

The Algorithm of Chemical Risk Assessment in a Welded Construction Company

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There is no industrial sector in which welding is not used as a manufacturing process. Welding assembly is a highly polluting technology process, especially of the atmosphere and soil. The formation of gases in the welding process is the result of burning the electrodes, flows, forming the molten metal bath and making the weld seam. Welding operators are exposed to smoke and toxic gases resulting from the welding process, which may be dangerous to health. Many acute intoxications due to excessive exposure or short-term exposure to smoke and gas resulting from the welding process have been studied over time. However, in addition to general effects such as respiratory irritation, long-term effects have been directly attributed to the influence of smoke and toxic gases, for example, the chronic effects due to the presence of chromium, nickel and aluminum. There are some welding sections where the level of noxes exceeds the limits allowed by the law, and in these cases it is fairly possible to speak of so-called chemical risk. The paper aims to measure the emissions of noxious substances in case of welding of welded specimens and if the limits allowed by the welding laws are exceeded, to present a chemical risk assessment algorithm, going through three stages: inventory of materials and products used at a workstation, hierarchy of potential risks noted IRP and ultimately, the risk assessment.

Keywords: welded, chemical risk, noxious, gas welding, chemical composition

A large number of welders experience some adverse health effects. Respiratory problems encountered with full-time welders, include bronchitis, respiratory irritation, smoke-induced fever, changes in lung function, decreased immunity to infections, and a possible increase in lung cancer risk. The effects on the body and the skin after exposure to the smoke resulting from welding have long-term health consequences [1-3].

Welding is an important way of making high quality metal parts. In essence, all metals and alloys can be welded, some easily, others involving special precautions [4-6].

Welding works only begin after ensuring the safety of the work. In order for the work to be carried out under normal conditions, preventive measures against electrocution, harmful action of gases that emanate from the combustion of metals, fluxes and coatings of electrodes and burns caused by splashes of metal and slag must be taken. The most important rules regarding the work safety technique during work with welding equipments and equipments are:

- for spark protection, splashes of molten metal, as well as light, infrared and ultraviolet radiation, workers must use appropriate eye protection equipment such as retractable metal glasses with masks and masks provided with appropriate plate filter glass;

- the clothing of the welding operators must be made of hard flammable materials, closed in buttons, without cuffs, close to the wrist or leather shorts;

- the location of welding sections is not allowed in the basements of buildings or upstairs;

- to prevent air pollution, local aspiration systems will be applied near the flame;

- when operating in narrow spaces, a vapor and exhaust gas evacuation system must be provided and continuously introducing clean air to prevent the formation of a noxious atmosphere;

- the welded parts must be secured in advance against overturning or displacement,

- permanent work places will necessarily show the machine's instructions and safety signs;

- cylinder containers containing combustible gases, oxygen or protective gases can not be stored in narrow spaces;

- all sectors that have welding works of any kind, will draw up detailed instructions for labor protection depending on the technological process and the equipment used.

The welding noxes consist of two categories:

- particles of metals, non-metals and certain substances with harmful or dangerous, potential or concrete effects, contained in the welding smoke;

- toxic or dangerous gases emitted by the welding process caused by the thermal effect and by some chemical reactions occurring in the welding process as a side effect of the welding process.

Experimental part

Determination of the noxes in shielded gas welding with tubular wire

Shielded gas welding process has been chosen because it is a very widespread in industry, being used extensively in repair shops.

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Table1
CHEMICAL COMPOSITION OF S235JR STEEL (ON THE SAMPLE OF LIQUID STEEL)

Name	Designation	Standard Number	Chemical composition					
			C [%]	Mn[%]	Si[%]	S[%]	P[%]	Other [%]
Steels for metals, boilers and pressure vessels	S235JR	NF EN 10028-2	max 0.17	1.40	max 0.30	max 0.045	max 0.045	N=0.09

Table 2
THE CHEMICAL COMPOSITION OF THE E 71T-1H4 WELDING WIRE IN PERCENT

C %	Mn %	Si %	S %	P %
≤0.08	0.95-1.75	0.35-0.70	≤0.03	≤0.03

For the examination of the emissions of noxes, specialized and certified appliances were used in the systems, with the necessary accessories and equipment.

