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SUMMARY
DOCTORAL THESIS

Research on Improving Occupational Safety and Health in the field of tire rubber processing

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- 2023 -

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Introduction

Noise represents one of the most widespread risk factors of the work environment and is obviously one of the current problems for many organizations in the world.

Noise takes the form of a loud or disturbing sound and is dangerous not only in intensity, but also in the duration of the worker's exposure during the working day.

Every working day, millions of workers around the world are exposed to a high level of noise at their workplace, as well as to all the risks it generates as a result of prolonged exposure.

Exposure to occupational noise at values above those stipulated in the legislation affects not only the auditory organ, producing hypoacusis or occupational deafness, but also has a negative influence on the entire human body by affecting the central nervous system, the appearance of metabolic disorders and cardiovascular diseases, hypertension etc.

* * *

The paper is structured in two parts, Part I "The current state of research on Safety and Health at Work at the international and national level" includes 3 chapters, and Part II "Contributions to the improvement of Safety and Health at Work in the field of rubber processing tires" includes 6 chapters, the content of which is briefly presented in the following.

In the first chapter, called "European and national strategy in the field of Safety and Health at Work", the general and specific objectives of the OSH strategy at both the European and national level were presented. Also, the legislative framework regarding OSH in general and the national requirements regarding noise exposure were presented.

The second chapter, entitled "The current state of research on occupational noise" presents statistics regarding noise and the situation of cases of occupational disease due to exposure to occupational noise in Romania from 1996 to the present. Chapter 2 reviews the effects of noise on the human body and activity, the physical characteristics of noise, and general noise reduction methods.

Chapter 3 presents the conclusions regarding the current state of research on Occupational Safety and Health at the international and national level.

Part II of the doctoral thesis includes the personal contributions brought to the improvement of Safety and Health at Work in the field of tire rubber processing and is structured into the following chapters:

Chapter 4 presents the main objective of the doctoral thesis, the directions of research and development, respectively the research methodology applied to achieve the proposed objectives.

Chapter 5, entitled "Research on occupational health and safety management related to noise" presents how noise is managed as a risk factor in the work environment, through the application of audits, evaluation procedures, etc.

In chapter 6, called "Research on occupational noise exposure assessment methods", there are 3 technical methods used to determine the exposure of workers in the work environment and to calculate the noise exposure level. Chapter 6 contains information on choosing the right measurement method for a particular situation, among the 3: task-based measurement, function-based measurement, and whole-day measurement. It also presents a series of important steps: work analysis, choice of a measurement method, the way in which the measurements are carried out, the calculation method and the presentation of the obtained results.

Chapter 7 "Personal Contributions on Noise Exposure Assessment of Workers in a Tire Rubber Processing Plant" presents the case study of a tire rubber processing plant conducted by the function-based measurement method. The study presents the calculations and results of noise determinations for 73 groups with homogeneous noise exposure (totaling approximately 1,000 people participating in the assessment).

In chapter 8 entitled "Research and contributions on technical and organizational solutions to reduce noise in the tire rubber processing plant" a hierarchy of noise control is presented regarding the technical and/or organizational measures that can be applied within organizations when the noise exceeds the limits provided in the legislation.
An investigation is carried out to identify the sources of noise that leave their mark on the daily exposure of workers, which consists of a series of analyzes and determinations of the noise emission produced by certain work equipment, in frequency bands and the comparison of the results obtained with the values of the sound pressure levels in octave bands corresponding to the Cz curves.
Also, a noise reduction solution is presented using acoustic screens and determining the most suitable sound-absorbing materials that produce noise reductions below the maximum allowable limit. This chapter also presents the effectiveness of the noise maps made in the production sections belonging to the tire rubber processing plant.

In the last chapter of the thesis, entitled "Final conclusions and main contributions regarding the improvement of Safety and Health at Work in a tire rubber processing factory" the final conclusions are presented, personal contributions are summarized and perspectives and directions for further development are presented.

Part I.

The current state of research on Occupational Safety and Health at international and national level

Chapter 1. The European and national strategy in the field of Safety and Health at Work

1.2. Safety and Health at Work Strategy at European level

One of the most important and developed aspects of social policy in the European Union is safety and health at work. The ultimate goal of occupational health and safety activity is to protect the life, integrity, and health of workers against the risks of injury and occupational disease that may occur at work and to create working conditions designed to ensure their physical, mental and social comfort.

At the level of the European Union, the issue of OSH constituted and continues to constitute a very important field, with a special socio-economic impact, which has been the object of several strategies over time.

Thus, the "Community Strategy 2007-2012 regarding health and safety at work" had as its objective "the continuous, sustainable and homogeneous reduction of work accidents and occupational diseases". [54]

The subsequent evaluation of the Community strategy confirmed that its implementation was generally effective and that its main objectives were achieved, thus contributing to the improvement of the implementation of OSH legislation. [76, 96]

Despite the significant reduction of occupational accidents and the improvement of prevention, OSH in the EU still requires additional actions, the motivations being the following [35]:

* Every year, approximately 4,000 employees lose their lives in work-related accidents, and more than three million workers fall victim to serious workplace accidents involving more than three days' absence from work.
* 24.2% of employees believe that their safety and health are threatened because of the work they do, and 25% declare that their professional activity has a negative effect on their health.
* In addition to affecting workers' lives, the direct and indirect costs generated by medical leave are estimated at 3.2% of the gross domestic product of the European Union.
* Social insurance costs attributable to occupational diseases or accidents at work are also unacceptably high.

In these conditions, it appears as a priority to improve the safety and health of workers and, in this sense, it is essential to mobilize all prevention actors in order, through joint actions, to increase the level of safety and health protection of workers at workplaces. [68]

The new Community OSH strategy for the period 2021-2027 aims to reduce the number of occupational deaths by 2030, the so-called "vision zero" objective, while ensuring a safer working environment and in line with new emerging needs. An essential condition for a healthy and productive workforce is the existence of safe and healthy working conditions. No one should suffer from work-related illnesses or accidents. [55]

1.3. National Strategy of Occupational Safety and Health

Ensuring safe and healthy workplaces, maintaining, and improving the health of workers, as well as achieving and supporting the desired well-being at the workplace is the main medium and long-term concern of the structures with responsibilities in the field of OSH in order to function and sustainable development from the economic and social point of view of Romania. [37]

The purpose of the National Strategy in the field of safety and health at work for the period 2018-2020 was to continue the specific actions established at the national level, taking into account the 3 main challenges established at the level of the European Union, as well as the strategic objectives established by the Strategic Framework European 2014-2020 regarding safety and health at work.

The OSH strategy aimed to:

- ✓ Preventing risks and promoting safer and healthier conditions at work.
- ✓ Maintaining a good state of health of workers.
- ✓ Preventing work accidents and occupational diseases and promoting the health of employees throughout their entire professional life.

Chapter 2. Current state of occupational noise research

2.1. Occupational noise statistics

Noise-induced hearing loss, described by the World Health Organization as "the most common irreversible industrial disease", is usually caused by prolonged exposure to excessive noise, above 85 dB (A).

Following some research in recent years, it was found that: [18, 19]

- ✓ 29% of workers in Europe are exposed to noisy working conditions for more than a quarter of their working time.
- ✓ 20% of workers in Europe need to raise their voice above the normal conversational level at least half of their working time to be heard.
- ✓ It is estimated that around 40 million workers in Europe are exposed to such a high level of noise at work, at least half of their working time or even more.

- ✓ Around 7% of workers in Europe believe that their work affects their health in the form of hearing impairment – which represents more than 13.5 million workers.
- ✓ more than 3 million workers (18% of the workforce) in France are exposed to noise above 85 dB(A), of which 6% are exposed to noise levels exceeding 85 dB(A) for more than 20 hours per week.
- ✓ It is estimated that around 500,000 people in the UK suffer from work-related hearing impairment.

As a result of this phenomenon, a series of measures have been implemented at the level of organizations to reduce the level of noise at workplaces.

2.3. The effects of occupational noise on the body and human activity

2.3.3. Occupational deafness

If, following a short-term exposure to the action of intense noise, the damage to the inner ear is reversible at first, later, in the case of a long exposure, irreversible changes may occur, leading to the appearance of deafness. [11, 14, 19]

When this long exposure occurs in the work environment this deafness is called **occupational deafness**.

Fig. 2.8. age-related hearing loss and noise-induced hearing loss are presented. It can be seen that in people over 50 years of age, hearing degradation occurred much faster than in young people.
At the same time, presbycusis can vary according to sex, being more acute in men than in women.

