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POSSIBLE HAZARDS OF WORK ENVIRONMENT IN METAL PROCESSING INDUSTRY IN LATVIA

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The aim of this study was to investigate risk factors in the work environment of Latvian metal processing industry using the database of the Laboratory of Hygiene and Occupational Diseases of the Institute of Occupational Safety and Environmental Health, Rīga Stradiņš University. During the period between 1996 and 2005, 703 measurements were made in metalworking enterprises. In Latvia, approximately 2.4% of the workforce is involved in the metal processing industry. Physical (noise, lighting, vibration) and chemical (abrasive dust, welding aerosol and contained metals) risk factors were analysed. In the assessed metalworking workplaces, the work environment was estimated to be of poor quality, because occupational exposure limits or recommended values were exceeded in 42% (n = 294) of cases. Noise, manganese and welding aerosols most often exceeded the occupational exposure limits or recommended values, the significance was $P < 0.001$, $P < 0.01$ *and* $P < 0.05$, *respectively.*

Key words: *metal processing industry, risk factors of the work environment, noise, abrasive dust, welding fume.*

INTRODUCTION

The metal processing industry is comprised of a large number of different types of enterprises in metal production, finished hardware production, wellhead equipment, machinery and machine tools production, and metal recycling. There is a wide array of existing professions in the metal processing industry, but in Latvia the most common occupations are locksmith, metal working master, welder, metal founder, engineer, the technician. According to data of the Central Statistics Bureau, the metal processing industry in Latvia employs approximately 2.4% of the working population.

Operations involved in the metal processing industry include metal production, recycling, processing (turning, grinding, welding) and others. The study showed that the majority of the employees in the metal processing industry are simultaneously subjected to effects of several risk factors: mechanical risk factors (tools, equipment, machinery, cranes), physical risk factors (noise, vibration, microclimate and lighting), chemical risk factors (abrasive dust, welding dust, metals, etc.), and extensive physical load (Ahasan *et al*., 1999; Jelinic *et al*., 2005; Anonīms, 2007). In metal processing, noise usually is elevated, especially metal cutting with grinding machine, cutting with guillotine and metal pressing. Elevated noise can lead to hearing impairment and even to occupational deafness (Eglīte, 2000). Work with hand tools like grinding machines, drills and other equipment generating vibrations can increase risk of pathologies of palm and hand vascular system, peripheral nervous system and musculoskeletal system (Kaļķis un Roja, 2001; Anonīms, 2007). An important risk factor in the metal processing industry is lighting. Unsatisfactory lighting of small details demands increased eye effort. Ultraviolet light is produced by electric arc which often causes welders to experience an eye condition called acute photo kerato-conjunctivitis or “arc eye” (Antonini, 2003).

One of the most common risk factors in the metal processing industry includes chemicals. Grinding produces abrasive dust, welding produces welding fumes containing different metal oxides, and during preparation and painting of metal constructions volatile organic compounds are released. During degreasing of metal surfaces different oil products and alkaline substances are released in the workplace air. All these hazardous components in the workplace air can significantly impact the workers health by inhalation or direct skin contact (Antonini, 2003; Hałatek *et al*., 2005; Ellingsen *et al*., 2006; Kim *et al*., 2005).

The aim of this study was to investigate risk factors in the work environment of the metal processing industry in Latvia for the period from 1996 to 2005.

MATERALS AND METHODS

During the period between 1996 and 2005, 703 measurements were made in different metalworking enterprises (n = 58) by the Laboratory of Hygiene and Occupational Diseases personnel of the Rīga Stradiņš University. The following measurements were made:

1) dust (welding aerosol, abrasive, wood dust) and chemical substances (manganese, chromium) levels (220 samples);

2) noise at the working locations of workers of the metal processing industry (121 samples);

3) lighting (illumination) (114 samples) and microclimate (196 samples); and

4) general and local technology vibration (58 samples).

