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VEHICLE'S EXTERNAL NOISE AS A PARAMETER FOR URBAN ECOLOGY

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Apstract: *In dense settlement regions, highly serious problem is loading of the human environment with emission of exhaust gases and noise from highway traffic. Exhaust gases emission is become so close to their nature limits, but problem with external noise from vehicles in town still persist. Today, mobility play very important role in living and nobody wants to abandon of that. Because of that, we have increase use of vehicle and of course, the increase outwards noise that encumber to most people in city. For this reason, reducing the traffic noise has a special significance. European union is very active in this part of researches, wanting to reduce by double traffic noise until the end of 2020. This can obtain only with sentence of external noise that came from singly vehicle and with intensify of traffic rules in city, primarily in limits of vehicle speed. Today, only rule for limit value of vehicle acoustic, in Europe and in our country is Regulation ECE 51.02. In this paper,some possibilities for reducing passenger vehicle's external noise are considered with singly example. Also, the analysis of main sourse of passenger vehicle noise and their significance in satisfaction of rules and the testing results for suggested external noise measuring method which will be regulated by Regulation ECE 51.03, are given.*
Key words**:** *vehicle, external noise, highway traffic, traffic noise, reducing noise, ECE Regulation 51.03*

INTRODUCTION

The noise is one of the physical agences which are harmful for our health, and this is known for a long time ago. The noise levels existing in the urban environment are not enough high to damage hearing, but they are producing a lot of undesriable effects.

Medical researches show that lasting noise action to the human makes different diseases like falling into hysterics, which influnces to sickness of heart, blood system and belly. Because of increasing number of vehicles on the roads and cities, the great attention should dedicate to the traffic noise.

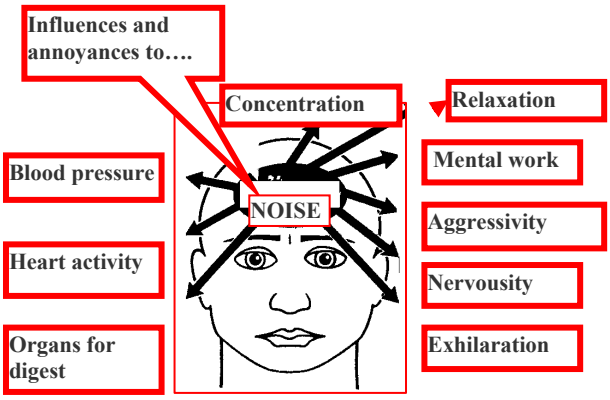


Fig. 1 Noise influences to the human

There is no a precise definition for noise, but it can be said that this is any undesirable sound or whir making unpleasantness and discomfort. Serious anxiety about noise presence resulted into alarming calls to the science and practice in the fight against it. Global aim of vehicle development is minimizing its negative effect to the environment. Over 30 years the policy of noise in the human environment, in EU substantially is based on the legislation which is giving a maximal allowable levels for vehicles, airplanes and machines. Vehicles and equipment at the producing moment are liable to the boundary noise values defined by directives. Because of that, passenger vehicles noise is reduced more then 10 times from 1966. Figure 2. illustrates that approximately, sum of today's 10 vehicles, running in the same time and the same place, gives the noise

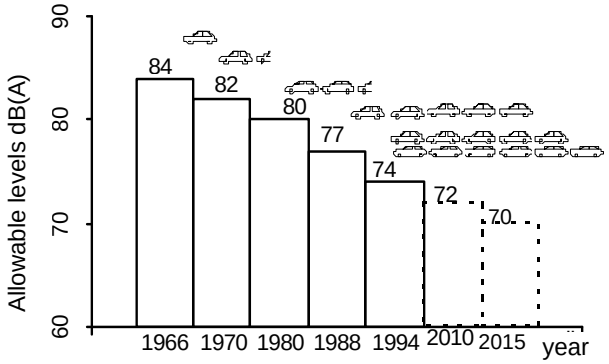


Fig. 2Allowable noise level by Regulation ECE 51

level of only one vehicle from 1966. Working Party on Noise (GRB) for 2010. announces external noise level at 72 dB(A).

2 TRAFFIC NOISE

Researches in many countries show that traffic noise is on the first place as pollutant of human environment. When the engine is starting and vehicle is running after that, there is a noise called traffic noise. By the driving style, the driver can significantly affect to acoustic energy which vehicle emits to the environment. External noise of the one regular vehicle depends on the degree of perfection of its construction and efficiency of materials used for noise reduction.

