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WORKPLACE QUALITY DURING THE WELDING PROCESS

12.1 INTRODUCTION

Despite the constant development of the industry, greater awareness of employers and employees in the field of Occupational Health and Safety, the man largely exposed to the harmful and disruptive factors in the environment of economic activity. According to research conducted by the Central Statistical Office (CSO) one in ten Polish employees work in their life-threatening conditions. Over 50% of workers are exposed to noise, while 20% are exposed on the dusts. The dust is one of the main factors harmful occurring in the workplace. According to the CSO in 2014 year in terms of their exposure to the harmful effects of working in the industry 125.000 workers. 95.500 people were exposed for industrial dusts, 29.500 of them were exposed for carcinogenic dusts. The harmful effects of dust on the human body can cause many diseases, including pneumoconiosis. In 2014 year, CSO found 890 cases of pneumoconiosis, which represents 15.7% of the ascertained occupational diseases. According to the Labour Code in all workplaces should be carried out actions to effectively reduce or eliminate occupational risks resulting from exposure to harmful factors, including dusts. Noise is the most common factor in harmful work environment. According to the Central Statistical Office in 2014 year. In terms of noise pollution employed 220 thousand people, which accounted for more than 1/3 of the total number of employees worked in hazardous conditions harmful work environment.

There are more than 80 different types of welding and associated processes. Some of the most common types of welding are: arc welding, which includes “stick,” or shielded metal arc welding (SMAW), the gas-shielded methods of metal inert gas (MIG) and tungsten inert gas (TIG), plasma arc welding (PAW) and submerged arc welding (SAW). Other welding processes may use oxy-acetylene gas, electrical current lasers, electron beams, friction, ultrasonic sound, chemical reactions, heat from fuel gas and robots. Welding is a potentially hazardous activity and precautions are required to avoid electrocution, fire and explosion, burns, electric shock, vision damage, inhalation of poisonous gases and fumes, exposure to intense ultraviolet radiation and noise. Welding creates major problems for health and safety, e.g.: fumes that may cause airway disease and contain carcinogenic substances, and working in confined places and/or in awkward positions. Different technology, substrates, fillers, and working conditions create many different scenarios [9].

Welding “smoke” is a mixture of very fine particles (fumes) and gases. Many of the substances in welding smoke, such as chromium, nickel, arsenic, asbestos, manganese, silica, beryllium, cadmium, nitrogen oxides, phosgene, acrolein, fluorine compounds, carbon monoxide, cobalt, copper, lead, ozone, selenium and zinc, can be extremely toxic. Generally, is used; coatings and paints on the metal being welded, or coatings covering the electrode; shielding gases supplied from cylinders; chemical reactions which result by the action of ultraviolet light from the arc and heat; process and consumables used; and contaminants in the air, for example vapors from cleaners and degreasers. The health effects of welding exposures are difficult to list, because the fumes may contain so many different substances that are known to be harmful. The individual components of welding smoke can affect any part of the body, including the lungs, heart, kidneys and central nervous system. Exposure to welding smoke may have short-term and long-term health effects [7].

Noise emitted by welding equipment is occasionally discussed in research concerning welding workers’ health. However, investigations into noise exposure and its effects among welding workers are scarce. The aim of the study was to present the exposure to noise and dusts in the workplace of the welder.

12.2 HEALTH PROBLEMS GENERATED BY WELDING

During the welding process different substances are generated and they can have the various effects in humans [2], [11]:

- the fumes generated by welding have diameters in the range of 8 to 0.01 μm and can enter the deeper parts (alveolae) of the lungs,
- metal contained in fumes like iron oxides and aluminium oxide place a strain on the respiratory tract and lungs, meaning that effects in the sense of a chronic inflammation (chronic bronchitis) may occur by an overload of particles,
- fumes containing fluorides, manganese oxide, copper oxide, have a toxic or toxic-irritating effect,
- fumes containing chromium (VI) compounds and nickel oxides are carcinogenic, may cause allergies and can occur when stainless steel is being welded,
- ozone in high concentrations is very toxic, it irritates the respiratory system and the eyes; it leads to tussive irritation, shortness of breath and sometimes oedema of the lungs,
- NO_x can also cause oedema of the lungs,
- carbon monoxide is a very toxic gas that can cause oxygen deficiency in tissues and asphyxiation; it is also a reproductive toxicant,
- as presented in the literature a wide variety of additional hazardous substances may be generated during the process that cause additional problems in humans, such as formaldehyde (cancerogenous), isocyanates (sensitising) and additional metal oxides (e.g. zinc oxide causing metal fume fever).

