Considerations for Reducing Fire Risks During The Gas Flame Welding Process

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Abstract. This piece of work describes the main technical conditions for the operation and use of the welding equipment the technical elements on the fire security the welding works, the general security measures, necessary for the welding operation. The majority of operations, necessary for human activities, consist of many individual elements, which require a fixed joining to make up a single piece. In order to achieve some structures, required by the contemporary human activities, the welding engineering represents an important option, capable of solving the top technical issues, ranging from microprocessors welding to the mega-structures welding. The welding technology outworking assumes to establish the conditions for the execution of the weld joining, the serious knowledge of the welding technological parameters, the specific technological recommendations, the performances of the welding equipment and their operation, the selection of the add up materials etc. The welding technology establishing is specific to each of the used methods, by melting or by pressing. Each of these welding operations requires some prevention measures applying for avoiding burns, the electrical shock, the eyes wounding, the toxic gas and smoke inhalation, the exposure to ultraviolet rays etc. For implementing these measures, we presented the requirements provided in the technical norms, technical regulations and the provisions of the legal documents, regarding fire risk prevention, including the binding contribution of the technical-engineering staff, as well as of all the workers, irrespective of their hierarchical position.

Keywords: fire, welding, prevention, process, self-ignition.

Received: April 21, 2022. Revised: August 17, 2023. Accepted: September 13, 2023. Published: October 2, 2023.

1. Introductory chapter

On the execution of metallic structures, welding represents a dangerous manufacturing process, involving high temperatures, inflammable gases and high voltages, according to the used specific process. The gas flame and the electric arc, the mixture of acetylene with air or oxygen and the contact of the compressed oxygen with organic substances (fats, oils etc.) determine explosions and fires by self-fire. Each welder or oxy-acetylene cutter must be qualified, possessing a graduation/vocational certificate of competence and an authorization (for the categories of works to be performed) confirming the graduation of a specialty course for using gases compressed in cylinders, for handling acetylene generators and for the work on open fire**[1].**

An essential element on appraising the explosion risk at the job places, where it can come out explosive atmospheres, is represented by the private electrical installations and protection equipment (EIP), installed and maintained so that they shall not generate sources of fire **[2].** Regarding the electrical installations located in the places with identified explosive atmospheres, it is necessary to provide the prescribed level of security if the electrical equipment are used according to the established parameters, to fulfil some specific conditions, from structure point of view and use, respectively, if the installation is maintained according to the codes of practice, with reference to over-currents, local short-circuits and other electrical faults fighting-protection **[3].** The requirements for explosions prevention and fighting-protection are regulated by specific norms and standards and a good deal of the risk of explosions appraisal requires the appraisal of the equipment/installations conformity with the respective requirements. From the quality assurance point of view, the welding operation is a „special process", resulting in the necessity to permanently watch the welding process and the involved staff, respectively, meaning that, during any welded structures manufacturing operation, the presence of a coordinator of the welding operation is compulsory. Due to the crisis of staff, specific to the welding field, at present it is stringent requirement for education and training. To create the framework for a single training in the welding field, at all job levels, the European Weld Federation (EWF) and the Institute of Welding (IIW) developed a harmonious European and international system for training the welder staff. This system has been implemented, at present, I over forty countries, Romania included, and it is specific both to the manufacturing staff (welders, as per EN 287-1 and to the welder operators (as per, EN 1418) and to the coordinating and inspection staff (as per, norm provisions EN ISO 14731). The national technical norms, specific to the performance and achievement of the welding operations, contain Romanian standards, aligned to the European norms (e.g., SR ISO 4063:2011 Welding and connected methods. Name list of methods and reference numbers; SR ISO 10462:2014/A1:2019 Cylinders for gas. Acetylene cylinders. Periodical inspection and maintenance works. Amendment 1; SR EN ISO 6947 Welding and connected methods. Welding positions; SR EN ISO/TR 15608:2017 Guide for groups of metallic materials system; SR EN ISO 15614-1:2017 Specification I Welding methods qualification; SR EN 13067:2020 Staff for plastics welding. Welders training work. Plastic welded fixed joining; SR EN ISO 9606-1:2013 Staff training for obtaining the welder certificate etc.) and technical norms ISCIR (e.g. PT CR 7 – 2013 Welding methods approval for steel, aluminum, aluminum and polyethylene high density alloys - PE-HD; PT CR 9 - 2013 regarding the authorization of welders performing welding operations on the under pressure installations and on the elevator systems and of the operators welding pipes and fittings made of high density polyethylene - PEHD). The testifying of the economic companies' capacity to perform welded metallic structures under the incidence of some control Organic Structures (TUV, SGS, ISCIR, ISIM CERT END etc.) is achieved in collaboration with the National Institute of Research – Development in Welding and Materials Tests - ISIM Timişoara. The field of application, within the welding process, is one of the most standardized of the industry branch, by which the welding resulting risks can be reduced, by correctly applying the standards for performing these operations. The outlooks, related to risk, are specified in several standards (e.g. EN 1090-2 Technical requirements for steel structures; EN 15085 Quality requirements for metallic materials welding by melting; SR ISO 4705-1999 Non-welded, steel gas cylinders, rechargeable; SR ISO 4706-1998 Welded, steel, gas cylinders, rechargeable). By approving the directives 2014/68/UE (transposed in the Romanian legislation through H.G. no. 123/2015 regarding the terms establishing for rendering available on the market, of the under-pressure equipment, with further modifications and completions 2014/29/EU (SPV) and the provisions art.17 paragraph (5) of the Norm (EU) no. 305/2011, the European regulation authority objective was to render harmonious the outlook, the manufacturing, test and appraisal of the equipment conformity, so that to let open the European home market to the compatible equipment which observe the norms requirements for health and security, the methods used for the conformity appraisal and which are marked with the EC brand. The EC brand is the unique brand for certifying the conformity of one product for structures of the regulated field, provided at art. 21 paragraph (5) of the no. 622/2004 Romanian Government's Decision no. 622/2004 regarding the conditions for marketing construction products with (further) modifications and completions, so that for being applied, it is necessary to observe the system for the fire reaction performance, the fire-fighting performance or the outdoor fire performance (the classes based on the products reaction performance are established as classes for the essential requirement "Fire security")**[4,5].** Also, through the Norm (EU) 2019/1784 from October 1st, 2019 (in force since 1.01.2021) establishing the requirements for the ecologic design, applied to the welding equipment, they establish the ecologic design requirements for implementing on the market/putting in operation the power-supplied welding equipment (referring to the power efficiency, in force since January 1st 2023, to the use of the resources efficiency and for information, in force since January 1st 2021). In order to apply fire and explosion prevention measures at the welder's workstation, we consider it necessary to describe the working conditions and procedure in the case of gas flame welding, the characteristics of the weldable materials, as well as the presentation of welding defects, their repair, as well as the check of welded parts.