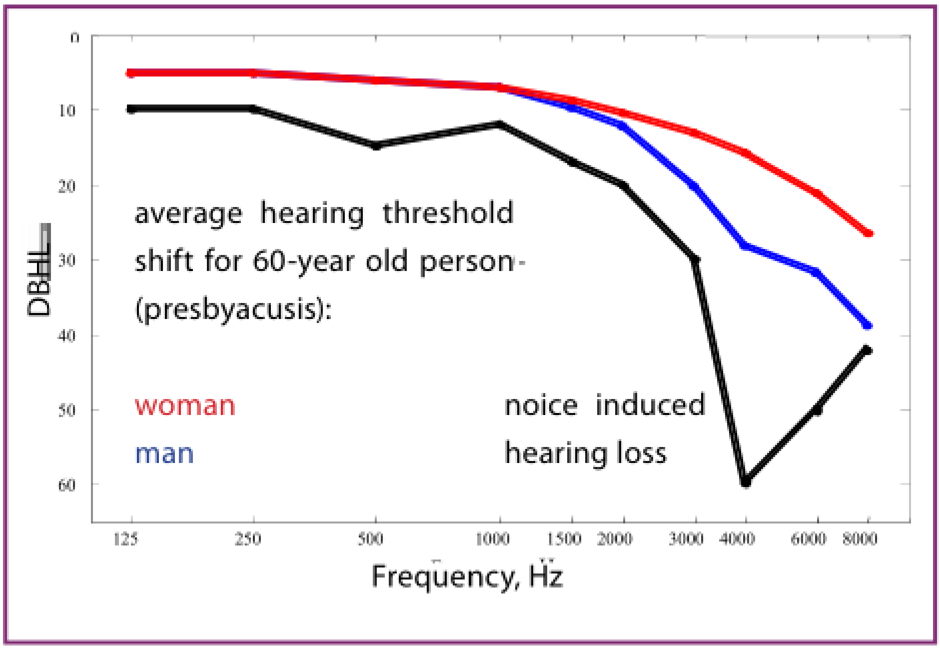


Fig. 2.8. Hearing loss with age and noise-induced hearing loss. [33]

2.4. Physical characteristics of noise

The three fundamental characteristics of noise are:

- sound pressure level in decibels.
- content in frequency.
- total duration and mode of noise variation over time.

2.5. General noise reduction methods

Noise combating methods are recommended to be part of one or more of the following categories:

- methods of combating noise at the source.
- methods of combating noise on propagation paths.
- methods of combating noise at the receiver.

2.5.1. Noise reduction with the help of acoustic screens

Acoustic shields (applied at the source) are planar or spatial arrangements of panels or other constructive elements that partially mask the noise source from the considered reception points and that are located within the near acoustic field of the source, as seen in Fig. 2.22. [119]

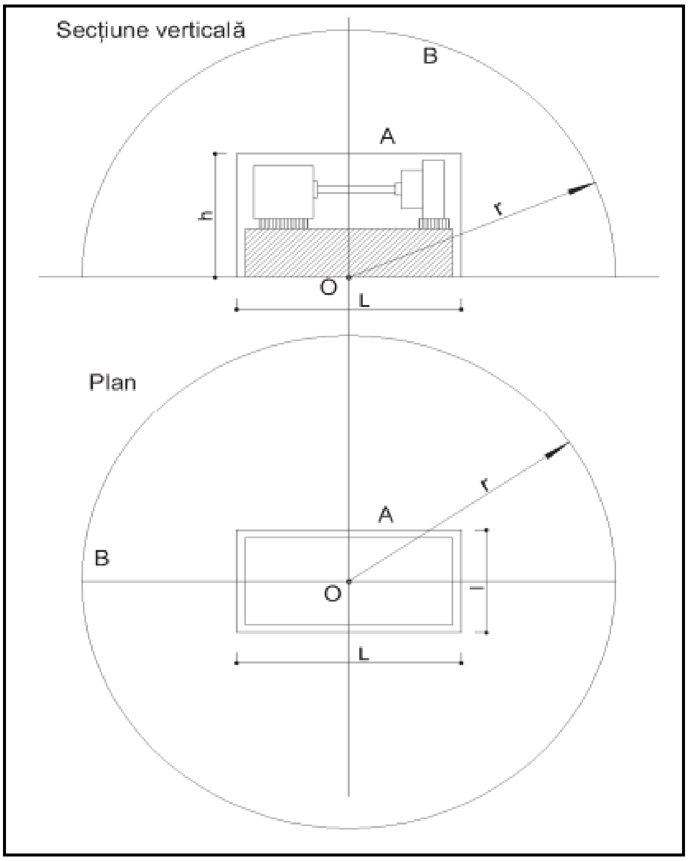


Fig. 2.22. Establishing the limits of the near acoustic field, corresponding to a noise source. [119]

Chapter 3. Conclusions on the current state of research on Occupational Safety and Health at international and national level

From the analysis of the current state of research and development regarding safety and health at the workplace at the international and national level, important conclusions can be drawn, as follows:

- Occupational Safety and Health is much more than an objective to be met. When we refer to OSH, we think of all the activities carried out by organizations to create working conditions that ensure the well-being of workers and, last but not least, we want to eliminate work accidents and occupational diseases arising from exposure to risk factors at workplace. (v. § 1.1).
- OSH represents one of the most important areas of social policy within the European Union. (v. § 1.2).
- The final goal of the OSH activity is to protect the life, integrity and health of workers against all risks of occupational injury and illness that may occur at the workplace during their entire professional life and, last but not least, to create working conditions that have the right aim to ensure physical, mental and social comfort for all workers in all organizations, regardless of field. (v. § 1.2).
- At the EU level, the OSH issue constituted and continues to constitute a very important field, so that, over time, several strategies have been implemented. (v. § 1.2).
- The "Community Strategy 2007-2012 regarding OSH" aimed at "the continuous, sustainable and homogeneous reduction of work accidents and occupational diseases". (v. § 1.2).
- The implementation of the strategy within the organizations produced the expected effects, many of the proposed objectives being fulfilled. However, despite the significant reduction in occupational accidents and the improvement of OSH, additional actions are recommended in the EU, because:
    - thousands of employees lose their lives in work accidents or are victims of serious accidents at work.
    - many employees consider that their safety and health are threatened because of the work performed at the workplace, and the activity carried out has negative effects on health.
    - still die from occupational diseases or a high number of new cases occur annually. (v. § 1.2).
- The new Community OSH strategy for the period 2021-2027 has set as its main long-term objective the reduction of occupational deaths and work accidents, through the so-called "vision zero" objective. (v. § 1.2).

- The national strategy in the field of OSH for the period 2018-2020 aimed at the continuation of specific actions and their implementation at the national level as well. The target objectives were:
  - ∗ preventing risks and promoting safer and healthier conditions at work.
  - ∗ maintaining a good state of health of workers.
  - ∗ preventing work accidents and occupational diseases and promoting the health of employees throughout their entire professional life. (v. § 1.3).

- The existence of an OSH legislative framework at EU level is absolutely essential to ensure the highest possible degree of worker protection and to create a level playing field for all companies, regardless of their size, geographical location or sector of activity. EU OSH legislation consists of a framework directive and 24 specific directives. (v. § 1.4).
- The legislative framework of the field of OSH in Romania was created by transposing the provisions of the Community legislative framework into the Romanian legislation. (v. § 1.5).
- At the level of our country, the minimum requirements regarding the exposure of workers to noise are specified by HG no. 493/2006 which establishes the minimum requirements for the protection of workers against risks generated by exposure to noise, especially against risks for hearing. In this decision, the physical parameters used as predictors of risk are specified, as well as the exposure limit values and the values from which the employer's action regarding the security and health protection of workers is triggered. (v. § 1.5.1).
- The onset of occupational deafness caused by prolonged exposure to excessive noise, over 85 dB (A), is described by the WHO as "the most common irreversible industrial disease". (v. § 2.1.).
- Knowing the number of new declared cases of occupational deafness is the starting point for monitoring and implementing preventive actions. According to the "Occupational Morbidity in Romania" Report, noise, compared to other causal agents, was in first place in the period 2001-2002 with a number of 696 and 890 declared cases of occupational deafness. Even though the number of cases has gradually decreased in the following years, in 2020 noise was ranked 5th. Consequently, noise still poses a danger to workers and can lead to the appearance of negative effects on the human body. Therefore, noise must be monitored in all organizations, and where exceeding the maximum permissible value, measures must be taken to reduce or eliminate it. (v. § 2.2.).
- Millions of workers in the European Union are exposed daily at their workplaces to the action of excessive noise, as well as to all the risks arising from its action on the body and human activity. The action of noise at the workplace must not affect either the safety of work or the health of the worker. (v. § 2.3.).

- The effects of noise that can occur on the human body can be of 2 types: auditory effects (hearing fatigue, tinnitus, hypoacusis or occupational deafness) and extra-auditory effects (disturbances in the function of various devices and systems of the body). Also, noise can affect verbal communication between workers, can contribute to work accidents in the case of pregnant workers, can affect the fetus during pregnancy and can cause cardiovascular and neuropsychiatric disorders. (v. § 2.3.).
- The three fundamental characteristics of noise are: sound pressure level in decibels, frequency content and total duration, and the way noise varies over time. (v. § 2.4.).
- In the situation where it is found that the noise at the workplace exceeds the maximum allowed limit, according to the legal provisions, the employer must take measures to reduce or eliminate the noise. The anti-noise methods can be: anti-noise methods at the source, anti-noise methods in the propagation paths or anti-noise methods at the receiver. (v. § 2.5.).

Part II.

