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Measuring Concentration of Welding Fumes in Respiratory Zones of Welders: An Ergo-Toxicological Approach

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Abstract: Welding is a critical and important operation in various industries. The operation produces poisonous fumes and gases that can cause respiratory problems towelding technicians. National Institute of Occupational Safety and Health estimates that at least 2 million workers arerecruited as welders. This makes it necessary to preserve and protect the well-being of researchers by measuring the level of fumes inhaled by researchers. A descriptive-cross sectional study was carried out in welding workshops within the Nahav and Hamadan City of Iran. In order to measure the density of welding fumes in respiratory spaces, NIOSH 7300 and 7048 were followed. The collected data were compared with NIOSH and ACGIH standards and the results were presentedin tables and diagrams. As shown by the results, out of 15 specimens taken from the respiratory system of subjects, 3 (20%) met the standards and 12 (80%) exceeded the standards. This result indicated an imperative need to find alternative processes, provide ventilation systems for research shops and welding spots, equip the workers with respiratory masks, carry out routine check-ups so that their exposure to welding fumes can be reduced.

Key words: Ergo-toxicology, respiratory, zone, welding, fume

INTRODUCTION

One of the highly required expertizes in the industry is welding (Antonini *et al*., 2004). It is one of the key processes in almost all industries. According to the National Institute of Occupational Safety and Health (NIOSH) about 2 million workers were involved in welding operations in 1988 (Hedenstedt *et al*., 1977; Yoon *et al*., 2003). Welding is a risky operation and the technicians are at high risk; therefore, detecting and preventing these risks could improve the health and guarantee the safety of these researchers (also the most valuable asset) (Yoon *et al*., 2003). According to the welding institute, welding is the process of attaching two pieces of metalsat high temperatures with or without a filler metal. The profession deals with cutting metals, brass working and soldering (Sjogren, 1994). Among several hazardous factors such as fumes, gases, vapors, high temperatures, noise, non-ionizing radiations (e.g., UV) that are involved in welding operations, fumes are the main risk factors with

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regards to occupational health (Yoon *et al*., 2003). Welding fumes are metallic oxides that evaporate from metal and oxygen reactions. The respiratory system of technicians might be exposed to the fumes. The main element in fumesis iron oxide (Antonini *et al*., 2004). Inhaled particles are smaller than 10 μ in diameter and may reach the smallest pulmonary bubbles (Giahi *et al*., 2014). Other metal elements such as manganese, nickel, chrome, copper, lead, molybdenum, cobalt, cadmium and aluminum can be found in welding fumes (Hassani *et al*., 2012). Reports estimate that 5 million weldersare exposed to welding fumes every day in the world (Yu *et al*., 2011). There are also reports that 462,000 welders are full-time workers in the USA and this figure probably increasedby 5% in 5-7 years (Sriram *et al*., 2010). Concentration of fumes produced in a welding operation is a function of welding operation, type of alloy, voltage, impedance volume, gas content in the environment, evaporation, temperature, chemical reactions and the elements used in electrod (Antonini *et al*., 2004). Common respiratory diseases among welding technicians are rhinitis, asthma, chronic bronchitis and emphysema (Yoon *et al*., 2003; Barkhordari *et al*., 2011). The International Agency for Research on Cancer (IARC) has classified welding and cutting fumes into 2B classes, i.e., probable causes of cancer (Nielsen and Wolkoff, 2010). Taking into account the unwanted effects caused by welding fumes on the health of welders, American Conference of Governmental Industrial Hygienists (ACGIH) recommends the acceptable exposure level to welding fumes be equal to TLV-TWA 5 mg/m^2 (Liu *et al*., 1995). In addition, gases and vapors produced by welding operations (e.g., ozone, nitrogen oxide, CO and metallic vapors) can afflict the respiratory system and reduce respiration ability of the workers (Castleman and Ziem, 1994). With this introduction, the present study aimed at measuring density of welding fumes within there spiratory environment of researchers in welding workshops.

