



## ANALYSIS OF SYSTEMATIC MEASUREMENTS OF NOISE IN CITIES

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**Abstract** - *This paper presents an analysis of the reports on systematic measurements of noise in several Serbian cities. The analysis considered the contents of the report, type and number of data which are presented in the reports (noise level, the description of measurement, measurement conditions, etc.). The analysis was made from the point of application of standards SRPS ISO 1996-1:2010 and SRPS ISO 1996-2:2010. Chart review indicates which data are presented in individual reports. In order to provide unification of measurements and presentation of the results, a minimum content of the report is proposed. The analysis includes a critical review of the possibilities of application of the obtained data for implementation of control points in noise maps. Besides, in the paper are shown the activities which were carried out by local governments on basis of the reports.*

### 1. INTRODUCTION

The sound is part of our daily lives, but it can often be uncomfortable or unwelcome, thus representing noise. Environmental noise - communal noise is unwanted or harmful sound external environment created by human activity. The main source of noise pollution is traffic. Engine operation, the sound of sirens, squeaking brakes, work of technically defective vehicles and, in particular, restarting a vehicle after stopping at a traffic light (at the same time when moving large numbers of vehicles) are effects which increase the noise level. There are many sources of noise at different frequencies, so it is difficult to identify individual contributions to the overall noise level. Besides traffic, as the most important source of noise in the streets, there are other sources of noise, such as the frequent strong closing of vehicle doors, people buzz on the street, barking dogs, noise from independent workshops and restaurants, music from the sound system, as well as many other phenomena that increase noise and which are present on the streets of cities.

As opposed to the industrial noise, which primarily damages the hearing, communal noise primarily affects quality of life, disrupting the natural rhythm of work and rest. The most common causes are uneasiness, tension and lack of concentration.

There is a large number of regulations governing the measurement of environmental noise: the Law on the Protection of the noise in the environment, the regulation of noise indicators, limits, methods for evaluating indicators of noise, disturbance and adverse effects of environmental noise, rules of the methodology for determining acoustic

zone, regulations on methods of measuring noise, the content and scope of the report on the measurement noise, the ordinance on the conditions to be met by a professional organization to measure noise, as well as the documentation submitted with the request for authorization for noise measurement, acoustic zoning, Standards SRPS ISO 1996-1:2010 and SRPS ISO 1996-2:2010.

In addition to these regulations, the relevant institutions in each city make additional decisions on protective measures against noise and systematic measurement of acoustic noise in the established areas of the city.

Analysis of the results of systematic noise measurements in cities shown that the main parameters and process of the noise measurements are applied according to the appropriate standards.

### 2. THE METHODOLOGY FOR MEASURING

Measurement of noise in cities was performed on a varying number of measurement locations and in varying times of the day and night. Number of measuring locations ranges from 3 to 40 and are differently defined areas in which noise is measured. According to the standard, defined by the six acoustic zone as follows:

- areas for recreation, hospital and rehabilitation zones, cultural and historical sites, great parks;
- tourist areas and small villages, camps and school zones;
- purely residential areas;
- business and residential areas, commercial and residential areas and playgrounds;
- city center, craft, trade, administrative zone with flats, along area highways, highways and city roads;
- industrial, warehouse and service areas and transportation terminals without residential buildings.

For each measuring point, in addition to noise level data, the reports include information on the conditions of measurement, description of location where the device was set to measure, traffic frequency, and graphic attachments.

In Table 1 is shown which of the basic data should be included in a report on noise measurement according to the SRPS ISO 1996-2:2010, and to what extent these data are represented in the reports for cities in Serbia.

**Table 1.** Information listed in the report on the measurement of noise in cities

Cities which are included in the analysis	Novi Sad	Zrenjanin	Vršac	Pančevo	Indija	Užice	Kragujevac	Niš	Kraljevo	Beograd
Measurement information that is must be recorded and noted in the report										
The time, date and place of measurement	•	•	•	•	•	•	•	•	•	•
Instruments and their calibration	•	•	•	•	•	•	•	•	•	•
Measured and, if relevant, corrected sound pressure levels ( $L_{eqT}$ , $L_E$ , $L_{max}$ ), A-weighted (and optional C-weighted), and optionally, in the frequency bands	•	•	•	•	•	•	•	•	•	•
Measured levels of N percentage ( $L_{N,T}$ ) including the accrual (sampling rate and other parameters)	•	•				•		•	•	
Evaluation of uncertainty of measurement together with the probability of coverage		•								
Information on sound pressure levels during the measurement of residual volume	•	•				•	•	•	•	
Time interval measurements	•	•	•	•	•	•	•	•	•	•
Description of working conditions, including the number of passes of cars / trains / planes listed for each respective category	•	•			•	•	•	•	•	•
Description of meteorological conditions, including wind speed, wind direction, cloudiness, temperature, barometric pressure, humidity, precipitation, and the presence and location of sensors for wind and temperature	•	•			•	•	•	•	•	
The methods used for the exploitation of the measured values for other conditions										

