) and at 35 km/h for heavy vehicles

(M2>3.5t, N2, N3 and M3) which represents normal urban driving behaviour. For light vehicles, it seeks to approximate real partial throttle operation with a weighted average of a wide-open throttle test (wot) from 50 km/h with a constant speed test at 50 km/h. This ensures a better consideration of all noise sources emitted by road vehicles in urban traffic compared to what was achieved by the earlier applied method. Therefore, a decrease of limits regarding this new method will affect noise exposure in urban areas more efficiently than method A. It also provides the basis for evaluation of new propulsion technologies like hybrid and fuel cell vehicles in a technological neutral manner.

Proposal for new vehicle categories and new limit values

The European Automobile Manufacturers' Association (ACEA) gave a proposal² on new vehicle subcategories and new limit values in August 2010 based on the new collected monitoring data from method B, see Table 1.

Comments on the new test method B applied on hybrid/electric vehicles

The WG42 committee has had access to extensive in-use data to determine the actual driving behavior from light duty vehicles in urban traffic. To establish the operation criteria in method B, WG42 used the in-use vehicle data which showed that the most traveled speed is 50 km/h in urban areas⁵. Furthermore, a traffic noise study⁶ showed that 73 % of the annoyed people lives along main streets with speed limit 50 km/h, while 23 % lives along residential streets with speed limit 30 km/h. The test speed for light duty vehicles were therefore set at 50 km/h.

The main idea with the wot (wide-open-throttle) test from 50 km/h is to simulate a worst-case-scenario with a focus on driveline noise, while the idea with the constant speed test at 50 km/h is to focus on tyre/road noise. The weighted average (L_{urban}) is then a combination of both driveline and tyre/road noise so that all relevant noise sources are considered. However, this may not be the case for low noise vehicles with weaker engines, i.e. hybrid or pure electric vehicles.

Measurements show that for electric vehicles with a low power-to-mass ratio (e.g. PMR<40), the main focus at wot test from 50 km/h is on tyre/road noise instead of the driveline noise due to the quite driveline. The weighted average (L_{urban}) is then only considering tyre/road noise. This may be correct for urban traffic conditions at main streets with speed limit 50 km/h and with very few traffic lights. However, it does not give a fair picture of the noise reduction potential on streets where the acceleration phase normally starts from speeds below 50 km/h, i.e. main streets with speed limit 50 km/h and with lots of traffic lights or residential streets with speed limit 30 km/h. A wot test with a start speed below 50 km/h gives more room for the driveline noise. Therefore, it is here recommended that the wot (wide-open-throttle) test for electric cars with weaker engines (e.g. PMR<40) are to be performed at a lower start speed, e.g. 20 km/h.

3 MEASURED AND COLLECTED NOISE DATA FROM PASSENGER CARS

Sound measurements on passenger cars (M1) have been performed according to ECE R51 method B based on ISO 362-1:2007. Measurements on one hybrid and four pure electric cars were performed by ACL in June 2011. Noise emitted from 34 normal passenger cars were collected from measurements performed by the SAE Cooperative Research Program¹.

The measured and the collected noise data are summarized in Figure 2. It presents the constant speed test at 50 km/h (L_{crs}), the wide-open-throttle tests from 50 km/h (L_{wot}) and the final result, L_{urban} , which is calculated as a weighted average of L_{wot} and L_{crs} in order to simulate real urban driving conditions and to include all relevant noise sources.

The results presented above reveal that electric and hybrid passenger cars emits about 5-10 dBA lower noise levels compared to normal passenger cars during normal urban driving on a urban main street with speed limit 50 km/h and with very few traffic lights.

Stenlund⁸ present detailed measurement results on the hybrid/electric cars that have been included in this study.

4 EXTERIOR NOISE CLASSIFICATION

4.1 Noise classes for passenger cars

Five different noise classes (A, B, C, D and E) covering the whole range in exterior noise from passenger cars according to ISO 362:2007 have been developed. Noise class A is the quietest class, while E is the noisiest. Information about these noise classes are given in the Table 2. The upper limit of noise class A-D and the measured and collected exterior noise data (L_{urban}) are presented in Figure 3. Note that noise class C corresponds to the proposed equivalent limit for M1-1 shown in Table 1 (L_{urban} 72 dBA).

4.2 Environmental friendly passenger cars with respect to noise

There exists up to now no definition on what qualities regarding noise that shall be required from a vehicle in order to be considered a “quiet” vehicle. The definition of environmental vehicles are up to now only including chemical emissions and not noise. Therefore, a proposal is given on what noise limit a car has to fulfil in order to be considered as a quiet environmental friendly car.

