Emission of acoustic sources of noise in the industrial plants

Prof. Zbigniew Łukasik, PhD, DSc

Aldona Kuśmińska-Fijałkowska PhD,

Jacek Kozyra PhD

University of Technology and Humanities
Faculty of Transport and Electrical Engineering
ul. Malczewskiego 29
26-600 Radom,Poland

Abstract- Reviewing legal and normative acts that have been put into practice in recent years, it can be observed that the issue of acoustic emissions is more and more emphasized as a negative effect of anthropogenic activity. Monitoring of acoustic threats showed that there are sectors in the industry having high influence on the components of environment due to non-adjustment to EU standards. This situation creates a huge research space that should help to keep emission rates through selecting appropriate protection measures (also

through constructional changes of newly designed devices and industrial systems)

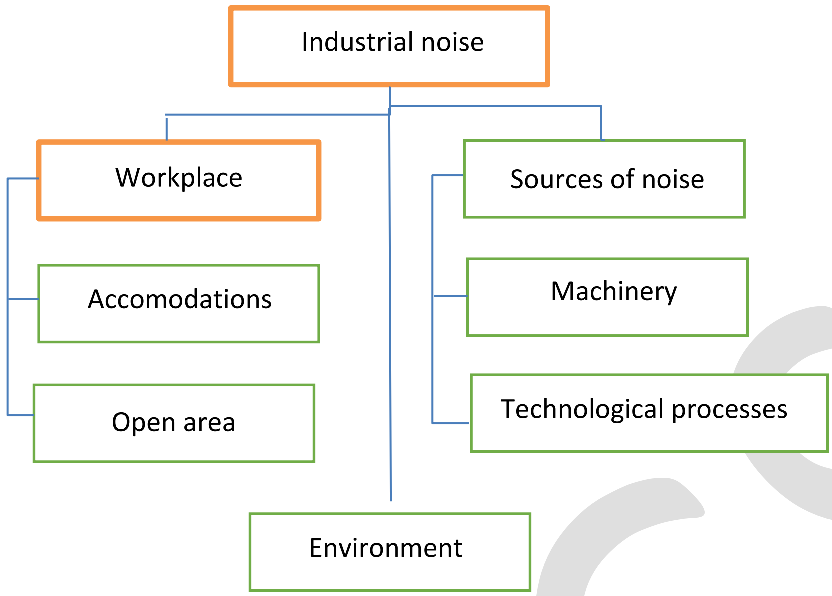
Keywords: noise, industry

Introduction

Noise is defined as every sound, which is unwanted, bothersome or even harmful to health. Harmfulness or nuisance of noise depends on its volume, frequency, character of changes in time and inaudible components, as well as such traits as health state, age, mental condition and individual sensitivity to sounds of every human.

One of the main sources of noise are technical installations and industrial plants [2, 4, 6, 8, 21]. Regardless of the technological process conducted in a plant, its machines are often based on elementary devices and apparatuses configured in different ways and belonging to different series of types.[22] As a result, different technological processes can be realized by the same devices, for example, bending brakes, laser cutters, stoves or fans having different parameters of work and various locations in a technological cycle. (Fig. 1) Level of sound emitted by the sum of these production means of industrial products depends on:

- type of technological process realized in an industrial plant,
- degree of mechanization and automation,
- type and configuration of machines,
- technical state of machines,
- form of operation of machines.



Rys. 1 Industrial noise

Limiting the danger of environment noise and vibrations depends on many factors. As a result, it is necessary to:

- conduct research and implementation works related to reduction of emission form sources of noise,
- create mechanisms forcing quick implementation of new, less noisy, but more reliable means of production and transport,
- introduce mandatory common attestation of devices emitting vibroacoustic energy to environment (permanent supervision of new products, periodic supervision of exploited means of production and transport),
- eliminate the use of means of production and transport which are based on too noisy technologies and implementing quiet technologies, automation and robotization – in order to minimize noisy processes,
- attestation and control bodies must become fully independent from producers and users of means of production and transport,
- working out and implementing legal acts (working out new ones, amendments to regulations and norms), regulating these issues [5,6,7],
- working out a system of circulation of information about the state of acoustic climate,

Above factors depend on creating an appropriate legal and economic system that will stimulate taking various activities. A basic threat for a human – a threat for civilization – can be reduced.

