



Occupational Noise Legislation in Asia-Pacific Region

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ABSTRACT

To prevent hearing loss of workers from serious noise in the workplace, laws and regulations regarding occupational noise have been enacted in Western countries. Regarding occupational safety and health laws and regulations in Western countries, at present, "permissible exposure limit (PEL: 8-hour average)", "exchange rate (ER)", and "upper limit of impulsive/impact noise" regarding occupational noise and other requirements for noise exposure are not unified. On the other hand, not many international reports on laws and regulations related to occupational noise in the Asia-Pacific region exist. Therefore, in this study, authors investigated the laws and regulations for occupational noise in the Asia-Pacific region, and PEL, ER, "upper limit of impulsive/impact noise", "maximum permissible level", "wearing personal protective equipment", "auditory test request", "Penalties", etc. are summarized. PEL and ER were specified in 20 of the 27 countries surveyed in this study. For those countries, PELs of 85 dBA or 90 dBA, ERs of 3 dB or 5 dB and limits for impact noise of 140 dB (C) were stipulated as in Europe and the Americas. However, in South Asia, Southeast Asia and Oceania excluding Australia and New Zealand, some countries and regions still have no permissible levels. Therefore, international supports for the Asia-Pacific countries are expected in the future.

1. INTRODUCTION

In the world, there are still many workers who develop noise-induced hearing loss due to excessive noise exposure in noise workplaces such as construction work, forestry, manufacturing, transportation, etc. [1]. Since hearing loss due to prolonged noise exposure in the workplace can be prevented, permissible exposure restrictions are stipulated by law and employers are required to comply with them in many Western countries. At present, the permissible values of each country are not unified and differ depending on the country or region [2-4]. In this study, authors conducted an internet search survey on the status of legislation regarding occupational noise in the Asia-Oceania region, where legislation regarding occupational noise exposure seems to be delayed compared to Western countries.

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2. OCCUPATIONAL NOISE LEGISLATION IN WESTERN COUNTRIES

United States: In 1971, OSHA (occupational safety and health administration) established a standard with permissible exposure limit (hereafter; PEL) of 90 dBA and exchange rate (hereafter; ER) of 5 dB. Penalties for employers who violate the standards are also stipulated, and the law regarding occupational noise is strongly enforceable. Employers are obliged to have workers wear appropriate hearing protections such as earplugs and earmuffs if the worker's exposure level exceeds the limit. In 1974, ANSI S 3.19 stipulated a method for measuring the sound attenuation performance of hearing protectors [5,6]. Furthermore, in 1979, the U.S. Environmental Protection Agency (EPA) stipulated the noise reduction rating (NRR) as a single number rating for sound attenuation performance, and legislation for the hearing protection devices was also established.

Europe: Since 1970, which is the same period as the United States, many countries have specified the PEL based on the A-weighted sound pressure level. The PEL of 90 dBA or 85 dBA, and the ER of 3 dB or 5 dB have been widely used in Europe region. In recent years, it seems that many countries have set PEL of 85 dBA. In 2003, the EU Directive stipulated PEL of 87dBA [7], apart from the permissible limits of each country.

3. SURVEY METHOD

In this study, we investigated the permissible exposure level of occupational noise in the Asia-Oceania region by searching for legislations, academic papers, country reports, etc. that are open to the public on the internet. In the Asia-Oceania region, languages are often different from country to country. Therefore, not only the information in English but also the information in each country's language (Japanese, Chinese, Korean, Thai, Vietnamese, Myanmar, Indonesian, etc.) was included in the survey. The laws and regulations regarding workplace noise in Japan, our home country, are provided only in Japanese and not in English, so it seems that searching for information from outside Japan is not easy.

By the method described above, the laws and guidelines regarding occupational noise in a total of 27 countries in Asia-Pacific region were examined. Regarding the available information on laws and regulations, PEL, ER, and upper limit for workplace noise were mainly investigated. The regulations regarding the engineering controls, the audiometric tests in special health examinations and the penalty for the violation by employer were also investigated.

4. OCCUPATIONAL NOISE LEGISLATION IN ASIA-PACIFIC REGION

Table 1 summarizes the survey results of laws and regulations related to occupational safety and health.

