SOURCES AND CAUSES OF NOISE EMISSION IN PACKAGING PLANTS – RECOMMENDATIONS NOISE REDUCTION

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In Poland, according to the Central Statistical Office, there are approx. 8 000 packaging plants. In the area of production there are approx. 230 000 employees. Most of hazards occurring at manufacturing plants are related to the operation of machines, working conditions (excessive noise and the combined impact of noise and chemical agents) as well as shift work. In many cases (depending on the type of technology applied for the manufacturing of packaging), machines and equipment are the source of excessive noise exceeding the values of maximum admissible intensity of noise. The paper presents noise sources as well as causes of noise emission at workstations in the packaging plants. Also it contains prevention activities for workers’ protection against the effects of exposure to noise in the work environment.

Keywords: sources, noise emission, packaging industry

1. Introduction

According to data of the Polish Chamber of Packages in the plants producing packages there is employed approx. 230 000 people [1, 2]. Most of hazards occurring at manufacturing plants are related to the operation of machines, working conditions (excessive noise and the combined impact of noise and chemical agents) as well as shift work [3, 4, 5]. In many cases (depending on the type of technology applied for the manufacturing of packaging), machines and equipment are the source of excessive noise exceeding the values of maximum admissible intensity (MAI) of noise [6]. The European Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) [7] and the regulation implementing it into Polish legislation [8] as well as other national regulations [9,10,11,12] require to assess the occupational risk associated with noise exposure in the work environment. Principles of occupational risk assessment are specified in Polish Standard PN-N-18002: 2011 [13]. In accordance with the recommendations of this Standard, values of the parameters characterizing exposure, in particular exposure to noise, provide a basis for estimation of occupational risk. For excessive noise occurring in the work environment, according to the regulation [9], the employer is under an obligation to either to eliminate the risks associated with risk exposure at source or to limit it to the lowest possible level, taking into account the solutions available along with technological progress. This involves simultaneous application of technical and organizational solutions properly selected based on detailed analysis of acoustic conditions at workstations.

In this paper noise sources and causes of noise emission at workstations in the packaging plants producing packages of plastics, paper and metal are determined. Also prevention activities for workers’ protection against the effects of exposure to noise in the work environment are described.
2. Test method and tested workstations

Measurements of parameters characterizing noise within the audible frequency range were performed at selected workstations in plants manufacturing cardboard, plastic and metal packagings. The following values were measured or determined: equivalent A-weighted sound pressure level (SPL) normalized to an 8-hours working day, maximum A-weighted SPL and C-weighted peak SPL. During the noise measurements the task-based measurements strategy described in the Standard EN ISO 9612: 2011, was applied [14,15].

Workstations selected for testing in the cardboard plant were associated with operation of the following machines and manufacturing lines: cardboard gluing machines (single and double), cardboard transport lines and process lines for cardboard cutting and printing (3 and 5 colours), rotational cutting, flatbed cutting and receipting of finished products (Fig. 1).

![Figure 1: Workstation of receipt of finished products](image)

Measurements of the noise level at the plastic packaging plant were carried out at workstations for the operation of automatic machines for manufacturing packaging, i.e. blowing machines (from polypropylene and polyethylene), workstations for packaging finished articles and at the workstation for operating a machine for plastic granulation (recycling).

Noise measurements at the metal packaging plant were carried out at workstations for the operation the lines for the manufacturing of metal lids (one and two components) and at workstations for conceptual works placed in (separated) rooms adjacent to the manufacturing building. The manufacturing rooms had no acoustic adaptation.

3. Results

Figure 2 presents results of the noise exposure level determined based on measurements carried out at selected workstations in the plant manufacturing cardboard. Based on the results of measurements of noise levels at selected workstations at the cardboard packaging plant, the determined noise exposure levels normalised to an 8-hours working day ranged from 70.2 dB to 90.7 dB, and thus exceeded the value of MAI of noise (85 dB), except for the main cardboard machine operator workstation (the workstation No. 3 in the Fig. 2). At this workstation the noise exposure level normalised to an 8-hours working day amounted to 70.2 dB, mainly due to work in a cabin (approx. 330 minutes per working shift). However the A-weighted equivalent SPL measured during the stay at this workstation amounted to 75.1 dB and exceeded the noise annoyance criterion (65 dB) [16].
The measured maximum A-weighted SPLs ranged from 85.8 dB to 92.2 dB, while the values of peak C-weighted SPLs ranged from 96.8 dB to 119.0 dB and did not exceed the values of MAI of noise which amount to 115 dB and 135 dB, respectively.

Figure 2: The results of the noise exposure level at workstations in the cardboard plant.

Results of the noise exposure level determined based on measurements carried out at selected workstations in plastic packaging plant are presented in Fig. 3.

At the workstations in the plastic packaging plant, the noise exposure levels normalised to an 8-hours working day ranged from 85.1 dB to 95.4 dB, the measured maximum A-weighted SPLs ranged from 86.2 dB to 104.9 dB, while the peak C-weighted SPLs ranged from 102.8 dB to 118.5 dB. At all the tested workstations, the noise exposure levels exceeded the exposure limit value of 85 dB. The remaining exposure limit values of the maximum A-weighted SPL and the peak C-weighted SPL were not exceeded.

Figure 3: The results of the noise exposure level at blowing machines in plastic packaging plant.

Figure 4 shows the results of the noise exposure level at workstations in metal packaging plant. Meanwhile, as regards the metal packaging plant, the noise exposure levels normalised to an 8-hours working day ranged from 70.5 dB to 98.9 dB, the measured maximum A-weighted SPLs ranged from 77.3 dB to 104.5 dB, while the peak C-weighted SPLs ranged from 100.1 dB to 122.1 dB. At all of the tested workstations the noise exposure levels exceeded the exposure limit value of 85 dB, exceptions include the packaging of finished products workstation (No 4 in the Fig. 4) and the manufacturing line process controller workstation (No 8 in the Fig. 4).