The sampling and examination of particulates from smoke and gas released into the welding air shall be carried out in accordance with the methods in the standards in force [7,8].



Fig.1 The welded sample and the filter sample

The welded sample is shown in figure 1a and the particulates sample filter collected from the welding smoke during sample execution in figure 1.b.

The base material on which the welding seam was made is S235 JR, the chemical composition of which is shown in table 1.

The welding equipment used for the welded sample intended for shielded gas welding process is FILCORD 3600 TEC, having a maximum welding current of 600 A, is shown in figure 2.

For the cruciform welded sample, was used for welding the 1.2mm diameter rutile core wire, symbolized E 71T-1H4, in accordance with AWS A5.20. These wires with rutile cores are especially recommended for welding metal structures such as buildings, street and railway bridges, pressure vessels where it is necessary to guarantee resilience at low temperatures (-20°C). This wires are also recommended for welding of shipbuilding and manganese carbon steels with fine grain in CO₂ [9,10].

The chemical composition of the welding wire in percent is described in table 2.

Figure 3 shows the portable gas analyzer.



Fig. 2 FILCORD 3600 TEC welding equipment

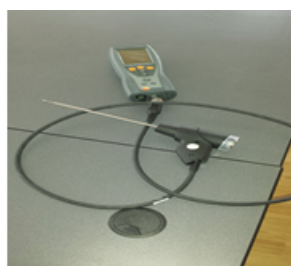


Fig. 3. TESTO 327 Gas Analyzer

Table 3

ANALYSIS OF THE PARTICULES IN WELDING SMOKE SAMPLES

Number	Chemical element	Sample filter no.1 The FRX method
1	Mo, ppm	3.12±5.34
2	Pb, ppm	0.00±14.15
3	Zn, ppm	0.47±100
4	Cu, ppm	1.16±100
5	Ni, ppm	0.2±15.5
6	Fe, ppm	18.8±500
7	Mn, ppm	14.3±600
8	Cr, ppm	1.73±500
9	V, ppm	3.3±100
10	Ti, ppm	1.5±200
11	Ca, ppm	123.300±1.100
12	K, ppm	17.8±200
13	Cd, ppm	3.400±21.92
14	Ba, ppm	1.8±100
15	Sn, ppm	0.8±100

The results of X-ray fluorescence analysis for the particulates in welding smoke sample presented in figure 1.b, are shown in table 3.

The examination of toxic gas emissions was carried out by the direct method during the welding test. The concentration of the gases emitted in the welding zone was determined. The multiple gas detector was placed on the welding table at a distance of about 300 mm from the electric arc welding. The measurements are relevant for the concentration of the gases emitted in the breathing air at the workplace in the breathing zone of the welder in accordance with the standards in force [11].

In the stabilized phases of the welding process, the emission levels of the gases emitted are: 4.13-5.84% CO₂; 0.78-1.47 ppm NO₂; 15-29 ppm H₂; 5-35 ppm CO. These values exceed the exposure limit (8 h per day, 5 days a week): 5% CO₂; 1.0 ppm NO₂; 30 ppm CO. Emissions of toxic gases in case of shielded gas welding process, represent a health risk to the welder.

Several measurements were made to determine the concentration of toxic gases in the vicinity of the workplace, at a distance of about 3 meters from the electric arc, during the welding tests. The concentration levels of the gases emitted are as follows: 0.12% CO₂; 0.10 ppm NO₂; 0 ppm H₂ and 1 ppm CO. The determinations made here show

Effects on health		Fire explosion		Environmental Impact	
Danger	Potential exposure	Flammability	Potential for ignition	Danger	Potential for transfer
Risk phrases	Quantity used	Risk phrases	Stock quantity	Risk phrases	Amount used
	Frequency of use		Ignition sources	Classification of the hazardous waste	Quantity stored
				Aggregation state	

Table 4
CRITERIA USED TO
CALCULATE THE
POTENTIAL RISK SCORE
OF A CHEMICAL AGENT

that levels of harmful or toxic gas concentrations near the welding station have values below to those at the welding station. However, because the determined concentrations at the welding station exceed the exposure limits mentioned in the literature, it is necessary to proceed further a chemical risk assessment.

