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DETERMINATION OF BACKGROUND NOISE WHEN DESIGNING SANITARY PROTECTION ZONES AND AIRPORT ZONES

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***Abstract**: When hygienic standards for regulating noise factor in the environment are developed in accordance with the existing regulatory-methodical base, it is necessary to take into account all possible sources of noise that are located in close proximity to an object that produces adverse effects (noise exposure). Noise produced by such sources is taken into account as background one. It is especially important to take background noise into account when designing zones with specific purpose for their use (specific zones) and in a case when noise is a priority exposure factor (in particular it is true for sanitary protection zones (SPZ) and zones near airports and airfields (airport zones or AZ) or when examining project data. The present work generalizes methodical approaches to taking background noise into account and also dwells on a procedure for combining calculated and instrumental data via energy summation. It contains results obtained via testing this combined methodical approach on a large industrial enterprise located in a large industrial city. As per acoustic calculation results noise levels varied from 29.7 dBA to 44.4 dBA within boundaries of an established sanitary protection zone. Instrumental measurements performed in a zone influenced by the examined enterprise at two control points located in the closest residential area showed noise levels varying from 40-43 dBA (at night) to 48-50 dBA (during a day). Having compared calculated and field data, we obtained discrepancies for the control points that varied from 1.0 dBA to 27.0 dBA and it allowed obtaining summated (aggregated) noise level varying from 40.4 to 51.0 dBA accordingly at the control points within the SPZ. Our experience and methodical approaches to calculating and assessing background noise exposure will allow meeting legal requirements on taking side sources of noise exposure into account as background noise within specific zones and passing sanitary-epidemiologic examinations with satisfactory results.*

***Keywords:** acoustic calculation, noise measuring, background noise, energy summation, sanitary-protection zone, zones near airports (airport zones)*

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1. INTRODUCTION

Issues related to assessing physical exposure factors are becoming more and more vital nowadays and specific attention should be paid to physical exposure when performing ecological and sanitary-hygienic assessment of living conditions; such assessments are usually performed when new objects that can cause adverse effects on population are planned to be built or new sanitary protection zones are planned for existing objects. The issue related to exposure to physical factors is especially vital in large cities due to intense traffic combined with significant noise exposure, considerable network of electromagnetic radiation (EMR) sources and, to a lesser extent, exposure to vibration [1].

Assessment and account of exposure to physical factors is regulated by several documents that focus on providing sanitary-epidemiologic welfare of the population (according to the Federal Law issued on March 30, 1999 No. 52-FZ [2] and item 3.12 in the SER 2.2.1/2.1.1.1200-03 [3]). In particular, certain documents regulate assessment of physical factors that occur due to economic activities, in particular, when it comes to developing projects of sanitary protection zones and zones near airports that are included into a list of specific zones according to item 4, Clause 1, Chapter 1 of the RF Town-planning Code [4]. Such zones are substantiated and established, among other things, as per results obtained via acoustic calculations and EMR calculations. The present work dwells on assessing noise exposure as the most significant physical factor according to the State report "On sanitary-epidemiologic welfare of the population in the Russian Federation in 2019" [5].

According to the RF Government Order issued on March 3, 2018 No. 222 [6] and the RF Government Order issued on December 02, 2017 No. 1460 [7], economic entities are classified as operating ones, objects under reconstruction, and objects being planned; sanitary protection zones or zones near airports are to be established for such objects taking into account acoustic situation, both the existing and future one, including background noise (item 3.5. SER 2.2.1/2.1.1.1200-03). Our research dwells on a procedure for taking exposure to a background noise into account when substantiating boundaries of a specific zone as per noise criteria.

It is rather difficult to take background noise pollution into account since there is no regulatory-methodical basis for spotting out background noise and taking it into account. In certain cases it can be a significant barrier in passing sanitary-epidemiologic inspections that are aimed at estimating project documentation when sanitary protection zones or zones near airports are established. It is confirmed by absence of such a concept as “background noise” in legal documents, absence of any substantiation for background noise calculation or use of results obtained via instrumental research that allow establishing background noise parameters. However, it is beyond any doubt that background noise should be taken into account when noise factor is assessed.

In particular, there are several typical mistakes occurring when noise is assessed:

– hygienic assessment without taking background noise into account (acoustic calculation includes only noise coming from an object that causes noise exposure);
– hygienic assessment as per instrumental measurements (without assessing a contribution made by an object producing adverse effects);
– noise factor being underestimated given different intensity of operations occurring in an examined zone (traffic, trains passing, aircrafts flying).