1. Classification of source types (point, line, area)

The industrial sources are of very variable dimensions. They can be large industrial plants as well as small concentrated sources like small tools or operating machines used in factories. Therefore, it is necessary to use an appropriate modelling technique for the specific source under assessment. Depending on the dimensions and the way several single sources extend over an area, with each belonging to the same industrial site, these may be modelled as point sources, source lines or area sources. In practice, the calculations of the noise effect are always based on point sources, but several point sources can be used to represent a real complex source, which mainly extends over a line or an area.

The real sound sources are modelled by means of equivalent sound sources represented by one or more point sources so that the total sound power of the real source corresponds to the sum of the single sound powers attributed to the different point sources.

The general rules to be applied in defining the number of point sources to be used are:

- line or surface sources where the largest dimension is less than 1/2 of the distance between the source and the receiver can be modelled as single point sources,
- sources where the largest dimension is more than 1/2 of the distance between the source and the receiver should be modelled as a series of incoherent point sources in a line or as a series of incoherent point sources over an area, such that for each of these sources the condition of 1/2 is fulfilled. The distribution over an area can include vertical distribution of point sources,
- for sources where the largest dimensions in height are over 2 m or near the ground, special care should be administered to the height of the source. Doubling the number of sources, redistributing them only in the z-component, may not lead to a significantly better result for this source,
- in the case of any source, doubling the number of sources over the source area (in all dimensions) may not lead to a significantly better result. The position of the equivalent sound sources cannot be fixed, given the large number of configurations that an industrial site can have [9]

2. Sound power emission

You must have information on the input data shown below to calculate the propagation of sound:

- Emitted sound power level spectrum in octave bands
- Working hours (day, evening, night, on a yearly averaged basis)
- Location (coordinates x, y) and elevation (z) of the noise source
- Type of source (point, line, area)
- Dimensions and orientation
- Operating conditions of the source
- Directivity of the source.

The point, line and area source sound power are required to be defined as:

- For a point source, sound power L_W and directivity as a function of the three orthogonal coordinates *(x, y, z)*,
- Two types of source lines can be defined:
- source lines representing conveyor belts, pipe lines, etc., sound power per metre length $L_{W'}$, and directivity as a function of the two orthogonal coordinates to the axis of the source line,
- source lines representing moving vehicles, each associated with sound power L_W and directivity as a function of the two orthogonal coordinates to the axis of the source line and sound power per metre $L_{W'}$, derived by means of the speed and number of vehicles travelling along this line during day, evening and night; The correction for the working hours, to be added to the source sound power to define the corrected sound power that is to be used for calculations over each time period, C_W, in dB, is calculated as follows:

$$C_W = 10 \times \lg\left(\frac{T}{T_{ref}}\right) \quad (2.1)$$

where:

V Speed of the vehicle [km/h];

n Number of vehicles passages per period [-];

l Total length of the source [m],

- For an area source, sound power per square metre L_W/m^2, and no directivity (may be horizontal or vertical). The working hours are an essential input for the calculation of noise levels. The working hours shall be given for the day, evening and night period and, if the propagation is using different meteorological classes defined during each of the day, night and evening periods, then a finer distribution of the working hours shall be given in sub-periods matching the distribution of meteorological classes. This information shall be based on a yearly average. The correction for the working hours, to be added to the source sound power to define the corrected sound power that shall be used for calculations over each time period, C_W in dB, is calculated as follows:

$$C_W = 10 \times \lg(\frac{T}{T_{ref}}) \qquad (2.2)$$

where:

T is the active source time per period based on a yearly averaged situation, in hours;

T_{ref} is the reference period of time in hours (e.g. day is 12 hours, evening is 4 hours, night is 8 hours).