Contributions regarding the improvement of Safety and Health at Work in the field of tire rubber processing

Chapter 4. Directions, main objective and research-development methodology related to the improvement of Safety and Health at Work in the field of tire rubber processing

4.1. Research and development directions

Based on the findings from the analysis of the current state, the following research and development directions regarding the improvement of OSH in the field of tire rubber processing are considered to be current:

- ✓ assessment of workers' exposure to occupational noise, given that prolonged exposure to excessive noise can cause permanent hearing damage, but can also have other negative effects on the human body;
- ✓ the analysis and appropriate choice of technical and/or organizational noise reduction measures to be applicable in the tire rubber processing factory, with the aim of ensuring comfort, both physical and mental, for workers;
- ✓ the continuous and permanent reduction, up to "zero" of occupational diseases (occupational deafness) considering that noise as a causative agent was in the first 5 places in 2020, and according to statistics, people still die from occupational diseases or, a high number of new cases appear annually.

4.2. The main objective of the research-development activity

Taking into account the data and conclusions derived from the analysis of the current state, as well as the directions of research and development regarding the improvement of OSH in the field of tire rubber processing, it is determined as the main objective of the doctoral activity: the assessment of occupational noise exposure of workers and the proposal of measures technical and organizational noise reduction measures with the final aim of improving the OSH of tire rubber processing workers.

Following the completion of the research and development directions and for the fulfillment of the main objective, the achievement of the following specific objectives will be pursued:

- ✓ auditing the security level regarding occupational noise in the tire rubber processing plant.
- ✓ assessment of daily noise exposure of workers in the work environment.
- ✓ choosing the most effective technical and organizational measures to reduce occupational noise that may be applicable in the tire rubber processing plant. The employer is obliged, in accordance with the legal provisions, to take protective measures to improve the working conditions of the workers.

4.3. Research and development methodology

The research-development methodology is designed as a reference system for the actions that will be taken to achieve the main objective of the doctoral work, as well as future developments.

The methodological benchmarks are as follows.

(1) *Investigation*

Investigating what is already known that might be relevant to the field of OSH in general and noise in particular. In order to carry out the proposed objectives, a well-documented analysis was carried out consisting of the consultation of books, magazines, studies or specialized publications as well as the national legislation in the field of OSH (in particular, noise).

(2) *Establishing the research methodology*

The research procedure includes:

- Carrying out the bibliographic study;
- Application of the occupational noise risk assessment procedure which aims to identify workers exposed to the risks generated by noise and establish their exposure level. The objective of the procedure is to identify the necessary actions to be taken when the exposure values established by the legislation in force are exceeded;
- Auditing workplaces within the tire rubber processing factory in order to establish the level of security regarding noise at the workplace;
- The study of the SR EN ISO 9612:2009 standard for the determination of occupational noise in order to choose the most suitable method to evaluate the daily exposure to noise of workers in the work environment, among the 3 methods presented: the measurement based on the task, the measurement based on the function or the measurement throughout the day;
- Traveling to the premises of the tire rubber processing plant and performing noise measurements in all production sections;
- Carrying out the practical part of the thesis, meaning measurements of $L_{p,\mathrm{A,eq}T}$ (the equivalent continuous sound pressure level, weighted A, over a period T) and $L_{p,\mathrm{Cpeak}}$ (the peak sound pressure level, weighted C) in a factory tire rubber processing. Noise measurements were carried out in all production sections of the factory for approximately 1000 workers;
- Field data processing, meaning calculation of daily noise exposure level for groups with homogeneous noise exposure and calculation of measurement uncertainty;

- Presentation of results for all groups with homogeneous noise exposure;
- Analysis and interpretation of noise results performed in the tire rubber processing plant. The results obtained were compared with the maximum permissible noise values provided in the legislation;
- Analysis and identification of noise sources that leave their mark on the daily exposure of workers by determining the noise emission produced by the sources, in frequencies (31.5 Hz – 8,000 Hz);
- Choosing the most effective technical and organizational measures to reduce occupational noise that may be applicable in the tire rubber processing factory;
- The design of an acoustic screen to be placed between a source that emits noise above the maximum allowed limits and the adjacent work area and to ensure the protection of workers against the harmful action of noise;
- Determination of the absorption coefficient for 2 types of sound-absorbing materials in order to choose the variant that produces a greater attenuation for a wider range of frequencies;
- Mapping the noise in the production sections of the tire rubber processing plant and creating a noise map, which is intended to be a useful tool for raising awareness among workers about high noise areas;
- Checking the awareness of workers and the importance of noise maps at workplaces in the tire rubber processing plant, by applying a questionnaire;
- Establishing future directions regarding the implementation of technical projects aimed at reducing noise at sources that generate exceedances above the maximum allowed limits;
- Presenting the conclusions in a concise manner, highlighting personal contributions.

(3) *Research tools*

In the framework of the thesis, mathematical calculation formulas and computer calculation tools (Microsoft Excel) will be used, as well as specific software (BZ 5503 – application for processing data measured with the Bruel&Kjaer sound level sonometer type 2250, Protector 7825 – application for processing data measured with the Bruel&Kjaer type 4448 dosimeter, Noise at Work – an application that allows noise mapping at the workplace).

(4) *Presentation of results*

The obtained results indicate that the assessment of workers' noise exposure is essential for the early detection of noise-related risks to which workers are exposed. The identification and monitoring of occupational noise still remain topical and must be kept under control.

Chapter 5. Occupational Health and Safety management research related to noise

5.1. Noise risk assessment procedure

Noise risk assessment is essential to protect workers from risks to their health and safety from noise exposure. The risk assessment identifies workers at risk from noise and determines their level of noise exposure. Risk assessment is not an end in itself, its objective is to identify actions required when exposure values that trigger action are reached or exceeded. [33]

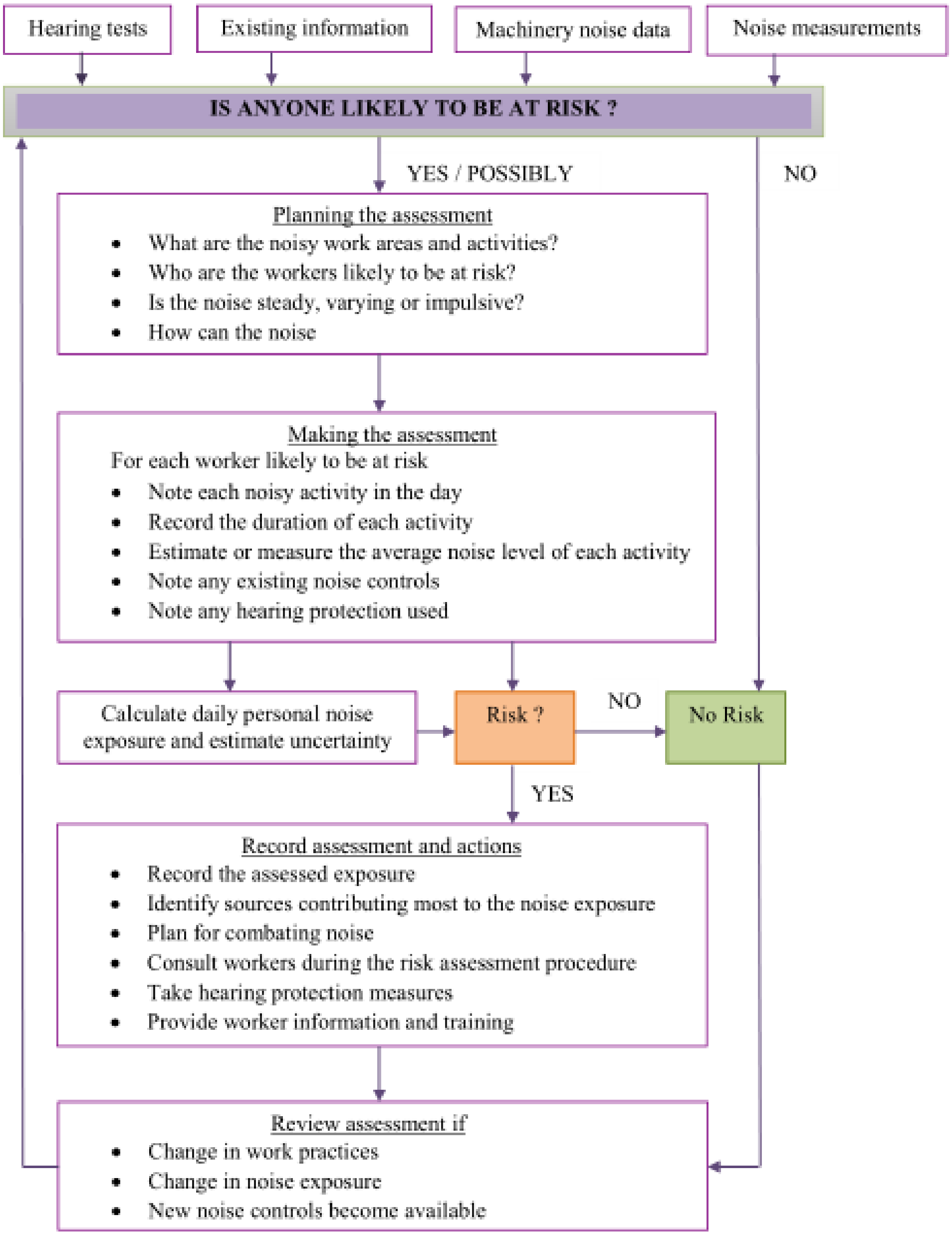


Fig. 5.1 Diagram showing the stages of the assessment procedure [33]

Chapter 6. Research on occupational noise exposure assessment methods

The determination of exposure to noise in the work environment is carried out according to the international standard SR EN ISO 9612:2009. [6]

The standard presents 3 technical methods for measuring the exposure of workers to noise in the work environment and for calculating the noise exposure level.