Epidemiological studies on welders have shown respiratory effects such as bronchitis, airway irritation, lung function changes, and a possible increase in the incidence

of lung cancer [11]. In some few cases nasal septum perforation occurred in long time stainless steel welders [6]. A recent study among 6000 Danish welders pointed at an increased risk of cardiovascular disease as well [11]. Siderosis (welder's lung) is an acknowledged occupational disease on the list of the European Union [13].
Medical surveillance of the workers may be needed, if there is:

- an exposure to carcinogenic compounds, such as chromium VI, nickel, cadmium,
- an exposure to fluorine and inorganic fluorine compounds,
- an exposure to dust concentrations above the OEL,
- need to wear breathing protection; a surveillance is needed because of the high strain from wearing PPE, carrying heavy equipment, working in uneasy postures and confined spaces and in high temperatures or outdoors.

Some hazardous substances which pass into the human organism through the inhalation of welding fumes can be determined in biological material (especially urine, full blood or blood serum or in the red blood cells). Thus, biomonitoring could be included in the medical examinations.

Noise effects were divided into two groups [3]: health effects and functional. Functional effects of the impact of noise on the human body primarily affect the efficiency, as well as on the quality of the work on the workstation through loss of concentration, orientation in the environment, or the loss of comfort. Health effects that have serious consequences can be divided into acting on the ear, and those who by their actions interfere with the work of the whole organism, that is, the effects other than on hearing [10]. Exposure to noise may pose a variety of health and safety risks to workers:

1 Hearing loss: Excessive noise damages the hair cells in the cochlea, part of the inner ear, leading to loss of hearing. "In many countries, noise-induced hearing loss is the most prevalent irreversible industrial disease". It is estimated that the number of people in Europe with hearing difficulties is more than the population of France.

2 Physiological effects: There is evidence that exposure to noise has an effect on the cardiovascular system resulting in the release of catecholamines and an increase in blood pressure. Levels of catecholamines in blood (including epinephrine (adrenaline)) are associated with stress.

3 Work-related stress: Work-related stress rarely has a single cause, and usually arises from an interaction of several risk factors. Noise in the work environment can be a stressor, even at quite low levels.

4 Increased risk of accidents: High noise levels make it difficult for staff to hear and communicate, increasing the probability of accidents. Work-related stress (in which noise may be a factor) can compound this problem.

The Control of Noise at Work Regulations 2005 requires employers to take action if daily or weekly exposure to noise is at or in excess of exposure action levels. It is recommended employers take the following steps: conduct a noise assessment, take steps to prevent or control the risks, where possible eliminate exposure to noise at source, control exposure to noise, provide Personal Protective Equipment (PPE), provide information and training, and regularly monitor and review the effectiveness of the measures. All these negative effects of noise on the human body have the social and economic aspects. It was estimated that about 50% of accidents occurring during the use of machinery and technological devices are caused by excessive noise, resulting in a general distraction. The body itself is unable to defend him self, before all existing threats, it is important to use prevention and training of employees and employers in the field of prevention and elimination of hazards caused by noise.

The most common instruments used for measuring noise are the sound level meter (SLM), the integrating sound level meter (ISLM), and the noise dosimeter. In Tab. 12.1 some properties of the equipment are presented [4].