Traffic noise is not yet sanctioned by any rule. Regarding to external noise, it is regulated by the Regulation ECE 51.02. or ISO 326. Basic sources for noise levels at motor vehicles are: combustion noise (engine), intake and exhausting, transmission and gear box, fan and tires. Noise level reduction needs infallibly big pecuniary resources. For example, in Germany, it is calculated that for every person should be payed about 10 Euros, to reduce noise level for 1 dB(A). Valuable data shows that in the last 15 years, there is no significant improvement in the area of environment protection from traffic noise. World Health Organizaation suggested noise level of 55dB(A), because with this noise level all activities can be done normally.

Connecting settlements, road traffic accelerates human mobility, development of science and technological processes, but on the other hand, it affected to deterioration of human environment. polluting with noise and other waste materials. Acoustic pollutant level, especially in the big cities, is very high, with increasing tendency. Aproximatly about (30-40)% of people is exposed by noxious affect of noise levels. One of the basic sources of this noise is a road traffic noise. As a result of high density of roads in the Europe, the most people population is exposed to traffic noise.Road traffic noise depends on:

- noise made by every individual vehicle,
- road traffic composition,
- traffic intensity,
- vehicle running mode,
- technical condition of motor vehicles,
- category and condition of the roads,
- lacaly relief and
- atmospheric influence.

Because of rules for boundary values of external noise of vehicle, regulated by EC, motor vehicle producers had to always reduce noise level, what was about (10-15) dB(A) by unit, comparing with period of time before (30 till 35) years. To give an evaluation for noise level generated by traffic, because of large number of influenting variables, two basic methods are used:

- noise level determination for individual vehicles,
- measurement of noise level for traffic.

Vehicle producers have a duty to reduce noise of each individual vehicle, because of rules and customer demands. Noise reduction is based on reduction of noise sources apart. Reduction of traffic noise can be obtained by the following way:

- decrease vehicle speed,
- limited transit for trucks,
- reaction on vehicle acceleration,
- traffic transfering to desolate areas,

- prohibited traffic for trucks, motorcycles, motor scooters during the night over certain routes,
- less delay behind the semaphore,
- one way streets establishing, etc.

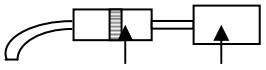
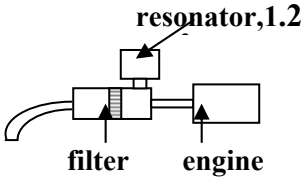
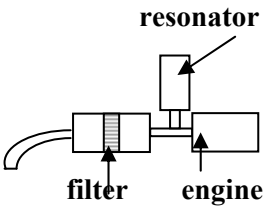
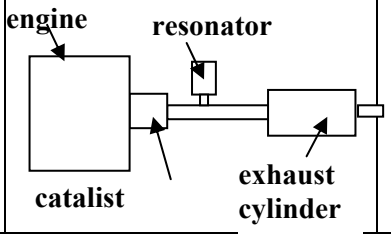
3 VEHICLE NOISE SOURCES

Analizing noise, it should go from the origine place, i.e. noise source, till the place where this noise is harmful. As dominated vehicle's external noise sources it is usual to take propulsion group, engine, intake and exhaust systems and tires. By technology development, more silent engine with electronic injection, ignition and intake air control are produced. Because of that, the noise level of intake and exhaust systems is much more reduced, and therefore tyre noise becomes first for reducing. It should be always in mind that every noise source lower for more then 10 dB(A) from dominating source can be conditionaly neglected. In the past, the dominated contribution to the noise was the combustion process, and the noise from interaction between tyre and road was beside this. However, for today's vehicles, only noise from interaction between tyre and road enables further noise level reduction.

Engine is very powerful source for vibration energy, which begins because of reciprocal and rotational balance of gas forces, and structural engine parts must be adequate suspended over appropriate well choosen supports. Construction and support location require carefull study, to avoid menace of engine performances, easy gear shifting, low vibration level, etc. Noise emission from the combustion process mostly depands on the mixture pressure realized into the engine cylinder, i.e. on the quantity and fuel injection mode in the cycle. Emition noise level reduction from combustion process is realized by decreasing fuel preinjection period, engine loads, etc. However, elimination of the one disaster makes another. So, reduction of the level of emited engine noise significantly depands on the construction and the structure of the engine. Partly eliminating of the engine noise is done by coating several engine department walls with materials for insulation, noise apsorption and vibration suppression. Some vehicle producers make capsulation of the propulsion group. Gear box noise, principally, is not represent as a great noise source at the vehicle.

Primary role for intake manifold system is to introduce fresh air into the engine cylinder. With this, it occurs the intake system noise which depands on air filter characteristics, used for air filtration and combustion process noise suppression. Acoustic properties of air filter depand on different elements onto intake system as connecting pipes, protective hats etc. Correct choice for intake pipes compose of that reflected sound pulse from the end of intake pipe comes into the cylinder at the moment of closing intake valve. Noise reduction can be improved by adding a resonator and with control of precisely needed intake air quantity. Intake noise has low frequency character. The influence of resonator application (1.2 dm^3) to external noise for examinated vehicle model is shown in Table 1.