### 3. DATA ANALYSIS AND RESULTS OF THE NOISE MEASUREMENTS

Measurement interval in all cities is 15 minutes, while the number of measurements during the day and night varies. Some cities in the reports of a systematic measurement noise have data on two measurements during a day (6-18h), one during the evening (18-22h) and two during the night (22-6h), while some reports have data about a day and night measurements noise.

Numeric values that are shown in the reports are:

- the value of daily noise indicators ( $L_{day}$ ) in the environment;
- the value of the indicator evening noise ( $L_{evening}$ ) in the environment;
- the value of the indicator nighttime noise ( $L_{night}$ ) in the environment;
- the value of the total noise indicators ( $L_{den}$ ) in the environment;
- percentage of the population endangered by noise (A%) of road traffic during the day and during the night and the percentage of the population highly vulnerable to noise (NA%) (comparing to the determined value of  $L_{den}$  at measuring points) - Novi Sad;

- the recorded values of the equivalent noise level ( $L_{Aeq}$ );
- the permissible noise level;
- average noise level (day, evening, night) – Kraljevo;
- the established value of the frequency for a fixed maximum equivalent noise level - Novi Sad.

Number of measurements on a monthly and annual basis also varies. In Novi Sad and Zrenjanin noise measurements are performed each month at all measuring points, while in Niš, Kraljevo, Kragujevac, Užice and Belgrade are made in spring or autumn measurements.

The analysis revealed the following:

- there are consecutive terms of measurement noise, which is not desirable;
- the data for the measurement of spring and autumn in some cities are identical, which raises concern about their credibility;
- measured data for some measurement points in different occasions coincide completely, which also raises credibility concerns;
- institutions that deal with measurement of noise usually publish partial or complete reports on their

websites or on the official website of the city government;

- it is not possible to look at recent reports on the noise measurement, because the data are not updated regularly;
- measures to be taken regarding noise protection are not clearly defined in the report on systematic measurements of noise in cities.

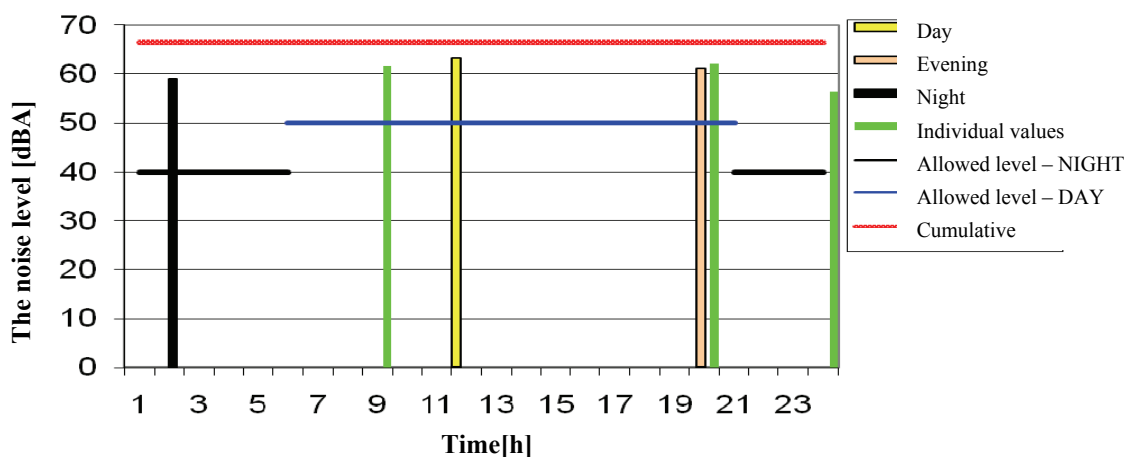
In Table 2 are shown the numbers of noise measurements on a monthly and annual basis in the cities that were included in the analysis, and Table 3 shows basic data measurement noise in Kraljevo for one measuring point where traffic has a dominant effect on the noise.