Tab. 12.1 Guidelines for instrument selection

Type of Measurement	Appropriate Instruments (in order of preference)	Result	Properties
Personal noise exposure	Dosimeter	Dose or equivalent sound level	Most accurate for personal noise exposures
	ISLM*	Equivalent sound level	If the worker is mobile, it may be difficult to determine a personal exposure, unless work can be easily divided into defined activities
	SLM**	dB(A)	If noise levels vary considerably, it is difficult to determine average exposure. Only useful when work can be easily divided into defined activities and noise levels are relatively stable all the time
Noise levels generated by a particular source	SLM	dB(A)	Measurement should be taken 1 to 3 metres from source (not directly at the source)
	ISLM	Equivalent sound level dB(A)	Particularly useful if noise is highly variable; it can measure equivalent sound level over a short period of time (1 minute)
Noise survey	SLM	dB(A)	To produce noise map of an area, take measurements on a grid pattern.
	ISLM	Equivalent sound level dB(A)	For highly variable noise
Impulse noise	Impulse SLM	Peak pressure dB(A)	To measure the peak of each impulse

*ISLM stands for Integrating Sound Level Meter.
** SLM stands for Sound Level Meter.
Source: [1], [5]

12.3 EXPERIMENTAL PART

12.3.1 Characterization of the welder's workplace

An employee in this position is responsible for the assembly of parts and components made of steel with a welding Magomig 550. In this work, a semi-automatic welding MIG (Metal Inert Gas) is used. This method consists of welding with an electric arc that forms between a consumable electrode in the form of wire, weld material argon. The welding industry is the most commonly used method is characterized by versatility, good quality welds, and welding high efficiency and relatively low cost of consumables. The duties of the person holding the position of the welder include: transport works, preparatory work, welding of steel structures.

Welding works are performed on the part of the production hall equipped with cranes controlled from the cab, smaller cranes controlled from the operating level and welding screens (Fig. 12.1). The hall, transport track or forklift truck, construction should be fully prepared for the welding process. The edges of the structural elements are carefully cleaned, chamfered and dotted stuck spot together. View the final design prepared material for welding is presented in (Fig. 12.2). Transport employee begins work on connecting structural elements located in a designated place for four chains crane fitted with hooks (Fig. 12.3). Thus prepared, the material is transported to the position of the welder and placed directly on the floor or rack welding (Fig. 12.4).

Fig. 12.1 View of the production hall designed for the welding process

Source: [14]

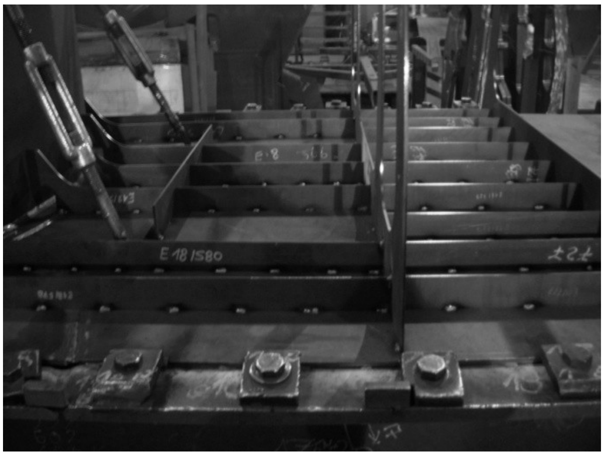

Fig. 12.2 The material prepared for final welding

Source: [14]

According to the observations, due to the nature of the work in this position, workers are exposed to: excessive noise, dust and fumes inorganic, the impact of the radiation emitted by the welding arc, and burns.

The main way to reduce harmful factors in the working environment of the welder is to use personal protective equipment. Worker welding protective clothing consisting of: welding helmet, welding hood, welding gloves, protective footwear, proofing suit dielectric properties, and helmet (used during transport using a crane).

Regulations concerning the requirements for protective clothing against welders and related occupations are included in the PN-EN 470-1. Requirements and recommendations for welding and welding stations, equipment and materials technology, skills and how to perform welding work are contained in the Regulation of the Minister of Economy, Labour and Social Policy of 14 January 2004 on safety and health at work for cleaning the surfaces, spray painting and thermal spraying.