MATERIALS AND METHODS

A descriptive-cross sectional study was carried out in a welding workshop in Nahavand, Hamadan, Iran. NIOSH 7300 and NIOSH 7048 standards were followed in order to collect specimens from respiratory spaces and to measure the density of fumes produced in welding processes. Respiratory space of a researcher is a sphere with 30 cm in diameter around the nose and mouth of the researcher (Liu *et al*., 1995). The equipment used for sampling included cellulose ester filters (dried out in desiccator in advance), cassettes, personal sampling pumps with 1-3 L discharge rate, connection pipesand a scale (0.8 μ). SKC personal sampling pump (made in the UK) and cellulose ester filter with 0.8 μ in pore size and 37 mm in diameter were used according to the standards. In order to conduct the sampling, the pumps were calibrated by rota meter and then the filter was placed in the desiccator filled with active silica gel (humidity absorbent). The preliminary weight of the filters was recorded before placing them in the cassette. The sampling circuit was closed by connecting the pipes and adjusting discharge rates of the pump and then the samples were collected. The filters were weighed after sampling and density of the fume was obtained by subtracting the secondary weight from the preliminary weight. The figures obtained were compared with national and international standards and NIOSH codes (Table 1, 2 and Fig. 1-3).

Table 1: Density of fumes measured in respiratory space

Density (mg/m^3)	Required volume (mL)	Time (min)	Discharge (L m^{-1})	Difference between the early secondary weights of the filter (mg)	Secondary weight (w) (mg)	Early weight (w) (mg)	Specimen
7.84	0.1020	60	1.70	0.8	26.8	26.0	1
7.05	0.1275	75	1.70	0.9	27.2	26.3	2
5.88	0.1020	60	1.70	0.6	27.1	26.5	3
5.22	0.1530	90	1.70	0.8	28.3	27.5	4
4.20	0.1190	70	1.70	0.5	27.5	27.0	5
5.49	0.1275	75	1.70	0.7	27.7	27.0	6
6.53	0.1530	90	1.70	1.0	27.2	26.2	7
9.8	0.1530	90	1.70	1.5	27.4	25.9	8
3.92	0.1020	60	1.70	0.4	27.2	26.8	9
5.22	0.1530	90	1.07	0.8	27.1	26.3	10
4.84	0.1445	85	1.70	0.7	26.7	26.0	11
8.49	0.1530	90	1.70	1.3	27.6	26.3	12
6.86	0.1020	60	1.07	0.7	26.8	26.1	13
5.88	0.1360	80	1.70	0.8	26.8	26.0	14
7.18	0.1530	90	1.70	1.1	27.3	26.4	15

Table 2: Comparing the measured values with NIOSH's standards

Results	Acceptable density (NIOSH) (mg/m^3)	Obtained density	Specimen
Non-acceptable	5	7.84	A
Non-acceptable	5	7.05	B
Non-acceptable	5	5.88	C
Non-acceptable	5	5.22	D
Acceptable	5	4.20	E
Non-acceptable	5	5.49	F
Non-acceptable	5	6.53	G
Non-acceptable	5	9.80	H
Acceptable	5	3.92	I
Non-acceptable	5	5.22	J
Acceptable	5	4.84	K
Non-acceptable	5	5.49	L
Non-acceptable	5	6.86	M
Non-acceptable	5	5.88	N
Non-acceptable	5	7.18	O