2. Gas flame welding technology [6]

2.1. General issues

The welding technology involves some research on the factors leading to a good quality welding seam, which is why the process requires analyses regarding the properties of the base material (mechanical, technological, chemical composition), the operating conditions of the welded structures, the weldability of the materials and the concrete possibilities of the parts. This technology includes the sequence of operations required for the execution of the welding joints and for handling the welding machine (torch). The gas flame welding torch (device) consists of: acetylene generator or acetylene cylinder, fitted with a pressure baffle; scrubber or chemical filter; oxygen cylinder with pressure baffle; hoses for conducting the two gases (red – C2 H2, blue – O2); the welding burner (or welding kit); various accessories (wire brushes, hammers, etc.).

The welding operations are performed in the following order:

a) The parts are placed in a favorable position (identical to the position after joining) and fixed with devices, pliers or vices;

b) The flame is ignited, adjusted and oriented towards the areas of the parts to be heated;

c) In the welding metal pieces (when close to the melting temperature), the *filler metal wire* is inserted into the flame; together with the molten metal of the welded piece, they make up the *molten metal bath*.

Depending on the thickness and thermal conductivity of the base material, different welding methods can be used, each having its own characteristics:

a) For sheets up to 5 mm thick, the filler material is positioned *in front of* the burner, and it moves from right to left, which is why it is called "*left*ward welding". With regard to the gas used and other necessary elements, the sequence of the working operations is the following:

- the required acetylene consumption in liters/h is calculated as: Q = (80-120) × s [l/h], where 's' is the thickness of the metal sheets, in [mm];
- the burner size is determined, depending on the acetylene consumption;
- the oxygen pressure and the filler material are chosen, depending on the quality of the base material (as per the quality certificate) and the diameter of the filler wire (d) is determined by the thickness of the sheets, according to the formula: d = (s/2) + 1 (mm).

b) For sheets over 5 mm thick, the filler material is positioned *behind* the burner, and it moves from left to right, which is why it is called "*right*ward welding". Compared with the first method, the order of operations is identical, the only difference is the use of *acetylene*, which is calculated as: Q = (120-150) × s [l/h].

c) For metal boards placed in an *upright position*, where the resulting seam is *vertical* (*bottom-up*), the welding method used is called "vertical welding with double seam". In this case, welding is carried out simultaneously by two welders, placed on either side of the joint. From a qualitative point of view, the method is both productive and economical.