The standard also contains a series of important stages: work analysis, choice of a measurement procedure, measurements, error treatment and uncertainty assessments, calculations and presentation of results. This standard presents three different measurement methods: load-based measurement, function-based measurement and whole-day measurement. The standard presents indications regarding the choice of the measurement method suitable for a certain work situation and for the purpose of the investigation.

6.3.1 Research and contributions on the calculation of the daily noise exposure level when using function-based measures

The calculation of the daily exposure level when using measurements based on homogeneous noise exposure groups (HENGs) involved the following steps:

- Step 1: Work analysis

Workers at the production line do the same job: they operate and control a production line and intervene in the event of a production incident. Their work encompasses many tasks (eg, material supply, production control, product removal, adjustments). However, during the analysis of the work, no possible distinctions could be made between tasks, for the following reasons: the conditions of noise exposure of the workers are similar from one task to another and the daily duration of each task cannot be determined from the job descriptions . The workers form an homogeneous exposure noise group, consisting of 16 people. The effective duration of the working day, for this HENG, is 7.5 h.

- Step 2: Choise of procedure

From the analysis of work for this HENG, consisting of 16 workers, it appears that it is neither practical nor desirable to carry out a detailed analysis of the tasks. As a result, was chosen function-based measurements.

- Step 3: Measurements of noise levels

The choice of measurement plan was guided by the following specifications:

- the total minimum duration of the measurements is given in Table 1: for a group of 16 persons, this is 10.25 h.

- a minimum of five noise level samples of the same duration is required.

Starting from these, it has been decided to make 8 measurements and to set the measurements duration to 80 minutes each. The distribution of the 8 measurements among the workers in this HENG and over the working duration is made knowing that:

- two dosimeters are available;
- working periods for the group are: 07:00 - 15:00; 15:00 - 23:00 and 23:00 - 07:00.

Eight workers are randomly selected from the 16 members of the HENG.
The chosen distribution of the measurements is as follows:
Day 1: The morning team, 2 different workers; measurement periods: 8:00 - 9:20 and 8:40 - 10:00
Day 2: The morning team, 2 different workers; measurement periods: 10:00 - 11:20 and 10:30 - 11:50
Day 1: The afternoon team, 2 different workers; measurement periods: 15:30- 16:50 and 17:00 - 18:20
Day 2: The afternoon team, 2 different workers; measurement periods: 15:10- 16:30 and 18:00 - 19:20

The eight measurements result in the following values of A-weighted equivalent continuous sound pressure of the sample *n* for HENG (Lp,A,eqT,n) is presented in Table 6.5.

- Step 4: Calculation and presentation of results and uncertainty
  Calculation of the A-weighted noise exposure level, presentation of results and uncertainty

The standard uncertainty, u_2, due to the equipment (the device used was a dosimeter): u_2 = 1.5 dB
The uncertainty contribution due to the microphone position: u_3 = 1.0 dB
The standard uncertainty of the measured values is: u_1= 2.0 dB
Contribution to uncertainty due to the sampling of the function noise level (value taken from the Table 6.4. for N = 8 and u1= 2.0 dB): c_1u_1 = 1.1 dB
The coefficients of sensitivity: $c_2 = c_3 = 1$
The standard uncertainty, u_2, due to the equipment (the device used was a dosimeter): u_2 = 1.5 dB
The standard uncertainty due to the microphone position is: u_3 = 1.0 dB
The standard uncertainty, u: $u^2(L_{EX,8h}) = 1.1^2 + 1.5^2 + 1.0^2 = 4.46$; (6.19)
$u(L_{EX,8h})$ = 2.11 dB
The expanded standard uncertainty: $U(L_{EX,8h}) = 1.65 \times u = 3.5$ dB (6.20)

Final result of the calculation was as follows:

For an effective duration T_e of the working day equal to 7.5 h and for an average noise level $L_{p,A,eqT}$ = 87.7 dB, the daily A-weighted noise exposure level of this 16 members HENG, is 87.3 dB. Associated expanded uncertainty, $U(L_{EX,8h})$ = 3.5 dB

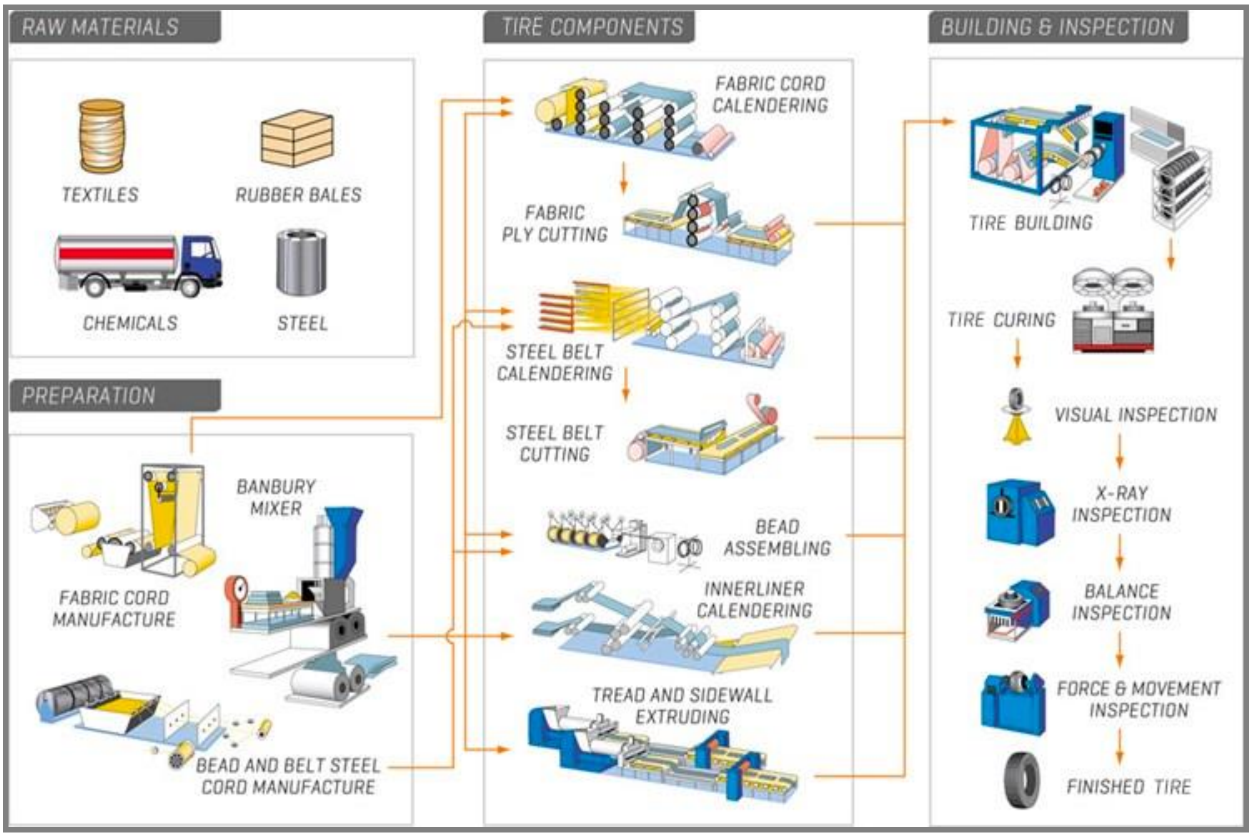
Table 6.5. Calculation of daily noise exposure level [25]

n		1	2	3	4	5	6	7	8
N		8	8	8	8	8	8	8	8
$L_{p,A,eqT,n}$		90.2	85.9	89.7	87.3	86.1	85	86.6	87.8
$10^{0,1*Lp,AeqT,n}$		1.047E+09	3.89E+08	9.33E+08	5.37E+08	4.07E+08	3.16E+08	4.57E+08	6.03E+08
1/N*$10^{0,1}$*Lp,AeqT,n		130891069	48630643	1.17E+08	67128975	50922535	39528471	57136024	75319948
1/N*suma $10^{0,1}$*Lp,AeqT,n	5.86E+08								
$L_{p,A,eqTe}$	87.68057								
	expunere grup omogen								
	$L_{EX,8h}$	87.30071							

Chapter 7. Personal contributions on noise exposure assessment of workers in a tire rubber processing plant

7.1. Presentation of noise sources in the production sections of the tire rubber processing plant

In Fig. 7.1. the technological process of tire rubber processing is presented.