Air samples of welding dust, abrasive dust and wood dust were collected from the breathing zone of the workers during active work periods. Cellulose acetate membrane filters (Millipore, 0.8 μm) with a 37-mm open-face cassette were used as collection media. The flow rate was 2 L/min (Buck and GilAir sampling equipment were used), and the sample time varied from 45 to 90 minutes according to work phase. After sampling, the filters were removed and stored for a day in a special weighing room with constant microclimate. The inhalable dust concentration was then calculated from the weight difference of the filters before and after sampling and the corresponding air volume (Bader *et al.*, 1999). The filters were then suspended in 4 ml 65% nitric acid and 2 ml 33% hydrogen peroxide, and kept at 90 °C till the filters were fully dissolved (Bake *et al.*, 1998). The concentration of manganese and chromium in air samples was determined by atomic absorption spectrophotometry (AAS) with electrothermal atomization in a graphite furnace, and Zeeman background correction.

Noise level was determined by Controller Integrating Sound Level Meter 2237 and 2231 with vibration detection by Brüel & Kjaer. Microclimate was measured with a Testo 400, and illumination by a Testo 545.

In the statistical data analyses, adequate methods were used. Assessed work place / process indicators were analysed by years and exceeding or not exceeding of occupational limit value or recommended limit value. The differences were analysed with χ^2 tests. The limit for statistical significance was set at 0.05. The statistical processing of the results was implemented by using SPSS 14.0 software (company SPSS Ltd., USA) and Microsoft Excel.

RESULTS

Figure 1 shows the distribution of measurements made in the metal processing industry. The most frequently measured indicators were noise (17%, n = 121), lighting (16%, n = 114), and microclimatic indicators: humidity (9%, n = 66), temperature (9%, n = 66), air flow velocity (9%, n = 64), and other risk factors. In the work environment of the metal processing industry, measurement of wood dust, vibration of the whole body, and asbestos were performed, as they were related to assessment of risk factors present in various spheres of the metal processing industry. The number of measurements made rapidly increased since 2003 (Table 1).

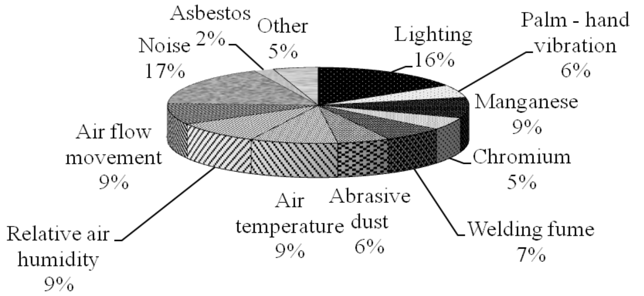

Fig. 1. Distribution of measurements in the metal processing industry taken during 1996 to 2005, made by the Laboratory of Hygiene of Occupational Diseases of the Institute of Occupational Safety and Environmental Health, Rīga Stradiņš University.

In the metal processing industry, of overall 703 assessed workplaces / processes, in 294 (42%) cases the risk factor of the working environment exceeded the permissible or recommended standards. In general, welding fume exceeded the occupational exposure limit (OEL) in 55% cases (n = 26, $P < 0.05$), abrasive dust in 63% (n = 25, $P > 0.05$), lighting in 54% (n = 61, $P > 0.05$), noise in 34% (n = 41, ($P < 0.001$); of microclimatic factors, humidity in 46% (n = 30, $P > 0.05$), temperature in 52% (n = 34, $P > 0.05$), air flow velocity in 72% (n = 46, $P < 0.01$), and manganese in 34% cases (n = 21, $P < 0.01$). Most often measured parameters are shown in Table 2. During the time period from 2004 to 2005, the number of abrasive dust measurements was increased, hence an increase was observed in the number of results that exceeded the OEL value. Statistically there was no evidence of $P > 0.05$, which means that exceeding of limit value depends on a number of measurements.

Of risk factors, the highest exposure was observed for noise ($P < 0.001$, exceeded by 1.4 to 2.3 times), as well as welding fume ($P < 0.05$) and manganese ($P < 0.01$, exceeded by 1.8 to 2.7 times).