Studies performed on the issue by experts from the North-West Scientific Center allowed establishing that requirements on taking background noise into account fixed by authorities responsible for sanitary-epidemiologic inspections are not properly substantiated and are not fixed in the current legislation [8].

The issue has “two sides”: on one hand, according to the valid regulatory-methodical base, there are no formal requirements to taking background noise into account; on the other hand, provision of sanitary-epidemiologic welfare for the population should take into account all environmental factors, without any exclusion, both existing and future ones. It is fixed in the Federal Law issued on March 30, 1999 No. 52-FZ with its aim being provision of sanitary-epidemiologic welfare of the population as a basic condition for fulfilling citizens’ constitutional rights for health protection and favorable environment.

But at the same time, it is necessary to take practical steps aimed at creating clear mechanisms for using the existing methodical base and providing favorable municipal environment in terms of exposure to noise.

Therefore, relying on the provisions fixed in the Federal Law issued on March 30, 1999 No. 52-FZ and other legal documents, all economic entities, project organizations, and environmental inspections should take into account existing regulatory-methodical documents that regulate noise factor assessment and account within their competence and according to the valid accreditation.

Our research goal was to develop methodical approaches to taking exposure to background noise into account in order to perform reliable sanitary-hygienic assessment and sanitary-epidemiologic inspection of project documentation.

2. DATA AND METHODS

The present work dwells on basic methodical approaches to accounting and assessing noise factor taking into account background noise assessment and its use for hygienic assessment when a specific zone is established.

The existing state sanitary-epidemiologic standardization gives clear outline of basic environmental factors that determine sanitary-epidemiologic welfare of the population in the RF. The Federal Law issued on March 30, 1999 No. 52-FZ that was mentioned above and Sanitary-Epidemiologic Rules 2.2.1/2.1.1.1200-03 provide legislative base for physical factors account whereas Methodical guidelines 4.3.2194-07 [9] and State Standard GOST 23337-2014 [10] are “operational documents” that contain basic requirements to measuring and controlling noise levels, including those occurring within established sanitary protection zones.

In particular, according to item 4.2 in MG 4.3.2194-07, “*when SPZ boundaries are being established via calculating, it is obligatory to take into account all noise sources that exert their impacts on population living in a zone influenced by an enterprise: neighboring enterprises, motorways, and other sources of noise produced by land transport etc*”. Should all noise sources mentioned in item 4.2 be taken into account, it helps obtain overall background noise that, together with a source of basic noise impacts, creates complex acoustic exposure at SPZ boundaries. Practical implementation of item 4.2 in MG 4.3.2194-07 involves some additional issues: there is no regulatory-methodical base, either for creating an aggregated list of noise sources (economic entities) or creating databases on noise sources and performing local acoustic calculations.

To achieve our goal, we examined approaches to taking background noise into account that were fixed in the existing methodical documents and tried to develop new approaches that included a combination and sequence of taking noise exposure factors into account. Two methodical approaches are suggested within the present work; they allow meeting a requirement fixed in item 4.2, MG 4.3.2194-07 on providing authentic data on acoustic exposure when a specific zone is established.

We developed our approaches taking into account methodical approaches on performing acoustic calculations via implementing GOST 31295.2-2005 (ISO 9613-2:1996) and Sanitary rules 51.13330.2011 and using program software (“Ekolog-SHUM”, “SHUM” software complex, and “Akustika” automated working environment). Besides, we took into consideration the existing regulatory-methodical base for performing instrumental measurements applied to assess background noise and calculated data verification. Energy summation was considered an optimal procedure for aggregated exposure calculation and background noise assessment.

3. RESULTS

3.1. Approaches to calculated and instrumental background noise assessment

Calculation. Creation of maximum complete (etalon) electronic database in specialized software is the simplest way to establish complex acoustic exposure caused by both an object under consideration and background noise sources. Such widely used software complexes as "Ekolog-SHUM", "Akustica" or "SHUM" can be use for the matter as they are usually applied when it is necessary to implement approaches fixed by regulatory-methodical documents that are valid in the RF. Basic difficulties that can occur when such an aggregated database is created include the following:

– there are no aggregated registers that include all noise exposure sources located within boundaries of each economic entity;
– limited data or even their absence when it comes down to existing traffic flows (structure, intensity, other parameters) that make their contribution into overall noise exposure.