2.2. Weldable materials

2.2.1. Steels

Steels are welded according to their content of carbon and alloying elements, as follows: a percentage of carbon content exceeding 0.22% influences the oxy-acetylenic process, as the parts require pre-heating at temperatures of 150-350°C and similar temperatures have to be maintained during welding. After welding, a normalization heat treatment is required, at temperatures ranging between 700 and 800°C.

Alloy steels are welded with a similar quality filler wire and flame welding is recommended only for thin sheets. Post weld heat treatment (re-annealing) and *pre*heating are required after welding.

Stainless steels (with over 12% chromium) are welded using strictly neutral flame and fluoride-based fluxes and appropriate post weld heat treatments are required.

Manganese steels (cast into parts containing more than 1% carbon and over 12% magnesium) are welded by heating to 1000 °C (with a carburizing flame), using aluminum dust.

2.2.2. Cast iron

Cast iron is welded by cold flame and requires *pre*heating (at temperatures between 600°C and 700°C, using fluxes to dissolve iron oxide) and strong burners, with an excess amount of acetylene. White cast iron pieces are welded with white cast iron rods and after welding, the parts become malleable.

2.2.3. Non-ferrous metals and alloys

a) *Copper* falls into the category of heavy *non*-ferrous metals and in the welding process, copper exhibits the following properties: at its melting temperature (1083 °C), it becomes fluid and absorbs gases (oxygen and hydrogen) and it has very high thermal conductivity (which is why, when welded, it requires strong flames), high coefficient of expansion and shrinkage (so it is necessary to provide an open joint for the welding end). Copper is fragile at temperatures ranging between 450°C and 650°C (in which case, hammering is prohibited), and the filler metal used is the copper-silver bar (1% silver, 4-8 mm in diameter and 1m long) or the electrolytic bar. After welding, the seam requires hammering both in the hot state (at a temperature above 650°C) and in cold state (temperatures below 450°C). The minimum values of the mechanical properties for a good quality weld are: 19 daN/mm – tensile strength, 25% – elongation and 160° – bending angle.

b) Copper alloys: *brass* (contains between 28% and 42% zinc), *tombak* (contains between 10% and 20% zinc), *alpaca* (contains between 20% and 45% zinc and 8 to 10% nickel, respectively) and *bronzes* (the melting agent used is *borax*).

c) Other materials: *nickel* (oxy-acetylene flame), *zinc* (oxy-hydrogen flame), *and lead* (oxy-hydrogen flame).

d) *Aluminum*: it falls into the class of light non-ferrous metals and it is welded under special conditions, because aluminum oxidizes easily (the melting temperature of the resulting oxides exceeds the melting temperature of the metal itself).

2.3. Welding defects, repair and check of the welded parts

In the case of flame welding of metal pieces, we can encounter several types of defects, the most dangerous ones being: non-penetration, notches, metal burning and overheating, weak section of the seam, seam pores and cracks. Cracks are discontinuities made by spot breaks in the material, which are caused by the material's inner tensions exceeding its strength limit in a particular area **[7].**

Areas with welding defects can be remedied. Thus, these surfaces are processed using flame burners and high-power oxygen jet. In this situation, cracks, defective welds or other surface defects are removed, after which the processed area is re-welded. The prevention of internal tensions and deformations is possible by applying a series of constructive and technological measures (judicious placement of the part in the opposite direction to its deformation tendency, ensuring a precise stability, pre-heating the parts, applying post weld heat treatments, etc.**[8].** The quality control of the welded joints is performed both visually and using non-destructive testing methods (such as ultrasonic defectoscopy or X-rays) **[9].**

2.4. Hazards identified in the welding process:

a) The high risk of electrocution that can be prevented if the welder is properly equipped, i.e. if he has protective clothing and footwear;

b) Inhalation with carbon dioxide and argon, which in large quantities become toxic; this can be avoided if a welding mask is used;

c) Wounds caused by burns that can be prevented by wearing a flame retardant suit and professional gloves;

d) The strong light resulting from the flame can cause damage to the eye, a situation that can be avoided by using special welding glasses.