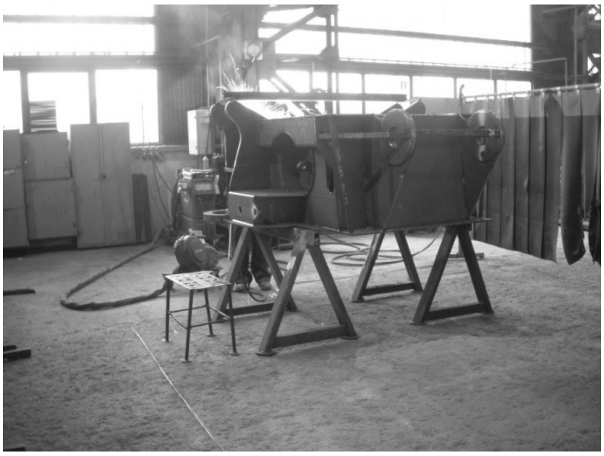

Fig. 12.3 Transportation construction on the weld

Source: [14]

Fig. 12.4 The construction is placed on racks welding

Source: [14]

12.3.2 Methods used in the work

Noise measurements were made on the basis of the following standards: PN-N-01307:1994, "Noise – Permissible values of noise in the workplace – Requirements for measurement" [12] and PN-EN ISO 9612:2011 "Acoustics – Determination of occupational noise exposure – Engineering method" [8]. Measurement of noise made by the indirect method. The research was carried out during the three basic operations. The position of the welder was welding operations on steel structures, preparatory work and transport, as well as social break. The studies included measurements of the unit, the sound equilibrated A, the maximum sound level A, C peak sound level and the level of noise exposure in relation to 8-h dimension of work. Measuring instruments used were: sound level meter SVAN 955, SV 30A acoustic calibrator.

Dust measurements were made on the basis of the following standards:

1 PN-91/Z-04030.05. „Air purity protection. Total dust content tests on workstations with filtration-weight".

2 PN-91/Z-04030.06. „Air purity protection. Research dust content. Determination of reparable dust on workstations with filtration-weight".

3 PN-Z-04008-7:2002/Az1:2004 "Air purity protection. Sampling. Principles of air sampling in the workplace and interpretation of results".

4 PN-91/Z-04018.04. „Air purity protection. Studies of the free crystalline silica" [3]. Determination of free crystalline silica in the respirable dust completely and in the presence of silicates in workplaces. Measuring instruments used were: aspirators measuring AP-2, AP-8, SKC, and rotameter R 06.

All the measurements were done in period 2012-2014.

12.4 RESULTS OF THE STUDY

In Tab. 12.2 and Tab. 12.3 the concentration of particulate matter in both total dust and respirable and noise levels are presented, respectively.

Tab. 12.2 The concentration of total and respirable dusts

Name factor	Circumstances sampling	Years	Sample numbers		Individual concen-tration [mg/m³]	Exposure index [mg/m³]	Cw/ NDS
Other toxic industrial dusts including free crystalline silica below 2%	Consumption during welding steel structures, welding, automatic welding Magomig, preparatory works and social gaps. Exposure time: 480 min	2012	Total dust	12/C	3.5	Cw=3.5	0.35
			Respirable dust	12/R	1.4	Cw=1.4	–
		2013	Total dust	13/C 13A/C	11.4 8.2	Cw=9.8	0.98
			Respirable dust	13/R	3.7	Cw=3.7	–
		2014	Total dust	14/C 14A/C	8.4 8.1	Cw=8.3	0.83
			Respirable dust	14/R	1.3	Cw=1.3	–

Source: Own elaboration

Tab. 12.3 Results of the measurement noise

Measure-ment date	The action at the workplace	Duration of activity working-Tm [min]	The duration of the measureme-nts[min]	Individual results [dB]	At the same weighted sound level A[dB]	Max. level sound A [dB]	Peak sound level C [dB]	Noise exposure level for 8h LEX,8h [dB]	Multiple limit LEX,8h
2012	1. Welding of steel structures	230	15	86.2 85.1 84.9	85.4	93.4	110.4	83.3	0.68
	2. Preparatory work, transport +noise from the hall	220	15	80.7 79.6 79.8	80.1	84.4	101.0		
	3. Social break	30	15	56.8 56.0 56.2	56.3	68.7	85.3		
2013	1. Welding of steel structures	230	5	90.6 91.0 91.1	90.9	95.1	124.2	88.4	2.19
	2. Preparatory work, transport +noise from the hall	220	5	85.1 83.0 82.8	83.8	103.2	123.2		
	3. Social braek	30	5	60.5 57.6 58.6	59.1	79.0	94.0		
2014	1. Welding of steel structures	230	5	90.1 89.4 89.7	89.7	95.3	118.1	87.0	1.58
	2. Preparatory work, transport +noise from the hall	220	5	80.1 81.0 80.7	80.6	84.5	101.3		
	3. Social break	30	5	57.1 57.5 58.0	57.5	68.3	86.5		

