

Methods of Organizing Measures Directed to Environmental Safety and Noise Protection Management in Urban Areas

Natalia Teliura^{1[0000-0003-0732-7789]},
Alona Reshetchenko^{1[0000-0003-0767-8597]}, Nataliia Tsapko^{2[0000-0003-2480-3636]},
Oksana Myrgorod^{3[0000-0002-5989-3435]} and Oleksandr Pirohov^{3[0000-0002-0958-0801]}

¹ O. M. Beketov National University of Urban Economy in Kharkiv,
17 Marshala Bazhanova Street, Kharkiv 61002, Ukraine
natalya.telyura@kname.edu.ua

² Ukrainian Scientific and Research Institute of Ecological Problems,
6 Bakulina Street, Kharkiv 61165, Ukraine

³ National University of Civil Protection of Ukraine
94 Chernyshevska Street, Kharkiv 61023, Ukraine

Abstract. In order to implement ecologically safe noise protection practical solutions, it is necessary to improve the method of environmental safety management, which aims to implement the algorithm proposed in this article for monitoring the acoustic space in terms of noise pollution and making decisions regarding the protection of agricultural zones of urban systems from above-standard noise levels. The environmental safety management mechanism consists of groups of functional and environmental mechanisms, which in turn function through environmental audits, environmental programs, environmental impact assessment, and environmental monitoring. Among the popular urban planning solutions to reduce noise levels, the maximum greening of agricultural zones and dividing strips of main streets is singled out as an economically profitable and ecologically safe justified noise protection method, taking into account the prevention of the occurrence of unplanned road construction and other types of public utility works, which entails a change in general plans of built-up cities and significant reconstructions of the infrastructure network.

Keywords: Physical Pollution, Monitoring, Innovative Solutions, Regulatory Framework.

1 Introduction

An urgent problem of the urban systems functioning is the anthropogenic influence of the transport infrastructure. With rapid urbanization, the number of private vehicles is increasing, which leads to environmental pollution. In addition to the introduction of polluting substances with emissions into the atmospheric air, the operation of vehicles creates a noise load.

Recently, the impact of urban noise on the environment and public health has increased by almost 25 percent. According to the "Future Noise Policy" (Publications Office of the EU), more than 80% of the noise load in residential areas of urban systems is caused by road traffic. In European countries, this has led to the development and implementation of legislation to reduce the impact of excessive noise levels on the territory of urban systems. The EU Directive [1] calls for the harmonization of standards governing the procedures for determining noise levels and exposure in Europe in order to provide free and accessible information about noise regimes in densely populated cities and leaves free space to choose the requirements regarding the scope, form and means of providing the community with relevant cartographic information. materials for each EU member state. Among the factors that negatively affect and complicate the environment in the process of environmental safety management of noise protection in urbanized areas, the following should be highlighted: lack of monitoring data on the results of noise exposure and scientific solutions for noise protection; multi-factorial parameters of the noise generation process. The lack of systematic surveys and the necessary equipment for conducting observations or the ineffectiveness of existing technical solutions can lead to an increase in the noise level due to unplanned construction of roads and other types of public works. This is due to the imperfection of the existing regulatory and methodological approaches, in particular, the lack of guidelines regarding the principles of placement of monitoring sites, frequency and procedure for determining noise levels in the territories of agricultural zones within the influence of the road network.

The aim of the paper is to substantiate the expediency of the organization of noise pollution level monitoring and to improve the system of scientific and methodical approaches to the organization of experimental studies on the determination of noise levels in the monitoring system in order to reduce man-made transport and linear load on the environment.

2 Formulation of the problem for the development of architectural and planning solutions to reduce noise pollution at the level of urban systems

Since January 2020, the Law "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period Until 2030" entered into force, which specifies the existing problems and the current state of the environment in Ukraine. Among the root causes of Ukraine's environmental problems are the inefficient state management system in the field of environmental protection and the unsatisfactory state of the state environmental monitoring system, in particular from noise impact, which requires the introduction of a system and ecological approach to industry policy and improvement of the environmental management system.

Analyzing the state regulatory legal framework [2-4], we can come to the conclusion that the organization of experimental studies of the noise characteristics of traffic flows passing along residential buildings is not fixed at the legislative level.