3. Location and fire compliance of the room for welding operations. Welding place organization. Basic requirements and interdictions for metals welding and cutting operations

The closed rooms, destined to this operation, are usually located, so that they may not allow the fires easy propagation for a standard period of time providing the minimum security distances or dividing them by compartments, using fire-fighting walls, according to a high value heat load. The compliance to fire has in view that the organization and the equipping of the room shall not render favorable the fire and explosion propagation. The welder job place is called welding place, a special arranged place for performing welded and preparing works, under direct current, supplied from one welding converter or from one alternative current rectifier, under an alternative current, respectively, supplied from one welding transformer**[10].** The welder stationary job place is equipped into welding cabins. Each cabin must have the following characteristics:

— Cabin sizes – 2000 × 2000 mm or 2000 × 3000 mm;

— Cabin frame made of steel and steel and steel angle bars, for the walls (h – 1800–2000 mm) it is necessary to use thin metallic sheets, asbestos-cement kitchen ranges and other fireproof materials, painted in a light color with a white zinc ceruse or made of chromium yellow titanium or other paints, well absorbing the electric arc UV rays, whereas inside, it shall be mounted a cubicle for the electrodes calcination (getting heated) and one lever circuit-breaker or magnetic starter for disconnecting the electric current source;

— The hole for the cabin door is closed by a curtain made of fireproof material;

— The cabin floor is covered by refractory materials: cement, concrete, stone or brick;

— Natural or artificial lighting with ventilation associated, including the installation of one individual fan for absorbing the noxious gases;

— one table for welding – with the sitting work height of 600 mm and 900 mm for stand up work – equipped with moving drawers for electrodes, instruments and accessories (one mask for preventing the negative impact over the eyes, as against the noxious effects of radiations and fluid metal drops, the infrared rays, one brush of steel for dirt, rust removal from metals, before welding and scoria after finishing the welding joint; sharp headed hammer, used for scoria removal from the joint surface; chisels for cutting the welding faults: frozen metal drops cutting from the product surface), for preserving the technical documents, respectively. The table area is 1 sq. m, on which it is placed a cast iron plate, thick of 25 mm (the cast iron does not exfoliate on heating) or made of steel, of 15-20 mm, and to the leg of the table, it is welded one steel bolt for fixing the current wire from the supply source and for providing the earth fighting protection;

— One metallic chair, in which the useful part is made of one power insulated material and one installed, small rubber, protective carpet, under the welder feet.

The welder temporary (moving) job places are organized for the works, directly performed on big sized-parts and equipment, installations, which cannot be moved, physically, or they cannot be moved to the welding station. In this case, the welder must move all around the welding station perimeter, either for welding an extended pipe or one fixed frame, requiring a division limit by special, fireproof screens (shields),fire extinguishing means and protection against atmosphere negative impact (existence of water steam or rain which can result in electric shocks). With the view to perform the welding works and to apply the prevention measures, it is necessary to observe the main requirements and interdictions, detailed as follows **[11]:**

- the use of power generators and of welding equipment in vertical position), as well as of the homologated cylinders (provided only with a pressure reducing device) under good condition, providing flexible tubes for acetylene and oxygen (including the performance of the under water pressure tightness control and of the adequate water level in the hydraulic valves);
- checking operation of the welding burners, power cables (provided with heat sources fighting-protection)and the electric welding aggregates, before starting work, so that the acetylene and oxygen cocks shall be perfectly closed, and the condition of the protective shield be not damaged and be well earthed;
- location at minimum security distances, norms-provided, between the flame working place and the acetylene generator (10 m) or the oxygen cylinder(5 m);
- removal of the inflammable materials and substances near the working place, around at least 10 m or their protection with wet tarpaulins, asbestos plates, non-flammable screens and other means;
- metallic parts cleaning with paint, mineral oils, textile materials in the area of the welding or cutting place;
- laboratory analyses and measurements performance with adequate equipment, on the existence of inflammable steam or gases, in the area of the working place, before the work starting, as well as during the welding or cutting operations;
- use of keys and other instruments or adequate tools, non-generating sparks by hitting, namely the copper content for the mis less than 65%;
- information of the firemen team of the organization on whose territory there are performed welding operations;
- prevention of the oxygen contact with oils, greases, plastics and other substances with a high oxidating exothermic capacity oxidation, a phenomenon followed by self-firing and explosion;
- avoiding acetylene contact with substances or materials, such as metallic oxides (for example, rust) watery solutions of the copper, silver or mercury salts or, in the presence of water steam, acetylene can be obtained even with the respective metals;
- location of the power generators n ventilated places, for preventing acetylene accumulations that can form explosive mixtures, in combination with the air (1,5-8,1%);
- protection of power generators and oxygen or inflammable gases cylinders against the sources of excessive heat, as well as the water of the power generators against the cold;
- power generator complete emptying and carbide evacuation on the work interruption or finish;
- acetylene fixed generators re-loading only after the carbide complete de-composition, mud removal, loading chimney washing and unloading;
- carbide shlam depositing in containers or in pools buried in the earth, located in places far from fire sources;
- electrical appliances for pre-heating the welding electrodes must be under good condition and power supplied from adequate sources; the remaining electrodes can be preserved in metallic boxes;
- release of the work with fire authorizations, before starting the works
- supervising and control of the working places and neighborhoods, both during operations and on their completion, as well as after one hour, at most.

