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Preliminary communication

Methodology for Uncertainty Estimation of Long-Term Environmental Noise Measurements

Darko MIHAJLOV*, Momir PRAŠČEVIĆ, Miomir RAOS, Roumen IANKOV

Abstract: The ISO 1996 series harmonize the methods for the description, measurement and assessment of environmental noise from all source types. In addition, the standards contain the guidelines for estimating the uncertainty of environmental noise measurements that consider the impact of different sources of uncertainty. The standards do not describe in detail the procedure for estimating the measurement uncertainty, but they can be used as a foundation for developing a detailed procedure based on the conducted acoustic measurements and collected data important for sound propagation. The aim of this paper is to provide a detailed step-by-step procedure for estimating the uncertainty of long-term environmental noise measurements conducted during long-term time intervals consisting of several reference time intervals. The input data are a large number of independent measurements of equivalent continuous sound pressure levels at the assessment point under well-defined sound emission and meteorological conditions. The measurement results are stratified into different windows, i.e., a combination of sound emission and meteorological conditions. The output data is the uncertainty of long-term environmental noise measurements estimated using the measured data obtained by the continuous environmental noise monitoring, taking into account possible sources of measurement uncertainty.

Keywords: environmental noise; long-term measurement; measurement uncertainty; noise indicator

1 INTRODUCTION

The European Noise Directive [1] introduced noise indicators for describing environmental noise, which are related to the harmful effects of environmental noise. Additionally, most European countries, including the countries of the Western Balkan, have transposed the Directive and the noise indicators into their national legislation [2-5].

The noise indicators can be determined either by measurement at the assessment position according to ISO 1996-1 [6] and ISO 1996-2 [7] or by calculation using the Common Noise Assessment Method (CNOSSOS) which is specified in Annex II of the Directive [1].

In recent years, the researchers in the field of acoustics have published many investigations [8÷16] that show that the annual average value of noise indicators can be estimated by long-term measurements in long-term time intervals (often called monitoring period), which represent some fraction of the year and encompass a series of reference time intervals specified in national legislation usually as day, evening and night period.

The determination of noise indicators can be achieved through two methods: long-term unattended measurements or making many attended sampled short-term measurements [7]. The first type of measurements directly provides the values of noise indicators in the monitoring period, while the second type requires postprocessing of the measured data.

Both types of measurements have a certain degree of measurement uncertainly, which must be estimated and reported because measurement uncertainty is a quantitative indicator of the reliability of the reported measurement result. It is especially important when making comparisons between the measured values and limit values specified in national legislation. Several rules for accepting and rejecting the measurement results concerning the limit values and the specification zone are given in [17].

In recent years, there has been considerable interest in investigating uncertainty of environmental noise measurements. Many papers [17-26] address environmental noise measurement uncertainty, possible sources of measurement uncertainty and approaches for estimating environmental noise measurement uncertainty, which complies with ISO/IEC Guide 98-3 (GUM) [27]. Most of these papers address the uncertainty of short-term measurements. Some papers [24-26] address the uncertainty of long-term measurements, but not according to the ISO 1996-2 guidelines [7].

The methodology for estimating the uncertainty of long-term environmental noise measurements according to the ISO 1996-2 guidelines [7] is presented in this paper as well as the example that illustrates the uncertainty range in long-term environmental noise measurements.

2 METHODOLOGY

2.1 Determination of the Noise Indicators

To determine the noise indicators as long-term equivalent continuous sound pressure levels during the monitoring period (minimum of several days) and associated measurement uncertainty, it is necessary to conduct a large number of independent measurements of equivalent continuous sound pressure levels at the assessment point under well-defined sound emission and meteorological conditions. As required by table 3 in ISO 1996-2 [7], the independent measurements are successive measurements with a minimum time gap between two measurements, so that the sound emission conditions and the meteorological conditions are statistically independent of the same conditions in other measurements in the measurement series. For example, the minimum time gap between two measurements must be 24 h for an assessment point at a distance of less than 100 m from road.