For the more dominant sources, the yearly average working hours correction shall be estimated at least within 0,5 dB tolerance in order to achieve an acceptable accuracy (this is equivalent to an uncertainty of less than 10 % in the definition of the active period of the source).[9]

3. Source directivity

The source directivity is strongly related to the position of the equivalent sound source next to nearby surfaces. Because the propagation method considers the reflection of the nearby surface as well its sound absorption, it is necessary to consider carefully the location of the nearby surfaces. In general, these two cases will always be distinguished:

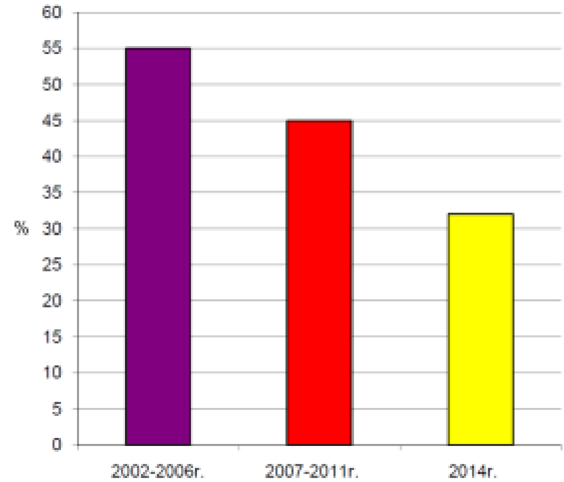
- a source sound power and directivity is determined and given relative to a certain real source when this is in free field (excluding the terrain effect). This is in agreement with the definitions concerning the propagation, if it is assumed that there is no nearby surface less than 0,01 m from the source and surfaces at 0,01 m or more are included in the calculation of the propagation,
- a source sound power and directivity is determined and given relative to a certain real source when this is placed in a specific location and therefore the source sound power and directivity is in fact an 'equivalent' one, since it includes the modelling of the effect of the nearby surfaces. This is defined in 'semi-free field' according to the definitions concerning the propagation. In this case, the nearby surfaces modelled shall be excluded from the calculation of propagation.

The directivity shall be expressed in the calculation as a factor $\Delta L_{W,dir,xyz}(x,y,z)$ to be added to the sound power to obtain the right directional sound power of a reference sound source seen by the sound propagation in the direction given. The factor can be given as a function of the direction vector defined by *(x,y,z)* with $\sqrt{x^2+y^2+z^2}=1$ This directivity can also be expressed by means of other coordinate systems such as angular coordinate systems. [9]

4. Industrial noise in Poland

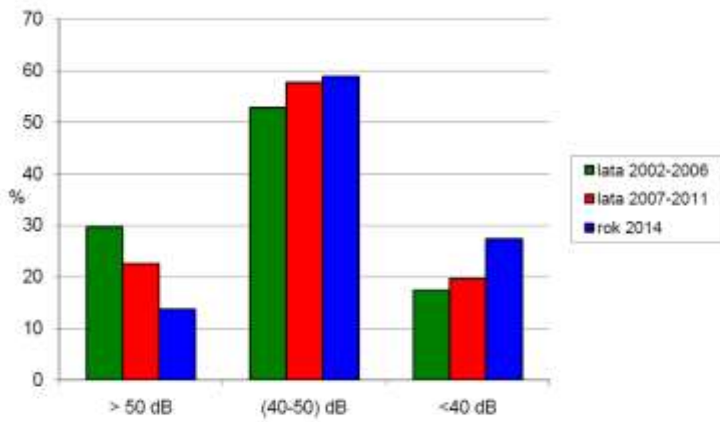
Assessment of the state of acoustic climate in Poland within industrial noise showed considerable decrease in number of plants that exceed permissible noise levels.

According to summary of previous five-year cycle (2007 – 2011), 45 % of examined plants exceeded permissible levels of noise. Whereas, on December 31, 2014, this percentage was only 32. (Fig. 2)