Twenty of the 27 countries in the Asia-Pacific region surveyed had PEL and ER regulations for workplace noise. In many countries, PEL for 8 hours a day was 85 dBA or 90 dBA, and for ER was 3 dB or 5 dB. This is also common to Western laws and regulations. Many national legislations required workers exposed to noise above PEL to wear appropriate hearing protectors and to undergo regular hearing tests. Penalties for employers were also stipulated in Hong Kong, Thailand, Singapore, etc.

There were limits on impulsive/impact noise in 14 countries. Many countries have adopted the limit of 140 dB. However, the frequency weighting characteristics applied when determining the limit value were various, such as A-weighted, C-weighted and Flat. Also, the time characteristics are not unified, such as peak level or no designation. In China and South Korea, the number of impulsive/impact noise for 8 hours a day is specified according to the upper limit. In the Philippines and Thailand, PEL is regulated by 8 hours of working (exposure) hours per day as in other countries, but the working hours per week is 48 hours (6 days a week). In addition, the surveyed countries in the Asia-Oceania region other than Japan stipulate the limit for the worker's noise exposure, but the current guideline in Japan stipulate the limit for the noise level in the specific workplaces.

Table 1: Permissible exposure levels, exchange rates and other requirements for noise exposure.

	Country	Year	PEL [dBA]	ER [dB]	L_{max} [dB]	Level [dBA] Controls	Level [dBA] Auditory	Impulsive noise [dB]	Note
East Asia	China	2007	85	3		>85 P,T	>85	*1	
	Hong Kong	1993	85	3		>85 P,T		140, *2	Pe
	Japan	1992	85	3		>85 P,T	>85		Pl
	Korea	2021	90	5	115	>90 P,T,H	>90	*3	
	Mongolia	—	—	—					
	Taiwan	2020	90	5	115 A	>85 P,>90 T	>85	140	
South Asia	Bangladesh	—	—	—					
	Bhutan	2012	90	5		>90 P,H	>90	140 A	
	India	2022	85	5	110 A	>85 P,T	>85	140 pk	
	Maldives	—	—	—					
	Nepal	2017	90	5	115 A				
	Pakistan	—	—	—					
Southeast Asia	Sri Lanka	2019	85	3	*4	>85 P		140 A,pk	
	Brunei	—	—	—					
	Cambodia	2003	85			>85 P			
	Indonesia	2011	85	3	*5			*6	
	Laos	2009	85	3	*7				
	Malaysia	2019	85	3	115 A	>85 P,T	>85	140 C	
	Myanmar	—	—	—					
	Philippines	2013	90	5		>90 P		140 pk	48h/w
	Singapore	2011	85	3		>85 P,T	>85	140 C,pk	Pe
	Thailand	2006	90	5		>85 P,T	>85	140 A,pk	48h/w, Pe
Oceania	Vietnam	2016	85	3	115	>85 P			
	Australis	2021	85	3		>85 P,T	>85	140 C,pk	Pe
	New Zealand	2017	85	3		>85 P,T		140 pk	
	Fiji	2016	85	3		>85 P,T	>85	140 pk	
	Papua New Guinea	—	—	—					

Level [dBA] Controls; Noise limit for engineering control, **P;** Hearing protector, **T;** engineering treatment, **H;** Hearing conservation program, **Level [dBA] Auditory;** Noise limit for auditory test in special health check, **Note; Pe;** Penalty, **Pl;** Noise limit is defined by noise levels in workplace, not exposure levels
***1;** <122.5dB,10,000 times, <132.5dB, 1,000 times, <142.5dB, 100 times, ***2;** 200 Pa (peak sound pressure), ***3;** <120 dB, 10,000 times, <130 dB, 1,000 times, <140 dB, 100 times, ***4;** 100 dB per 15 min, ***5;** 118 dB per 14 sec., ***6;** 139 dB per 0.1 sec., ***7;** 106 dB per 4 min.

The following is an overview of the laws and regulations of each country.