The measured data are then stratified into different windows, i.e., a combination of sound emission (e.g., day, evening, night) and meteorological conditions (e.g. four different windows as recommended by table 2 of ISO 1996-2 [7]). Tab. 1 shows the stratification model of the measured daily values of noise indicators at the assessment point.

In Tab. 1, the minus sign on wind speed indicates that the wind direction is from receiver to source. Also, "day" refers to the time between sunrise and sunset, while "night" refers to the time between sunset and sunrise [7]. N is the number of stratified samples in the corresponding window. In Tab. 1 and the following equations, the measured and calculated values of daily noise indicators are marked with ′, and for simplicity of the equations, the noise indicators are marked with L_d, L_e and L_n instead with L_{day}, $L_{evening}$ and L_{night} as recommended by the Directive [1].

Table 1 Stratification of the measured daily values of noise indicators at the assessment point into different windows

	Meteorological window Mw			
Emission window	M1 Unfavourable $v < 1$ m/s (day) $v < -1$ m/s (night)	M2 Neutral $1 \le v < 3$ m/s	M3 Favourable $3 \le v \le 6$ m/s	M4 Very favourable $v > 6$ m/s (day) $v \ge -1$ m/s (night)
day	L'_{di}, $i = 1,\ldots,N_{d,M1}$	L'_{di}, $i = 1,\ldots,N_{d,M2}$	L'_{di}, $i = 1,\ldots,N_{d,M3}$	L'_{di}, $i = 1,\ldots,N_{d,M4}$
evening	L'_{ei}, $i = 1,\ldots,N_{e,M1}$	L'_{ei}, $i = 1,\ldots,N_{e,M2}$	L'_{ei}, $i = 1,\ldots,N_{e,M3}$	L'_{ei}, $i = 1,\ldots,N_{e,M4}$
night	L'_{ni}, $i = 1,\ldots,N_{n,M1}$	L'_{ni}, $i = 1,\ldots,N_{n,M2}$	L'_{ni}, $i = 1,\ldots,N_{n,M3}$	L'_{ni}, $i = 1,\ldots,N_{n,M4}$

The total number of stratified samples for each emission window is given by:

$$N_d = \sum_{w=1}^{4} N_{d,Mw}, \tag{1a}$$

$$N_e = \sum_{w=1}^{4} N_{e,Mw}, \tag{1b}$$

$$N_n = \sum_{w=1}^{4} N_{n,Mw}. \tag{1c}$$

The frequency of occurrence of stratified samples for each emission window and meteorological window Mw (w = 1-4) is given by:

$$p_{d,Mw} = \frac{N_{d,Mw}}{N_d}, \tag{2a}$$

$$p_{e,Mw} = \frac{N_{e,Mw}}{N_e}, \tag{2b}$$

$$p_{n,Mw} = \frac{N_{n,Mw}}{N_n}. \tag{2c}$$

The average values of the noise indicators for each meteorological window are calculated based on the measured values of the daily noise indicators as follows:

$$\overline{L}'_{d,Mw} = 10\log\left(\frac{1}{N_{d,Mw}}\sum_{i=1}^{N_{d,Mw}} 10^{0.1\cdot L'_{di}}\right), \tag{3a}$$

$$\overline{L}'_{e,Mw} = 10\log\left(\frac{1}{N_{e,Mw}}\sum_{i=1}^{N_{e,Mw}} 10^{0.1\cdot L'_{ei}}\right), \tag{3b}$$

$$\overline{L}'_{n,Mw} = 10\log\left(\frac{1}{N_{n,Mw}}\sum_{i=1}^{N_{n,Mw}} 10^{0.1\cdot L'_{ni}}\right). \tag{3c}$$