7.3. Results of noise determinations carried out in the tire rubber processing plant

The results of the noise measurements carried out in the tire rubber processing plant are presented separately by production sections and for each group with homogeneous noise exposure belonging to the respective sections:

Section 101 – 111 – 400

Operators BY 1, BY 2, BY 3, Self-Sealing 1 – Level 0

- The homogeneous group was made up of 36 people, a number of 18 people participated in the measurements, 18 measurements corresponding to this group were performed;
- The measurements were carried out between 13.02.2018 - 16.02.2018, time interval 8:40 - 16:00;
- The duration of the measurements was 60 minutes/measurement;

- The 36 members of the homogeneous noise exposure group receive an A-weighted daily noise exposure level of 90.4 dB with an uncertainty of 3.4 dB.

n		1	2	3	4	5	6	7	8
N		18	18	18	18	18	18	18	18
$L_{p,A,eqT,n}$		89	93.8	91.1	92.8	92.8	86.6	93.9	93.4
$10^{0.1*Lp,AeqT,n}$		794328234.7	2398832919	1288249552	1905460718	1905460718	457088190	2454708916	2187761624
$1/N*10^{0.1}*Lp,AeqT,n$		44129346.37	133268495.5	71569419.54	105858928.8	105858929	25393788.3	136372717.5	121542312.4
$1/N*suma\ 10^{0.1}*Lp,AeqT,n$	1192047241								
$L_{p,A,eqTe}$	90.7629347								
	expunere grup omogen								
	$L_{EX,8h}$	**90.3830745**							

9	10	11	12	13	14	15	16	17	18
18	18	18	18	18	18	18	18	18	18
88.5	87.5	87.3	88.5	86.1	90.9	87.1	84.6	92.3	91.5
707945784	562341325	537031796	707945784	407380278	1230268771	512861384	288403150	1698243652	1412537545
39330321.4	31241184.7	29835100	39330321	22632237.7	68348265.05	28492299.1	16022397.2	94346869.58	78474308.03

Fig. 7.6. Noise measurement results – Operators BY 1, BY 2, BY 3, Self-Sealing 1 – level 0

<u>Quick Control Laboratory</u>

- The homogeneous group was made up of 16 people, a number of 8 people participated in the measurements, 8 measurements corresponding to this group were performed;
- The measurements were carried out between 14.02.2018 – 15.02.2018, time interval 12:10 – 17:30;
- The duration of the measurements was 80 minutes/measurement;
- The 16 members of the homogeneous noise exposure group receive an A-weighted daily noise exposure level of **76.5 dB** with *an uncertainty* of 3.7 dB.

n		1	2	3	4	5	6	7	8
N		8	8	8	8	8	8	8	8
$L_{p,A,eqT,n}$		77	77.9	78.8	78.6	72.6	73.9	73.2	78.3
$10^{0.1*Lp,AeqT,n}$		50118723.4	61659500	75857758	72443596	18197009	24547089	20892961	67608298
$1/N*10^{0.1}*Lp,AeqT,n$		6264840.42	7707438	9482220	9055450	2274626	3068386.1	2611620	8451037
$1/N*suma\ 10^{0.1}*Lp,AeqT,n$	48915617								
$L_{p,A,eqTe}$	76.894475								
	expunere grup omogen								
	$L_{EX,8h}$	**76.5146**							

Fig. 7.13. Noise measurement results – Quick Control Laboratory

<u>Transport Operators –level 0</u>

- The homogeneous group was made up of 17 people, a number of 9 people participated in the measurements, 9 measurements corresponding to this group were performed;
- The measurements were carried out between 21.02.2018 - 27.02.2018, time interval 09:15 - 15:10;
- The duration of the measurements was 80 minutes/measurement;
- The 17 members of the homogeneous noise exposure group receive an A-weighted daily noise exposure level of **85.4 dB** with *an uncertainty of 4.0 dB.*

n		1	2	3	4	5	6	7	8	9
N		9	9	9	9	9	9	9	9	9
$L_{p,A,eqT,n}$		88.1	88.3	82	85.9	89.2	79.7	82.9	83	83.3
$10^{0.1*Lp,AeqT,n}$		645654229	676082975	158489319	389045145	831763771	93325430	194984460	199526231	213796209
1/N*$10^{0.1}$*Lp,AeqT,n		71739359	75120331	17609924	43227238	92418197	10369492	21664940	22169581	23755134
1/N*suma $10^{0.1}$*Lp,AeqT,n	378074197									
$L_{p,A,eqTe}$	85.77577									
	expunere grup omogen									
	$L_{EX,8h}$	85.39591								

Fig. 7.21. Noise measurement results - Transport Operators – level 0

Section 102 – 112

<u>Triplex, SRH Operators</u>

- The homogeneous group was made up of 60 people, a number of 30 people participated in the measurements, 30 measurements corresponding to this group were performed;
- The measurements were carried out between 02.07.2018 - 02.12.2018, time interval 09:10 - 17:40;
- The duration of the measurements was 60 minutes/measurement;
- The 60 members of the homogeneous noise exposure group receive an A-weighted daily noise exposure level of **83.2 dB** with *an uncertainty of 3.0 dB.*

n		1	2	3	4	5	6	7	8
N		30	30	30	30	30	30	30	30
$L_{p,A,eqT,n}$		81.7	81.9	81.7	82.4	81.1	82.1	83.5	83.4
$10^{0.1*Lp,AeqT,n}$		147910839	154881662	147910839	173780083	128824955	162181010	223872114	218776162
1/N*$10^{0.1}$*Lp,AeqT,n		4930361.3	5162722.1	4930361.3	5792669.4	4294165.2	5406033.7	7462403.8	7292538.7
1/N*suma $10^{0.1}$*Lp,AeqT,n	227446877								
$L_{p,A,eqTe}$	83.5688								
	expunere grup omogen								
	$L_{EX,8h}$	**83.18894**							

9	10	11	12	13	14	15	16	17	18	19
30	30	30	30	30	30	30	30	30	30	30
82.2	86.4	81.9	82.4	82.6	83.2	82.3	83.6	83.3	85.2	83.5
165958691	436515832	154881662	173780083	181970086	208929613	169824365	229086765	213796209	331131121	223872114
5531956.4	14550527.7	5162722.1	5792669.4	6065669.5	6964320.4	5660812.2	7636225.5	7126540.3	11037704	7462403.8

20	21	22	23	24	25	26	27	28	29	30
30	30	30	30	30	30	30	30	30	30	30
84.1	82.3	82.9	82.8	80.4	87.1	82.3	82.8	87.3	84.2	85.8
257039578	169824365	194984460	190546072	109647820	512861384	169824365	190546072	537031796	263026799	380189396
8567985.9	5660812.2	6499482	6351535.7	3654927.3	17095379	5660812.2	6351535.7	17901060	8767560	12672980

Fig. 7.38. Noise measurement results – Triplex, SRH Operators

Section 103 – 113

Modulo Plus operators

- The homogeneous group was made up of 96 people, a number of 48 people participated in the measurements, 48 measurements corresponding to this group were performed;
- The measurements were carried out between 21.11.2017 – 24.11.2017, time interval 09:00 - 19:00;
- The duration of the measurements was 60 minutes/measurement;
- The 96 members of the homogeneous noise exposure group receive an A-weighted daily noise exposure level of **80.7 dB** with *an uncertainty of 3.0 dB.*

n		1	2	3	4	5	6
N		48	48	48	48	48	48
$L_{p,A,eqT,n}$		80.2	81.1	84.5	84.8	80.7	81.9
$10^{0,1*Lp,AeqT,n}$		104712855	128824955	281838293	301995172	117489755	154881662
$1/N*10^{0,1}*Lp,AeqT,n$		2181517.8	2683853.2	5871631.1	6291566.1	2447703.2	3226701.3
$1/N*suma\ 10^{0,1}*Lp,AeqT,n$	127621632						
$L_{p,A,eqTe}$	81.059243						
	expunere grup omogen						
	$L_{EX,8h}$	80.679383					

7	8	9	10	11	12	13	14	15	16
48	48	48	48	48	48	48	48	48	48
80.9	80	80	84.4	78.6	80.1	83	84.7	80.7	85.6
123026877	100000000	100000000	275422870	72443596	102329299	199526231	295120923	117489755	363078055
2563059.9	2083333.3	2083333.3	5737976.5	1509241.6	2131860.4	4156796.5	6148352.6	2447703.2	7564126.1

17	18	19	20	21	22	23	24	25	26
48	48	48	48	48	48	48	48	48	48
85	83.6	80.2	79	81.9	82.3	86.7	82.3	84.6	84.8
316227766	229086765	104712855	79432823	154881662	169824365	467735141	169824365	288403150	301995172
6588078.5	4772640.9	2181517.8	1654850.5	3226701.3	3538007.6	9744482.1	3538007.6	6008399	6291566.1

27	28	29	30	31	32	33	34	35	36	37
48	48	48	48	48	48	48	48	48	48	48
79.2	80.2	81.8	80.2	81.2	79.6	78	78.9	79.8	80.1	82.1
83176377	104712855	151356125	104712855	131825674	91201084	63095734	77624712	95499259	102329299	162181010
1732841.2	2181517.8	3153252.6	2181517.8	2746368.2	1900023	1314494.5	1617181.5	1989567.9	2131860.4	3378771

38	39	40	41	42	43	44	45	46	47	48
48	48	48	48	48	48	48	48	48	48	48
81.2	78.5	81.2	80.5	80	80.7	83.4	81.3	80	80.7	81.8
131825674	70794578	131825674	112201845	100000000	117489755	218776162	134896288	100000000	117489755	151356125
2746368.2	1474887.1	2746368.2	2337538.4	2083333.3	2447703.2	4557836.7	2810339.3	2083333.3	2447703.2	3153252.6

Fig. 7.42. Noise measurement results – Modulo Plus operators

Chapter 8. Research and contributions on technical and organizational noise reduction solutions in the tire rubber processing plant

8.1. Hierarchy of occupational noise control

Controlling occupational noise exposure is essential to protect workers. Managers of organizations have a responsibility to protect all workers from the harmful effects of noise generated by various work equipment in their workplace. The noise control hierarchy is used by managers to determine practical and effective methods of noise control in an organization. This approach groups control measures according to their likely effectiveness in reducing or eliminating the hazard called noise. Using this hierarchy within an organization can reduce workers' exposure to noise and, by implication, in the long term, reduce the risk of occupational deafness.