The proposal is that a passenger car has to fulfil noise class A or B, i.e. $L_{urban} < 68$ dBA, in order to be considered as an environmentally friendly car regarding exterior noise, see Table 2. This information will help the buyer to ensure that their cars are environmentally friendly with respect to noise and not only regarding chemical emissions.

4.3 Further work on other vehicle categories

This study handles passenger cars only. Similar work can be performed on other vehicle categories as well. However, this requires access and analysis of exterior noise data on these types of vehicles with new propulsion technologies like hybrid and fuel cell vehicles. In 2008, ACL performed similar studies on hybrid city buses as part of another project. These results are however not presented in this paper.

5 CONCLUSIONS

The following conclusions are given in this study:

- Type approval according to ECE R51 method B (ISO 362 :2007)
- Full acceleration test from 20 or 30 km/h instead of 50 km/h for electric passenger cars with weak engines (e.g. PMR < 40). More studies should be made in this area.

- A passenger car that are considered environmentally friendly has to fulfil $L_{\text{urban}} < 68$ dBA (i.e. noise class A or B)
- Similar noise limits should be developed also for other vehicle categories in order to be ranked as environmentally friendly with respect to noise

6 ACKNOWLEDGEMENTS

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7 REFERENCES

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Table 1 - Proposal for new subcategories and equivalent limit values. The table is taken from reference [2] page 9.

Category	Subcategory		Equivalent limit values in dB(A)	
			On Road	Off Road ¹⁾
M1	M1-1	pmr <125 kW/t	72	74
	M1-2	125 kW/t < pmr <= 150 kW/t	73	74
	M1-3	pmr > 150 kW/t	75	75
N1/M2-A	N1/M2-A1	GVM <= 2500 kg	72	74
	N1/M2-A2	GVM > 2500 kg	74	75
N2/M2-B	N2/M2-B1	rated speed > 3000 min ⁻¹	76	77
	N2/M2-B2	rated speed <= 3000 min ⁻¹	78	79
N3	N3-1	2 axles, P _n <= 180 kW	79	80
	N3-2	2 axles, 180 kW < P _n <= 250 kW	81	82
	N3-3	2 axles, P _n > 250 kW	82	83
	N3-4	> 2 axles	84	85
M3	M3-1	P _n < 180 kW	76	77
	M3-2	180 kW < P _n <= 250 kW	78	79
	M3-3	P _n > 250 kW	80	81

¹⁾ off road as defined in R.E.3 and in addition have a wading depth exceeding 500 mm and a hill climbing ability exceeding 35°

Table 2 - Five different noise classes covering the whole range in exterior noise from passenger cars.

Noise class	Noise limit ISO 362:2007 (L _{urban})	Environmentally friendly regarding noise	Typical passenger car types
A	<64 dBA	YES	Pure electric cars
B	64 - 68 dBA	YES	Hybrid cars
C	68 - 72 dBA	NO	Normal passenger cars
D	72 - 76 dBA	NO	Large passenger cars
E	>76 dBA	NO	Sport cars and pickups

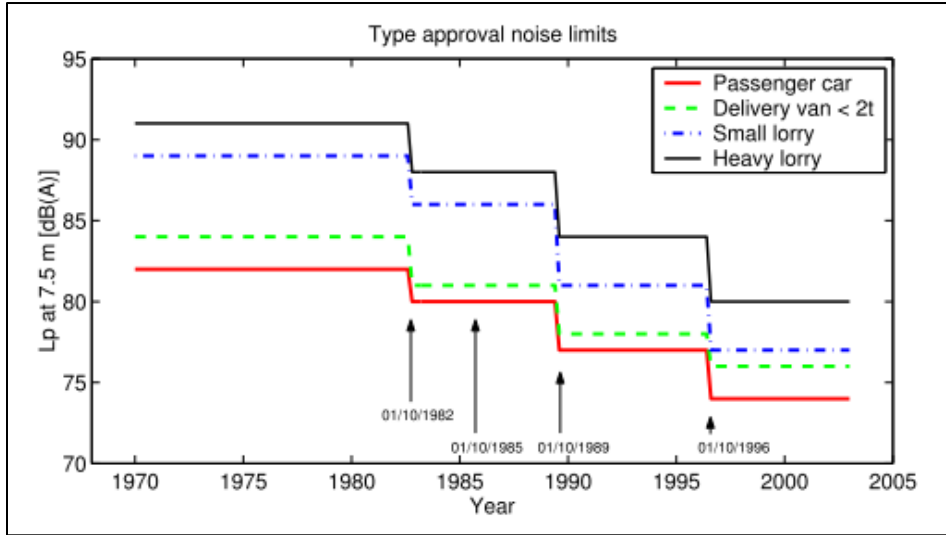


Fig. 1 - Historical development in EU type approval noise limits based on ECE R51 method A. The figure is taken from reference [3] page 51.

