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OCCUPATIONAL HEALTH AND WELDING: THE RULES OF THE MINISTRY OF LABOR IN BRAZIL AND THE HARMFUL EFFECTS OF EXPOSURE ON WORKERS' HEALTH

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Abstract: To weld is an indispensable step in the industrial sector and different materials and processes can be used to carry it out. The joining of parts through heat, arc flash, pressure or explosion emits gases and fine particles that remain in suspension in the work environment. With a view to avoiding the exposure of workers to the harmful effects resulting from the welding process, rules were drawn up in Brazil and abroad determining the use of protective equipment and establishing standard operating procedures. The first objective of this article was to gather and analyze these standards, followed by a literature review on the harmful effects of welding fumes on human health. The injuries caused by exposure indicate inadequate or absent use of protective equipment, it is necessary to understand the causes.
Keywords: Air pollution. Welding fumes. Radiations. Emissions. Worker's health.

INTRODUCTION

Welding consists of a complex list of activities aimed at joining two or more parts through heat, arc, pressure or explosion, aiming at coating, maintenance or joining materials. Currently, these processes have been improved based on new technologies and specific markets. There are approximately twenty different types of processes that can be used for this purpose: aluminothermy, submerged arc, thermal spraying, friction or friction, brazing, brazing or lamination, atomic diffusion, coated electrode, electrogas, electroslag, explosion, electron beam, laser beam, MIG MAG (metal inert gas/ *metal active gas*), o *narrow gap*, plasma, a resistência, o *stud welding*, TIG (*tungstenio inert gas*), e o ultrassom.

The fusion welding process involves a base metal, a filler metal, a torch or pliers, a torch and a shielding gas. These materials will promote a weld pool in which the metal will be in liquid form as a result of the process, and which will result in a weld bead that will keep the pieces together.

Tin for solder or solder wire is a compound made from tin and lead bases that are mixed and prepared in the most diverse proportions. Other elements can be added in small amounts, such as antimony and silver.

The Brazilian Occupational Catalog (CBO, 2022) describes welders as professionals who join and cut metal alloy parts, prepare equipment, accessories, welding and cutting consumables, and the parts that will receive the process. As in other metallurgy processes, welding provides different occupational hazards and can affect the integrity of the professional. The process produces emissions that are known as welding fumes and radiation. Welding fumes are extremely fine particles that are generated during the welding process, the particle size of this powder is 0.01-1 μm, which means that it is easily inhaled by workers present in the environment. This metallic dust inhaled by workers is extremely harmful to health, for this reason several NBR standards address this issue.

Based on the occupational hazards involved in the welding processes, the Ministry of Labor developed rules to protect workers from exposure resulting from the activity. The purpose of this article is to describe occupational exposures to welding fumes and radiation through a bibliographic and documentary review.

METHODOLOGY

This is a documental and bibliographic review study. The regulatory norms of the Brazilian Ministry of Labor were used for the composition of this review, they fit in the documentary search. In addition to the evaluation of the standards, the recommendations of the North American "Safety in Welding and Cutting" regulation

(ANSI Z49.1:2012) were reviewed.

The bibliographic search was performed on the electronic portal of PUBMED magazines using the keyword "soldering" alone. Three articles were selected that deal in a generic way with the health of welding workers, allowing to contextualize the theme. Then the terms were used: "welding fumes" alone and "occupational health", "emissions", "atmospheric pollution" combined with "welding". Due to the large number of articles found, the "randomized controlled trial" filter was applied. The search results are shown in the table below.:

Key words	Number of articles found	Number of articles published in the last five years
Welding	7.178	50
Welding fumes	831	5
Occupational Health X Welding	1.282	7
Emissions X Welding	232	1
Air Pollution X Welding	111	0

Table 1: Results of the bibliographic search

Articles that evaluated the use of heat in medical procedures and studies whose exposure outcomes were related to dermatological health, eye health outcomes and duplicate articles were excluded. Articles that present the association between exposure to emissions from welding processes by workers in the sector were included.

RESULTS

Document review of the standards used as a reference in Brazil.

On May 1, 1943, Decree Law 5,452 unified the existing labor legislation in Brazil. The main objective of this decree was to regulate individual and collective labor relations, meeting the needs of workers. Since its publication, the CLT has been revised several times.

Law No. 6,514, of December 22, 1977, amends chapter V, which deals with occupational safety and medicine. In this context, regulatory norms (NRs) are complementary provisions that aim to ensure the safe and healthy exercise of work functions, dealing with the rights and duties of employers and workers in order to prevent the occurrence of diseases and accidents. For its elaboration, the parity tripartite system is adopted, recommended by the International Labor Organization (ILO), in which the commissions are composed of representatives of the government, employers and workers. The Permanent Tripartite Paritary Commission (CTPP) is responsible for writing and updating regulatory standards, aiming at the continuous improvement of the occupational environment.