The A-weighted equivalent SPL measured during the stay at a controller workstation (placed in a cabin) amounted to 75.1 dB and exceeded the noise annoyance criterion (65 dB) [16]. The exposure limit values of the maximum A-weighted SPL and the peak C-weighted SPL were not exceeded.
4. **Sources and causes of noise emission at workstations**

The following sources and causes of noise emission in the tested work environment were determined:

- emissions of noise from the machines and equipment (power transmission systems, compressed air components, article transport components, shafts and devices for packaging and palletising),
- in the case of transport lines, moving metal products strike each other during transport, and this causes impulse noise,
- incorrect placement of machines and equipment (presses for metal semi-finished products were placed too close to each other), which leads to propagation of noise emissions to neighbouring workstations,
- placement of packaging workstations in proximity to process lines (and the workstations are not separated or protected with screens),
- the rooms in which manufacturing lines are usually placed are large-sized, “open space” rooms without partition walls. In addition, sound reflective walls and floors contribute to poor acoustic conditions in rooms. Rooms’ walls have no proper insulation or acoustic treatment. Even if those are present, they are either partial or, frequently, improper (e.g. corrugated sheet panels, reflecting sound waves),
- in certain manufacturing buildings there are separated rooms with office or mental workstations, into which the manufacturing noise still penetrates,
- ventilation shafts in which rapid airflow occurs due to numerous tight radius bends, narrow pipes and valves.

In addition, in paint shop departments and in certain press areas, combined effects of noise and chemical substances occur, which can accelerate the deterioration of hearing loss due to the synergistic effect of harmful factors.

5. **Recommendation of noise reduction at workstations**

The existing noise hazard at workstations in the tested packaging plants results mainly from technological noise, improper distribution of workstations and the acoustic properties of the room in which they are placed. Machines and equipment components (e.g. power transmission systems, compressed air components) and product transport components are the sources of technological noise. Their wear out and technical conditions have a significant effect on the emissions of noise to the work environment. Some placement of workstations (e.g. for receiving and packaging finished articles) are placed in close proximity to manufacturing lines, therefore technological noise has a decisive effect on the noise at these workstations.
The rooms (in which manufacturing lines in the plants are placed) are usually large-sized industrial halls without acoustic adaptation. It follows from studies into acoustic conditions of rooms, carried out at the Central Institute for Labour Protection – National Research Institute, that the acoustic properties of walls, ceilings and floors have a significant effect on the reverberation noise level at workstations. It follows from the results of these tests that reverberation noise in rooms without acoustic adaptation increases by approx. (4–8) dB [17].

In order to protect employees against the effects of noise in the work environment comprehensive preventive measures aimed at preventing the adverse effects of noise need to be taken [18,19]. In the tested packaging plants, the noise reduction may be obtained by the application of technical solutions e.g. properly selected insulation between the machines and the floor base (insulation joints or vibration dampers) and silencers in the case of pneumatic valves or cylinders. Technical solutions eliminating or limiting the occupational risk arising from the exposure of employees to noise should be supported by organisational measures. These include e.g. breaks at work and reduction (if possible) of working time at noisy workstations (it should be noted that the reduction of exposure duration by a half only decreases the exposure level by 3 dB) as well as application of appropriate collective protection measures, e.g. enclosures or baffles. Making systematic diagnoses as regards wear out of hearing protection devices, properly selected for the spectrum of the noise occurring at a workstation, should be used.

In order to improve the acoustic conditions of a room, appropriate acoustic treatment needs to be performed. It primarily involves increasing the sound absorption of walls and ceilings of industrial halls by covering them with appropriate sound absorbing materials and adequate placement of machines, the use of partition walls, barriers and acoustic screens. As regards the arrangement of the tested workstations, the distance between manufacturing lines should be increased. Moreover, the distance between the finished products receipt and packaging workstations and manufacturing lines should be increased and in certain cases these workstations should be separated from manufacturing lines with acoustic screens. Where the noise level in the vicinity of a particular workstation exceeds the acceptable level, and where it is difficult to immediately reduce it using all other available methods, hearing protection devices, properly selected for the spectrum of the noise occurring at a workstation, should be used.

The employer should not only provide personal protection equipment (PPE) but also supervise the proper use of PPE. The PPE should be used where a particular noise occurs rarely or where an employee must only periodically enter the room where noise occurred.

In addition, employees should be provided with periodical training on the influence of harmful factors in the work environment in order to raise their awareness and motivation to use individual hearing protection devices.

The above-mentioned actions limiting the influence of noise on employees in the work environment should be accompanied by preventive medical examination, including preliminary and periodic examination which should be provided by the employer. On the one hand, its aim is to avoid employing people whose functional status of the body is abnormal (as these deviations can aggravate under noise exposure conditions), while on the other, it is to limit the health effects associated with noise exposure of the already employed persons.

6. Conclusions

Based on the results occupational noise measurements at the selected workstations in the packaging plants it is concluded that:

- the measured equivalent A-weighted SPLs exceeded 85 dB at workstations.
- the maximum A-weighted SPL and a C-weighted peak SPL are below the limit values for all workstations.

The obtained results confirm the harmfulness and annoyance of noise at workstations in the field of producing packaging. In order to limit the noise exposure of workers at workstations, some technical and organizational prevention measures must be taken.
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REFERENCES


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11. Regulation of the Council of Ministers dated 3 April 2017 on the list of jobs prohibited (annoyance or harmful hazards) for pregnant and breastfeeding women. (Journal of Laws 2017 item 796).