A large number of scientific works are devoted to the problems of researching the noise characteristics of vehicles [5-10]. So, for example, in the article [5], the author conducted a number of experimental measurements of noise levels, during which special attention was paid to highways near residential buildings, a total of 165 points in the territory of Ivano-Frankivsk were studied. Based on the results of the study, individual zones with the highest noise load were identified in the City of Ivano-Frankivsk, acoustic load distribution profiles were constructed along the main streets, taking into account the equivalent sound level in the green areas of the city, which are located nearby. A noise map for the territory of Ivano-Frankivsk was built using the Surfer software.

The experimental studies analyzed above can be attributed to the monitoring of acoustic load levels, but the lack of a regulated legislative framework for the organization of such studies makes it impossible to carry out similar observations of noise load levels in areas of residential construction located in the zone of influence of urban transport infrastructure.

The generalized approaches proposed in the author's research [11] are aimed at solving the problems of pollution of the roadside space by traffic noise and can be implemented in the programs of greening the territories of Ukraine. But none of them can be 100% effective until a system is developed in the country that will constantly monitor the noise regime of urban systems and record noise levels exceeding the maximum permissible levels.

In order to achieve the specified goal of the research, it is necessary to solve a number of tasks: to create a structure, methodological and mathematical means of researching agricultural areas affected by linear sources of noise, to minimize the man-made load on the environment, and to improve the system of scientific and methodological approaches to the organization of experimental research on the determination of noise levels pollution in the territories of agricultural zones of urban systems, taking into account architectural and planning solutions of built-up areas.

Monitoring the noise levels of the street and road network of populated cities can be presented as a cyclical observation procedure that will ensure the creation and accumulation of a data bank of street noise observations. Figure 1 shows the proposed annual monitoring scheme.

To implement a noise monitoring system, first of all, it is necessary to select control points for field measurements. In compliance with the requirements of Directive 2002/49/EU, these points within urban areas of residential development should be chosen taking into account:

- possibilities of recording noise characteristics in the noisiest positions at the boundaries of territories and near the facades of residential buildings;

- the representativeness of the measurement data regarding the reflection of the acoustic situation in urban areas of residential buildings in general [12].

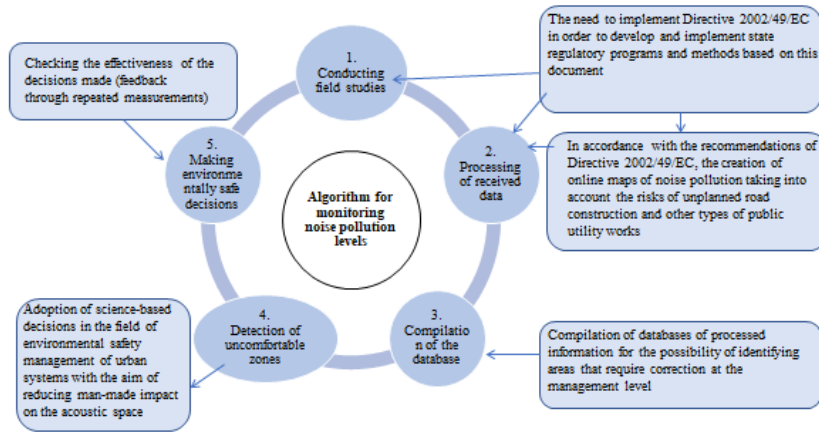


Fig. 1. Algorithm for organizing monitoring of noise pollution levels [6].

The step-by-step organization and implementation of the algorithm for monitoring the levels of noise pollution caused by the operation of vehicles is presented in the Table. 1.

Table 1. Algorithm for the step-by-step organization of noise level monitoring/

Stage name	Description	Normative base	Recommendations
1. Conducting field studies	Conducting noise measurements on each street of the road network of the settlement, with a fixed speed of traffic and at a distance of at least 50 meters from intersections and public transport stops, during a time interval covering the passage of 200 vehicles in both directions. For each existing category of roads, one street with steady traffic is selected and	Classification of transport highways based on the received noise level data in accordance with SBS B.2.3.-4:2015 "Automotive roads". Location of control points in accordance with recommendations (Fig. 2-3).	The control street must be made of asphalt concrete, the width of one lane is not less than 3 meters. The distance from the edge of the carriageway to the line of residential buildings is at least 10 meters. Special attention should be paid to the fact that there should be no enclosing structures, noise protection screens, green spaces and other factors that can shield the sound during field studies. The recommended distance for the location of the measuring device is 7.5 meters. Monitoring of