The noise control hierarchy has five levels of actions:

- Elimination of noise sources;
- Substitution/replacement of noise sources;
- Technical noise reduction measures;
- Administrative/organizational noise reduction measures;
- Individual hearing protection equipment (EIPA).

The occupational noise control hierarchy is shown in Fig. 8.1.:

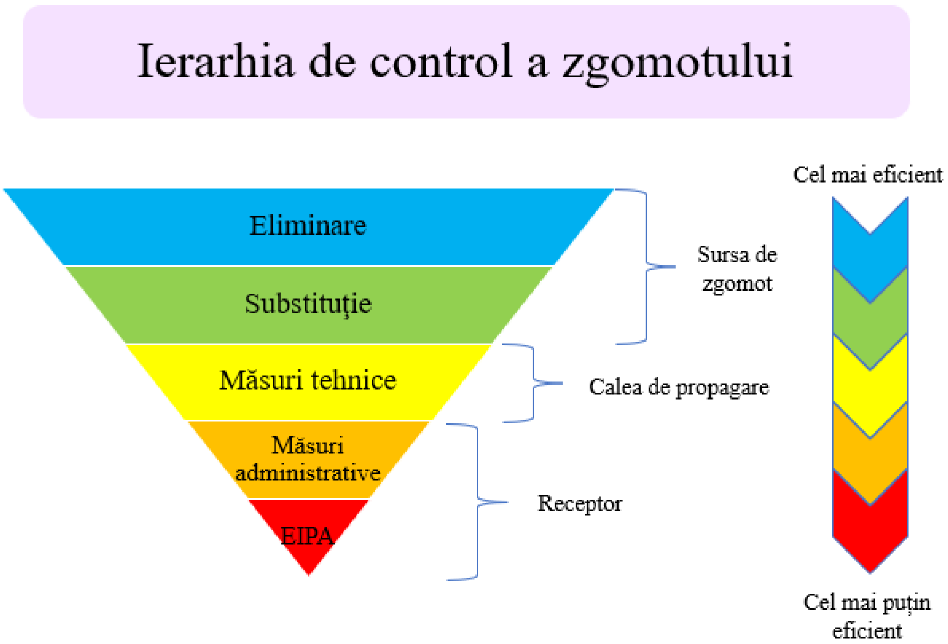


Fig. 8.1. Occupational noise control hierarchy. [107]

8.1.3. Technical noise reduction measures

Engineering control measures refer to the modification of work processes, machines or equipment so that workers are exposed to as little noise as possible. For example, one solution would be to reduce the noise with sound-absorbing screens or enclosures, which leads to a reduction in the noise level in the workplace.

8.1.3.2. Grinder equipment noise reduction solution

As we stated before, the noise determinations carried out in the work environment in the tire rubber processing factory highlighted the fact that from the way the technical equipment is distributed in the sections, it follows that the emission of noisy sources from a section influences the exposure to noise of all workers in the vicinity.

Due to the high noise level in the Grinder equipment area (L_A > 90 dB(A)), the exposure of workers in the surrounding area is definitely influenced.

Considering this fact, we considered it useful to design and make a sound-absorbing screen that can be placed between the Grinder equipment and the adjacent work area.

In order to see the effectiveness of this project, several steps are necessary:

A. Carrying out initial measurements of the work equipment;
B. Establishing the sound-absorbing material and determining the absorption coefficient for different thicknesses in order to choose the optimal thickness of the screens;
C. Design of acoustic screens;
D. Carrying out a new set of measurements to validate the noise reduction solution.

Carrying out initial noise measurements

The effectiveness of noise control must be determined and verified by taking into account the sound pressure level normally found in workplaces. Situations before and after the application of noise control measures can only be compared if the measurement method and operating conditions used are identical.

For the determination of the acoustic attenuation in situ, the unshielded acoustic field can be generated using the actual acoustic source to be shielded provided that the generated sound is reproducible, and the same sound must be used for measurements with and without a shield. If these conditions cannot be met, SR EN ISO 11821:2000 [157] provides for the use of an artificial acoustic source. The artificial acoustic source must be placed as close as possible to the real acoustic source to be shielded. The height of the artificial acoustic source must not be lower than the height of the real acoustic source. The frequency range must be at least 100 Hz to 5,000 Hz for third-octave bands and at least 125 Hz to 4,000 Hz for octave bands.

In Table 8.6. the noise level values obtained in Point 1 for the artificial noise source X are presented.

Table 8.6. The noise level values obtained in Point 1.

Point 1 – no screens	
Frequency [Hz]	***L* [dB]**
20	60
25	59,4
31,5	61,2
40	59,3
50	63,9
63	55,8
80	52,7
100	54,5
125	49,5
160	51,4
200	56,2
250	55,5
315	65,2
400	60,1
500	60,3
630	70,4
800	69,9
1 k	75
1,25 k	76,6
1,6 k	80,6
2 k	78,4
2,5 k	80,9
3,15 k	81
4 k	80,2
5 k	87,1
6,3 k	81,2
8 k	77,5
10 k	72,7
12,5 k	69,1
16 k	65,6
20 k	60,9

Equivalent continuous sound pressure level of artificial source X at **point 1: L_{Aech} = 91.9 dB(A)**

In Table 8.7. the noise level values obtained in Point 2 for the artificial noise source X are presented.

Table 8.7. noise level values obtained in Point 2.

Point 2 – no screens	
Frequency [Hz]	***L* [dB]**
20	57,9
25	57,8
31,5	57,5
40	58,6
50	66,7
63	54,5
80	53,4
100	53
125	63,4
160	59,4
200	61,7
250	68,8
315	71,4
400	71,3
500	75,3
630	74,2
800	78,5
1 k	81
1,25 k	83,1
1,6 k	81,4
2 k	82,3
2,5 k	81,9
3,15 k	79,8
4 k	76
5 k	71,3
6,3 k	66,8
8 k	62,6
10 k	58,3
12,5 k	51
16 k	50,2
20k	44,2

Equivalent continuous sound pressure level of artificial source X at **point 2: L_{Aech} = 90.5 dB(A)**

Establishing the sound-absorbing material and determining the absorption coefficient for different materials

In Fig. 8.9. the results of the absorption coefficient obtained for Rockwool Acoustic mineral wool samples with thicknesses of 50 mm and 80 mm are presented.

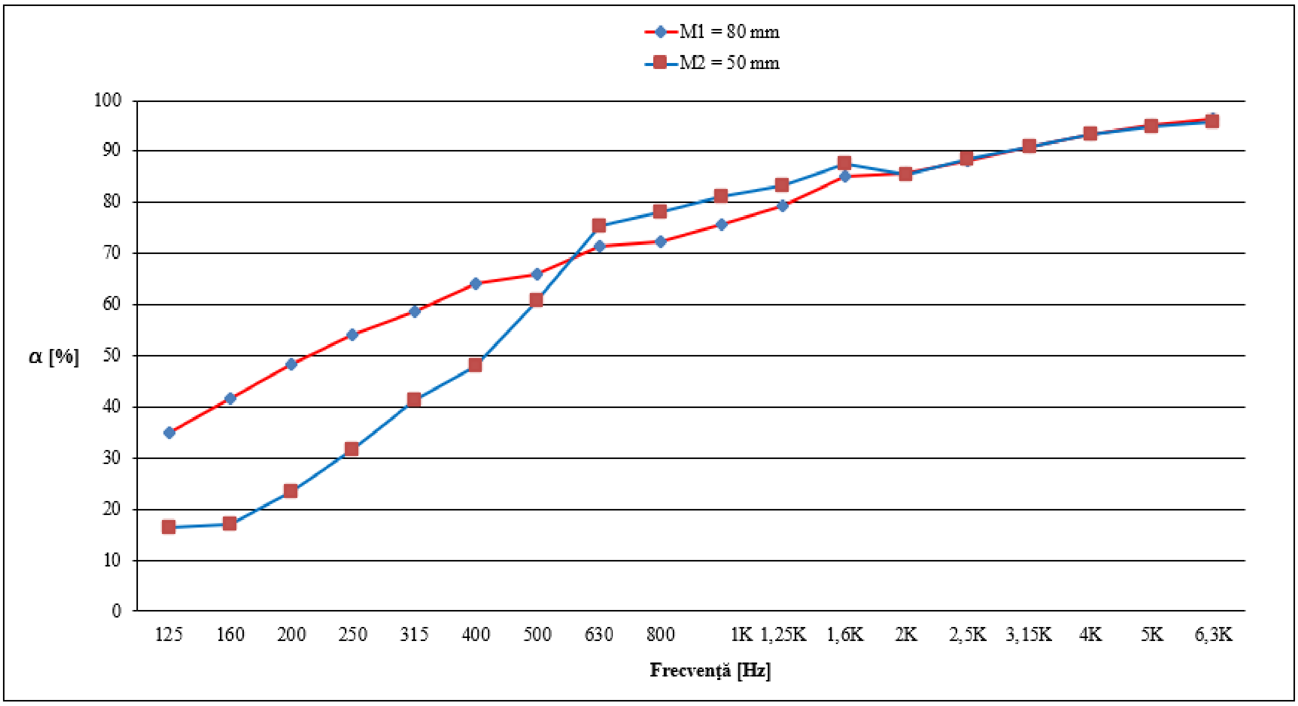


Fig. 8.9. Graphic comparing the results of the absorption coefficient obtained for Rockwool Acoustic mineral wool samples with thicknesses of 50 mm and 80 mm.