**Table 2.** Number of measurements during the months and year

Cities	Novi Sad	Zrenjanin	Vršac	Pančevo	Indija	Užice	Kragujevac	Niš	Kraljevo	Beograd
Number of measuring points	9	20	6	8	3	22	6	11	40	35
Monthly measurements	45	100	12	16	15	110	30	55	200	70
Annual measurement	540	1200	24	16	15	110	60	55	200	140

**Table 3.** The measured values of key indicators of noise in Kraljevo

No.	Time	Date	L <sub>Aeq</sub> [dBA]	L <sub>AF95</sub> [dBA]	L <sub>AF50</sub> [dBA]	L <sub>AFmin</sub> [dBA]	L <sub>AFmax</sub> [dBA]	Number of vehicles	
								„light“	„heavy“
1.	08.56-09.11	28.07.2011	61.6	50	57	51.3	77.7	267	15
2.	20.05-20.20	27.07.2011	62.1	45.5	53	47.7	72.5	165	8
3.	00.11-00.26	27.07.2011	56.3	34.5	43	35.1	71.7	56	0
Cumulative noise: 67.2 dBA									



**Fig. 1.** Graphic display of measurement results of noise

Figure 1 provides a graphical representation of the results of the noise measurements whose values are given in Table 3.

To measure the equivalent noise level were used sound level meters, of various types such as, Bruel & Kjaer Observer, 2260, 2250 or 2238-G type, class 1, With these instruments it is possible to do all the measurements and analysis on the assessment of noise pollution, and noise in the workplace. The instruments also meet all the required IEC (61672 standard) and ANSI standards.

The results are shown in decibels (dB), based on measurements of the equivalent noise level (L<sub>Aeq</sub>).

#### 4. STRATEGIC NOISE MAPS, „NOISE MAPPING“

For strategic noise mapping is used so-called basic indicators of noise. These are: the daily noise indicator (L<sub>day</sub>), evening-noise indicator (L<sub>evening</sub>), night noise indicator (L<sub>night</sub>) and an indicator that describes the noise annoyance over 24 hours L<sub>den</sub> (day-evening-night). These are longer, weighted average sound level for all of these periods in a year.

Strategic noise maps are data on the current and estimated noise levels, which are shown by noise indicators. The maps contain detailed information on the state of environmental

noise; (excess of the prescribed limits, estimating the number of people, households, schools and hospitals that are exposed to noise above the prescribed limit. Strategic noise maps for agglomerations in the territory of the local government makes local governments (Law on the Protection of the noise in the environment). Systematic measurement noise in cities should serve as a control point map noise.

Carrying out the day and night noise measurement would be impossible - because it is too time-consuming and expensive. Therefore, calculations based on a reliable methodology are being used. Digital terrain model, structural features of buildings, the number of people on one side and the road network, traffic volume, fences, existing speed limits on the other hand are used in making these calculations.

The above measurements of noise pollution and the geographic distribution of the noise emission are presented for an area by colors, where the colors represented different intervals sound level, in order to identify the problematic points in the urban environment where the noise level is higher than the norm.

This is the basis for planning processes and actions to reduce noise levels, and for planning and construction. Necessary steps would be collecting data on traffic and industry, the introduction of digital models that include buildings, boundaries, topography of the terrain and calculate the (future) of likely noise levels using appropriate software and noise propagation model. Proposal of basic data which should contain statements about the measurement noise are given in Appendix 1

## 5. CONCLUSION

A large number of cities, which perform systematic measurement of noise, did not respond to our request to send us their reports, at least in part. Therefore, we were not able

to make detailed comparisons of the measurement noise in all towns in Serbia.

The control system of traffic in cities has not changed enough to prevent excessive noise: setting up barriers between residential buildings, schools and main traffic roads is still in the conceptual stage. In Kraljevo, are made projects with sound barriers for school „Dimitrije Tucović” and settlements near a major overpass. Currently these projects are awaiting funding necessary for realization. It is also necessary to determine appropriate funding institutions that deal with the noise impact on the environment (in Kraljevo's Local Environmental Action Plan-LEAP). Respective authorities should be starting solving the problem of noise in cities because reports show that the noise in many cases above the permitted level.

## ACKNOWLEDGEMENT

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