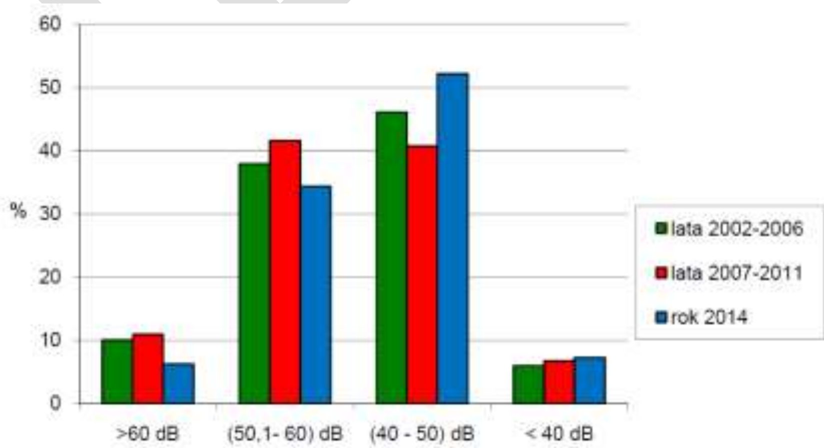


Rys. 2 Downward trend of measurements with exceeded permissible noise levels in the years 2007 – 2014 [2]

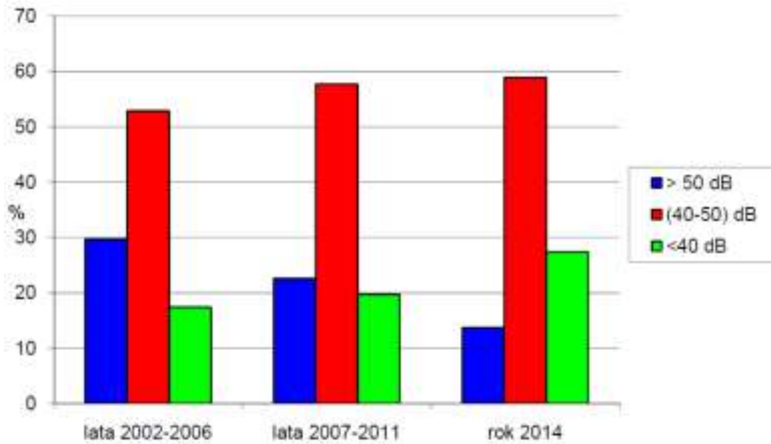
Discussed downward trend of measurements with exceeded permissible noise levels for industrial noise can be seen in the summaries below (Fig. 3- Fig. 7), which are the lists of results from 2014 with results for previous five-year cycles:



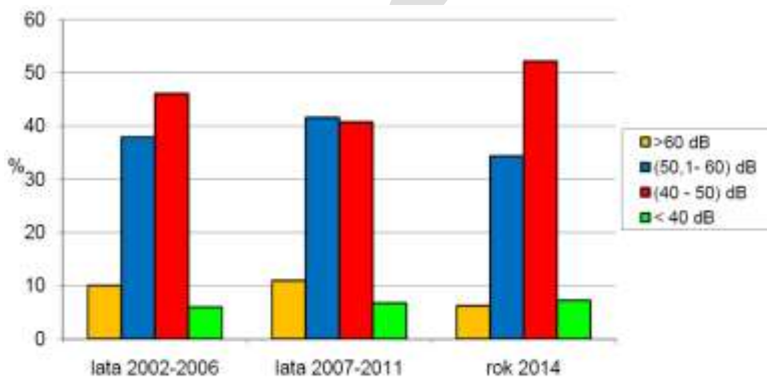
Rys. 3. Levels of noise emission of the plants in particular classes – night-time. Summary of the reporting year (2014) with results for previous five-year cycles *(lata-years, rok- year)* [2]



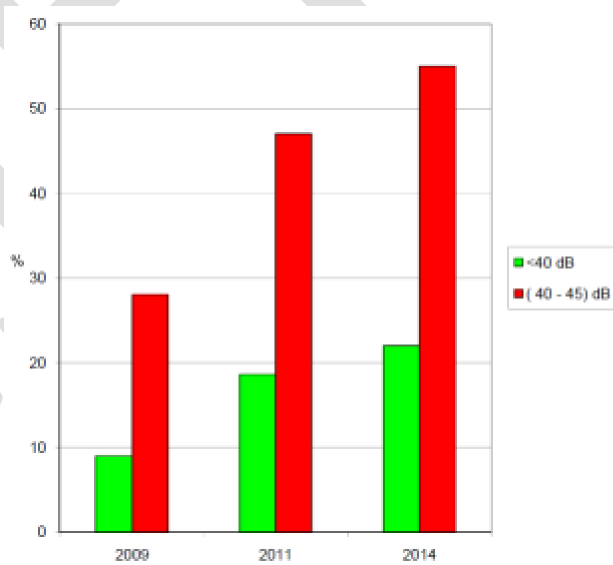
Rys. 4 Levels of noise emission of the plants in particular classes – daytime. Summary of the reporting year (2014) with results for previous five-year cycles *(lata-years, rok- year)* [2]