Source: Own elaboration

Although not exceeded NDS (maximum concentration) values for total dust containing free crystalline silica was less than 2% and the downward trend in 2014, these values were dangerously high. In 2013 the levels of both total and respirable dusts were the highest and amounted to 9.8 mg/m³ and 3.7 mg/m³, respectively. By contrast, in 2014, the concentration of dusts showed decrease. In the case of respirable dust was a significant decrease in the concentration and reached a value from 2012. Hoverer, total dust concentration slightly decreased to the value of 8.3 mg/m³, compared to 2013, which was 9.8 mg/m³ (Fig. 12.5). The persistence of high levels of total dust may be due to the deteriorating state of used machinery/equipment and ventilation equipment, causing no routine use of personal protective equipment, as well as an increase in the production capacity. The estimated risk of occurring in the described position in the three-tier scale based on the PN-N-18002:2000 specifies a little in 2012, while in the years 2013 to 2014 as an average.

The position of the welder in 2012-2013 found a high level of equilibrated sound level, which consists of separate measurements obtained. The results showed a downward trend in 2014. For the first step of the process, e.g. welding of steel structures, described parameter exceeded the limit of 85 dB over three years. In 2012, the value of the NDN (maximum exposure) has been exceeded by 0.4 dB. But, in the years 2013 and 2014 the values were 5.9 dB and 4.7 dB (Fig. 12.6). A similar situation occurred during other activities including the preparatory work and transport.

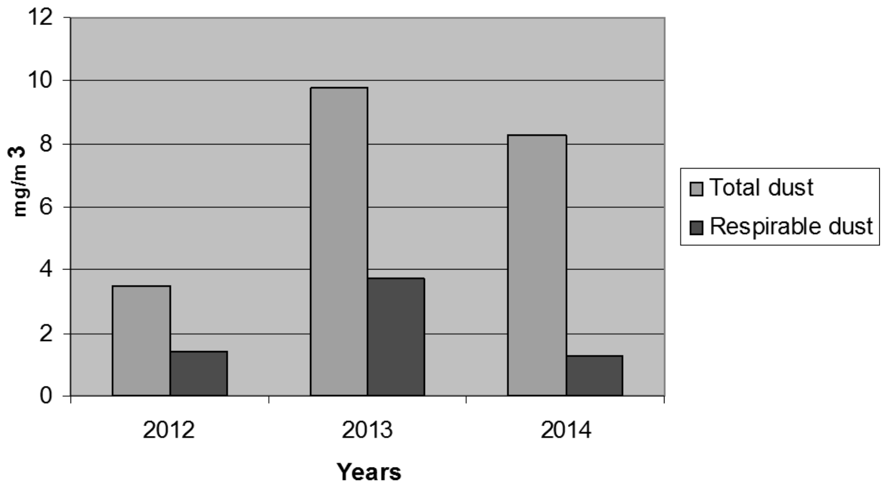

Fig. 12.5 Summary of the measured values of dust on the position of the welder in 2012-2014

Source: [14]

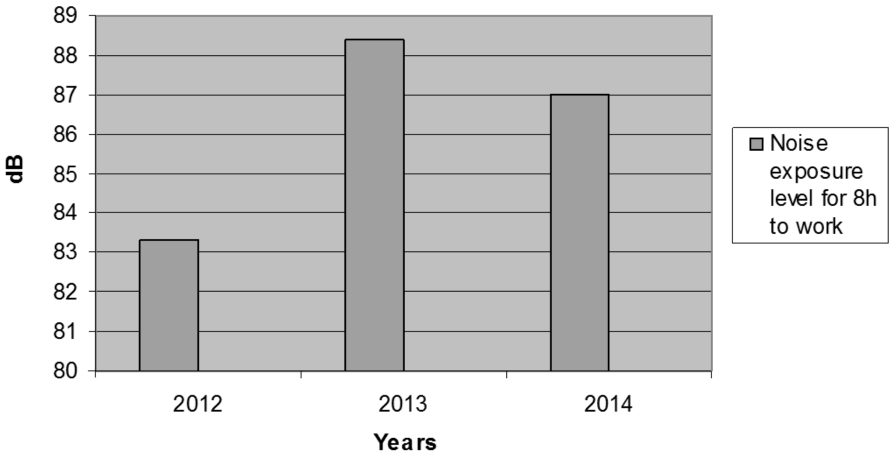

Fig. 12.6 Overview of the noise exposure level for an 8-hour operation at the position of the welder in 2012-2014

