Criteria for ensuring acoustic safety in the assembly shops of machine-building enterprises

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Abstract. We consider the problem of providing acoustic safety at the machine-building enterprises, where manual pneumatic tools and electrical tools are widely used in assembly shops. As an example we considered the noise during operation of pneumatic tools, which are the most preferable from the point of view of ensuring electrical safety. The necessity of monitoring audiograms of operators performing assembly operations, repair and adjustment at the machine assembly lines is justified. We analyzed the types of the used pneumatic tools and their service life, measured the level of generated noise and compared the obtained data with the passport acoustic characteristics from manufacturer. As a result, we showed the need to take into account the operating characteristics of instrument while ensuring acoustic safety. The main criteria for acoustic safety are defined.

1. Introduction
The high level of noise and vibration that accompanies operation of equipment and various hand tools used in assembly shops of machine-building enterprises leads to a decrease in labor productivity, deterioration of the product quality and the workers well-being [1,2]. With a significant proportion of heavy and unskilled work, noise and vibration can cause a decrease in hearing acuity and occupational diseases. Nowadays 800 thousand units of worn-out equipment are used in the Russian Federation, and a certain part of it is pneumatic hand tools [3]. The prolonged impact of production noise on the worker body is characterized by a specific damage to the auditory system and a nonspecific damage, that is, a damage to the nervous, cardiovascular, digestive and endocrine systems. In the Russian Federation, occupational hearing loss is up to 12% in the structure of occupational pathology and takes the 3rd place after damage of nervous system, musculoskeletal system and occupational dust pathology. Reducing noise to acceptable values is one of the requirements for occupational safety. Automotive enterprise must be certified according to the GOST R 54934-2012/OHSAS 18001:2007 [4]. This series of standards contains requirements and guidelines for development and
implementation of industrial safety and labor protection management systems, the use of which allows managing risks in the management system and increasing the efficiency of its operation. To manage risk in any type of production, it is necessary [5] to identify and analyze risks, and then decide what should be done to achieve an acceptable level of risk.

Safety analysis is necessary to ensure effective and high-quality management of any kind of risk, including those associated with an increased level of noise at the enterprise [3, 6]. Establishing the rules for assessing the risks of specific and non-specific damage to the auditory system under the influence of noise, adapted to the specificity of machine-building production, is an important task of ensuring acoustic safety. The solution to this problem requires the establishment of criteria for the formation of acoustic safety. The article discusses measures to protect workplaces from noise generated in the assembly shop with manual pneumatic tools such as YD-670A and MID-600. Only proactive risk management can reduce injuries and occupational morbidity, the reactive approach is incomplete [7, 8]. Thus, thanks to the successful implementation of measures to prevent industrial injuries in Quebec (Canada), the number of injuries from 1997 to 2013 was reduced by 50,000 people [9, 10]. The concept of efficiency of labor protection measures can be interpreted differently [11], but always implies the ability of enterprises to prevent occupational injuries, the absence of accidents and occupational diseases or injuries over a long period of time [6, 12,13], safe behavior and prevention of accidents using the continuous improvement approach [14,15-19]. Criteria for ensuring acoustic safety in the machine assembly shop were determined by examining the noise characteristics of two wrenches YD-670A and MID-600, taking into account the changing noise characteristics during operation.

2. Materials and methods
The purpose of this study is to substantiate the acoustic safety criteria in the workshops of machine-building enterprises when operating with manual pneumatic tools using the example of pneumatic tools YD-670A and MID-600. The other task is to justify the use of methods for improving the acoustic safety system, taking into account the operating characteristics of the instrument. To achieve the objectives of the study, we measured the level of noise generated by the instruments, which were compared with the passport acoustic characteristics of the instruments from the manufacturer. In addition to the types of pneumatic tools, we took into account the timing of their operation. The audiograms of various stages of professional hearing loss of an employee of an assembly shop of a machine-building enterprise were examined, which showed changes in the acuity of the employee’s hearing for three years. In the development of audiometric control programs, we used the recommendations of the OHSAS 18001:2007 document. Criteria were established according to which the employer must register a case as an occupational disease according to the system [4].