	control points are determined at which measuring devices should be located to determine the sound characteristics of the traffic flow.		noise levels should be carried out at least at three points on the selected control street to regulate the noise load on urban landscapes using measuring devices-noise meters. Noise meters used in noise monitoring must have frequency characteristic "A" with a frequency range of measurements of classes 1 and 2.
2. Processing of data obtained	The measured noise parameters are equivalent $L_{A_{eq}}$ noise levels and maximum $L_{A_{max}}$ noise levels.	Directive 2002/49/ EU	Measurements of the specified values should be carried out at least three times a day: during the day from 7:00 AM to 7:00 PM, in the evening from 7:00 PM to 11:00 PM and at night from 11:00 PM to 7:00 AM
3. Compilation of the database	Creating a data bank based on Microsoft Access	Not regulated	The main tables in the noise monitoring database should highlight the following information: Streets (names and codes of streets on which noise monitoring is carried out); Point_Location (location of monitoring points, taking into account addresses and type of territory); Traffic_Flow (characteristics of the studied traffic flows); Monitoring_Data (calculation data of equivalent $L_{A_{eq}}$ and maximum $L_{A_{max}}$ levels of noise with indication of date and time of measurements); Normative_Value (maximum permissible noise levels depending on the time of day and type of territory).

4. Detection of discomfort zones	Compare the calculated equivalent (L_{Aeq}) and maximum (L_{Amax}) noise levels with the specified permissible noise levels	On the approval of the State sanitary norms of permissible noise levels in the premises of residential and public buildings and on the territory of residential buildings	To identify the dynamics of noise pollution of urban systems, the obtained results should be compared with data from previous years. For each control point, the deviations of the obtained values are determined according to the following recommended formula: $A_i = L_{1 n_1} - L_{1 n_2}$, where A_i is the deviation at the i -th control point, dBA; $L_{1 n_1}$ – equivalent noise levels at the i -th point in the current year, dBA; $L_{1 n_2}$ – equivalent noise levels at the i -th point for the past year, dBA.
5. Decision taking	Implementation of generalized methods of protection of agricultural zones of urban systems from increased noise levels	1. SBS B.1.1-31:2013. Protection of the territories of buildings and structures from noise. 2. DSTU-H Б B.1.1-33:2013. Guidelines for the calculation and design of noise protection in rural areas.	Use of combinatorial noise protection practical solutions [6]

Taking into account the level of detail of each of the stages of monitoring noise levels, at the last stage of decision-making of monitoring, specific measures are implemented to select constructive solutions to reduce man-made pollution from noise, and the degree of environmental safety, at the same time, is ensured by the choice of rational combinatorial practical solutions for local greening of agricultural areas of urban systems.

3 Results of experimental data on the influence of infrastructure networks at the level of urban systems

In order to improve scientific and methodological approaches to the organization of the first stage of monitoring studies, the methodology of GOST 23337-78, valid in Ukraine until 01.01.2019, was improved for conducting experimental studies to determine the levels of noise pollution caused by the operation of motor vehicles, taking into account dense urban buildings and landscape greening of primary highway sections of urban systems.

During the long-term period of conducting experimental studies on the determination of noise levels published in [6, 13] and analysis of the obtained data, the most representative control points for measuring noise levels in the territories of agricultural zones of urban systems were identified. Taking into account the distance from the noise source to the measuring device regulated in GOST 23337-78 of 7.5 meters; types of street and road profiles and the width of red lines for main streets of 50-80 meters, and 15-25 meters for streets and roads of local importance; location of roadways, sidewalks, and landscaping strips, in order to take into account all the above recommendations and requirements regarding the distances between highways and agricultural areas, unified schemes (Fig. 2-3) are proposed for the organization of experimental studies to determine the noise levels of agricultural areas located in the zone of influence of highways, for the organization of the first stage of the system of monitoring observations.