The total values of the noise indicators in the monitoring period are calculated based on the average values of the noise indicators - Eq. (3a) to (3c) as follows:

$$L'_d = 10\log\left(\sum_{w=1}^{4} p_{d,Mw}\cdot 10^{0.1\cdot\overline{L}'_{d,Mw}}\right), \tag{4a}$$

$$L'_e = 10\log\left(\sum_{w=1}^{4} p_{e,Mw}\cdot 10^{0.1\cdot\overline{L}'_{e,Mw}}\right), \tag{4b}$$

$$L'_e = 10\log\left(\sum_{w=1}^{4} p_{e,Mw}\cdot 10^{0.1\cdot\overline{L}'_{e,Mw}}\right). \tag{4c}$$

The calculated total value of the day-evening-night noise indicator in the monitoring period is given by:

$$L'_{den} = 10\log\left(\frac{12}{24}\cdot 10^{0.1\cdot L'_d} + \frac{4}{24}\cdot 10^{0.1\left(L'_e+5\right)} + \frac{8}{24}\cdot 10^{0.1\left(L'_n+10\right)}\right). \tag{5}$$

2.2 Determination of the Measurement Uncertainty

The estimated (true) value of the day-evening-night noise indicator, L_{den}, on the selected assessment point with negligible influence of residual sound is defined as follows:

$$L_{den} = L'_{den} + \delta_{slm} + \delta_{loc1} + \delta_{loc2}, \tag{6}$$

where: L'_{den} - the calculated value of the day-evening-night noise indicator in the monitoring period according to Eq. (5), excluding residual noise; δ_{slm} - an error due to the selection of the measurement chain (sound level meter) [7]; δ_{loc1} - an error due to the selection of receiver location relative to reflection surfaces [7]; δ_{loc2} - an error due to the selection of microphone location representative of the assessment point (choice of microphone position, microphone height above ground level, microphone orientation) [28, 29].

An error due to the selection of microphone location, δ_{loc2}, is added to the budget uncertainty recommended by ISO 1996-2 [7] according to the guidelines in [28, 29].

The sum of an error due to deviations from the expected operating conditions of the source, δ_{sou}, and an error due to meteorological conditions deviating from the assumed meteorological conditions, δ_{met}, is determined based on independent measurements and included in the standard measurement uncertainty for the measured values of the day-time noise indicator, the evening-time noise indicator and the night-time noise indicator - Eq. (10).

The combined standard measurement uncertainty of the estimated value of the day-evening-night noise indicator, $u(L_{den})$, is given by:

$$u\left(L_{\mathrm{den}}\right)=\sqrt{\begin{array}{l}c^2\left(L'_{\mathrm{den}}\right)u^2\left(L'_{\mathrm{den}}\right)+\\+c_{\mathrm{slm}}^2u_{\mathrm{slm}}^2+c_{\mathrm{loc1}}^2u_{\mathrm{loc1}}^2+c_{\mathrm{loc2}}^2u_{\mathrm{loc2}}^2\end{array}}, \tag{7}$$

where: $c\left(L'_{\mathrm{den}}\right)$ - the sensitivity coefficient for L'_{den}, $c\left(L'_{\mathrm{den}}\right)=1$; c_{slm} - the sensitivity coefficient for the sound level meter, c_{slm} = 1; c_{loc1} - the sensitivity coefficient for selecting the receiver location relative to the reflection surfaces, c_{loc1} = 1; c_{loc2} - the sensitivity coefficient for selecting the receiver location relative to the assessment point, c_{loc2} = 1; $u\left(L'_{\mathrm{den}}\right)$ - the standard uncertainty for L'_{den} in dB; u_{slm} - the standard uncertainty due to the selection of the sound level meter in dB (u_{slm} = 0,5 dB for a class 1 sound level meter and u_{slm} = 1,5 dB for a class 2 sound level meter [7]); u_{loc1} - the standard uncertainty due to selection of the receiver location relative to reflection surfaces in dB (estimated according to Annex B of ISO 1996-2 [7]); u_{loc2} - the standard uncertainty due to selection of the receiver location relative to the assessment point in dB (u_{loc2} = 1 dB [30] or can be determined as the standard deviation of the measurement repeatability).