Interdictions:

- location of the acetylene generators and cylinders in the places with strong heat sources, or in non-ventilated closed rooms
- moving with the fired burner outside the working area or positioning this one (even extinguished) near the acetylene generator, the oxygen cylinder or with inflammable gas;
- control of the tightness of the flexible tubes, pipes and valves of the gas networks, using the open flame;

— use of faulty, distorted, twisted, bent, cracked flexible tubes, tighten with insulating band;
— acetylene generators operation at a temperature under +5°C;
— evacuation of mud and carbide rests to the sewerage networks or their spreading in different places;
— working place abandoning, fired burners maintain under voltage or with the supplying cocks completely unclosed;
— use of improvisations for the power supply of the electrical aggregates or the use of over-sized fuses;
— maintaining under voltage the power aggregates and power cables for their supply on the work interruption;
— welding works performance, inside the buildings with crowds of people, during the work with the public.

4. Inflammable gases and fluids used on welding

The source of thermal power used for the local heating of the parts, at the melting temperature, represents the heat supplied by one gas burning, in a current of oxygen, with a high hat value. The use of inflammable gases for welding depends om the following basic parameters: the flame maximum temperature; the burning speed during the oxygen mixing; the heat density. Taking into account the high melting temperature of the materials and alloys (aluminum 99% – 658°C; iron – 1538°C; nickel 97–99% – 1455°C; platinum –1768°C; copper – 1083°C; brass (copper and zinc alloy) – 900°C; cast iron – 1250°C; steel – 1450°C; tungsten – 3380°C) **[12],** for the gas- flamed welding process, it is necessary to use inflammable gases and fluids: acetylene, methyl-acetylene, methane, hydrogen, liquefied gases steam, propane and butane, gasoline, lamp oil or benzene steams and industrial oxygen, a case in which it is requested to know their properties and characteristics, indicated in the following presentation [**13,14**]:

a. Acetylene is the non-saturated, three-linked hydrocarbon, which de-composes into hydrogen and oxygen, which gives it the property of de-composition into carbon and hydrogen, releasing heat of approx. 54 Kcal./mol, very high heat and burning temperature and a big reaction capacity. The temperature of firing by itself, in the air, has the value of 335°C, whereas in the oxygen, the value is 300°C. It is the only inflammable gas for welding stee, whereas for welding oxy-acetylene, it provides the quickest heating and penetration of all gas combinations, resulted from the de-composition of carbide in contact with water. At the environment temperature and atmospheric pressure, it exists under gas condition, with a weak ether smell, if it is breathed for a long time, it is toxic, it is liquefied at the atmospheric temperature and the temperature under 80°C, under standard conditions: 1 N/m it weighs 1,11 kg, it is soluble in water (1:1 ratio), in alcohol (1:5) and acetone (1:25), it is unstable at high pressures (at pressures over 15–16 daN/cm² it can explode, a property justifying the use of acetylene as an inflammable gas. It burns in oxygen resulting a heat quantity, and the hat value is 5,6–5,7×10^{4}Kj/m³N.The reactions of acetylene are exothermic, resulting in additional reactions, in which the molecules of other substances join. The chemical decomposition of acetylene results in a quantity of power of approximately 2080 Kcal. /kg. In the case in which explosions occur in closed rooms, the pressure indicates a value twelve times higher than the initial pressure, a reason for which the devices are sized at the test pressure of 12 atm. The cylinder-container for acetylene is identical with that for oxygen, containing a porous mass (25%), acetone (38%), acetylene (29%) and dirts (8%), to avoid a possible decomposition and it is color-marked (painted in white or yellow, with the marking ACETYLENE).

b. Methileacetlene-propadien, a liquefied gas, in which the steams characteristics are quite identical with those of acetylene (flame temperature: 2925°C). It has a reduced capacity of explosion, mixed with the air, compared with acetylene, thus providing security in operation.

c. Methane is a colorless, odorless gas, lighter than the air **[15]**, with the boiling value under 161°C at the pressure of one atmosphere [**16**], whereas the melting value is of under188°C and the heat value of 3,58×10^7 J/m³N, it burns with low luminous flame, releasing a big quantity of heat (8560 kcal/m³) and the methane and oxygen mix (or methane and air) can blow up, under one spark or open fire conditions. The theoretical burning temperature, in the air, is 2000°C, the self-firing temperature in the air is 650°C and in the oxygen it is 556°C. The cylinder container for methane contains a quantity at the pressure of 147 daN/cm², it is color-marked (painted in red). It is used for welding and cutting light-fusible alloys.

d. Hydrogen has a stressed danger of fire and explosion, the limit of explosion ranging between 4 and 75% hydrogen in the air, the hydrogen-air mixture, under the heat action, can be fired at a variable temperature, between 400 and 580°C, with the heat value of 1,05×10^7 j/m³N, the flame temperature being 2000°and burning into oxygen.