Motor transport usually makes a significant contribution in dense residential areas; in some RF regions it is difficult to take this factor into account as it requires field observations. However, at present traffic flows modeling is widely used to solve tasks related to their optimization as well as optimization of road networks, passenger flows etc. For example, Municipal Traffic Management Administration that functions in Perm is responsible for traffic flows regulation and has all necessary data on traffic flows intensity. Figure 1 shows an example how background noise pollution occurs due to motor transport in the central part of Perm.

Fig. 1: Traffic flows distribution (a) and background noise exposure (b) in the central part of Perm

When an electronic database is created, the next step is to perform acoustic calculations at control points located at specific zones boundaries and on other territories and it allows taking into account all probable sources of adverse exposure to noise.

Calculated data can be verified with results obtained via instrumental measurements and it can either verify calculation authenticity or disprove it. Measurements can be single and performed in accordance with the conditions fixed for calculations, namely bearing in mind that all stationary noise sources do not function simultaneously; there are rush hours during a day and rush days during a week when it comes to traffic flows; screening elements taken into account both in calculations and in measurements; seasonal differences in performing assessments. Therefore, this way to take background noise into account is quite efficient and is performed without any significant efforts and costs.

Combined procedure. A combined procedure can be an alternative way to take background noise exposure into account; such a procedure includes calculated acoustic assessment of an object under consideration (that produces noise effects) and instrumental measurements of background noise exposure (including or excluding a contribution made by an examined object that produces negative effects).

As it was stated above, nowadays there is no regulatory-methodical base on creating registers and databases on noise exposure sources located within boundaries of economic entities and it releases such entities from any liability to collect such data; it is confirmed by absence of any control on the matter accomplished by Rospotrebnadzor authorities during documentary inspections.

Acoustic calculations within the second approach are performed similarly to the first approach described above when an electronic database is created, software complexes are used, and then noise levels occurring within reference or examined territories are assessed.

The essence of the second approach is combined use of instrumental measurements results obtained at the same control points used for establishing a specific zone. Instrumental measurements can be accomplished in two possible ways:

– Excluding a contribution made by an object that produces negative effects as per noise factor when a known noise source (background noise) is cut off. Possibility to perform such measurements is determined by whether it is possible to stop all production processes at the moment when instrumental measurements are performed.

In cases when it is not possible to cut off a known noise source at the moment when noise is being measured, sometimes it is allowed to measure background noise during maintenance or diagnostics of basic production equipment; or it can be done in acoustic shadow zones existing near such equipment when there are no exposure to any other significant noise sources.

When determining parameters of background noise that can be heard during short breaks in noise sources operations (for example, when there are breaks in traffic flows, trains passing, or aircrafts flying), it is possible to use interrupted measurements with their overall duration being not shorter than 5 minutes. In this case it is recommended to take average results as actual background noise level but this average value should be obtained as per not fewer than 3 time intervals.

– taking into account a contribution made by an object that produces negative effects as per noise factor (overall noise). This approach is used in all cases when it is impossible to spot out separate contributions made by background noise source and a known noise source.

It should be noted that all measurements aimed at assessing overall and background noise are to be performed subsequently at the same point.

Therefore, all the obtained results give a clear outline of separate components in noise factor exposure but they do not provide an insight into a contribution made by an object that produces negative effects into overall acoustic picture that can be then assessed as per hygienic criteria [11] and risk assessment criteria [12].

Combination of calculated and instrumental data via energy summation can be used as a tool for assessing complex acoustic picture.

3.2. Approaches to combining data via energy summation

Methodical base for energy summation is provided by the following methodical documents: GOST 23337-2014 [10], GOST 31295.2-2005 (ISO 9613-2:1996) [13], SR 51.13330.2011 [14], "Engineering acoustics. Theory and practice in noise prevention", a manual [15].

This approach is a well-known procedure for calculating aggregated noise according to provisions fixed in GOST 23337-2014 and SR 51.13330.2011. However, planners, designers, and other organizations that deal with sanitary-epidemiologic situation assessment when establishing sanitary protection zones and zones near airports do not use these approaches for physical factors assessment and in our opinion, it is rather incorrect.

Basing on calculated data and instrumental noise measurements at the control points, we performed aggregated (complex) assessment as a reduced value of acoustic exposure was calculated via energy summation.