4.1. East Asia

China: Legislation on occupational noise is specified in the 中国国家标准规格 (Guo jia Biao zhun: GBZ). PEL and ER are established in GBZ/T 189.8-2007 “工作场所物理因素测量 第8部分：噪声 (Measurement of Physical Agents in Workplace –Part 8: Noise)” and their criterion are 85 dBA and 3 dB, respectively. Countermeasures associated with categories of noise levels are specified in GBZ/T 229.4-2012 “工作场所职业病危害作业分级第4部分：噪声 (Classification of occupational hazards at workplaces –Part 4: Occupational exposure to noise)”. GBZ/T standard means recommended GB standard, namely, it is a standard to which the government recommends compliance (i.e. guideline). GBZ/T 229.4-2012 also includes provisions for impulsive noise, use of hearing protectors, promotion of medical examination and so on for each noise categories.

Hong Kong: Legislation on occupational noise is specified in the 工廠及工業經營(工作噪音)規例 (第59章, 附屬法例T) (Factories and industrial undertakings (noise at work) regulation (Cap. 59 sub. leg. T)) in 1993. The regulation specifies criteria for 初級措施聲級 (first action level) of 85 dBA, 二級措施聲級 (second action level) for 90 dBA and 頂級措施聲級 (peak action level) of 140 dB in terms of peak sound pressure level or 200 Pa in terms of peak sound pressure. It also requires reductions of noise exposure level so that noise exposure levels of employee are below “first action level” and “peak action level” as far as possible. For “second action level” exposures, it is required to wear hearing protection equipment and to clearly mark the hearing protection zone. Violation of these regulations may result in penalty charges.

Japan: The Guidelines for Prevention of Noise Disturbance was established in 1992. The guideline specifies a PEL of 85 dBA and an ER of 3 dB. However, PEL is determined by measuring noise levels of workplace rather than exposure levels of employee. Since this is the only exception in the Asia-Oceania region, the guideline is currently being reviewed for international consistency. The current guideline specifies use of hearing protectors, special medical examinations, noise control, health and safety training and so on. There are no provisions for impulsive noise. In addition, there are no penalties, and the guideline are not as strictly enforced as in Europe and the United States.

Korea: The 산업안전보건기준에 관한 규칙, 제 512 조 (정의) ~ 제 517 조 (청력보존 프로그램 시행 등) (Rules on occupational safety and health standards, Article 512 (Definition), Article 517 (Implementation of Hearing Preservation Program, etc.)) was established with partial amendment in 2021. The rule specifies criteria for 소음작업 (works exposed to noise), 강렬한 소음작업 (works exposed to intense noise), 충격소음작업 (works exposed to impulsive noise) and so on. The rule specifies a PEL of 90 dBA, an ER of 5 dB, a L_{max} of 115 dB and a limit for impulsive noise. Separately from the noise exposure levels of employee, 청력보존 프로그램 (Hearing Conservation Program) shall be established and enforced for workplaces that exceed noise criterion of the workplace and where health problems for employee has occurred by noise.

Mongolia: Although the МОНГОЛ УЛСЫН ХӨДӨЛМӨРИЙН ТУХАЙ ХҮҮЛЬ (Labor law of Mongolia) and the ХӨДӨЛМӨРИЙН АЮУЛГҮЙ БАЙДАЛ, ЭРҮҮЛ АХУЙН ТУХАЙ ХҮҮЛЬ (Law on labor safety and hygiene) were established in 1999 and 2008, respectively, any legislations on occupational noise were not found in our survey.

Taiwan: The 職業安全衛生設施規則 (Occupational Safety and Health Facilities Regulations), as amended in 2020, specifies a PEL of 90 dBA, an ER of 5 dB, a L_{max} of 115 dB and a limit for impulsive noise of 140 dB. If employee’s 8-hour daily noise exposure level exceeds 85 dBA, employers are required to implement hearing protection measures for employees, such as noise monitoring, use of hearing protectors, medical examination, safety and health education and so on.

4.2. South Asia

Bangladesh: The Bangladesh Labor Act established in 2006 is amended in 2018, and the Bangladesh Labor Rules also established in 2015. Any legislations on occupational noise were not found in our survey.

Bhutan: The Labor and Employment Act of Bhutan and the Regulation on Occupational Health, Safety and Welfare were established by Department of Labor, Ministry of labor and Human resources in 2007 and 2012, respectively, and a EPL for 90 dBA, an ER for 5 dB and a limit for impulsive noise of 140 dBA were specified in their regulations. Employers are required to implement hearing protection measures when noise exposure level of an employee exceeds EPL criterion (90 dBA). It is stipulated that hearing protectors should always be worn when employees exposed to noise levels of 90 dBA or higher and that hearing test should be taken once every six months.