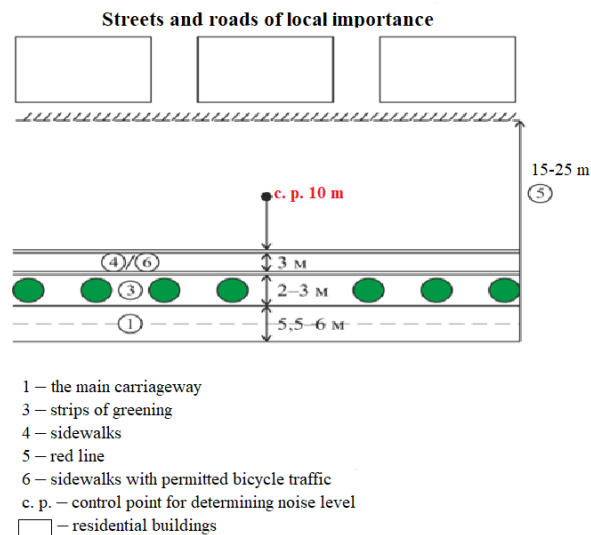


Fig. 2. Scheme of the location of the control point for conducting experimental studies on the determination of noise levels in the agricultural area adjacent to streets and roads of local importance.

Taking into account the architectural and planning conditions of the development of the agricultural zone bordering the streets and roads of local importance, during experimental studies, it was found that the most representative control point demonstrating the estimated levels of noise pollution of the studied area is a distance of 10 meters from the line of the carriageway. Such a distance covers a strip of greening that serves as a noise barrier in the way of sound wave propagation and is located at a sufficient distance from residential buildings that can serve as an additional source of noise (for example, with open windows, household noise can spread to the territory of the agricultural zone, and the standardization and conducting of experimental research in the middle of the premises has different normative documents and the nature of research), which in turn can lead to obtaining incorrect experimental data.

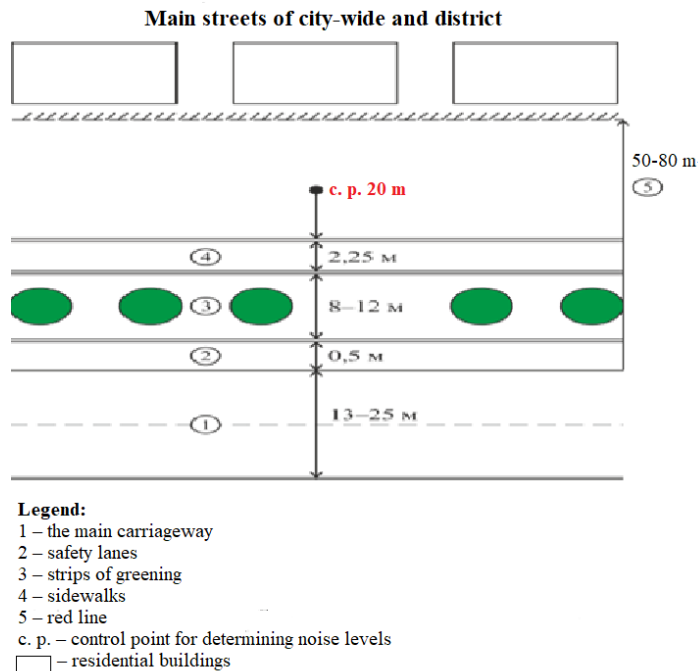


Fig. 3. Scheme of the location of the control point for conducting experimental studies on the determination of noise levels in the rural area adjacent to main streets of city-wide and district significance.

The location of the control point at a distance of 20 meters from the carriageway of main streets of city-wide and district importance is justified by the fact that such streets have a greater number of traffic lanes and a higher traffic intensity. The diagram also shows that the typical placement of residential buildings in the zone of influence of this type of street is at a greater distance from the highway. Therefore, in order to obtain correct data from measurements of noise levels, it is advisable to con-

duct experimental studies at a distance of 20 meters from a linear noise source covering a strip of protective green spaces and located at a sufficient distance from residential buildings.

Four full-scale objects of the City of Kharkiv were chosen to test the proposed schemes. Two objects are residential buildings bordering streets of local significance (No. 1, No. 2), and the other two objects (No. 3, No. 4) are residential buildings adjacent to main streets of city-wide importance. Experimental studies were conducted in the spring period (April-May) of 2021. The averaged results of equivalent noise levels in the selected areas are presented graphically in Fig. 4.

