Manufacturing Science and Education 2025

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 68, Issue Special III, August, 2025

DETERMINATION OF NOXIOUS EMISSIONS RESULTING FROM THE WELDING PROCESS

Nicoleta-Monica LOHAN, Mihaela PAȘCU, Anișoara CORĂBIERU, Elena MATCOVSCHI, Gheorghe BĂDĂRĂU, Mihai POPA, Mihai-Adrian BERNEVIG

Abstract: *In the engineering industry, metals and alloys used in the manufacture of metal products and structures are subjected to welding processes, which can release metal vapors, harmful dust and particles into the air, with negative effects on workers' health and the environment. Some joining methods generate hazardous gases, categorized as greenhouse gases, toxic gases, flammable gases and explosive gases. There are clear regulations on the permissible limits for concentrations of metallic and non-metallic particulates and gases emitted by various industrial processes, including welding. The aim of this research was to measure chemical agents in the workplace air as well as respirable and respirable dust concentrations in the workplace atmosphere at a company in the Semi-Fabricated Joining Section for the position of a manual electric welder. The determinations of chemical agents and of respirable and inhalable dusts were carried out in the workers' breathing zone between 08^{00} and 14^{00}.*
Keywords: *occupational health, welding, welding fume, risk factor.*

1. INTRODUCTION

At the European level, the issue of measuring welding emissions is extremely important, as research and development in the priority areas of science and technology continues to be carried out in order to restructure and modernize new environmentally friendly production technologies, new materials and traditional industrial sectors to bring them in line with modern health, safety and environmental protection requirements [1,2].

This has become a topical issue, based on the need to reduce the concentration of certain pollutants in the air breathed in workplaces and industrial process spaces for the production of welded structural metallic components, and specific technical solutions have been developed to reduce these emissions in accordance with the legislative requirements in force [3].

The problem of research into the emissions of harmful substances from specific welding and associated processes with a view to the development of environmental protection measures must be addressed simultaneously with “the development of environmental protection measures” [4]. These measures should be linked to strategies to protect workers' health by reducing the amount of harmful substances released into the environment from welding processes and related activities [5] Reducing production costs should not affect occupational safety, health and protection of workers, on the contrary this requires certain investments in the design and construction of installations, machinery, equipment and apparatus in order to make existing processes environmentally friendly and to introduce new ones with an environmentally friendly operating principle [6]. All these measures are in line with the development and implementation of "green" industries, which aim to reduce negative environmental impacts [7,8]. Fume and gas particles emitted during welding processes are sampled and controlled according to standard methods. Oxides emitted during welding include two categories [9,10]: (i) particles of metals (cadmium, beryllium), non-metals and specific

substances with potentially or specifically harmful or hazardous effects contained in welding fumes; (ii) toxic or hazardous gases resulting from certain chemical reactions occurring during the welding process as thermal and side effects. Welding workers are exposed to toxic fumes and gases generated during the welding process, which may pose a significant risk to their health [11, 12]. Many acute poisonings caused by excessive or severe short-term exposure to welding fumes and gases have been studied over a long period of time. "Acute and chronic health risks are associated with welding fumes. Occupational lung disease, including lung cancer, is the most common health risk for workers, but welding can also have negative effects on their eyes and skin" [13]. Effects on the respiratory system include irritation, asthma, metal fume fever, acute pneumonia or chronic obstructive pulmonary disease [14]. Other health effects of welding include skin effects (allergic contact dermatitis released during welding nickel and chromium), neurological effects, ocular melanoma or arc-eye. There is also no conclusive information on the effects of welding chromium, nickel and aluminium.

The present work aims to evaluate and measure the emissions of hazardous substances and pollutants in typical welding processes in the *Semi-Fabricated Joining* section, for the workstation *Manual Electric Welder*, during the working hours 08^{00}-14^{00}. In order to study, determine and measure the fume and gaseous emissions from individual welding processes, measurements were carried out in accordance with the requirements and conditions specified in the relevant industry standards

2. EXPERIMENTAL

For the Semi-Fabricated Joining Section of the company, for the post of Manual electric welder, the concentrations of chemical agents in the workplace air as well as respirable and inhalable dusts present in the atmosphere of the work area were determined. In the section there are 5 welding benches, numbered from 1 to 5, with a distance of 3 m between them, without partition panels; the workers perform electric welding operations with continuous wire, in a gas shielding environment. At the section level, the technological ventilation is composed of a system of nox exhausting by means of ventilation apparatus. The determinations of chemical agents were carried out by sampling with a Drager Accuro 2000 pump to which short-duration colorimetric tubes specific for each chemical agent were attached according to the standards in force: "*SR EN ISO 22065:2020 Workplace air - Gases and vapours - Requirements for evaluation of measuring procedures using pumped samplers"* [15]; "SR ISO 8760:2001 *Work-place air - Determination of mass concentration of carbon monoxide - Method using detector tubes for short-term sampling with direct indication"* [16]; "SR ISO 8761:2001 *Work-place air - Determination of mass concentration of nitrogen dioxide - Method using detector tubes for short-term sampling with direct indication"* [17]; "SR EN ISO 23861:2022. *Workplace air - Chemical agent present as a mixture of airborne particles and vapour — Requirements for evaluation of measuring procedures using samplers"* [18]; "SR EN ISO 689 +AC:2019 - *Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values"* [19].