The cylinder-container for hydrogen is color-marked (painted in dark red or brown).

e. The liquefied gases steam, propane and butane, the inflammable gases, used for cutting and welding, have the disadvantage that, in the reducing zone, they release a reduced quantity of heat: the propane flame temperature is 2000°C, and for butane it is 2100°C.

f. The steam of gasoline, lamp oil or benzene (the steam mixture of gasoline and oxygen releases a temperature of 2550°C, the oil steam mixed with oxygen releases a temperature of 2475°C and that of benzene, a temperature of 2550°C) are used for welding and cutting light fusible alloys.

g. The industrial oxygen is a colorless, transparent, odorless and tasteless gas, maintaining burning, heavier than the air (1 m^3 of oxygen at the temperature of 15°C weighs 1.38 kg). Under ordinary atmospheric pressure conditions, it is gaseous, by cooling operation, under180°C it liquefies, a property used for industrial manufacturing (through the chemical, electric-chemical method, fractions-divided distillation of the fluid air). The fluid oxygen is transparent, with a blueish shade. The reactions, occurring in the presence of oxygen, are reactions of oxidation. It is used in industry to obtain some high temperatures, necessary for melting or cutting metals, a reason for burning acetylene or hydrogen in oxygen and therefore obtaining a temperature of 3500°C. Oxygen is delivered under gaseous conditions, in cylinders (mounted into triangle frames), and under fluid condition, in tanks. The cylinder-container for oxygen is made of carbo steel, whereas the cock is made of brass (according to STAS 2499-1971), containing compressed oxygen at the pressure of 147 daN/cm^2 and the temperature of 15°C, the usual capacity being 40–50 dm^3, it is color-marked (painted in blue, with the marking OXYGEN). They use the oxygen complying with the type 99 and mixed with inflammable gases, to some ratios. After combustion, it generates a welding flame from the combustion of the gaseous mixture, made of acetylene and oxygen, at the outlet of one burner. Under standard burning conditions, the oxy-acetylene flame structure consists of four distinct zones (cold zone, nucleus, primary flame and secondary flame), The aspect and temperature of the oxy-acetylene flame depend on the volume ratio between oxygen and acetylene which, under a complete burning conditions, requires a unitary value.

The inflammable system, existing during the performance of welding, cutting, sticking or other similar operations, can generate the dangerous fires or explosion condition. For cancelling the possible fire danger, it is compulsory to observe the laws in the field of fires, to organize the fire-fighting operating, respectively, specific to the job place (the employees' obligations and tasks, methods on the evacuation, intervention, equipping with extinguishing means etc.)**[17,18]**. This particular situation requires that the respective operations can be achieved only after the implementation of the prevention measures (persons evacuation, removal or protection of inflammable materials, emptying, washing, screening the piping routes or the equipment, air ventilation or ventilation of the rooms, quipping the job places with adequate means for limiting and extinguishing fires) and after obtaining the license of working with fire, excepting the workshops whose business is exactly the performance of this type of works. The license for working with open fire is a document drawn up in two copies and it is released before the work starting (requiring a 24 h time), valid for one work shift and one single day **[19].** The performance of the above-mentioned works, in the rooms in which they are forbidden by technical norms, without a license of working with fire or the license-specified conditions are not secured, represents a contravention and it is fine-sanctioned, according to the applying regulations in force **[20].**

5. Use of the open fire and works performance regulation

The fire risk factors, specific to the works with open fire, are:

a. Firing. The big danger for starting some explosive fires is represented by the wide ranged burning gases (e.g. acetylene: around 4 - 80%).