3. Results
We analyzed measures to protect workplaces from the noise generated by manual pneumatic tools YD-670A and MID-600. We performed analysis of the types of instruments used, the service life of the instruments. Also we measured the noise level, which was further compared with acoustic characteristics specified in the instrument passport from the manufacturer. The production control at workplaces in the assembly shop showed, that the main sources of noise are the following: ventilation unit, background noise, manual battery and pneumatic tools. 15 workplaces were surveyed. The conducted measurements show that equivalent noise levels at workplaces of mechanic-assembly workers which use pneumatic wrenches exceed the maximum acceptable level by 2 dB. According to the passport data of the instrument manufacturer, the noise level generated by the tools is 78 dBA. The noise level of the pneumatic wrenches YD-670A and MID-600 was measured. The noise was measured at a distance of 0.5 m from the instrument and 100 mm from the human ear. The measurement results presented in Table 1 showed that the acoustic characteristics of the instrument should be carefully analyzed to reduce the noise level down to the maximum acceptable level, since a steady increase in the generated noise was observed as the service life increased.
Table 1. Measurements of actual noise level of pneumatic nut-wrenches YD-670A, MID-600.

| Nut-wrench   | Instrument operating time, months | Declared noise level in passport, dB(A) | Measured noise level, dB(A) |
|--------------|-----------------------------------|----------------------------------------|-----------------------------|
| MID-600      | 12                                | 78                                     | 92                          |
| YD-670A      | 7                                 | 78                                     | 88                          |

Thus, it can be concluded that as the wrenches operate, their noise characteristics can change significantly, which requires constant monitoring. The frequency of inspections at the workplace must satisfy the set result [20].

The increase in noise with an increase in operating time of a hand tool affects the change in timing of development of initial signs of noise affection on the human body. Figure 1 shows the audiograms of a worker at one station with a difference of 3 years.

![Figure 1](image1)

**Figure 1.** Audiograms of different stages of occupational hearing loss, which is characteristic for machine-building workers: hearing is normal and the initial stage of hearing loss.

To ensure an effective acoustic safety system, it is advisable to monitor audiometry in accordance with OHSAS 18001:2007 [4] at least once a year. The criteria is the following: if audiometry has shown the presence of a standard hearing threshold associated with the work, and if the worker’s general level of hearing is 25 dB or more above the audiometric zero, than the employer must register a case of occupational disease using the system [4]. Audiometric testing programs are regulated. The development of professional hearing loss depends on the total time of exposure to noise during the
working day and the presence of pauses, as well as the total period of work. The initial stages of occupational damage are observed for workers with an experience of 5 years, the expressed stages (hearing impairment at all frequencies, impaired perception of whisper and colloquial speech) are observed for experience over 10 years [2, 21].

4. Discussion
Assessing the efficiency of acoustic safety management is complex and is focused on several elements, including management commitment and risk management. The following criteria have been identified to ensure effective acoustic safety when working with manual pneumatic tools, taking into account the performance characteristics that change over time:

1. The procedure of daily inspection and adjustment by the operator on the line. Checking the noise level of a pneumatic instrument should be carried out by personnel directly working with the instrument (operators, masters). To adjust the noise level, one can use the torque control available on most modern models. The regulator allows one to avoid working at a higher moment than it is necessary. One can also adjust the noise level by checking the inlet air supply hose connection, since often the hose does not fit tightly to the instrument and a “whistle” effect occurs.

2. Conduct a regular risk assessment procedure. As a result of the risk assessment, problem areas of noise pollution are identified; control methods are determined; effects are assessed, a detailed noise control plan is determined: research or design; the need for revision of individual hearing protection and training programs is determined. For similar enterprises, the noise level of which exceeds the maximum permissible level, a risk assessment should be carried out at least once every 6 months. Since for 6 months according to Table 1, the level of the noise of the instrument may change significantly, this risk must be assessed together with the daily inspection and adjustment on the line.