Starting from Eq. (5) and applying the guidelines from Annex F of ISO 1996-2 [7] for a mixture of different sound emission conditions, the standard uncertainty $u\left(L'_{\mathrm{den}}\right)$ is determined as the combined measurement uncertainty:

$$u\left(L'_{\mathrm{den}}\right)=\sqrt{\begin{array}{l}c^2\left(L'_{\mathrm{d}}\right)u^2\left(L'_{\mathrm{d}}\right)+c^2\left(L'_{\mathrm{e}}\right)u^2\left(L'_{\mathrm{e}}\right)+\\+c^2\left(L'_{\mathrm{n}}\right)u^2\left(L'_{\mathrm{n}}\right)\end{array}}, \tag{8}$$

where: $c\left(L'_{\mathrm{d}}\right), c\left(L'_{\mathrm{e}}\right), c\left(L'_{\mathrm{n}}\right)$ - the sensitivity coefficients for the total values of the day-time noise indicator, the evening-time noise indicator and the night-time noise indicator in the monitoring period, respectively:

$$c\left(L'_{\mathrm{d}}\right)=\frac{\partial L'_{\mathrm{den}}}{\partial L'_{\mathrm{d}}}=\frac{12}{24}10^{0.1\cdot\left(L'_{\mathrm{d}}-L'_{\mathrm{den}}\right)}, \tag{9a}$$

$$c\left(L'_{\mathrm{e}}\right)=\frac{\partial L'_{\mathrm{den}}}{\partial L'_{\mathrm{e}}}=\frac{4}{24}10^{0.1\cdot\left[\left(L'_{\mathrm{e}}-5\right)-L'_{\mathrm{den}}\right]}, \tag{9b}$$

$$c\left(L'_{\mathrm{n}}\right)=\frac{\partial L'_{\mathrm{den}}}{\partial L'_{\mathrm{n}}}=\frac{8}{24}10^{0.1\cdot\left[\left(L'_{\mathrm{n}}-10\right)-L'_{\mathrm{den}}\right]}; \tag{9c}$$

$u\left(L'_{\mathrm{d}}\right), u\left(L'_{\mathrm{e}}\right), u\left(L'_{\mathrm{n}}\right)$ - the standard measurement uncertainties for the total values of the day-time noise indicator, the evening-time noise indicator and the night-time noise indicator in the monitoring period, respectively.

Additionally, starting from Eq. (4) and applying the guidelines from Annex F of ISO 1996-2 [7] for a mixture of different sound emission conditions, the standard measurement uncertainties $u\left(L'_{\mathrm{d}}\right), u\left(L'_{\mathrm{e}}\right), u\left(L'_{\mathrm{n}}\right)$ are determined as the combined measurement uncertainty. The procedure for calculating the standard measurement uncertainty $u\left(L'_{\mathrm{d}}\right)$ is provided below. Moreover, an analogous procedure is applied to the other noise indicators.

The standard measurement uncertainty $u\left(L'_{\mathrm{d}}\right)$ is given by:

$$u\left(L'_{\mathrm{d}}\right)=\sqrt{\begin{array}{l}\sum_{w=1}^{4}c^2\left(\bar{L}'_{\mathrm{d,M}w}\right)u^2\left(\bar{L}'_{\mathrm{d,M}w}\right)+\\+\sum_{w=1}^{4}c^2\left(p_{\mathrm{d,M}w}\right)u^2\left(p_{\mathrm{d,M}w}\right)\end{array}}, \tag{10}$$

where: $c\left(\bar{L}'_{\mathrm{d,M}w}\right)$ - the sensitivity coefficients for the energy average of the measured daily values of the day-time indicator stratified in the corresponding meteorological window, (see Tab. 1):

$$c\left(\bar{L}'_{\mathrm{d,M}w}\right)=\frac{\partial L'_{\mathrm{d}}}{\partial \bar{L}'_{\mathrm{d,M}w}}=p_{\mathrm{d,M}w}\cdot 10^{0.1\left(\bar{L}'_{\mathrm{d,M}w}-L'_{\mathrm{d}}\right)}; \tag{11}$$