b. The combustion of inflammable substances and materials occurs only under the gaseous stage. The compressed acetylene, nitrogen chloride, as well as other composed substances which can blow up, releasing heat, burn without the existence of oxygen in the air. Apart the combustion resulting flames, as combustion products, a series of gases and smoke are released. The welding smoke is a mixture of gases, steam and fine particles of metallic oxides (six valenced chromium, nickel, zinc, manganese, cobalt, aluminum) and its maximum concentration is at the moment of the welding value increase. Carbon oxide results in all fires, especially the smoldering ones or as a result of insufficient air, representing the biggest danger, as it is highly toxic (for the blood hemoglobin its affinity is 300 times higher than oxygen, making up carboxyhemoglobin). Visibility, under smoke conditions, has a major impact on the occupier's capability to safely evacuate them from a fire. The factors with an impact on the visibility are the quantity of smoke particles in front of the sight and the physiological effect on the eyes, which could affect the decisions-making. Some researchers propose the rule that the persons visibility, during their exit, shall be at least within three meters, in the primary compartment on fire and 10 m for the evacuation ways.

c. Self-firing (chemical origin) can generate on the substances with an intense capacity of combining oxygen (in the air), with water or with other substances (e.g. acetylene mixed with chlorine).

As a rule, the phenomena of high explosion and fire potential are caused by the mixture of acetylene with air or oxygen and by the contact of the compressed oxygen with organic substances (oils, fats, etc.). For providing some optimal working conditions to avoid the premature wear of the employees and the occurrence of working accidents, due to the use of manpower under special conditions, it is compulsory to observe some fire-fighting specific norms that can b implemented, in a cumulative manner detailed as follows:

a. The performance of welding operations is allowed at a 5 m distance from the inflammable materials and 10 m from the tanks with light inflammable fluids. In all these cases, the existence of fir extinguishing means is obligatory.

b. The selection of welding equipment depends on the appraisal of the technological and operation characteristics. First and foremost, there are accepted the electrodes and flows, characterized by minimum removals of toxic substances.

c. Before commissioning the welding equipment (power supplies and the working desk), it is compulsory to provide the electric shock fighting-protection (earthing operation) carried out according to the norms in force **[21].**

d. There are forbidden the under-voltage or under-pressure equipment welding operations, as well as smoking near the acetylene generator, within a distance of 10 m.

e. Regarding the metallic materials cutting and/or welding operations which are to be carried out, near the inflammable structural elements, it is necessary to implement some fighting-protections, by: covering the inflammable structural elements with asbestos plates, using extinguishers provided with carbon dioxide and water cylinders.

f. The fire extinguishing operation for an under-voltage welding equipment, can be performed after having power-disconnected the equipment, which can be confirmed only by an authorized operator.

g. All the working places shall be provided with printed directions of use for the security equipment and indicators.

h. The clothing of the welding operators requires some characteristic: it shall be non-inflammable (o fireproof), dark-colored, tightened on the hand wrist, it shall be sleeved, with open lapels and pockets hood-provided on the head and the feet, the footwear shall be resistant and heavy, providing feet protection against the hot metal. It is not allowed the existence of light inflammable substances on the working clothes (oils, fats, petrol etc.).

i. It is forbidden the welding of painted parts or welding operation near inflammable substances (as they can generate fires), as well as the parts binding and insulation with an insulating band.

j. It is compulsory to protect the welder face, neck and ears, by using screens and masks against radiations and drops, as well as protection glasses provided with colorless glass sights for cleaning the metal slag and drops.

Distinctly from the above-mentioned, all the economic companies in which metals welding and cutting operations are performed –irrespective of the social capital form of ownership and the way of their organization – they shall draw up their own instructions (periodically revised and modified, as a result of the law changes) of labor protection, according to the technological process and the equipment they use **[22, 23]**. According to the laws in force and the specialty literature, for this field of activity it is necessary to introduce the compulsory and common rules, applied to all welding and cutting methods for metals **[24]:**

a. The operations for cutting or welding metallic materials can be performed only by persons, aged over eighteen years, who know the installations, equipment and working method, who were trained, respectively, in terms of labor security and they are skilled for the working categories to be performed and later on, they were examined (in theory and practice), authorized or certified, being capable for the welder job, from medical point of view. As part of the examination, welders will perform the tests according to a welding procedure specification (WPS)**[25].**

b. The persons who are not trained for the welder job or they are not eighteen years old can be accepted at work, under standard conditions, as a welder assistant, only under the direct supervising of the skilled operators, trained for these works and only after they have acquired the labor security instructions. In this case too, it is compulsory to use the personal protection equipment, irrespective of the form of welding they practice (electric arc welding or with oxygen and acetylene).