India: Legislation on occupational noise was established in the Occupational Safety, Health and Working Conditions Code in 2020. The Model Factories Rules 120 Under Section 87, Operations Involving High Noise and Vibration Levels is also established by the Ministry of labor and employment, and a PEL of 85 dBA, an ER of 5 dB and a $L_{\max}$ of 100 dBA were specified in the rules. Impulsive noise must not be exceeded 100 times per day at 140 dB and 1,000 times per day at 130 dB, and its limit is 140 dB in terms of peak SPL.

Maldives: According to the country report published in 2019, the Occupational Health and Safety Act has been drafted for few years ago but it has not been established. No legislations for occupational noise are established.

Nepal: The Labor Act (Section 36) and the Standard of Permissible Exposure Limit for Noise at Workplace were established in 1992 and 2017, respectively, and a PEL of 90 dBA, an ER of 5 dB and a $L_{\max}$ of 115 dBA were specified in the standard. Noise monitoring procedure shall be as guided by the ISO 1996 and 1999.

Pakistan: Although the Punjab Occupational Safety and Health Act and the Punjab Occupational Safety and Health Law were established in 2019 and 2016, respectively, any legislations on occupational noise were not found in our survey.

Sri Lanka: The factory ordinance (Chapter 128, Section 58A) is established. In No.4, Section 105 of the Factories (Protection of Workers from Excessive Noise) Regulations established by the Ministry of Labor and Trade Union Relations, a PEL of 85 dBA, an ER of 3 dB and a limit for impulsive noise of 140 dBA (peak) are specified. Employees are required to wear hearing protectors when PEL exceeds 85 dBA.

4.3. Southeast Asia

Brunei: Any legislations on occupational noise were not found in our survey.

Cambodia: The Labor Law 1997 of the Kingdom of Cambodia and the Cambodia's Civil Code 2007 were established in 1997 and 2007, respectively. A PEL of 85 dBA is specified in the Prakas 138 on Noise in Workplace established in 2003. Employees are required to wear hearing protectors when PEL exceeds 85 dBA.

Indonesia: The Workplace Safety Act No. 1 of 1970 and Indonesian Labor Law Government Act No. 13 of 2003 were established in 1970 and 2003, respectively. In 2011, the Keputusan Menteri

Tenaga Kerja No. 13 Tahun 2011 (Decree of the Minister of Manpower) titled as “Nilai Ambang Batas Faktor Fisika Di Tempat Kerja” (Threshold Value of Physical Factors in the Workplace) was issued, and a PEL of 85 dBA and an ER of 3 dB were specified. There is no limit for impulsive noise, but PEL for impulsive noise is specified as 80 dBA per 24 hour or 139 dBA per 0.1 sec.

Lao PDR: The Labor Act, 1994 (Act No002/NA, Chapter X. Labor Protection, Section 49) was established in 1994. A PEL of 85 dBA under the condition of 8-hour work per day and an ER of 3 dB are specified in the ຂໍ້ຕົກລົງ ວ່າດ້ວຍການກຳນົດມາດຕະຖານສຽງດັງທີ່ເກີດຈາກໂຮງງານອຸດສາຫະກຳບຸງແຕ່ງ (Decision on the Determination of Noises from Processing Industry Factory) established by the Ministry of Industry and Commerce in 2009.

Malaysia: The Occupational Safety and Health Act 1994 and the Occupational Safety and Health Regulation (Noise Exposure) 2019 were established in 1994 and 2019, respectively, and a PEL of 85 dBA under the condition of 8-hour work per day, an ER of 3 dB and $L_{\max}$ of 115 dBA were specified in the regulation. A limit for impulsive noise of 140 dBC (peak) is also specified. Use of hearing protectors and technical measures are required when noise exposure of employees exceeds 82 dBA, and periodic hearing tests are required for those exceeding 85 dBA.

Myanmar: The Factories Act, 2016 was established in 2016, but any legislations on occupational noise were not found in our survey.

Philippines: The Occupational Safety and Health Standards, 1989 was established by the Department of Labor and Employment in 1989. The Occupational Health and Environmental Control, 2013 (Rule 1070; Occupational Health and Environmental Control) was established in 2013. A PEL of 90 dBA under the condition of 8-hour work per day and an ER of 5dB are specified in the rule. Use of hearing protectors is required when noise exposure level of employee exceeds 90 dBA. A limit for impulsive noise of 140 dB (peak) is also specified. The weekly working hours are specified as 48 hours.