Table 1

Variant	Variant scheme	dB(A)
1.		73.35
2.		72.70
3.		72.65
4.		72.05

Exhaust system noise is significantly changed with the change in the engine speed. Basic cause for occurence of streaming noise is the pressure change in the stream. Considerable exhausting noise is, really, result of turbulent gas streaming in the pipe. Today, a lot of vehicle producers are using precautions for reduction the noise in the exhaust system at the level which negligible increases vehicle's noise. Very important step in the exhaust system noise reduction is the noise

absorber choice and its location in the system. Noise absorbers builted in the exhaust system, are working on the principle of absorption and reflection, i.e. conversion of the sound energy into the heat and interference of the sound waves. By solving exhaust system noise problems, it is necessary to take care about optimal location of noise absorbers, their volumes and the diameter of the exhaust pipe. Today, exhaust system noise can be created, as you wish, by hardware or software using ANC (acoustic noise control) methods.

Example for exhaust system noise reduction by contracting cross section of the exhaust catalist pre-pipe. It is done three variants of nozzles: with internal diameter (the narrowest section) from 34, 30 and 26 mm. Optimizing nozzle parameters should not be able to make negative effects regarding to ecological and acoustical characteristics of engine i.e. vehicle. Exhaust system with nozzle for diameter 26 mm reduces external noise at idle for 0.5 dB(A).

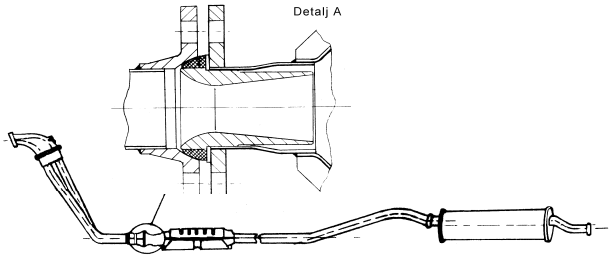


Fig. 3 Exhaust system for tested vehicle with nozzle

There is a great potential and significance of noise from interaction between tyre and road. For example, reducting the limit from 74 dB(A) for 5 dB(A) can be reached only if the noise from interaction between tyre and road is reduced for 6 dB(A). To enable measurement of noise from interaction between tyre and road, it should be eliminated affects of all other sources: engine sound radiation, noise from the openings, intake and exhaust system surfaces. This can be done by different insulations, capsulations, and also by making a special vehicle model designed only for tyre noise testing.

A time ago, tyre noise affected to vehicle's external noise for the speeds above 60 km/h. Today, tyre noise is important factor for the speeds above 30 km/h. It means that effective reduction for vehicle's external noise level implies and infallibly solving tyre noise levels. Tyre noise is expressed in frequency range from 500Hz till 2 kHz, while below 500 Hz intake and exhaust noise is dominated.

Tyre noise is not directly connected to the engine itself, but this problem is connected to the exploatation conditions. From the noise point of view, the ideal tyre is one with slick surface, but this is apsolutely wrong from the safety point of view, because of tyre coherence. Protector width affects significantly to the noise emission. Tyre with narrower protector is better. Radial tyre pattern also contributes to the lower noise level comparing to the axial tyre patern (regarding to the wheel axle). Pattern depth is also important, and if it is less then it is better for lower noise. It should avoid tyre protecting, i.e. new layer deposition, because this negatively affects to the noise. Today, automotive industry also sustains development of slower vehicles because of energent consumption reduction and acoustic improvements. Figure 4. shows noise level from interaction between tyre and road, and this explains that until 50% of total sound level for modern passenger vehicles.

Passenger car; gasoline; 100kW/t, urban; suburb; highway, normal (average) drive

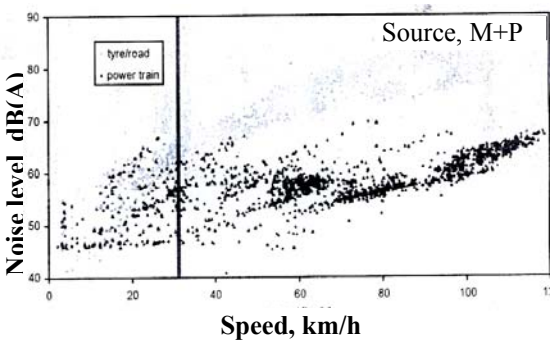


Fig. 4 Tyre noise vs. vehicle speed [3]

4 EXTERNAL NOISE TESTING RESULTS

External noise testing of several vehicle models was done according to the recommendation of Regulation ECE 51.03. External noise level (bypassing) measured according to the method described in this regulation, is a function of:

- vehicle behaviour: position, speed, engine speed,
- noise sources: tires, engine, intake, exhaust,
- transfer function: suppression and propagation.

