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 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.

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;

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

-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.
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].

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% CO\(_2\); 0.78-1.47 ppm NO\(_2\); 15-29 ppm H\(_2\); 5-35 ppm CO. These values exceed the exposure limit (8 h per day, 5 days a week): 5% CO\(_2\); 1.0 ppm NO\(_2\); 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% CO\(_2\); 0.10 ppm NO\(_2\); 0 ppm H\(_2\), and 1 ppm CO. The determinations made here show

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**Table 1**

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Standard Number</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steels for metals, boilers and pressure vessels</td>
<td>S235JR</td>
<td>NF EN 10025-2</td>
<td>C [%]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>max 0.17</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>C [%]</th>
<th>Mn [%]</th>
<th>Si [%]</th>
<th>S [%]</th>
<th>P [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.08</td>
<td>0.95-1.75</td>
<td>0.15-0.70</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Number</th>
<th>Chemical element</th>
<th>Sample filter no.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mo, ppm</td>
<td>3.12±5.34</td>
</tr>
<tr>
<td>2</td>
<td>Pb, ppm</td>
<td>0.06±1.15</td>
</tr>
<tr>
<td>3</td>
<td>Zn, ppm</td>
<td>0.4±100</td>
</tr>
<tr>
<td>4</td>
<td>Cu, ppm</td>
<td>1.16±100</td>
</tr>
<tr>
<td>5</td>
<td>Ni, ppm</td>
<td>0.2±15.5</td>
</tr>
<tr>
<td>6</td>
<td>Fe, ppm</td>
<td>18.8±500</td>
</tr>
<tr>
<td>7</td>
<td>Mn, ppm</td>
<td>14.3±500</td>
</tr>
<tr>
<td>8</td>
<td>Cr, ppm</td>
<td>1.73±500</td>
</tr>
<tr>
<td>9</td>
<td>V, ppm</td>
<td>3.3±100</td>
</tr>
<tr>
<td>10</td>
<td>Ti, ppm</td>
<td>1.5±200</td>
</tr>
<tr>
<td>11</td>
<td>Ca, ppm</td>
<td>123±300±1.100</td>
</tr>
<tr>
<td>12</td>
<td>K, ppm</td>
<td>17.5±200</td>
</tr>
<tr>
<td>13</td>
<td>Cd, ppm</td>
<td>3.40±21.92</td>
</tr>
<tr>
<td>14</td>
<td>Ba, ppm</td>
<td>1.8±100</td>
</tr>
<tr>
<td>15</td>
<td>Sn, ppm</td>
<td>6.8±100</td>
</tr>
</tbody>
</table>

---

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 CO\(_2\) [9,10].

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

Figure 3 shows the portable gas analyzer.

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**Fig. 1.** The welded sample and the filter sample

**Fig. 2.** FILCORD 3600 TEC welding equipment

**Fig. 3.** TESTO 327 Gas Analyzer
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 (GEO) 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 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 (Qi)
<table>
<thead>
<tr>
<th>Danger Class</th>
<th>Risk phrases and combinations of risk phrases</th>
<th>Pictograms</th>
<th>$VLE\ [mg/m^3]$</th>
<th>The nature of chemical agents AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>None</td>
<td>$\geq 100$</td>
<td>Iron / Grain and derivatives / Graphite / Building materials / Talc / Cement / Composite materials / Wood burning treatment / Metal-plastic welding / Vulcanization / Vegetable-animal materials ...</td>
</tr>
<tr>
<td>2</td>
<td>R35, R37, R38, R36/37, R36/38, R36/37/38, R37/38, R66</td>
<td>![Xi-Irritating]</td>
<td>$10 \leq VLE \leq 100$</td>
<td>Stainless Steel Welding / Ceramic Fiber - Plant / Lead Coating / Abrasive Discs / Sandblasting / Cutting Oil</td>
</tr>
<tr>
<td>3</td>
<td>R20, R21, R20L/21, R20/22, R20/21/22, R21/22, R33, R34, R40, R42, R43, R42/43, R58/20, 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, R52, R63, R64, R64, R67, R68</td>
<td>![Xi-Irritating]</td>
<td>$0.1 \leq VLE \leq 1$</td>
<td>Wood and derivatives / Metal Lead / Asbestos and Asbestos-containing materials / Casting and lead alloy / Tar and tar / Mercury / Petroleum (fuel) / ...</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Chemical agents emitted from processes</th>
<th>$VLE\ [mg/m^3]$</th>
<th>Danger Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powders from:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>5 (xoxd)</td>
<td>2</td>
</tr>
<tr>
<td>Stainless steel alloys</td>
<td>0.5 (Cr)</td>
<td>3</td>
</tr>
<tr>
<td>Aluminum</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Wood and derivatives</td>
<td>1 (for carcinogens)</td>
<td>4</td>
</tr>
<tr>
<td>Cereals and derivatives</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Fiber glass</td>
<td>10 (powders, fibril effect specific)</td>
<td>2</td>
</tr>
<tr>
<td>Construction materials (stone, bricks, concrete ...)</td>
<td>10 (powders with no specific effect)</td>
<td>2</td>
</tr>
<tr>
<td>Metallic lead</td>
<td>0.15 (vapors)</td>
<td>4</td>
</tr>
<tr>
<td>Talcum</td>
<td>10 (powders with no specific effect)</td>
<td>2</td>
</tr>
<tr>
<td>Cement</td>
<td>10 (powders with no specific effect)</td>
<td>2</td>
</tr>
</tbody>
</table>
to the quantity of the most commonly used chemical agent \( Q_{\text{Max}} \), after the relationship:

\[
Q_i / Q_{\text{Max}} = CC
\]  

(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...
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.

**References**

11. CHIVU, O., Metalurgija,Vol.52,no.4,2013, p. 465-468

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