Results and discussions

Chemical risk assessment

The chemical risk assessment method for health, safety and the environment is progressive and calls for simple and easily accessible criteria, being a step-by-step approach to optimizing the collection of information on the main chemical agent (ACP) and worktask.

The method comprises the following main steps:

- inventory of the products and materials used in a site, workshop or workstation;
- hierarchy of the potential risks (IRP);
- risks evaluation.

Product inventory is the most important step because it condition the quality of a risk assessment approach. The inventory of chemicals, raw materials, intermediate products should be as exhaustive as possible. In order to guarantee the success of this step, it is desirable that the working group appointed by the employer designate a team of specialists to deal with this.

The data collected at this stage are:

- the chemical or trade name of the product;
- the quantity used (in the previous months);
- the frequency of the use;
- the work area where the product is used;
- the information about the dangers indicated on labels (pictograms, risk phrases);
- Information mentioned in the risk phrases (dangers, physicochemical properties)

In the inventory phase, the risk phrases are an essential aid in this approach.

Regarding the *potential hierarchy of dangers* (IRP), due to the large number of products and raw materials used in a site, it is required the risk hierarchy necessary and prioritization because the deepening must begin with the most dangerous products. The hierarchy of the identified products is carried out using the IRP method. This method takes into account the dangers, the potential exposure (health), the potential for ignition (fire, explosion) and the transfer potential (environmental impact). The IRP method takes into account the criteria presented in table 4.

Combining the values of the classes of each parameter allows the calculation of a potential risk score. It sets the risk assessment priorities for an workshop, workstation, etc.

The IRP method provides objective elements for determining the situations that require with priority an risk assessment.

It is recommended to classify the assessment priorities in Homogeneous Exposure Groups (GOE) to organize the

next phase, *Risk Assessment*. An Homogeneous Exposure Groups - GOE corresponds to a set of workers, posts or work operations for which the exposure is estimated to be of the same nature and similar intensity as is the case of the welding section. The creation of an GOE can be done through 3 types of approaches:

- chemical agent approach*, which consists of assessing the risks for all GOE's sites using high risk chemical agents;
- working unit approach*, which consists of the risk assessment for all GOE's in an work area characterized by an important global potential risk (geographical notion);
- process approach*, which consists of assessing the risks to all GOE's of a site process characterized by a high potential risk (production line concept).

The *risk assessment* consists of a simplified determination of health, safety and environmental risks. These steps require more information to be collected than

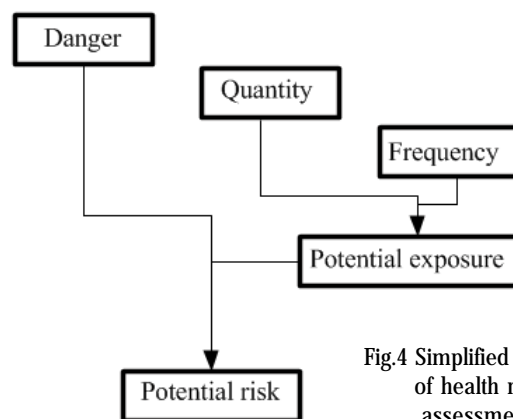


Fig.4 Simplified scheme of health risk assessment

in the hierarchy faze, regarding the handling conditions of various chemical agents. First, a potential hierarchy of potential risks (IRP) is made, following a scheme outlined in figure 4.

The main objective is, in the first instance, to classify chemical agents and workshops according to their potential risks. The required data are: the chemical or commercial name of the chemical agent, the label, the quantity used, the frequency of use, the place (s) where it is used.

The danger classification is then made, which is determined primarily by the information given in the FDS or the label. The information used to assign a danger class to a chemical agent is given in table 5. For the materials, the danger class is determined according to the type of chemical agent delivered by the processes, as shown in table 6.