External noise level at accelerated bypassing driving, today, is the only one regulated boundary value for vehicle acoustics.

For the next reduction of noise emission, it is expected to increase boundary values and/or testing procedures. Figures 6. and 7. show one by one, from four measurements done at the second and third gear shift.

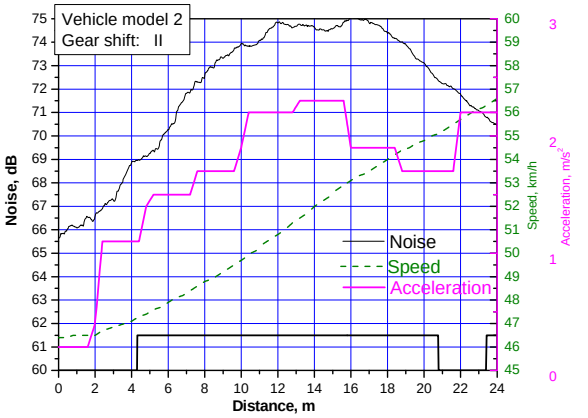


Fig. 5 External vehicle noise, right side

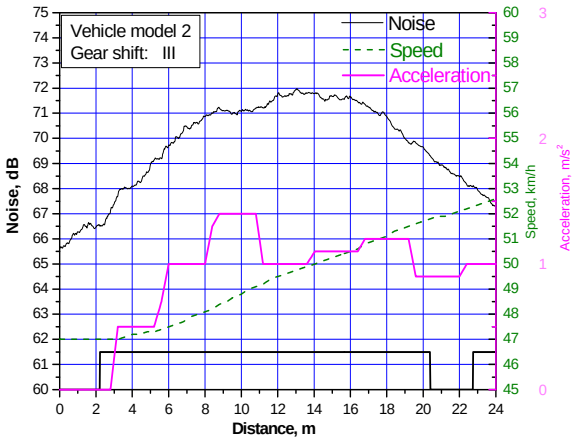


Fig. 6 External vehicle noise, right side

In urban areas, beside driving with constant vehicle speed, there are a lot of accelerations and deccelerations, and often with full load. Increase for vehicle's external noise level is in correlation with its acceleration. In Table 2. is shown a part of acquired measurement results and calculations for two vehicle models.

P-power, kW; m-mass, kg; a_{urban}-aimed acceleration, m/s^2; a_{wotref}-reference acceleration, m/s^2; L_{wot}-mean max value of 4 measurements at acceleration dB(A); L_{crs}-mean max value of 4 measurements at costant vehicle speed of 50 km/h, dB(A); L_{urban}-final max value of noise level (left and right side), dB(A).

Table 2.

Vehicle model	P/m	a_{urban}	a_{wotref}	L_{wot}	L_{crs}	L_{urban}
1	68.8	1.09	1,51	73.2	70.2	72.4
2	54.2	1.00	1.35	72.0	67.5	72.0

Vehicle Model 2 satisfied recommended limits for external noise. To make homologation for this model and after year 2015., the level of external noise should be reduced for more then 2dB(A), what means a big finanacial investments in researches.

5 CONCLUSION

Based on the newest testing results, it is remarked that noise contributes to handicap of human body, even if anyone is not complaining on noise level.

Reduction of traffic noise level depends on noise for every individual vehicle, and also on the number of vehicles. Vehicle speed significantly affects on the noise, for individual vehicle and also for traffic. At full engine loads, acceleration changing is in correlation with vehicle's noise level changing.

Recently, noise at engine combustion process was dominated, moving backward noise from interaction between tires and road. However, with today's vehicles, only noise from interaction between tires and road allows more of noise level reduction.

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ВЪНШНИЯТ ШУМ НА ПРЕВОЗНИТЕ СРЕДСТВА КАТО ПАРАМЕТЪР НА ГРАДСКАТА ЕКОЛОГИЯ

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СЪРБИЯ

Ключови думи: *превозно средство, външен шум, пътно движение, шум от пътното движение, намаляване на шума, Наредба ECE 51.03*
Анотация*: В гъсто населените области като особено сериозен проблем се очертава натоварването на околната среда с емисии на изгорели газове и шум от пътното движение. Емисиите на изгорели газове са близки до естествените граници, но проблемът с външния шум от превозните средства все още съществува в градовете. Днес мобилността е от съществено значение и никой не желае да се откаже от нея. Намаляването на шума от пътното движение е особено важно.*