Dust (non-specific effect particulate matter and ferric oxide dust) in the workplace was measured according to "SR EN 12341:2014 *Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter"* [20] and "SR EN 13205-2:2014 *Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 2: Laboratory performance test based on determination of sampling efficiency"* [21] with a Casella Microdust Pro CEL 712 real-time dust monitor, calibration was done with gravimetrically verified calibration factor.

3. RESULTS

3.1 Determination of chemical agents

The examination of gas emissions from the gas shielded arc welding process was carried out by authorized personnel. For the determination

of chemical agents in the air of the sampled workplaces, in the workers' breathing zone, between 08^{00} - 14^{00}, 3 measurements were performed for the left-side workbench (WB 1), the middle one (WB 3) and the right-side bench (WB 5).

The amounts of nitrogen dioxide (NO_2), ozone (O_3), carbon dioxide (CO_2) and carbon monoxide (CO) were determined for each workbench. The values obtained are presented in Tables 1-3.

Table 1

Gas concentration determination - WB 1

No crt.	Time of execution determination	NO_2 (mg/m^3)	Ozone (mg/m^3)	CO_2 (ppm)	CO (ppm)
1.	08^{00}	0,1	0,01	900	3,5
2.	10^{00}	0,2	0,02	1500	5,0
3.	13^{00}	0,25	0,03	1900	5,8
Average concentration		*0,183*	*0,02*	*1433,3*	*4,76*
Maximum short-term limit (15 min)		5	0,1	-	17.5
Maximum 8 hours		8	0,05	5000	26

Table 2

Gas concentration determination - WB 3

No crt.	Time of execution determination	NO_2 (mg/m^3)	Ozonee (mg/m^3)	CO_2 (ppm)	CO (ppm)
1.	08^{15}	0,1	0,01	1000	4
2.	10^{15}	0,25	0,02	1100	5,5
3.	13^{15}	0,40	0,03	2300	6.5
Average concentration		*0,25*	*0,02*	*1466.6*	*5.33*
Short-term maximum limit (15 min)		5	0,1	-	17.5
Maximum 8 hours		8	0,05	5000	26

From Tables 1-3 it can be seen from the analysis of the measured values that the occupational exposure limit values are not exceeded, as they fall within the normal workplace exposure values. With the exception of the values obtained for ozone, the values of the other gases increased with increasing exposure period, the highest values were recorded for WB 5, which was located at the opposite side of the section, located next to two walls, at the greatest distance from the entrance.

Table 3

Gas concentration determination - WB 5

No crt.	Time of execution determinatio	NO_2 (mg/m^3)	Ozon (mg/m^3)	CO_2 (ppm)	CO (ppm)
1.	08^{30}	0,2	0,01	1200	4
2.	10^{30}	0,25	0,02	1500	6
3.	13^{30}	0,35	0,025	2500	7
Average concentration		*0,266*	*0,0183*	*1733,3*	*5,66*
Maximum short-term limit (15 min)		5	0,1	-	17.5
Maximum 8 hours		8	0,05	5000	26

3.2 Determination of respirable and inhalable dusts

The gravimetric measurement to determine the mass fraction of particulate matter in the workplace was performed at three measuring points: left-side (WB 1), middle (WB 3), right-side (WB 5). Dust respirable fraction and inhalable fraction were determined.

Welding and deburring of metal parts is performed at all workstations where non-specific effect particles and Fe_2O_3 powders are present. The worker exposure time is 6 hours. The airborne particulate concentrations obtained are shown in Table 4.

Table 4

Determination of airborne particulate concentrations

Measuring point name	Dust Respirable fraction mg/m^3		Dust Inhalable fraction mg/m^3	
WB 1	8^{00}	0,620	8^{00}	0,300
	10^{00}	1,550	10^{00}	0,700
	13^{00}	1,660	13^{00}	1,500
	$C_{average}$	*1,276*	$C_{average}$	*0,833*
WB 3	8^{15}	0,800	8^{15}	0,650
	10^{15}	1,700	10^{15}	1,300
	13^{15}	2,000	13^{15}	1,480
	$C_{average}$	*1,5*	$C_{average}$	*1,143*
WB 5	8^{30}	0,715	8^{30}	0,700
	10^{30}	1,850	10^{30}	1,550
	13^{30}	2,150	13^{30}	1,600
	$C_{average}$	*1,572*	$C_{average}$	*1,283*

The reference values for chemical agents are in accordance with Decision 1218/2006 on the establishment of minimum health and safety requirements at work to ensure the protection of workers from the risks related to the presence of chemical agents - republished pursuant to art. IV para. (2) of Government Decision no. 53/2021 [22, 23].