3. Monitoring the audiograms of operators. Diagnostics of the initial stage of professional hearing loss is difficult, as at this stage speech intelligibility and tinnitus do not bother. Changes are detected only on the audiogram. None of the current regulations in the Russian Federation contains a clear algorithm for the actions of employers and medical workers aimed at primary, early and secondary prevention of occupational diseases among workers exposed to industrial noise. The problem of the primary diagnosis of occupational disease is not solved, the time of development of both the initial signs of the impact of noise on the organ of hearing, and the formation of subsequent clinical stages of hearing loss with an increase in the length of service of an employee are extended.

5. Conclusions
In the course of operation the acoustic characteristics of manual pneumatic tools can vary significantly and need constant monitoring. The increase in noise with the increase in the operation time of a hand tool affect the change in the development time of the initial signs of noise exposure on the human body, labor productivity and product quality [22]. Effective acoustic safety management of pneumatic tools can be ensured by observing the conditions of the daily inspection and adjustment procedure, the risk assessment procedure and the monitoring of the audiograms of the operators. Improving the quality of security management occurs through planning, tracking the progress of the planned actions, integrating monitoring data [23].

References
[1] Noise at work: Guidance for employers on the Control of Noise at Work Regulations 2005 Leaflet INDG362(rev1) HSE Books 2005 ISBN 0 7176 6165 2
[2] Pankova V B 2008 Professional hearing loss of transport workers Vestnik otolaringologii 3 11-4.
[3] Vanaev V S 2006 Safety of hand tools and their classification Bezopasnost’ zhiznedeyatelnosti 5 6-16.
[4] Occupational health and safety management systems – OHSAS 18001:2007.
[5] ILO Report on the World Day for Labor Safety - 2011 "The system of labor protection management: the path to continuous improvement." - ILO. 2011 - 32 pages.

[6] Mjasnikov V N, Salkucan V I 2014 Life Sci. J. 10 225-7.

[7] Roy M, Cadieux J, Fortier L, Leclerc L, 2008 IRSST 36.

[8] Sinelnikov S, Inouye J, Kerper S 2015 Saf. Sci. 72 240-8.

[9] CSST, 1997. Annual report of activities. Commission of Occupational Safety and Health. Montreal, Canada.

[10] CSST, 1997. Annual report of activities. Commission of Occupational Safety and Health. Montreal, Canada.

[11] Malayan K R 2016 Life Saf. 3 3-14.

[12] Malayan K R, Milokhov V V, Minko V M, Rusak O N, Faustov S A, Tsaplin V V, Tsvetkova A D 2014 Life Saf. 12 3-17.

[13] Yagovkin G N, Melnikova D A 2015 Basic principles for ensuring human safety in building a professional risk management system Bezopasnost’ zhiznedeyatelnosti 8(176) 9-13.

[14] Walker D, Tait R, Walker D 2004 Saf. Sci. 42 69–83.

[15] Hasle P, Limborg H J 2006 Ind. Health 44 6-12.

[16] De Koster R B M, Stam D, Balk B M 2011 J. Operat. Manage 29 753.

[17] Badri A, Gbodossou A, Nadeau S 2012 Saf. Sci. 50 190-8.

[18] Hinze J, Thurman S, Wehle A 2013 Saf. Sci. 51 23-8.

[19] Liu Y J, Chen J L, Cheng S Y, Hsu M T, Wang C H 2014 Process Saf. Prog. 33 166–171.

[20] Reiman T, Pietikäinen E 2012 Saf. Sci. 50(10).

[21] Zinkin V N, Sheshegov P M, Chistov S D 2015 Influence of features of industrial noise and infrasound on the morbidity and system of prevention measures Bezopasnost’ zhiznedeyatelnosti 5(173) 3-12.

[22] Kaverzneva T T, Smirnova O V 2013 Wear-out Effect of Construction Equipment and Hand Tools on Workers’ Labor Conditions Bezopasnost’ v tekhnosfere 3(42) 14-8.

[23] Li W, Liang W, Zhang L, Tang Q, Loss J 2015 Prev. Process Ind. 35 95–103.