Then we set the quantity class, as is presented in table 7. In order to establish this, it is essential first to determine the appropriate time period to which the process should relate: daily, weekly, monthly, yearly.

The determination of the quantity classes is based on the reported period, reporting the amount consumed (Q_p)





Danger Class	Risk phrases and combinations of risk phrases	Pictograms	VLE [mg/m ³]	The nature of chemical agents AC
1	None	None	>100	
2	R36, R37, R38, R36/37, R36/38, R36/37/38, R37/38 R66	 Xi-Irritating	>10-100<	Iron / Grain and derivatives / Graphite / Building materials / Talc / Cement / Composite materials / Wood burning treatment / Metal-plastic welding / Vulcanization / Vegetable-animal materials ...
3	R20, R21, R22, R20L/21, R20/22, R20/21/22, R21/22 R33, R34, R40, R42, R43, R42/43 R68/20, R68/21, R68/22, R68/20/21, R68/20/22 R48/20, R48/21, R48/22, R48/20/21, R48/20/22, R48/21/22, R48/20/21/22 R62, R63, R64, R64, R67, R68	 Xi - Irritating	>1-10<	Stainless Steel Welding / Ceramic Fiber - Plant / Lead Coating / Abrasive Discs / Sandblasting / Cutting Oil
4	R15/29 R23, R24, R25, R29, R31 R23/24, R23/25, R23/24/25, R24/25 R35, R39/23, R39/24, R39/25, R39/23/24, R39/23/25, R39/24/25 R39/23/24/25 R41, R45, R46, R48, R49, R48/23, R48/24, R48/25, R48/23/24, R48/23/25, R24/25, R48/23/24/25 R60 R61	 T - Toxic	>0,1-1<	Wood and derivatives / Metal Lead / Asbestos and Asbestos-containing materials / Casting and lead alloy / Tar and jar / Mercury / Petrol (fuel) / ...
5	R26, R27, R28, R32 R26/27, R26/28, R26/27/28, R27/28, R39, R39/27, R39/28, R39/26/27, R39/26/28	 T ⁺ - very toxic	<0,1	

Table 5
THE CLASSES OF DANGER DEPENDING ON LABELING, THE LIMIT VALUES EMITTED VLE AND THE NATURE OF CHEMICAL AGENTS AC EMITTED IN VARIOUS ACTIVITIES IN THE MACHINE BUILDING INDUSTRY

Table 6
THE LIST OF RELEASED CHEMICAL AGENTS AND PROPOSALS FOR CLASSIFICATION OF HAZARDS

Chemical agents emitted from processes		VLE [mg/m ³]	Danger Class
Powders from:	Iron	5 (xod)	2
	Stainless steel alloys	0.5 (Cr)	3
	Aluminum	10	1
	Wood and derivatives	1 (for carcinogens)	4
	Cereals and derivatives	5	2
	Fiber glass	10 (pulberi fără efect specific)	2
	Construction materials (stone, bricks, concrete ...)	10 (powders with no specific effect)	2
	Metallic lead	0.15 (vapori)	4
	talcum	10 (powders with no specific effect)	2
	Cement	10 (powders with no specific effect)	2

Powders from:	Ceramic fiber	(R40)	3
	Vegetable fibers	0.5	3
	Asbestos and asbestos-containing materials	(R45)	4
	Composite materials (resins + glass fibers, carbon fibers ...)	-	2
	Painting with lead	0.5 (estimate)	3
	Abrasive discs	0.1 (estimate)	3
	Sand blasting	0.1 (estimate)	3
	Graphite	2	2
Fumes from:	Burning treated wood	-	2
	Steel welding	5	2
	Casting of metals	-	2
	Stainless steel welding	0.5 (Cr)	3
	Casting and processing of lead	0.15	4
	Welding and thermoforming of plastics	-	2
	Vulcanization	-	4
Vapors and gases from:	Materials of plant or animal origin	-	2
	Tar and jar	0.2 (R45)	4
	Heating apparatus	55 (CO)	2
	Mercury	0.05 (steam)	4
	Processing with oils	19 (INRS)	3
	Fuel engines	-	2
	Gasoline (fuel)	Contains benzene	4
Aerosols from:	Cutting oils	1 (INRS)	3
	Water jet pickling	-	2
	Uncoiling oils	-	2