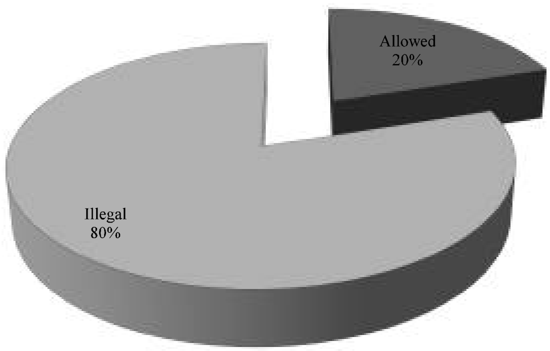

Fig. 1: Results of measurements

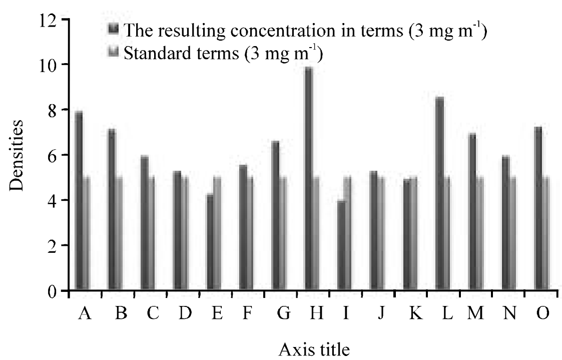

Fig. 2: Comparing the obtained densities with the standards

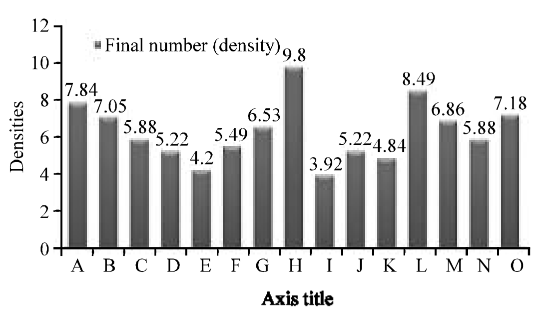

Fig. 3: Density of fumes in respirator space

RESULTS AND DISCUSSION

One of the main measures to detect occupational diseases is to survey the work environment and hazardous factors in details. General survey of the welding workshop in this study showed considerable volumes of respiratory pollutants at the site. Similar results have been reported in previous studies (Sharifian *et al*., 2011). As the findings showed (which were expected), exposure to metallic fumes results in the development of symptoms of respiratory diseases and loss of pulmonary functions (Giahi *et al*., 2014). From the results of accurate measurements it is clear that density of fumes in respiratory space of the subjects was not acceptable in 12 cases (80%). Acceptable range of fumes density according to NIOSH and ACGIH is TLV-TWA 5 mg/m^3. In order to reduce the risk of diseases and probable side effects caused by exposure to welding fumes, the exposure must be minimized. That is to avoid inhaling the fume and this needs a portable ventilation system, job rotation and provision of personal safety equipment.

Due to the high density of hazardous elements in a welding site, OSHA recommends at least one annual check-up for all welders; the check-up must include normal tests along side the lungs, skin, eyes, heart andhearing tests. It is essential to fill out respiratory symptoms questionnaire and carry out spirometry tests for welding researchers once a year (Sharifian *et al*., 2011). Administration Bonneville Power's (BPA) protocol necessitates doing annual check-ups on welders. Medical files, chronic diseases, special medicines taken by the individual, allergies, smoking or drinking habits, research records; general clinical examination with emphasis on the lungs, skin, eyes, heart, hearing and pre-clinical tests such chest X-ray must be checked every 5 years at the time of recruiting. With regards tospirometry test, NIOSH states that welders have to encounter the risk of exposure to hazardous welding gases, even when density of the elements is less than the acceptable level recommended by OSHA. The institute recommends following standard procedures and engineering controls in order to minimize exposure to the welding fumes (Loukzade and Johromi, 2013). Inhaling welding fumes causes different effects on the welder's pulmonary function which is subject to the condition in which measurements have been done (in laboratory or at site), different densitiesof fumes, different welding processes, time of exposure, ventilation system and other risk factors such as smoking (Antonini *et al*., 2003; Meo *et al*., 2003). At any rate, several studies have shown that exposure to welding fumes attenuates pulmonary function indices. There are reported relationships between dosage of exposure and research experience and indices of pulmonary function (Sharifian *et al*., 2011; Meo, 2003). Risk of developing allergies to respiratory airways in welding researchers is significantly higher than people who are not exposed to the fumes. Therefore, measures such as improving ventilation systems at welding sitesusing personal safety equipment andholding training courses for welders about welding fumes and the side effects neededto be taken (Davoodi and Bojari, 2009). Our findings showed that in more than 80% of the subjects, metal fumes exceeded ACGIH and NIOSH standards. This indicates the need to improve ventilation systems at the sites and to take managerial steps towards the reduction of exposure time to promote quality of safety equipmentand provide necessary education.

CONCLUSION

This study refers to theergo-toxicological approach in a new issue of occupational exposure. This exposure of welding may be referred to the posture at research. The quantitative aspect of ergonomics must be done (Kalte *et al*., 2014) and exposure assessment in respiratory zones must be conducted with analysis of welders' posture. Exposure assessment with macro ergonomics methods affect the safety of climate in occupational risk assessment (Khandan *et al*., 2011, 2012). Welding fume is very fine and exposure assessment based on nano-particlesmust be done as a new issue in assessment and gravimetric methods; it is old-fashioned and doesn't exactly need exposure assessment (Taghavi *et al*., 2013). The executive program from exposure control must be done in all industries such as infection control in hospital (Vatankhah *et al*., 2014).

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