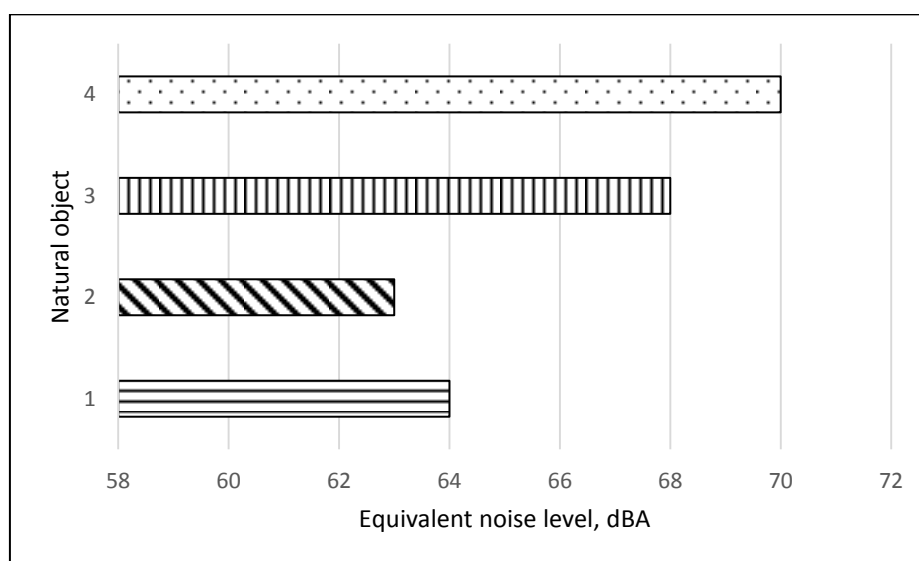


Fig. 4. Results of experimental measurements according to unified schemes for the location of control points.

To implement the fifth stage of the proposed algorithm for monitoring noise, development of conductive coatings for monitoring information systems [15], pollution levels in the decision taking part, it is recommended to be guided by the following known methods of reducing traffic noise in urbanized areas:

1. Reduction of the noise level of the source itself or its localization.
2. Direct isolation of the object of protection.
3. Reduction of the sound level on the path of its propagation.

The first two proposed methods of reducing noise levels in agricultural areas are impossible to implement due to the complex infrastructure of urban systems.

Important urban planning solutions that are used as anti-noise include:

1. Increasing the distance between the noise source and the protected object.
2. Application of acoustic screens, walls or screen buildings.
3. Various planning techniques that allow rational placement of "noisy" objects in micro-districts.

4. Use of terrain relief.
5. Maximum greening of agricultural zones and dividing lanes of main streets.

The first four solutions given above are difficult to implement in modern conditions due to the established architectural, planning, logistical ensemble of cities [14, 16], which was compiled more than 100 years later. In order to implement the above rational techniques for the construction of rural areas and main streets, it is necessary to make changes to the general plans of cities and carry out significant reconstructions. This is a very complicated, time- and money-consuming process. Especially if attention is paid to noise reduction in residential areas, it is necessary to take into account the fact that during the reconstruction of highways or any other construction works, additional noise pollution occurs due to the operation of construction machinery and other equipment.

The use of one or another method or their combination depends on the degree of noise reduction required, taking into account economic and operational constraints. The above allows us to come to the conclusion that the most effective noise-reducing solutions are the introduction of additional local greening as rational and effective solutions for ensuring the ecological safety of urban systems in case of man-made noise pollution and to prevent the occurrence of unscheduled road construction and other types of public utility works.

4 Conclusion

Based on the conducted analysis, the absence of correlations between the regulatory legislative and normative and methodological documents in the field of noise pollution and impacts on urbanized areas was highlighted.

It is proposed to improve the atmospheric air monitoring system in terms of noise pollution, taking into account the requirements of EU Directive No. 49 and the nationwide procedure for the implementation of European standards.

On the basis of generalized experimental studies conducted by the author and covered in scientific publications, recommendations were developed for the organization of experimental studies in the first part of noise monitoring, taking into account modern architectural planning, dense urban development and the growth of transport infrastructure of urban systems.

With the use of experimental research approval data on the basis of the proposed schemes for the location of control points, it was established that the exceed of the maximum permissible noise level in the territories of agricultural zones of the Kharkiv urban system reaches about 15%, and in order to ensure the ecological safety of the acoustic space, the latest directions of noise protection of agricultural zones should be implemented in the context of sustainable development bridge.