Singapore: The Workplace Safety and Health Act (Chapter 354A) 2009 and the Workplace Safety and Health (Noise) Regulations 2011 were established in 2009 and 2011, respectively, and a PEL of 85 dBA under the condition of 8-hour work per day and an ER of 3 dB were specified. 47 conditions ranged from 82 dB per 16-hour to 140 dB per 1 sec or less are specified in the regulation. A limit for impulsive noise of 140 dBC (peak) is also specified. Use of hearing protectors, technical measures, hearing test and so on are required when noise exposure level of employees exceeds 85 dBA, and penalties are also stipulated.

Thailand: The Labor Protection Act B.E. 2541 (1998) was amended in 2014. The Ministerial Regulation on the Prescribing of Standard for Administration and Management of Occupational Safety, Health and Environment in Relation to Heat, Light and Noise, B.E. 2549 (2006) was established by the Ministry of Labor in 2006. A PER of 90 dBA under the condition of 8-hour work per day, an ER of 5dB and a limit for impulsive noise of 140 dBC (peak) are specified in the regulation. Use of hearing protectors, technical measures, hearing test and so on are required when noise exposure level of employees exceeds 85 dBA, and penalties are also stipulated. The weekly working hours are specified as 48 hours as in the Philippines.

Vietnam: The Law on Occupational Safety and Health, 2016 was established in 2016. Also in the same year, the National Technical Regulation on Noise –Permissible Exposure Levels of Noise in the Workplace (QCVN 24:2016/BYT) was also established by the Ministry of Health Portal. A PEL of 85 dBA under the condition of 8-hour work per day, an ER of 3 dB and a $L_{\max}$ of 115 dBA (Fast)

are specified in the regulation. Measurements for noise exposure of employees are required to be in accordance with the ISO 9612:2009.

4.4. Oceania

Australia: The Model Work Health and Safety Bill and the Model Work Health and Safety Regulation (Chapter 4 Hazardous work, Part 4.1 Noise) and the Model Code of Practice 2020, Managing Noise and Preventing Hearing Loss at Work were established by the Parliamentary Counsel's Committee. These are a consolidated version of the Model Work Health and Safety Act and Regulations. These Act and Regulations are a national model law and are intended to provide the basis for nationally consistent work health and safety laws. These Act and Regulations do not, by themselves, have any legal effect. States such as NSW employs this regulation. A PEL of 85 dBA under the condition of 8-hour per day, an ER of 3 dB and a limit for impulsive noise of 140 dBC (peak) are specified in the national model law. Use of hearing protectors, technical measures, hearing test and so on are required when noise exposure level of employees exceeds 85 dBA, and penalties are also stipulated.

New Zealand: The Health and Safety in Employment Act 1992, Section 21 and the Health and Safety in Employment Regulations 2017 were established in 1992 and 2017, respectively. Since legislations of New Zealand basically adopts the Australian model law, a PEL of 85 dBA under the condition of 8-hour work per day and an ER of 3 dB are specified in New Zealand. On the other hand, a limit for impulsive noise of 140 dB (peak) without any acoustic weightings is specified. Use of hearing protectors and technical measures are required when noise exposure level of employees exceeds 85 dBA.

Fiji: The Health and Safety at Work Act 1996 was established in 1996. To provide criterions, National Code of Practice for Occupational Noise is referred from the Health and Safety at Work (General Work Conditions) Regulations 2003, Part 13 Noise established in 2016. Since legislations of Fiji are similar to that of New Zealand, a PEL of 85 dBA under the condition of 8-hour work per day and a limit of 140 dB (peak) without any acoustics weightings are specified. Use of hearing protectors and technical measures are required when noise exposure level of employees exceeds 85 dBA.

Papua New Guinea: Although the Industrial Safety, Health and Welfare Act of 1961 and the Industrial Safety, Health and Welfare Regulation 1965 (Cap 175A) were established in 1961 and 1965, respectively, any legislations on occupational noise were not found in our survey.