The number of noise measurements increased rapidly during the time period of 2003–2005. Even the lowest measured noise level exceeded the maximum acceptable noise level in the work environment, which means that the acceptable noise level was exceeded in all 66 measured workplaces in 2005.

Exposure index (EI) was used to estimate the probability of health risk caused by occupational exposure to a chemical factor. EI is the ratio of the real concentration of a substance in the workplace environment to the occupational exposure limit, reflecting the extent of occupational exposure and the probability of health impact. In cases when the exposure index is 1, there is a very high probability that chemical substances in the workplace environment can cause serious damage to workers' health. The collected data showed that abrasive dust concentration in workplace air exceeded the occupational exposure level (OEL) 2 mg/m^3 in 63% (n = 25) cases, welding fume exceeded OEL = 4 mg/m^3 in 55% (n = 24) of cases, concentration of manganese exceeded

Table 1

NUMBER OF MEASUREMENTS OF RISK FACTORS OF THE METAL PROCESSING INDUSTRY FROM 1996 UNTIL 2005[1]

Indicators assessed at work place / process	Number of measurements per year									Total
	1996	1997	1999	2000	2001	2002	2003	2004	2005	
Illumination	–	5	–	–	–	–	35	13	61	114
Palm – hand vibration	–	–	–	–	–	–	–	–	38	38
Vibration of whole body	–	–	–	1	–	–	–	1	18	20
Chromium (total)	–	–	–	1	–	2	3	12	19	37
Manganese	–	10	–	–	–	3	3	21	25	62
Welding fume	–	–	–	2	–	–	3	12	29	46
Abrasive dust	–	–	–	4	–	1	2	15	18	40
Wood dust	3	10	–	–	–	–	–	–	1	14
Relative air humidity	–	–	–	4	–	–	17	9	36	66
Air temperature	–	–	–	4	–	–	17	9	36	66
Air flow velocity	–	–	–	2	–	–	17	9	36	64
Noise (Leq)	–	5	–	3	–	–	22	25	66	121
Asbestos	–	–	3	2	1	2	2	4	1	15
Total	3	30	3	23	1	8	121	130	384	703

[1]NACE classification: DJ27, DJ28, DK29, DN37.

Table 2

LEVELS OF PHYSICAL FACTORS AND EXPOSURE TO DUST AND CHEMICAL SUBSTANCES IN WORKPLACES

Risk factor or chemical substance	Year	Number of measurements (n)		Minimum	Maximum	Mean ± SD	Occupational exposure level
		total	mismatch to OEL				
Noise (Leq), dB (A)	2003	22	–	70.8	90.1	81.8 ± 6.0	$L_{Ex,\ 8h}$ = 87 dB (A)*
	2004	25	12	66.0	103.9	84.2 ± 10.0	
	2005	66	25	87.3	129.8	95.8 ± 9.4	
Illumination, lx	2003	35	2	34	690	279 ± 154	300 lx**
	2004	13	8	130	986	437 ± 280	
	2005	61	14	36	884	304 ± 242	
Abrasive dust, mg/m^3	2003	2	2	2.3	3.0	2.7 ± 0.5	2 mg/m^3 ***
	2004	15	8	1.1	19.3	4.8 ± 5.6	
	2005	18	14	0.5	115.0	18.4 ± 31.4	
Welding fume, mg/m^3	2003	3	–	1.5	2.6	2.1 ± 0.6	4 mg/m^3 ***
	2004	12	5	0.4	30.0	7.3 ± 9.4	
	2005	29	19	1.7	32.9	8.3 ± 7.8	
Manganese, mg/m^3	2003	3	–	0.010	0.020	0.013 ± 0.006	0,05 mg/m^3***
	2004	12	5	0.002	0.360	0.046 ± 0.084	
	2005	66	15	0.001	0.500	0.133 ± 0.139	
Chromium, mg/m^3	2003	3	–	0.001	0.010	0.004 ± 0.005	1 mg/m^3 ***
	2004	12	–	0.001	0.025	0.013 ± 0.008	
	2005	19	–	0.001	0.140	0.022 ± 0.037	