$c\left(p_{\mathrm{d,M}w}\right)$ - the sensitivity coefficient for the frequency of occurrence of stratified samples for the day in the corresponding meteorological window, (see Tab. 1 and Eq. (2)):

$$c\left(p_{\mathrm{d,M}w}\right)=\frac{\partial L'_{\mathrm{d}}}{\partial p_{\mathrm{d,M}w}}= =10\,log(e)\frac{10^{0.1\cdot\bar{L}'_{\mathrm{d,M}w}}-10^{0.1\cdot L'_{\mathrm{d,max}}}}{10^{L'_{\mathrm{d}}}}; \tag{12}$$

$u\left(\bar{L}'_{\mathrm{d,M}w}\right)$ - the standard measurement uncertainty for the energy average of the measured daily values of the day-time indicator stratified in the corresponding meteorological window; $u\left(p_{\mathrm{d,M}w}\right)$ - the standard measurement uncertainty for the frequency of occurrence of stratified samples for the day in the corresponding meteorological window.

The value of $L'_{\mathrm{d,max}}$ in Eq. (12) is the highest energy average of the measured daily values of the day-time indicator (usually for the M4 meteorological window) and can be calculated as follows:

$$L'_{\text{d,max}} = \max\left(L'_{\text{d,M1}}, L'_{\text{d,M2}}, L'_{\text{d,M3}}, L'_{\text{d,M4}}\right). \quad (13)$$

The standard measurement uncertainty for the frequency of occurrence of stratified samples in the corresponding window has been estimated. The ISO 1996-2 [7] recommends a value of 0,05 for all windows.

The standard measurement uncertainty for the energy average of the measured daily values of the day-time indicators stratified in the corresponding meteorological window is determined directly from the measurement results stratified in the corresponding meteorological window (Tab. 1). This uncertainty is the combined measurement uncertainty that includes deviations from the expected sound emission conditions and deviations of meteorological conditions from assumed meteorological conditions. It is determined for each emission window (day, evening, night) and each meteorological window.

The standard measurement uncertainty of the energy average of the measured daily values of the day-time indicator within the meteorological window is given by:

$$u\left(\overline{L}'_{\text{d,M}w}\right) = \frac{10\log\left[10^{0.1\cdot\overline{L}'_{\text{d,M}w}} + s\left(\overline{L}'_{\text{d,M}w}\right)\right] - \overline{L}'_{\text{d,M}w}}{\sqrt{N_{\text{d,M}w}}}, \quad (14)$$

where: $\overline{L}'_{\text{d,M}w}$ - the average value of the measured daily values of the day-time indicator in the corresponding meteorological window, Eq. (3); $s\left(\overline{L}'_{\text{d,M}w}\right)$ - the standard deviation of the measured daily values of the day-time indicator in the corresponding meteorological window:

$$s\left(\overline{L}'_{\text{d,M}w}\right) = \sqrt{\frac{\sum_{i=1}^{N_{\text{d,M}w}}\left(L'_{\text{d}i} - \overline{L}'_{\text{d,M}w}\right)^2}{N_{\text{d,M}w} - 1}}. \quad (15)$$

If the difference between the measured values $L'_{\text{d}i}$ is small, then Eq. (14) and Eq. (15) can be replaced by:

$$u\left(\overline{L}'_{\text{d,M}w}\right) = \sqrt{\frac{\sum_{i=1}^{N_{\text{d,M}w}}\left(L'_{\text{d}i} - \overline{L}'_{\text{d,M}w}\right)^2}{N_{\text{d,M}w}\left(N_{\text{d,M}w} - 1\right)}}, \quad (16)$$

It is not clearly indicated in ISO 1996-2 [7], that $u\left(\overline{L}'_{\text{d,M}w}\right)$ is the standard deviation of the average measurement values (Eq. (14) and Eq. (16)) and not the standard deviation of the measurement results.