For particulate matter with no specific effect, the exposure limit value not to be exceeded is 10 mg/m^3 for the inhalable fraction and 5 mg/m^3 for the respirable fraction. For Fe_2O_3 dust the exposure limit value not to be exceeded is 5 mg/m^3.

The measured values of dust concentrations at the analysed workplaces listed in Table 4 do not exceed the permissible limit values. In this case, the obtained values increase with increasing exposure period and the highest values were recorded at WB 5.

4. CONCLUSION

The purpose of the work was to identify the agents harmful to the health of workers performing welding activities in the Semi-Fabricated *Parts Joining* Section, for the *Manual Electric* Welder workstation.

Measurements were made to identify chemical agents in the workplace air, in the workers' breathing zone and in the workplace atmosphere of respirable and inhalable dusts.

The results of the determinations were presented and interpreted and the following conclusions were drawn:

a) determination of chemical agents in workplace air - average concentration for each:

- Nitrogen dioxide (NO_2) - average concentration - 0.233 mg/m^3;
- Ozone (O_3) - average concentration - 0.02 mg/m^3;
- Carbon dioxide (CO_2) - average concentration - 1544.4 ppm;
- Carbon monoxide (CO) - average concentration - 5.25 ppm;

✓ Analysing the measured values of chemical agents, it is found that there are no exceedances of the occupational exposure limit values, the measured values falling within the normal exposure values of the workplace.

(b) determination of respirable and inhalable dust carried out in the workplace atmosphere:

- dust respirable fraction - average concentration - 1.449 mg/m^3;
- dust inhalable fraction - average concentration -1,086 mg/m^3;

✓ The measured values of dust concentrations at the workplaces analysed do not exceed the permissible limit values

The technological ventilation installed at the ward level (nox exhausting system by ventilation devices) operates according to specific parameters

5. REFERENCES

[1] Popović, O., Prokić-Cvetković, R., Burzić, M., Lukić U., Beljić B., *Fume and gas emission during arc welding: Hazards and recommendation*,Renewable and Sustainable Energy Reviews, ISSN 1364-0321, V.37, pp. 509-516, 2014

[2] Amza, G.h., Dobrota, D., Groza, M., Dragomir, Paise, S., Apostolescu Z., *Research on environmental impact assessment of flame oxyacetylene welding processes,* Metalurgija, 52 (4) pp. 457-460, 2013

[3] Koivisto, AJ., Eliat M, Jayjock, M., Hussein, T., Nicosia, A., *Quantifying relevant exposure determinants and conditions of use for welding emissions,* Open Res Europe, 5:38, 2025

[4] Udoh, V.E., Ekanem, I.I., Ikpe, A.E., *A Review of Welding and Fabrication Processes and Resulting Impacts on Environmental Sustainability: Risk and Control Measures*. Risk Assessment and Management Decisions, 1(1), pp. 142-153. 2024

[5] Matusiak, J., & Gliński, M., *Methods of eliminating pollutant emissions from the work environment in welding and related processes*, Welding international, *26*(11), pp. 852-861, 2012

[6] Murugan, S. Senthil, Sathiya, P., *Analysis of welding hazards from an occupational safety perspective*. Vietnam journal of science,

technology and engineering, 66(3)., pp. 63-74. 2024

[7] Mofeed Alam, M., Jha, A.K., Mukherjee, S., Panda, S., Chakraborty, S.S. *A Review on Friction Stir Welding—A Green Manufacturing Technology*. In: Recent Trends in Manufacturing and Materials Towards Industry 4.0. Osman Zahid, M.N., Abdul Sani, A.S., Mohamad Yasin, M.R., Ismail, Z., Che Lah, N.A., Mohd Turan, F. (eds), Lecture Notes in Mechanical Engineering. Springer, Singapore, 2021

[8] Bejinariu, C, Darabont, D.-C., Burduhos-Nergis, D.-P., Cazac, A.-M., Chiriac-Moruzzi, C. *Considerations Regarding the Application of the Occupational Injury and Illness Risk Assessment Method at Workplaces/ Workstations, in Relation to the ISO 45001 Standard*. Sustainability, 15(3):2121, 2023