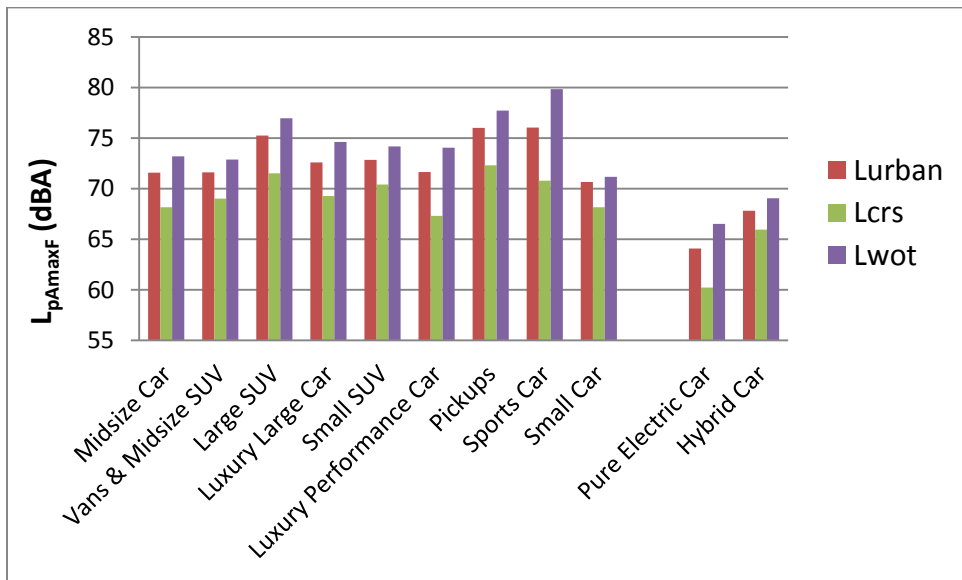


Fig. 2 - Measured and collected exterior noise data from passenger cars according to ECE R51 method B (ISO 362-1:2007).

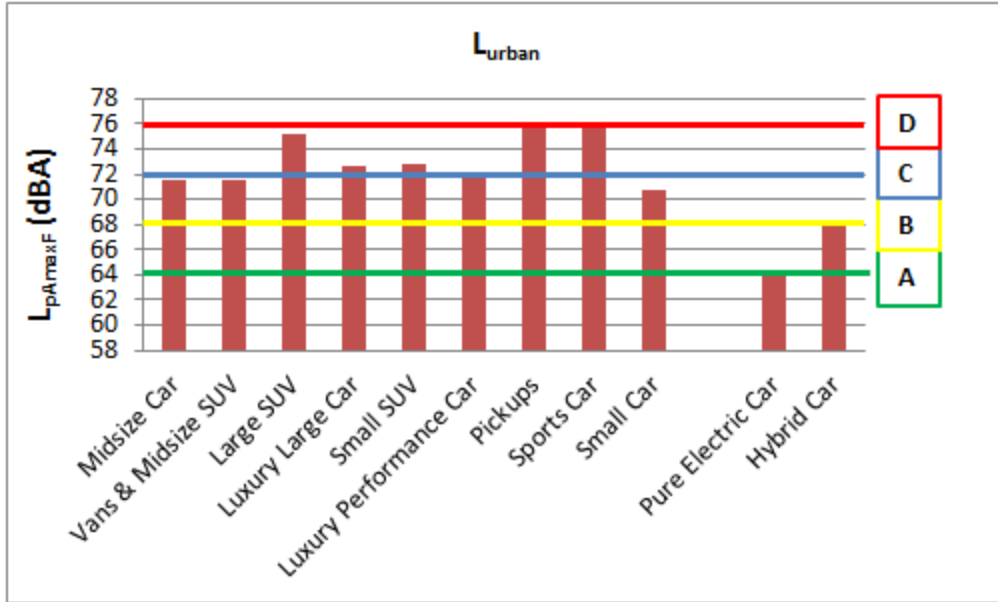


Fig. 3 - Measured and collected exterior noise data (L_{urban}) from passenger cars including the upper limit of noise class A-D.