References

1. Directive 2002/49/EC of the European Parliament and of the Council of 25/06/2002 Relating to the Assessment and Management of Environmental Noise Official Journal of the European Communities, 189, 12–25 (2002)
2. DSTU-N.BV 11-35: 2013. Guidelines for the calculation of noise in the premises and in the territories. [Effective from 2014/01/01]. Kind. ofits. Kyiv: Ministry of Regional Development of Ukraine, vol. 58 (2014).
3. DSTU GOST 31296.1: 2007. Noise. Description, measurement and assessment of noise in the field. Part 1. Basic values and evaluation procedure (GOST 31296.1-2005 (ISO 1996-1: 2003, IDT). [Valid from 2007/10/17]. Official Gazette of Kyiv: Derzhspozhyvstandart of Ukraine, vol. 154 (2009).
4. M 218 - 03450778 - 673: 2010 Methodology for estimating the forecasted noise level within the impact zones of the highway [Effective from 2010/01/01] Official Gazette of the State Research Institute, vol. 23, (2010).
5. Adamenko, Y., Coman, M., Kundelska, T.. Ecological safety of Ivano-Frankivsk urban system according to acoustical and electromagnetic load factors. Scientific Bulletin Series D: Mining, Mineral Processing, Non-Ferrous Metallurgy, Geology and Environmental Engineering. vol. 31 (2), pp. 27–33 (2017).
6. Reshetchenko, A.I.. Increasing the environmental safety of urban systems under man-made load from noise pollution [Text]: dis. ... Cand. tehn nauk . Sumy State University, 155 p. (2020).
7. Reshetchenko, A.I.. Investigation of the influence of motor transport flows on the acoustic environment of urban landscapes. Municipal utilities. Ser. Technical sciences and architecture: zb.nauk.pr.. vol. 146, pp.180–183 (2018).
8. Reshetchenko, A., Barannik, V., Stolberg, F.. Evaluation of the effects of the green plantings strip on the spatial distribution of noise level from the road traffic. Technogenic and ecological safety. vol. 6. pp. 49–53 (2019).
9. Reshetchenko, A., Vnukova, N., Vergeles, Yu. Assessment of the contribution of plantings of different functional purpose in reducing transport noise along motorway roads in urbanized areas. The scientific heritage. 46, pp. 40–46 (2020).
10. Teliura, N., Tsapko, N., Khabarova, H., et al.: Selection methodology of ecological safety priorities of sustainable development goals of urban agglomerations. In: Nechyporuk, M., et al. (eds.) Integrated Computer Technologies in Mechanical Engineering – 2021. LNNS, vol. 367, pp. 941–950. Springer, Cham (2022). https://doi.org/10.1007/978-3-030-94259-5_73
11. Yurchenko, V.O., Mikhailov, L.S. Influence of the road on the state of roadside ecosystems. Man and the environment. Problems of neoecology: science. Journal of Kharkiv National University named after VN Karazin. vol. 2 (15). pp. 63–67. (2010).
12. Reshetchenko, A.I., Borsuk, A.I., Vergeles, Yu. I. Analysis of the existing EU standards in comparison with the requirements of the Ukrainian legislation in the field of noise load in the urban ecosystem. Ecological security and balanced resource use, vol. 2 pp.16–23. (2019).
13. Reshetchenko, A.I. Recommendations for the implementation of noise monitoring of the road network of populated cities. Municipal utilities of cities. Series "Technical Sciences and Architecture". vol. 154. pp. 16–23. (2020).
14. Medved, I., Kovregin, V., Myrgorod O., Lysenko, A. Planning an Experiment for Low-Cycle Fatigue under Conditions Deep Cooling, Materials Science Forum-2021 vol. 1038, pp 9-14 (2021).

15. Khrypunov, G.S., Pirohov, O.V., Novikov, V.A., Zaitsev, R.V., Zaitseva, L.V., Khrypuno-
va, A.L. Development of Conductive Coatings for Gas-Sensitive Tin Dioxide Film Layers,
Journal of Nano- and Electronic Physicsthis link is disabled, 6(2), 02016, (2014). 07.07.Df,
68.37. – d
16. Medved, I., Pyrohov, A., Romin, A., Slovinskyi, V. and Venzhego, G.
Low Cycle Fatigue of Structural Alloys, Materials Science Forum Vol. 1038, pp 3-8
(2021).