Rys. 5 Summary of the reporting year (2014) with levels of noise emission of the plants in particular decibel classes for previous five-year cycles – night-time *(lata-years, rok- year)* [2]



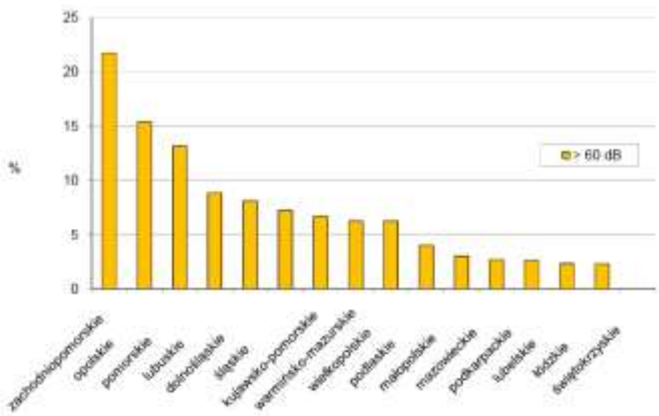
Rys. 6. Summary of the reporting year (2014) with levels of noise emission of the plants in particular decibel classes for previous five-year cycles – daytime *(lata-years, rok- year)* [2]



Rys.7. "Quiet" measurements of industrial noise in general number of measurements of industrial noise. [2]

The summaries (Fig. 3- Fig. 7) shows significant reduction of noise emission of the plants, in which measurements were performed in the last decade. It was achieved, on the one hand, by implementing protective measures. On the other hand, until the end of 2007, analysis of the state of acoustic climate within industrial noise was based only on measurements performed by wioś. On January 1, 2008, change of Environmental Protection Law was put in force and analyses were carried out both in „quiet" plants (in which measurements must be performed in accordance with art. 147 of Environmental Protection Law) and "noisy" plants.

Overall statistics concerning the noisiness of controlled plants in particular voivodeships and across the whole country can be seen on Fig. 8 below:



Rys.8 The percentage of number of controlled plants with high levels of emission (above 60 dB) in total number of examined plants – daytime [2]

Voivodeships with high percentage of measurements from art. 147 of Environmental Protection Law (Świętokrzyskie, Łódź, Mazovia, Subcarpathian) can be seen in the final part of Fig. 8. It should be added that on the Polish scale, almost half of recorded plants are measurements performed within art. 147 of Environmental Protection Law.

Conclusions

An attempt, in both European Union and Poland, to coordinate the fight with noise is one the development phase. It includes defining and standardizing methodology of measurement of noise across the European Union, checking current state of acoustic climate and building databases and implementing instruments limiting noise or protecting areas not exposed to this pollution.

Developing strategies of limiting noise should be made in two directions. On the one hand, through administrative regulations, setting and control of permissible noise levels. On the other hand, long-term educating of society about health effects of exposing to noise and changing individual and collective behaviours.

According to the measurements performed in 2014, only 32 % of plants exceeded permissible noise levels. The highest percentage of plants bad for environment was in the voivodeships: Pomeranian, Lower Silesia, Lublin, Opole, West Pomeranian, Lesser Poland. In 2014, the most noisy objects included mills, heating plants, as well as air conditioners and sound systems. Delivery transport at night is also a nuisance for a neighbourhood.

REFERENCES:

[1] Zagrożenie hałasem. Wybrane zagadnienia Luty 2012. Biuro Analiz i Dokumentacji. Zespół Analiz i Opracowań Tematycznych

[2] Instytut Ochrony Środowiska. Państwowy Instytut Badawczy- Podsumowanie Hałas

[3] E n g e l Z., P l e b a n D., Hałas maszyn i urządzeń – źródła, ocena, CIOP, Warszawa 2002.