5. OCCUPATIONAL NOISE LEGISLATION IN JAPAN

Table 2 summarizes the history of laws and regulations related to occupational health and safety in Japan. In 1972, the Industrial Safety and Health Act, the Enforcement Ordinance of Industrial Safety and Health Act and the Ordinance on Industrial Safety and Health were enacted, but permissible exposure limit for workplace noise is not stipulated in these legislations. In 1976, work environment measurement standards were also established. However, this standard only applied to specific indoor workplaces listed in the Occupational Safety and Health Regulations. In addition, the standard specifies how to measure noise levels in the workplace, rather than the currently internationally standard method for measuring personal exposure.

Regarding the permissible exposure limit for workplace noise, the Japan Society for Occupational Health recommended an exposure limit in 1969. The permissible exposure limit was basically evaluated by octave band analysis, but a limit of 90 dBA per 8 hours a day was tentatively set by the A-weighted sound pressure level. Furthermore, the permissible exposure limit by the Japan Society for Occupational Health in 1982 was also basically evaluated by frequency analysis by octave band analysis, but as a simple method, the PEL per 8 hours a day based on the A-

weighted sound pressure level was 85 dBA and ER was 3 dB. The permissible noise exposure limit has been still adopted to date.

In 1992, 20 years after the enactment of the law in 1972, guidelines for the prevention of noise hazards were enacted. The noise limit in the workplace is 85 dBA, and 3 dB is adopted as ER. The guidelines also stipulate wearing of hearing protectors, implementation of special health check, noise control, safety and health education, etc. However, there are no penalties and it is not operated as strictly as in Europe and the United States. The guidelines are currently being revised, and new guidelines are expected to be enacted by the end of 2022.

Table 2: History of Japanese legislation for industrial health and safety.

Year	Legislation
1972	Industrial Safety and Health Act
	Enforcement Order of Industrial Safety and Health Act
	Ordinance on Industrial Safety and Health
1976	Working Environment Measurement Standards
1992	Guidelines for Preventing Noise Hazards (noise limit in workplace; 85 dBA, ER; 3 dB)

6. CONCLUSIONS

In this study, we conducted an Internet survey on the laws and regulations related to occupational safety and health in the Asia-Oceania region and summarized the outline of the regulations regarding occupational noise.

Twenty of the 27 countries surveyed had occupational noise legislation in place. Regarding the permissible exposure noise level, 14 countries adopted 85 dBA, 6 countries adopted 90 dBA, and the exchange rate adopted 3 dB in 12 countries and 5 dB in 7 countries. A similar tendency was seen in Europe and the United States. Only 6 countries regulated the maximum permissible sound pressure level. Many countries require workers to wear hearing protection to ensure that their exposure level does not exceed PEL. Furthermore, although the impact sound was also specified in 14 countries, the frequency and time weighting characteristics of the sound pressure level are not unified, which is also the same as in Europe and the United States. In the Asia-Oceania region, the rate of compliance with laws and regulations is not as high as in Europe and the United States. It is desirable to ensure compliance with the PEL in order to prevent noise-induced hearing loss. In addition, there are still some countries for which legislation has not yet been established in the Asia-Oceania region, and international cooperation is desired.

7. REFERENCES

1. World Health Organization for South-East Asia, "Situation Review and Update on Deafness, Hearing Loss and Intervention Programmes Proposed Plans of Action for Prevention and Alleviation of Hearing Impairment in Countries of the South-East Asia Region" 2007.
2. I-INCE (convener: Tony F. W. Embleton), "Technical assessment of upper limits on noise in the workplace," Noise/News International, 97-1, 203-216, 1997.
3. T. K. Madison, Recommended changes to OSHA noise exposure dose calculation, 3M JobHealth, Highlights 25(8), pp. 1-15, 2007.
4. Jorge P Arenas, Alice H Suter, "Comparison of occupational noise legislation in the Americas: An overview and analysis," Noise & Health, Vol.16, Issue 72, 306-319, 2014.

5. ANSI S3.19-1974 (R1979), "*Method for the measurement of real-ear protection of hearing protectors and physical attenuation of ear muffs*," 1979.
6. S. Yokoyama, "A comparison of standardized methods for sound attenuation test of hearing protectors," Proc. of Inter.noise 2021, 2021.
7. Directive 2003/10/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), Official Journal of the European Union, L42, 38-44, 2003.