6. Conclusions:

Gas flame welding belongs to the category of processes that use thermo-chemical energy. The source of thermal energy used to locally heat the parts to the melting temperature is the gas flame. Depending on the gas used, the flame can be oxyacetylenic if the fuel gas is acetylene, oxymethane if the fuel gas used is methane (natural gas) and oxyhydrogen if the fuel gas is hydrogen. Non-alloyed and alloyed steels, grey cast iron, non-ferrous metals and their alloys (Al, Cu, Zn, Ni, Mg, etc.) as well as precious metals can be welded with gas flame. Flame welding (also known as autogen) uses a chemical substance, most commonly oxyacetylene, to melt and join metals, or to cut metal parts or materials. The procedure is imprecise, unsafe, because the flame gives off a very large amount of heat, which can lead to deformation of the material. In oxyacetylene welding, structural changes occur in the weld zone and, therefore, the process is only used for secondary metal constructions or for constructions from thin elements that cannot be electrically welded. Today, research and development efforts to improve the quality and properties of welding and reduce the costs of this operation are ongoing. The intense release of heat and high temperatures generated by the gas flame (the temperature of the flame varies, depending on the gas used, between 2500 and 3200°C), as well as the materials used for welding can produce explosions, fires and dangerous radiation, which is why, in the welding activity, it is necessary and mandatory to apply special technical measures of occupational safety, namely the performance of the occupational health and safety audit **[26]**. Through this audit, the degree to which the organization complies with the regulations of the law in force in the field in which it operates is evaluated. Following the audit, those responsible for labor protection will be able to determine the steps that must be followed for the organization to operate according to the law. The occupational health and safety audit is carried out at the employer's request, according to the provisions of the occupational health and safety law, by using two documents: the sheet for general risks, respectively the sheet for specific risks. At the organization level, the assessment of compliance in the welding activity requires the completion of the following sheets, regarding: management involvement; strategy, plans and procedures for safety and health at work; consultation of employees, together with the sheet for identification, assessment and prevention of occupational risks, alongside improvement and training of personnel in the field of safety and health at work. The two types of audits (compliance audit and management system audit) are aimed at identifying the degree of compliance with legislative norms (both legislative requirements and good practice rules, respectively requirements of the system model) and establishing corrective actions or necessary preventive measures.

Thus, the work process of which the welder is the executor consists in carrying out non-removable joining works of metal parts by welding with an oxyacetylene flame in the mechanical workshop. As part of the audit activity regarding the elements of the evaluated work system, we identify the following components:

a. **Work equipment**: acetylene generator with bell, oxygen cylinders, hoses, unverified pressure reducer, torches, fixed welding wrenches, filler material, strippers, wire brush, surface grinder, mobile drill, fixed grinder, stripper spray thinner, aerosol, forklift, cabinets and metal fittings for electrical installations, acetylene, carbide, carbide barrels, autogenous welder kit, tin.

b. **Work**: starting the work schedule, informing about the work to be performed, checking the welding equipment, checking and preparing the surfaces for joining and cutting, transporting the parts to the place where the welding operation is carried out, performing the actual welding, setting up the work area, including responsibilities in the field of fire prevention and fighting, and of prevention of electrocution and explosion.

c. **Work environment**: the welder carries out activity both in the specially arranged space (welding workshop) and outside or in the installations, depending on the object to be welded. In the specially designed space, there is no installation for exhausting the gases produced by welding. Inside, the space is heated in winter, but there are air currents from both ventilation and venting to exhaust the resulting gases. During welding operations, the gas complex specific to these activities is released; the lighting level, as well as the noise level (at the workshop) is within the acceptable limit.

The most important aspects of welded fabrication are health and safety measures. During welding activities, dust and gases are emitted that can adversely affect the health of welders. Considering that the job in the welding specialty is included in the category of jobs with special conditions, it is necessary to apply appropriate health and safety measures on the part of employers, namely the normalization of working conditions, to protect workers from these harmful substances. Depending on the welding materials used, the welding method and the conditions of application, the working areas must not contain harmful substances, that is, it is necessary to eliminate hazardous substances from the point of origin, and the ventilation system requires permanent operation.

7. Personal contributions:

In order to improve the working conditions of welders, it is necessary to apply technological measures in combination with sanitary-technical ones, respectively to use personal respiratory protection equipment. The first direction involves reducing the level of emissions in the air by choosing a technology and a welding method appropriate to the type and grade of the welding material. The second direction consists in the use of modern respiratory protective equipment that allows the protection of the respiratory organs of welders working in different conditions at the work stations.

We consider necessary and mandatory that the work area be provided with clean air, the main element for maintaining the health of employees.

This work has been funded by the European Social Fund from the Sectoral Operational Programme Human Capital 2014-2020, through the Financial Agreement with the title "Training of PhD students and postdoctoral researchers in order to acquire applied research skills - SMART", Contract no. 13530/16.06.2022 - SMIS code: 153734.

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