Finally, the reported expanded measurement uncertainty, U, is the uncertainty associated with a chosen coverage probability. By convention, a coverage probability of 95 % is usually chosen, with an associated coverage factor of 2 [7]. Therefore, the estimated value of the day-evening-night noise indicator in the monitoring period is reported as follows:

$$L_{\text{den}} = L'_{\text{den}} \pm U = L'_{\text{den}} \pm 2u\left(L'_{\text{den}}\right). \quad (17)$$

If the estimated values of day-time, evening-time and night-time noise indicators are reported, then the total measurement uncertainty of day-time, evening-time and night-time noise indicators can be calculated by Eq. (7), where L'_{den} is replaced with L'_{d}, L'_{e} and L'_{n}, respectively.

3 THE EXAMPLE OF MEASUREMENT UNCERTAINTY CALCULATION OF LONG-TERM ENVIRONMENTAL NOISE MEASUREMENT

Since 2014, long-term continuous environmental noise monitoring has been conducted in the city of Niš using the Brüel & Kjær Environmental Noise Management System. This system is based upon management software type 7843, and noise monitoring terminals (NMTs) type 3639-B-20. Sampling of sound pressure levels has been performed with a sampling frequency of 0,5 s. Based on these values, the values of equivalent continuous sound pressure levels for 15 minutes and one hour have been calculated as well as the daily, monthly and annual values of the noise indicators. The aim of the environmental noise monitoring is to determine the exposure level of the population to total noise from all noise sources at the assessment points. Some of the measurement results are published in [9, 13, 14, 16, 30, 31].

The methodology for estimating the uncertainty of long-term environmental noise measurements presented in this paper is applied to the measurement results of environmental noise monitoring in the territory of the city of Niš. The daily values of the noise indicators are stratified in different windows according to the sound emission and meteorological conditions, as shown in Tab. 1. In all the analysed cases, the monitoring period was one month. The monthly values of noise indicators are calculated as well as the corresponding combined and expanded measurement uncertainties. The calculation results for one assessment point (20 m from the highway section with an annual average daily traffic of 15 959 vehicles in 2021 [32], and 18 413 vehicles in 2022 [32]) are shown in Tab. 2. The NMT was located on the residential building with a microphone height of 4 m above the ground.

To calculate $u(L_{\text{den}})$ according to Eq. (7), the standard uncertainty resulting from the selection of receiver location relative to reflection surfaces is estimated to be 0,4 dB for the case of traffic noise incident from all angles and the microphone location, which implies the correction of 3 dB and meeting the requirements of B.5 in Annex B of the ISO 1996-2 [7]. The standard uncertainty resulting from the selection of receiver location relative to the assessment point is estimated to be 0 dB, because the microphone location remained constant throughout the monitoring period.

The average value of the estimated values of the monthly day-evening-night noise indicator during the monitoring period is 72,2 dB, and this value is the annual day-evening-night noise indicator. The average value of the expanded measurement uncertainties is 1,3 dB. Therefore, all the values of the monthly day-evening-night noise indicator are within the range of 72,2 dB ± 1,3 dB.