*"Labour Protection Requirements for Protection of Employees from the Risk Caused by the Noise of the Work Environment", where the lowest exposure value: ($L_{EX,\ 8st}$) = 80 dB(A); highest exposure value: ($L_{EX,\ 8st}$) = 85 dB(A) (the existing permissible exposure level also before 2003) and exposure boundary value ($L_{EX,\ 8st}$) = 87 dB(A); **one of the lowest most often applicable recommended values for illumination in working environment, referred to in ISO 8995:2002; *** occupational exposure limits according to standard LVS 89:2004.

OEL = 0.05 mg/m^3 in 34% (n = 21) cases. Therefore, the EI was exceeded in 63%, 55% and 34% cases, respectively.

DISCUSSION

In accordance with data of the Association of Mechanical Engineering and Metalworking Industries of Latvia, the metal processing industry was rapidly developing in the last eight years, and now it is one of the biggest contributors to the Latvian industry. As shown by other authors, from the viewpoint of the occupational health, metal processing is a very complicated industry, because the employees are subjected to different risk factors of the working environment. Physical injury from heavy equipment, vibration, electrocution, eye injuries from projectiles and radiation, exposure to solvents from degreasing, working in hot environments or those contaminated by other substances hazardous to health such as asbestos, welding fume, need to be taken into account in assessing health and safety (Hewitt, 1996).

Laboratory assessment of risks in the work environment is essential for the improvement of the work environment. During the period between 1996 and 2005, among the 703 measurements made in different metalworking enterprises, in 42% of cases (n = 294) occupational exposure limits or recommended values were exceeded. Since 2003, there was a significant increase in the number of measurements, because:

1) since 2002, many legislative acts about work protection and hygiene normative were introduced, increasing the responsibility of employers;

2) the European Union has allocated structural funds for modernisation of production equipment and working environment.

The world wide literature shows that the working conditions in the metal processing industry constitute a significant problem of occupational health in many countries. The reason for the large number of measurements exceeding the occupational exposure limits or recommended values, in Latvia, is the lack of proper ventilation facilities and use of technologically obsolete equipment.

Concentrations of chemical substances in workplace air depend on the duration of work, used materials, used technology (for example, arc welding creates higher concentrations of welding aerosols and manganese than other welding types), and effectiveness of the ventilation system. When air is evacuated from under, front or from side, compared to above, this increases the risk of inhalation of chemical substances in elevated quantities.

Manganese concentrations vary in wide range in the workplaces. Ellingsen *et al.* estimated the geometric mean manganese concentrations in the workplace air to be 0.097 mg/m^3 (range 0.003 – 4.62 mg/m^3) (Ellingsen *et al*., 2006); Lucchini *et al.* reported that in the last ten years (from 1985) the average exposure levels in different work areas have diminished from a range of 0.007 – 1.59 mg/m^3 to a range of 0.003 – 0.270 mg/m^3 (Lucchini *et al*., 1995). The manganese concentration in the investigated metal processing companies in Latvia was similar to those estimated in other countries.

In most cases, occupational exposure limits for welding fume, manganese and other metals from welding materials were exceeded in welding. Inhalation of welding fumes allows these metals to enter the bloodstream and to accumulate in inner organs, causing functional disturbance (Antonini, 2003; Kim *et al*., 2005; Park *et al*., 2006). Special care should be taken in welding in closed spaces (containers, bunkers, shafts), where adequate ventilation is not possible (Kaļķis un Roja, 2001).