[4] Ż u c h o w i c z - W o d n i k o w s k a I., Emisja i propagacja hałasu przemysłowego w środowisku zewnętrznym, Instytut Techniki Budowlanej, Warszawa 2008.

[5] Dyrektywa 2002/49/WE Parlamentu Europejskiego i Rady z dnia 25 czerwca 2002 r. odnoszą- ca się do oceny i zarządzania poziomem hałasu w środowisku, DzU WE L 189/12.

[6] PN-EN SO 8297:2003: Akustyka. Wyznaczanie poziomów mocy akustycznej zakładów przemysłowych z wieloma źródłami hałasu w celu oszacowania wartości poziomu ciśnienia akustycznego w środowisku. Metoda techniczna.

[7] PN-EN ISO 1996-3:1999: Akustyka. Opis i pomiary hałasu środowiskowego. Wytyczne dotyczące dopuszczalnych poziomów.

[8] Metody określania emisji i immisji hałasu przemysłowego w środowisku, instrukcja Instytutu Techniki Budowlanej nr 338/2003, Warszawa 2003.

[9] Dyrektywa Komisji UE 2015/996

[10]Łukasik, Zbigniew, Waldemar Nowakowski, and Aldona Kuśmińska-Fijałkowska. "Zarządzanie bezpieczeństwem infrastruktury krytycznej." *Logistyka* 4 (2014): 758-763.

[11] Zakrzewski, B., and D. Zakrzewska. "Przedsiębiorstwo produkcyjne i procesy realizowane w sferze produkcji." *Logistyka* (2014).

[12]Zbigniew Łukasik, Kozyra Jacek, Aldona Kuśmińska-Fijałkowska Efektywne ograniczenie zużycia energii elektrycznej w zakładach przemysłowych Technika Transportu Szynowego 12/2015

[13] Zakrzewski, B., and D. Zakrzewska. "Rola zaopatrzenia i metodyka wyboru dostawcy w działalności przedsiębiorstw przemysłowych." *Logistyka* (2014).

[14] Kuśmińska-Fijałkowska, A., and Z. Łukasik. "Efekty wynikające z wdrożenia Systemu Zarządzania Jakością." *Logistyka* (2014).

[15] Kuśmińska-Fijałkowska, A., and Z. Łukasik. "Koordynowanie działań w organizacji w odniesieniu do systemu zarządzania jakością." *Logistyka* (2014).

[16] J Kozyra Strategia rozwoju energetyki odnawialnej w Polsce Odnawialne źródła energii 2014 ISBN 978-83-267-1

[17] Łukasik, Z., Kuśmińska-Fijałkowska, A., and Kozyra, J. (2015). Technologiczny proces spawania z wykorzystaniem robota przemysłowego. TTS Technika Transportu Szynowego *12/2015*, 2707–2710.

[18] Kuśmińska-Fijałkowska, A., Łukasik, Z., and Nowakowski, W. (2015). Concept of robotics in manufacturing company. Logistyka *4*, 4387–4392.

[19] Łukasik, Z., Kuśmińska-Fijałkowska, A., and Kozyra, J. (2015). Model of Control and Visualization of Work of Belt Conveyors. International Journal Of Engineering Research and General Science *3*, 1326–1332. ISSN 2091-2730

[20] Łukasik, Z., Kuśmińska-Fijałkowska, A., and Nowakowski, W. (2015). Europe's energy efficiency requirements for household appliances. Przegląd Elektrotechniczny *91*, 194–196.

[21] Łukasik, Z., Kuśmińska-Fijałkowska, A., and Nowakowski, W. (2014). Ecological Powder Coating Technology Based on Innovative Solutions. IJARET (International Journal of Advanced Research in Engineering and Technology) *5*, 26–30.

[21] Z Łukasik, S Olszańska Optymalizacja zarządzania flotą transportową jako istotny element dyspozycji środkami transportu. Logistyka 4, 4586-4591, 2015.

[22Faheem Khan, Avneet Kr. Singh, Shobha Ram A Study of Noise Pollution in Greater Noida City – U.P., India International Journal of Engineering Research and General Science Volume 4, Issue 1, January-February, 2016 ISSN 2091-2730