Design of acoustic screens

The basic calculation in the design of acoustic screens is: the minimum size "l" of an acoustic protection screen, must meet the condition given by relation 8.1.:

$$l \geq \frac{340}{f_0} \; [m] \tag{8.1}$$

where: f_0 = the lowest frequency of the range in which the screen must produce attenuations of the noise produced by the source, [Hz];

l = minimum screen height, [m].

In the present case, the condition we must respect is: l ≥ 340/200 ≥ 1.705 [m]

This condition is met because l in our case is 4.01 m.

The proposed solution consists of 8 panels, sandwich type, with dimensions of 2,410 mm x 2,005 mm x 50 mm. The sandwich wall is made of 1.5 mm sheet - 50 mm sound-absorbing material (Rockwool Acoustic mineral wool) - 1 mm perforated sheet.

Carrying out final noise measurements

After the sound-absorbing screen was installed, a new set of measurements was performed to validate the noise reduction solution.
The noise level reduction obtained for the artificial noise source X, in the 4 measurement points, is presented in Table 8.16.

Table 8.16. Noise level reduction obtained for the artificial noise source X

	P1	**P2**	**P3**	**P4**
Noise level values without screens [dB]	91,9	90,5	91,2	91,4
Noise level values with acoustic screens [dB]	83,2	81,4	81,3	82,5
$\Delta L_{es}(f)$ [dB]	**8,7**	**9,1**	**9,9**	**8,9**

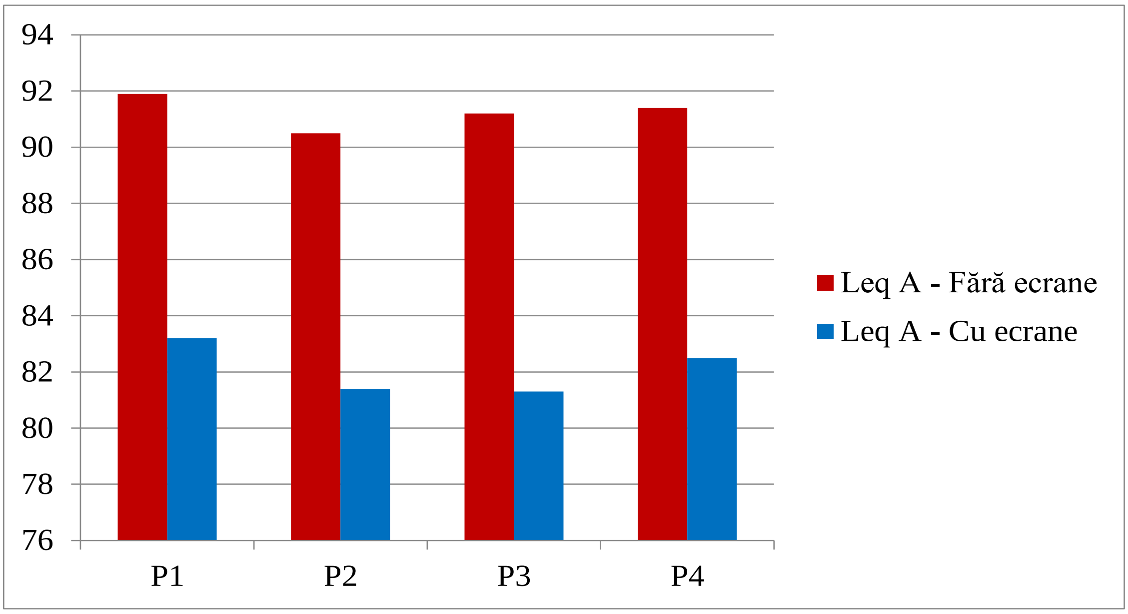


Fig. 8.14. – Comparative analysis of the noise level obtained for the artificial noise source X, in the 4 measurement points, without screens and with screens.

Analyzing the obtained results, a reduction in the equivalent level of acoustic pressure can be observed in all the measured points. The most significant reduction is obtained at measurement point 3, 9.9 dB.

We can conclude that the solution to be implemented to reduce the noise at work point X is an effective one.

8.1.4.1. Noise maps

A good practice in informing, training and raising awareness of workers about the risk of noise exposure is noise mapping.

Noise maps are essentially noise monitoring and control tools.

After 6 months of the implementation of this solution in the tire rubber processing factory, a check was carried out in the form of a questionnaire, the purpose of which was to see if these noise maps had any impact on the workers and what is the level of awareness at that moment.

560 workers from all production sections of the tire rubber processing plant participated in this survey.

The question was: Do you think that the display of noise maps in the workplace has been beneficial for awareness of the danger to which you are exposed? The answer options were: Yes / No / I don't know.

The obtained results are presented in Fig. 8.16.

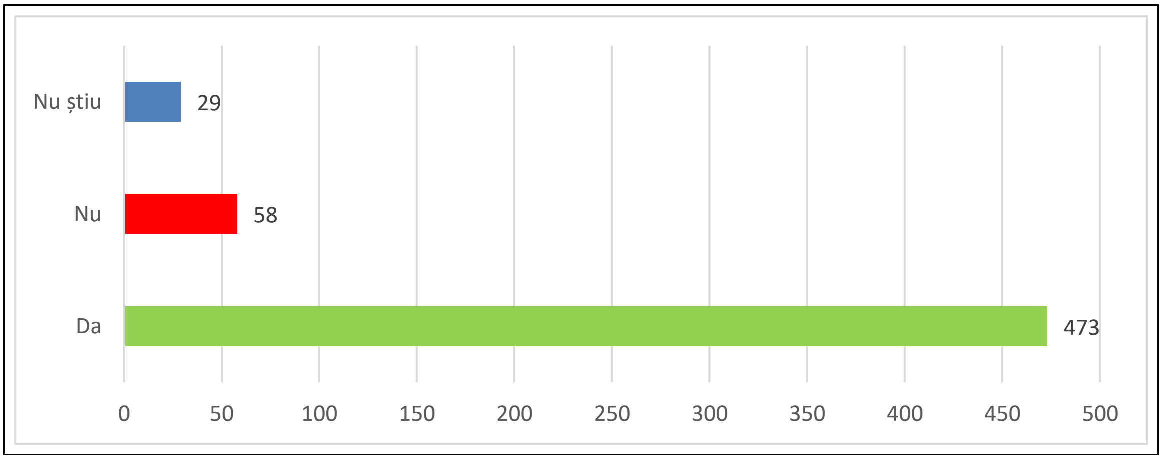


Fig. 8.16. Results of the Workplace Noise Map Questionnaire.

Following the centralization of the answers, it was found what is the degree of awareness of the workers and the importance of displaying the noise maps at the workplaces.

8.1.5. Personal Hearing Protection Equipment (EIPA)

EIPA provides protection to workers against any adverse effects on hearing caused by exposure to high noise levels by acting as a barrier between the noise and the hearing (ear). This method is the last option in the hierarchy of control and should be used as a last resort after all efforts to eliminate or reduce noise levels by technical and organizational means have been exhausted.

Chapter 9. Final conclusions and main contributions to the improvement of Safety and Health at Work in the field of tire rubber processing

(1) From the analysis of the current state of research on safety and health at the workplace at the international and national level, important conclusions emerged, which are presented in Chapter 3.

(2) Considering the data and conclusions from the analysis of the current state regarding the improvement of OSH in the field of tire rubber processing, the research and development directions were considered promising, as presented in § 4.1.

(3) In relation to the current state and directions of research and development regarding the improvement of OSH in the field of tire rubber processing, it was determined as the main objective of the research and development activity within the doctorate (see and § 4.2.): the assessment of exposure to the occupational noise of workers and the proposal of technical and organizational measures to reduce noise with the final aim of improving *the Occupational Safety and Health* of workers in the field of tire rubber processing.

9.1. Final conclusions

The relevant conclusions regarding the doctoral research and development activity to achieve its main objective, in relation to the methodological reference elements (see § 4.3.), are as follows:

- ✓ Noise risk assessment is essential for the protection of workers against risks to their health and safety from prolonged exposure to noise and identifies workers at risk from noise by determining their level of exposure. The objective of the noise risk assessment is to identify the necessary actions to be implemented by the management of the organization when the exposure values that trigger the action are reached or exceeded, according to the legislation in force. The reduction of noise at the workplace leads to the improvement of working conditions aimed at providing workers with physical and mental comfort.
  (see § 5.1.).