Table 7

THE CALCULATION OF QUANTITY CLASSES (CC)

Quantity classes	Q_i / Q_{Max}
1	<1 %
2	Between 1 % și 5 %
3	Between 5 % și 12 %
4	Between 12 % și 33 %
5	Between 33 % și 100 %

Table 8

THE DETERMINATION OF THE FREQUENCY USE CLASSES

Use	<i>Occasional</i>	<i>Intermittent</i>	<i>Frequency</i>	<i>Permanent</i>
Daily	< 30 min	30-120 min	2-6 h	> 6 h
Weekly	< 2 h	208 h	103 days	> 3 days
Monthly	<1 day	106 days	6-15 days	> 15 days
Annual	<5 days	15 zile-2 months	205 months	> 5 months
Class	1	2	3	4
0: AC has not been used for over a year, AC is no longer in use				

to the quantity of the most commonly used chemical agent (Q_{Max}), after the relationship:

$$Q_i / Q_{Max} = CC \quad (1)$$

Classes can be calculated on a workshop and / or on the entire industrial organization.

The usage frequency classes are analyzed. To determine, the reporting time, this must be the same as that used for determining the quantity classes: daily,

weekly, monthly, yearly, taking into account the values shown in table 8.

The potential exposure classes are of great importance. For a chemical agent, the potential exposure results from the combination of quantity and frequency classes of use (for chemical agents from material transformation, only the frequency counts). In general, the higher the amount and frequency of use, the more likely the exposure of

Quantity class						
5	0	4	5	5	5	
4	0	3	4	4	5	
3	0	3	3	3	4	
2	0	2	2	2	2	
1	0	1	1	1	1	
	0	1	2	3	4	Frequency class

Table 9
THE DETERMINATION OF POTENTIAL EXPOSURE CLASSES

Clasă de expunere potențială						
5	100	1000	10000	100000	1000000	
4	30	300	3000	30000	300000	
3	10	100	1000	10000	100000	
2	3	30	300	3000	30000	
1	1	10	100	1000	10000	
	1	2	3	4	5	The danger class

Table 10
DETERMINATION OF POTENTIAL RISK (IRP SCORE)

Table 11
CHARACTERIZATION OF PRIORITIES ACCORDING TO THE POTENTIAL PRODUCT RISK SCORE

IRP score / product	Priority
≥ 100000	Great
100-100000	Average
<100	Low

workers is. The exposure classes can be determined using the grid in table 9.

Knowing these elements we can determine the potential risk score (RP). The potential risk results from the combination of danger and potential exposure classes. This means that, the the probability of observing a risk is based on the general conditions of use (quantity, frequency) of a main chemical agent (ACP).

The potential risk score determination (RP) is made using the grid shown in table 10. The scores are additional to allow hierarchy of different entities.

The priority of concern for a product is determined from the decision table presented in table 11.

Finally, potential hierarchy can be made. This allows the ACP classification and the establishment of GOE's that require in-depth and priority chemical risk assessment. This stage allows differentiation of the Chemical Agents Examination. In the case of equal scores, the priority will have higher risk class of the chemical agent AC.

Conclusions

As a result of the determinations made in the welding section in different work areas, at the respiratory level it was found that the value of the concentrations of inhalable powders, aerosols and fumes from different metals exceeds the admissible value in different places of measurement and in different proportions, so there is a major chemical risk;

Because the determined concentrations at the welding station exceed the exposure limits mentioned in the literature, it is necessary to proceed further a chemical risk assessment.

The determination of the potential risk of welding was done starting from the quantity class, then determining: the frequency of use class (which is 4); the hazard class (which is 100,000); the priority class (which is high), resulting ultimately in a potential risk of large welding;

The simplified environmental impact assessment was based on the results of the measurements made, and was then done: a hierarchy of potential risks; a determination of the the quantity classes; danger classes and the determination of the potential impact on the environment (IEp = 5000 analyzed), which corresponds to an important environmental impact.

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