According to Table 1 in Appendix B, GOST 23337-2014 and item 7.6 SR 51.13330.2011, we suggest performing energy summation of expected calculated noise levels (produced by an economic entity) and instrumental data (taking into account contributions made by all noise sources that crate background noise).

Using formula 6 in Appendix 2, GOST 23337-2014 (formula 1) and formula 2.9 taken from "Engineering acoustics. Theory and practice in noise prevention", a manual, (formula 1), we calculated aggregated noise exposure at control points.

$$\boldsymbol{L_{сум.} = 10lg\,(10^{0,1L1} + 10^{0,1L2})} \qquad (1)$$

where
L_1 is sound coming from noise sources belonging to an economic entity as per acoustic calculations results;
L_2 is measured background noise.

To facilitate practical calculations, one can use an auxiliary table for summating sound levels basing on differences between obtained levels at a control point (Tab. 1 in Appendix B, GOST 23337-2014) (Table 1).

Difference between calculated and measured noise at a control point, dBA	0	1	2	3	4	5	6	7	8	9	10	15	20
Addition to a greatest value, dBA	3	2.5	2.1	1.8	1.5	1.2	1.0	0.8	0.6	0.5	0.4	0.2	0

Tab. 1: An auxiliary table applied in energy summation of noise levels

According to Tab. 1, when there is a difference between summated levels of expected calculated noise coming from a source and actual background noise, the greatest value should be added with a figure taken form Tab. 1. In case this difference between calculated and measured noise level exceeds 20 dBA, the lowest value out of two can be neglected.

The total value obtained via energy summation is an ultimate value showing exposure to noise factor caused by an economic entity taking background noise into account.

3.3. Testing methodical approaches to taking background noise into account

We tested the combined approach to taking background noise into account at a large industrial enterprise; the procedure involved using acoustic calculations results combined with instrumental measurement results via energy summation.

Testing involved using an electronic database existing at the examined enterprise containing data on 594 noise sources and 196 background noise sources (neighboring enterprises as well as 3 large motorways that contributed into overall acoustic picture).

Acoustic calculations were performed at 65 control points within a unified sanitary protection zone for the whole industrial cluster, 31 control points located in the closest residential area, and 15 control points located in neighboring gardening cooperative societies that belonged to territories standardized as per item 5.1, SER 2.2.1/2.1.1.1200-03 [3].

Acoustic calculations results allowed obtaining noise levels at the control points within SPZ and standardized territories (Tab. 2).

№	Control point/standardized parameter	Minimal noise value, dBA	Maximum noise value, dBA
1	2	3	4
Sanitary protection zone (SPZ)			
1	Equivalent noise level ($L_{Aequ.}$)	29.7	44.4
Residential area (RA)			
2	Equivalent noise level ($L_{Aequ.}$)	26.0	41.5
Gardening cooperative society (GCS)			
3	Equivalent noise level ($L_{Aaequ.}$)	23.2	38.4

Tab. 2: Acoustic calculation results obtained for control points within SPZ and standardized territories

Results obtained via instrumental measurements of background noise were applied to verify acoustic calculations; background noise included all noise exposure sources existing in the industrial cluster as a whole, together with neighboring motorways and roads. We obtained averaged noise exposure levels at the control points as per instrumental measurement results; these noise levels characterized a responsibility zone for the examined economic entity (Table 3).

Considered points where instrumental measurements were performed in Osentsy village and Subbotino village characterized background noise for calculated points at SPZ boundaries and on the closest standardized territories located to north-east and south-west accordingly.

No.	Place where measurements were performed	Time	Equivalent noise level, dBA
1	2	3	4
1	Osentsy village	day	48
		night	40
2	Subbotino village	day	50
		night	43