[9] Bonthoux, F., *Factors Affecting the Capture Efficiency of a Fume Extraction Torch for Gas Metal Arc Welding*, The Annals of Occupational Hygiene, 60 (6), pp. 761–770, 2016

[10] Lehnert, M., Pesch, B., Lotz, A., Pelzer, J., Kendzia, B., Gawrych, K., Heinze, E., Gelder R., Punkenburg, E., Weiss, T., Mattenklott, M., Hahn, J.-U., Möhlmann, C., Berges, M., Hartwig, A., Brüning, T., *The Weldox Study Group, Exposure to Inhalable, Respirable, and Ultrafine Particles in Welding Fume*, The Annals of Occupational Hygiene, 56(5), PP. 557–567, 2012

[11] Popović, O., Prokić-Cvetković, R., Burzić, M., Lukić, U., & Beljić, B. *Fume and gas emission during arc welding: Hazards and recommendation*, Renewable and Sustainable Energy Reviews, 37, pp. 509-516, 2014

[12] Mehrifar, Y., Karimi Zeverdegani, S., Faraji, M., & Rismanchian, M. *Risk assessment of welders exposure to the released contaminated gases in different types of welding processes in a steel industry*, Health Scope, 7(4). 2019

[13] Riccelli, M. G., Goldoni, M., Poli, D., Mozzoni, P., Cavallo, D., Corradi, M. (2020). *Welding fumes, a risk factor for lung diseases*, International journal of environmental research and public health, 17(7), 2552. 2020

[14] Antonini, J. M. *Health effects of welding*. Critical reviews in toxicology, 33(1), pp. 61-103, 2003

[15] SR EN ISO 22065:2020 *Workplace air — Gases and vapours — Requirements for evaluation of measuring procedures using pumped samplers*

[16] SR ISO 8760:2001 *Work-place air — Determination of mass concentration of carbon monoxide — Method using detector tubes for short-term sampling with direct indication*;

[17] SR ISO 8761:2001 *Work-place air — Determination of mass concentration of nitrogen dioxide — Method using detector tubes for short-term sampling with direct indication*;

[18] SR EN ISO 23861:2022. *Workplace air — Chemical agent present as a mixture of airborne particles and vapour — Requirements for evaluation of measuring procedures using samplers*;

[19] SR EN ISO 689 +AC:2019 - *Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values*

[20] SR EN 12341:2014 *Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter*

[21] SR EN 13205-2:2014 *Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 2: Laboratory performance test based on determination of sampling efficiency*

[22] Decision 1218/2006 on the establishment of minimum health and safety requirements at work to ensure the protection of workers from the risks related to the presence of chemical agents

[23] Government Decision no. 53/2021

Determinarea emisiilor de noxe rezultate din procesul de sudare

În industria ingineriei, metalele și aliajele utilizate în fabricarea produselor și structurilor metalice sunt supuse proceselor de sudare, care pot elibera vapori de metal, praf și particule în aer, având efecte negative asupra sănătății lucrătorilor și asupra mediului. Unele tehnici de îmbinare generează gaze periculoase, clasificate în categorii precum gaze cu efect de seră, gaze toxice, gaze inflamabile și gaze explozive. Există reglementări clare privind limitele admisibile pentru concentrațiile de particule metalice și nemetalice, precum și de gaze emise de diverse procese industriale, inclusiv cele de sudare. Scopul acestei cercetări a fost de a măsura agenții chimici din aerul locurilor de muncă, precum și concentrațiile de pulberi respirabile și inhalabile în atmosfera locurilor de muncă, în cadrul unei firme din Secția de Îmbinare a semifabricatelor, pentru postul de sudor electric manual. Determinările de agenți chimici și de pulberi respirabile și inhalabile au fost efectuate în zona respirabilă a lucrătorilor, în intervalul orar $0^{:00}$-14^{00}.

Nicoleta-Monica LOHAN, Assoc.prof.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety, nicoleta-monica.lohan@academic.tuiasi.ro, +40742834256.

Mihaela PAȘCU, Mast.stud.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety, mihaela.pascu@staff.tuiasi.ro.

Anișoara CORĂBIERU, Assoc.prof.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety. anisoara.corabieru@academic.tuiasi.ro

Elena MATCOVSCHI, Lect.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety. elena.matcovschi@academic.tuiasi.ro.

Gheorghe BĂDĂRĂU, Assoc.prof.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Science, gheorghe.badarau@academic.tuiasi.ro.

Mihai POPA, Lect.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety, mihai.popa@academic.tuiasi.ro.

Mihai-Adrian BERNEVIG, Lect.dr.eng, Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, Department of Materials Engineering and Industrial Safety, mihai-adrian.bernevig@academic.tuiasi.ro.