Table 2 The values of noise indicators and measurement uncertainties for long-term environmental noise measurement, in dB

	Monitoring period - month/year											
	08/21	09/21	10/21	11/21	12/21	01/22	02/22	03/22	04/22	05/22	06/22	07/22
$L_{\mathrm{den}} \pm U$	73.2 ± 1,3	72.4 ± 1,3	73.2 ± 1,3	71.9 ± 1,3	72.4 ± 1,3	72.4 ± 1,3	71.7 ± 1,3	71.6 ± 1,3	71.9 ± 1,4	71.8 ± 1,3	71.6 ± 1,3	71.8 ± 1,3
$u(L_{\mathrm{den}})$	0,66	0,66	0,66	0,66	0,66	0,67	0,66	0,66	0,68	0,66	0,65	0,65
L'_{den}	73,2	72,4	73,2	71,9	72,4	71,5	71,7	71,6	71,9	71,8	71,6	71,8
$u(L'_{\mathrm{den}})$	0,14	0,16	0,15	0,15	0,15	0,18	0,15	0,14	0,24	0,14	0,12	0,13
L'_{d}	69,9	69,5	70,0	69,7	70,2	69,1	69,4	69,2	69,4	69,3	69,3	69,4
$u(L'_{\mathrm{d}})$	0,11	0,26	0,26	0,25	0,25	0,26	0,26	0,25	0,35	0,25	0,20	0,21
L'_{e}	68,9	68,1	68,1	67,6	68,0	67,1	67,4	67,3	68,0	67,5	67,3	67,5
$u(L'_{\mathrm{e}})$	0,10	0,24	0,24	0,23	0,24	0,15	0,23	0,07	0,27	0,07	0,12	0,11
L'_{n}	65,7	64,5	64,2	63,7	64,3	63,5	63,6	63,5	63,8	63,6	63,6	63,6
$u(L'_{\mathrm{n}})$	0,23	0,25	0,24	0,23	0,25	0,32	0,23	0,24	0,34	0,24	0,18	0,19

4 CONCLUSION

The uncertainty of long-term environmental noise measurements must be determined and reported because it is a quantitative indicator of the reliability of the measured results. It is especially important when comparing the values of noise indicators and limit values specified in national legislation.

Therefore, the methodology for estimating the uncertainty of long-term environmental noise measurements according to ISO 1996-2 guidelines [7] is suggested in this paper. The measurement uncertainty estimation process is described in greater detail and with greater clarity in the proposed approach than in the ISO 1996-2 standard. In addition, the uncertainty budget recommended by ISO 1996-2 standard is extended by an error due to the selection of microphone locations representative of the assessment point (choosing microphone position, microphone height above ground level, and microphone orientation).

The recommended methodology was applied to stratified independent measurements of the day-time noise indicator, the evening-time noise indicator and the night-time noise indicator, but it can also be applied to independent measurements of hourly values of the equivalent continuous sound pressure levels, taking into account relevant meteorological data for defining the corresponding meteorological windows.

The standard measurement uncertainties in the given example for the measured values of noise indicators have relatively small values in the range of 0,07 dB to 0,34 dB because they only consider the impact of the emission and meteorological conditions. The standard measurement uncertainties of the estimated values of the monthly day-evening-night noise indicators have higher values in the range of 0,65 dB to 0,68 dB because they take into account the impact of the sound level meter and the selection of receiver location relative to reflection surfaces.

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Contact information:

Darko MIHAJLOV, PhD, Associate Professor
(Corresponding author)
University of Niš,
Faculty of Occupational Safety,
Čarnojevića 10a, 18 000 Niš, Serbia
E-mail: darko.mihajlov@znrfak.ni.ac.rs

Momir PRAŠČEVIĆ, PhD, Full Professor
University of Niš,
Faculty of Occupational Safety in Niš,
Čarnojevića 10a, 18 000 Niš, Serbia
E-mail: momir.prascevic@znrfak.ni.ac.rs

Miomir RAOS, PhD, Full Professor
University of Niš,
Faculty of Occupational Safety in Niš,
Čarnojevića 10a, 18 000 Niš, Serbia
E-mail: miomir.raos@znrfak.ni.ac.rs

Roumen IANKOV, PhD, Full Professor
Bulgarian Academy of Sciences,
Institute of Mechanics,
Ac. Georgi Bonchev, bl. 4, 1113 Sofia, Bulgaria
E-mail: iankovr@abv.bg