- ✓ Auditing workplaces in order to establish the level of security regarding occupational noise is important and can give the employer the opportunity to know the real situation at each workplace, from the point of view of safety and health, and to take the most preventive measures appropriate to the given situation. The implementation of preventive actions in an organization aims to reduce or eliminate the dangers of occupational injury and/or illness in the work process. (see § 5.2.).

- ✓ Knowing the methods for assessing the occupational noise exposure of workers is essential because it influences the choice of the measurement procedure suitable for a certain work situation and for the purpose of the investigation. Applying the right measurement method is important when a determination of noise exposure is required for detailed studies of noise exposure, for epidemiological studies of hearing impairment or other adverse effects. (see § 6.).

- ✓ From the analysis of the results of the noise determinations carried out in the production sections of the tire rubber processing factory and by comparing the results with the maximum admissible limits provided in the legislation in force, it follows that the limits are exceeded in terms of noise exposure for several categories of personnel. (see § 7.3.).

- ✓ Managers of organizations have a responsibility to protect all workers from the harmful effects of noise generated by various work equipment in the workplace. The use of the noise control hierarchy is useful to managers, as this approach groups control measures according to their likely effectiveness in reducing or eliminating the hazard called noise. Using this hierarchy within an organization can reduce workers' exposure to noise and, by implication, in the long term, reduce the risk of occupational deafness. (see § 8.1).

- ✓ Since it was found that the daily noise exposure values for several categories of personnel, located in different production sections and taking into account the legislative provisions stipulating the employer's obligation to take measures to prevent and protect workers against the action of noise, were exceeded, considered necessary to carry out an analysis of the noise sources that generate these exceedances. The investigation consisted of a series of analyzes and determinations of the noise emission produced by the sources (work equipment), in frequency (31.5 Hz – 8,000 Hz) and comparing the results with the values of the acoustic pressure levels in octave bands corresponding to the Cz curves. (see § 8.1.3.1.).

- ✓ Considering the fact that sources have been identified that generate exceedances of the maximum limits allowed for noise exposure, noise reduction solutions have been presented. A technical solution is to place a sound-absorbing screen between the noise source and the silent area. The acoustic screen was designed and measurements were made to determine the absorption coefficient in order to choose the most effective material. This solution proved to be an effective one, as an attenuation of the noise level of almost 10 dB was achieved. (see § 8.1.3.2.).

- ✓ A good practice in informing, training and raising awareness of workers about the risk of noise exposure is noise mapping. Noise maps are noise monitoring and control tools and are part of organizational measures to reduce noise in the workplace. In the tire rubber processing factory, noise mapping was carried out, which highlighted areas with strong noise sources. A survey was also carried out to check the awareness of workers and the importance of noise maps at workplaces in the tire rubber processing plant. 85% of workers surveyed consider noise maps to be a useful tool in the workplace. (see § 8.1.4.1.).

9.2. Personal contributions

In achieving the main objective of the doctoral research-development activity, this doctoral thesis makes a series of contributions, the most important of which are as follows:

- ✓ An original synthesis of the main aspects related to occupational noise (definitions, identification in national legislation of safety and health requirements regarding exposure to noise, presentation of the main effects of noise on the body and human activity, presentation of the fundamental characteristics of noise);

- ✓ Carrying out a research on occupational morbidity and presenting statistical data on morbid entities from the last 25 years, in Romania, highlighting the situation of cases of occupational deafness;

- ✓ Researching the noise reduction methods (at the source, on the propagation paths, at the receiver) most appropriate to be applied in the tire rubber processing plant;

- ✓ Auditing the security level regarding noise in the production sections of the factory;

- ✓ Studying occupational noise assessment methods and carrying out case studies in order to choose the most suitable method that can be applied in the tire rubber processing factory;

- ✓ Conducting noise determinations for approximately 1,000 workers in a tire rubber processing plant using the function-based measurement method and calculating the daily noise exposure level;

- ✓ Interpretation of the results obtained and comparison with the limits provided for in the legislation in force in Romania;

- ✓ Identification of noise sources that affect the health and safety of workers in the tire rubber processing factory, by determining the noise emission produced by the sources, in frequency bands and presenting the results obtained in the form of graphs, comparing the values obtained with the $C_Z\ 80$ noise curves ;

✓ Proposing technical and organizational measures to prevent and protect workers against the harmful effects of noise at work, by applying the noise control hierarchy;

✓ Determining the absorption coefficient for different materials in order to choose the most effective sound-absorbing material, designing an acoustic screen and determining the level of noise reduction through measurements with and without a screen;

✓ Creation of a noise map in the factory, with the role of highlighting areas with high noise and informing and raising awareness of workers regarding the risk of exposure;

✓ Applying a questionnaire to 560 workers in all production sections, regarding the verification of workers' awareness and the importance of noise maps in the workplace;

✓ Establishing optimal solutions that can be applied in the tire rubber processing plant, aimed at reducing noise exposure and improving the working conditions of workers.

* * *

This doctoral thesis, through the issue, approach and results, develops the assessment of exposure to occupational noise and the improvement of OSH in the field of tire rubber processing, through theoretical and practical research, the results of which were presented at various scientific conferences organized in the country or abroad or publication in various specialized magazines or in the proceedings of international events.

The scientific importance of this doctoral thesis is supported by the contributions made to the improvement of OSH in the field of tire rubber processing through the proposed noise reduction solutions.

The practical importance of this doctoral thesis lies in the fact that it offers methods for evaluating exposure to occupational noise, technical solutions to reduce noise using sound-absorbing screens, organizational measures to reduce noise using noise maps and leads to the improvement of the working conditions of workers.

The partial results were written as scientific papers and presented as follows:

✓ The article "Occupational Noise Management In A Romanian Tires Manufacturing" was presented, as an author, at the IBIMA International Conference, held in Granada, Spain, on November 4-5, 2020. The article was published in the proceedings of the IBIMA International conference, ISBN: 978-0-9998551-5-7, USA. IBIMA international conference papers have been indexed by Thomson Reuters (Web of Sciences) since 2006 and SCOPUS since 2005.
https://ibima.org/accepted-paper/occupational-noise-management-in-a-romanian-tires-manufacturing/ [26]

- ✓ The article "Assessment of occupational noise exposure in tire manufacturing" was presented, as an author, at the ModTech Modern Technologies in Industrial Engineering International Conference, held in Iași, Romania, on June 23-27, 2020. The articles presented at the conference were ISI indexed. The article was published in the IOP Conference Series: Materials Science and Engineering, Great Britain. DOI 10.1088/1757-899X/916/1/012094 https://iopscience.iop.org/article/10.1088/1757-899X/916/1/012094 [25]
 1 citation, 0,81 Field Citation Ratio, 155 Total downloads;
 https://app.dimensions.ai/details/publication/pub.1142557153?order=times_cited&or_subset_publication_citations=pub.1130750007

- ✓ The article "Managing noise exposure and prevention of the hearing loss risk in tire manufacturing" was presented at the International Symposium Occupational Health and Safety SESAM, held in Bucharest on October 19, 2017. The article was published in Proceedings of the Symposium Vol. 2, ISSN 1843 – 6226, INSEMEX Publishing House, indexed BDI.
 https://sesam2017.insemex.ro/downloads/SESAM_2017_Preliminary_Agenda.pdf [27]

- ✓ The article "Methods for determination of occupational noise exposure" was drafted, as the author, and sent for review in order to be accepted for publication at Scientific Bulletin, Series D Mechanical Engineering, University Politehnica of Bucharest, BDI indexed journal.

- ✓ The article "Reducing the noise level at the workplaces using acoustic screens" was drafted, as the author, and sent for review for acceptance for publication at the Journal of Research and Innovation for Sustainable Society, a BDI indexed publication.

Participation in projects

During my doctoral studies, I benefited from participation in the project - Scholarships for entrepreneurial education among doctoral students and postdoctoral researchers (Be Entrepreneur!) Code M SMIS: 124539 Human Capital Operational Program.

The doctoral thesis can be a useful tool:

- ✓ To students and teaching staff, through theoretical and practical information that can help to better understand how occupational noise exposure assessment is carried out by the function-based method and by providing a technical noise reduction solution that can be applied with success in many organizations depending on the situation on the ground;
- ✓ organizations from all sectors, especially industrial ones;
- ✓ specialists in the field of OSH or noise who can adapt the solutions presented to the specifics of their activity, as the case may be.

9.3. Perspectives

The issue of occupational noise calls for a continuous research-development activity, to determine the risks deriving from prolonged exposure to occupational noise, because the negative effects it can have on the body and human activity are not at all negligible. For the future, I propose the implementation of several technical and/or organizational solutions, specific to each situation in the tire rubber processing factory.

I also propose to carry out studies on the assessment of noise exposure of workers in other fields of activity (hydropower sector, rail and air transport, etc.) in order to know the current situation regarding noise in these organizations and, if necessary, to implement customized solutions and ensure that as many workers as possible benefit from safe and healthy working conditions.

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