Source: [14]

During these measurements into account noise coming from the hall. In this case no exceeding of the maximum of intensity. It should be noted that in 2013 the value of the noise level was close to the upper limit value. On the other hand, in the years 2012 and 2014, the level of noise was at a similar level close to 80 dB. Measurements made during the third action, i.e. social gap, were in the range of 56.3 dB – 59.1 dB. Both, the maximum sound level and peak sound level C the position of the welder did not show NDN exceeded the measuring period. In 2013, compared to 2012, there was a significant increase in the parameters studied, even by several decibels. The highest value of the maximum sound level recorded during the operations in the number 2 (preparatory work, transport + noise from the hall) – 103.2 dB. The highest peak sound level C measured in step 1 (welding of steel structures) and amounted to 124.2 dB. The noise exposure level was exceeded for 8-hours working time of 85 dB in both 2013 and 2014 (Fig. 12.6). Times the limit value was 2.19 and 1.58 respectively, where 1 corresponds to the NDN. In 2012, the level of exposure for 8-hours limit value was not exceeded, and is characterized by multiplicity of 0.68 level.

CONCLUSIONS

Risks arising from the harmful and annoying noise, and industrial dusts are often underestimated, because the effects of the activities of these factors accumulate over time, and the measurable effect of the lack of protection is often very serious. Access means of individual and collective is unlimited. The only serious barrier is finance, which today are often layered over the health of the employee.

Measurements of the level of exposure for an 8-hours operation, which is a meaningful value that specifies the noise when changing jobs over three years significantly more likely to exceed the specified limit, or were close to the upper limit of the action causing a nuisance. During a visit to the property which is the subject of research on the position of the welder not found to be protective against noise and industrial dusts. Production hall, designed to produce large structures conducive to the production of noise coming from a variety of sources. Transport processes and those associated with strokes to remove a thin layer of slag welding are the main source of noise generation. The main source of industrial dust formation on the position of the welder is welding smoke containing particles. Regardless of the risk assessment, concentration of the industrial dust and noise level in the workplace should be monitored in accordance with the indicated frequency, and the actions and preventive measures standard. Besides the pulsed current welding machines, which improve the quality of the welds and reduce the amount of fumes, the technological development has brought more “quick and dirty” welding machines on the market as well, such as flux cored wire welding without shield gas. These can be used very easily, because they need very little training and preparations, but may cause high exposures. Therefore it is all the more necessary that the enterprises find equally easily accessible health and safety guidelines and assistance. More efforts should be put in the development of such tools or the improvement of existing ones.

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WORKPLACE QUALITY DURING THE WELDING PROCESS

Abstract: *The article presents the exposure to noise and dusts occurring during the welding process. The results of the measurements of industrial dust and noise at the welder's workplace in the period 2012-2014 are presented. Health problems generated during the process are presented. In particular, the attention is paid how to improve the quality of the work during the welding process. Proactively proposing actions that will improve the quality of the work during the welding process are described.*

Key words: *occupational exposure, welding process, industrial dust and noise, health risk*

JAKOŚĆ PRACY PODCZAS PROCESU SPAWANIA

Streszczenie. *W artykule omówiono narażenia związane z hałasem i pyłem przemysłowym występujące podczas procesu spawania, a wpływające w istotny sposób na jakość pracy i zdrowie spawacza. W części doświadczalnej przedstawiono wyniki pomiarów pyłu przemysłowego oraz hałasu na stanowisku pracy spawacza w latach 2012-2014. Zaproponowano działania prewencyjnie, które poprawią jakość pracy podczas procesu spawania i ograniczą zagrożenia zdrowotne.*

Słowa kluczowe: *narażenie zawodowe, pył przemysłowy, hałas, proces spawania, ryzyko zdrowotne*

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