Tab. 3: Results obtained via instrumental measurements of background noise

No.	Minimal/ maximum LAaequ.	Period	Control point	Equivalent noise level (La), dBA					
				$L_{design\ noise}$	Point where background was estimated	$L_{background\ noise}$	Discrepancy,D	Addition	$L_{сум,}$
1	Minimal	day	SPZ	29.7	Osentsy	48	18.0	0.0	48.0
2	Minimal	day	RA	26	Osentsy	48	22.0	0.0	48.0
3	Minimal	day	GCS	23.2	Osentsy	48	25.0	0.0	48.0
4	Minimal	night	SPZ	29.7	Osentsy	40	10.0	0.4	40.4
5	Minimal	night	RA	26	Osentsy	40	14.0	0.2	40.2
6	Minimal	night	GCS	23.2	Osentsy	40	17.0	0.2	40.2
7	Maximum	day	SPZ	44.4	Osentsy	48	4.0	1.5	49.5
8	Maximum	day	RA	41.5	Osentsy	48	7.0	0.8	48.8
9	Maximum	day	GCS	38.4	Osentsy	48	10.0	0.4	48.4
10	Maximum	night	SPZ	44.4	Osentsy	40	4.0	1.5	45.9
11	Maximum	night	RA	41.5	Osentsy	40	2.0	2.1	43.6
12	Maximum	night	GCS	38.4	Osentsy	40	2.0	2.1	42.1
13	Minimal	day	SPZ	29.7	Subbotino	50	20.0	0.0	50.0
14	Minimal	day	RA	26	Subbotino	50	24.0	0.0	50.0
15	Minimal	day	GCS	23.2	Subbotino	50	27.0	0.0	50.0
16	Minimal	night	SPZ	29.7	Subbotino	43	13.0	0.2	43.2
17	Minimal	night	RA	26	Subbotino	43	17.0	0.2	43.2
18	Minimal	night	GCS	23.2	Subbotino	43	20.0	0.0	43.0
19	Maximum	day	SPZ	44.4	Subbotino	50	6.0	1.0	51.0
20	Maximum	day	RA	41.5	Subbotino	50	9.0	0.5	50.5
21	Maximum	day	GCS	38.4	Subbotino	50	12.0	0.4	50.4
22	Maximum	night	SPZ	44.4	Subbotino	43	1.0	2.5	46.9
23	Maximum	night	RA	41.5	Subbotino	43	2.0	2.1	45.1
24	Maximum	night	GCS	38.4	Subbotino	43	5.0	1.2	44.2

** SPZ means sanitary protection zone, RA means residential area, GCS means gardening cooperative society*

Tab. 4: Energy summation of noise levels at estimation points

Performed energy summation allowed revealing that calculated acoustic model built on acoustic calculation of noise coming form an economic entity without taking into account background noise provided lower values that did not correspond to the actual noise level on the territory; namely, calculated noise levels at the control points varied from 29.7 to 44.4 dBA (at SPZ boundary), from 26.0 to 41.5 dBA (in residential area), from 23.2 to 38.4 dBA (on GCS territory). And discrepancy between calculated and actually measured noise levels in a zone influenced by the examined economic entity varied from 1.0 dBA (SPZ) to 27 dBA (On GCS territory).

Therefore, background noise on a territory near the industrial enterprise that was established via instrumental measurements and energy summation of this noise and acoustic calculation results at the control points at SPZ boundaries and standardized territories allowed obtaining summated noise levels varying from 40.4 to 51.0 dBA (at SPZ boundary), from 40.2 to 50.5 dBA (in residential area), from 40.2 to 50.4 dBA (on GCS territory).

4. CONCLUSION

The suggested methodical approaches to taking background noise levels into account when developing sanitary protection zones and zones near airports are extremely vital and relevant given growing significance of impacts exerted by physical factors, noise in particular, on population health and the environment.

It is truly important to implement the suggested approaches in everyday operations performed by economic entities and transport infrastructure exploitation when establishing sanitary protection zones and zones near airports. The combined approach becomes extremely relevant when it comes to project development and actual design of objects that can cause noise pollution. When calculated noise levels are combined with the existing situation (background noise) and noise sources that belong to an object that is planned to be constructed are added to the existing ones, it allows modeling an acoustic picture that will exist at the moment the examined object is put into operation. This model will provide decision-makers with relevant data on acoustic situation in a neighboring residential area and probable health risks for population caused by the examined object when it is put into operation.

Results obtained via testing the suggested approaches for establishing SPZ boundaries allowed determining that acoustic calculation results, even though they take into account a significant number of noise sources located on neighboring territories, still are a bit understated at the control points (ranging from 29.7 to 44.4 dBA); it indicates that the applied acoustic model is no longer relevant. Instrumental measurements verification confirmed our assumption and allowed reducing discrepancies between calculation results and actual values obtained at the control points (ranging from 40.4 to 51.0 dBA).

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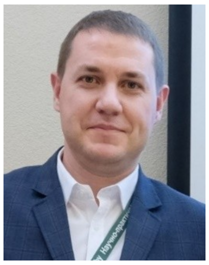

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