The welding exposure is unique. There is no material from any other source directly comparable to the composition and structure of welding fumes. The fume refers to the solid metal suspended in air that forms when vaporised metal condenses into very small particulates. The vaporised metal becomes oxidised when it comes in contact with oxygen in air, so that the major components of the fumes are oxides of metals used in the manufacturing of the consumable electrode wire fed into the weld. Some metal constituents of the fumes may pose more potential hazards than others, depending on their inherent toxicity. The most common welding fume components are discussed as follows: chromium, nickel, iron, manganese, silica, fluorides, zinc, aluminium, copper and cadmium (Hewitt, 1996; Edmé *et al*., 1997; Antonini, 2003; Park *et al*., 2006; Schaller *et al*., 2007).

It is estimated that more than 1 million workers worldwide perform some type of welding as part of their work duties (Antonini *et al*., 2003b; Hałatek *et al*., 2005). The consequences of these types of exposure have become recognised health hazards, not only their neuropsychological impact, but also for the multi-organ damage that has come to be associated with welding. One of the toxic metals that have received considerable attention is manganese (Bowler *et al*., 2003). Chronic exposure to this metal can cause a neurodegenerative disease named "manganism" with symptoms that resemble Parkinson's disease (Lucchini *et al*., 1995; Bowler *et al*., 2003; Bowler *et al*., 2006; Quintanar, 2008). Epidemiological studies have shown that exposure to welding fumes is associated with metal fume fever and increased respiratory symptoms. In addition, welders experience an increased prevalence of inflammatory lung diseases such as asthma and chronic bronchitis (Antonini, 2003; Antonini *et al*., 2003a; Antonini *et al*., 2003b; Hałatek *et al*., 2005; Kim *et al*., 2005).

Physical stress in forced positions (working in standing, sitting or inconvenient positions) is a risk factor for metalworkers. Taking into account that tools are of different weight, work is physically hard and conducted in forced, inconvenient positions, the following health problems can develop: back, hand and leg pain/trauma/frost-bite, nervous system and blood circulation disorders (Ahasan *et al*., 1999; Eglīte, 2000).

The conclusion is that the working conditions in metal processing companies visited by our laboratory in Latvia over the study period were poor, because out of the total of 703 evaluated workplaces / processes, in 42% of cases (n = 294) occupational exposure limits or recommended values were exceeded. By analysing the results of measurements performed in metal processing industry, it can be observed that in general, most frequently, limiting or recommended values of occupational exposure were exceeded by abrasive dust (63%, n = 25), as well as welding fume (55%, n = 26), lighting (54%, n = 61), noise (34%, n = 41), humidity (46%, n = 30), temperature (52%, n = 34), air flow velocity (72%, n = 46), and manganese (34%, n = 21).

Policy makers and employers need to ensure that the provision of a safe and healthy work environment is a key consideration in all investment and production decisions, and that the workers are involved in those decisions. In this regard, the attitudes of professionals should be more possible in renouncing the unsafe working conditions.

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RISKA FAKTORU ANALĪZE METĀLAPSTRĀDES NOZARĒ LATVIJĀ

Pētījuma mērķis bija veikt galveno darba vides riska faktoru analīzi Latvijas metālapstrādes uzņēmumos, izmantojot Rīgas Stradiņa universitātes Darba drošības un vides veselības institūta Higiēnas un arodslimību laboratorijas datu bāzi. Laika periodā no 1996. gada līdz 2005. gadam tika veikti 703 mērījumi dažādos metālapstrādes, ražošanas un pārstrādes nozares uzņēmumos. Analizēti fizikālie riska faktori (troksnis, apgaismojums, vibrācija), ķīmiskie riska faktori (abrazīvie putekļi, metināšanas aerosols un tā sastāvā ietilpstošie metāli, u.c.). Apsekotajās metālapstrādes nozares darba vietās darba vides apstākļu radītais iespējamais risks strādājošo veselībai ir nozīmīgs, jo 42% (n = 294) mērījumu tika pārsniegtas arodekspozīcijas robežvērtības vai rekomendējamie lielumi. Visvairāk rekomendējamos lielumus vai arodekspozīcijas robežvērtības pārsniedz troksnis ($P < 0.001$), metināšanas aerosols ($P < 0.05$), mangāns ($P < 0.01$).