In 1978, the first twenty-eight norms were published through Ordinance of the Ministry of Labor 3,214 and, in the following years, another eleven norms were included, totaling thirty-seven NRs in force.

Among the thirty-seven existing standards, those that are related to the health of the welding worker were chosen, they are standards 4, 5, 6, 7, 9, 15, 16, 18, 20, 33 and 34.

Indirectly, the exercise of welding operations is regulated by standards 4, 5, 6, 7 and 9. Regulatory standard 4 was published on June 8, 1978 and underwent several revisions, the last of which was in 2016, this standard has the objective of ensuring the health and protecting the physical integrity of workers in their workplace. Through this NR, private and public companies, public bodies of the direct and indirect administration and of the Legislative and Judiciary powers, which have employees governed by the Consolidation of Labor Laws - CLT, are obliged to maintain Specialized Services in Safety Engineering and in Occupational Medicine dimensioned

from the degree of risk to which the branch of activity implies.

The Internal Commission for Accident Prevention (CIPA) was established by the regulatory standard 5, which dictates the parameters and requirements for this commission, aiming to prevent accidents and occupational diseases, making work compatible with the preservation of life and promoting the health of workers. Published with the first NRs in 1978, the last revision of this standard was in 2021.

Personal Protective Equipment (PPE) means devices for individual use by the worker, which aim to protect against risks that may threaten safety and health at work, were established by NR 6 whose last revision was in 2018.

NR 7 establishes guidelines and requirements for the development of the Occupational Health Medical Control Program (PCMSO) in companies, aiming to protect and preserve the health of employees in relation to occupational risks raised through the risk assessment of the Risk Management Program (PGR) of the organization.

The welding activity exposes you to chemical and physical risks, this exposure is provided for by NR 1 in the Risk Management Program (PGR) and by NR 09 which establishes the requirements for the assessment of occupational exposures to physical, chemical and biological agents and for preventive measures against occupational hazards.

Norms 15 and 16 deal respectively with insalubrity and dangerousness. NR 15 (Unhealthy Activities and Operations) regulates work in hyperbaric conditions in its annex 6, in topic 2 on submerged work this NR classifies welding actions in item 8 of hazardous conditions. This same standard also regulates the use of welding electrodes containing manganese and welding with cadmium in the maximum degree of insalubrity.

Annex 2 of NR (regulatory rule) 16 (Dangerous Activities and Operations) of hazardous activities and operations with flammables includes maintenance activity and operations involving welding processes.

Welding processes aimed at civil construction are covered in NR 18 (Safety and Health at Work in the Construction Industry) which establishes administrative, planning and organizational guidelines, aiming to implement preventive safety systems in the processes, conditions and in the working environment in the construction industry. According to this Occupational Safety Regulatory Standard, welding, gouging, grinding, cutting or other activities that may generate sources of ignition or flame are included in the hot work category.

Safety and health at work with combustibles and flammables, applicable to welding processes, is governed by NR (regulatory rule) 20, which establishes minimum requirements for the management of safety and health at work against risk factors for accidents arising from extraction, production, storage, transfer, handling and handling of flammable and combustible liquids. In the topic that deals with the maintenance and inspection of the installations, it is established that the hoses must have a mechanism against the return of the flames at the exit of the cylinder and arrival of the torch in welding and hot cutting operations using flammable gases.

Since welding processes can often take place in confined spaces, NR 33, which regulates safety and health parameters for work in confined spaces, applies to this sector. The minimum requirements for the identification of confined spaces and the recognition, assessment, monitoring and control of existing risks are listed in this NR (regulatory rule), ensuring the safety and health of workers who

work in these spaces. In topic 33.3 which deals with the management of safety and health in work in confined spaces, in its sub-item 33.3.2.4 it is established that it is necessary to adopt measures aiming to contain the risks of fire or explosion in hot work.

NR 34 establishes the requirements and measures to protect safety, health and the work environment in the activities of the shipbuilding, repair and dismantling industry. The term "welding" is mentioned 35 times in this standard that regulates a series of protective measures for workers in the sector.

Safety risks arising from welding processes are related to burns, eye injuries, electric shock, cuts and crushing (OSHA, 2022). The document "Safety in Welding, and Cutting", in its topic number seven, details protection at the individual level, starting with the general protective aspects and then indicating the best way to act in a safe way. preventive measures regarding PPE and work in confined spaces. Item number eight addresses health protection and ventilation (ANSI Z49.1:2012).

The American Welding Society in its publication "Safety and Health Fact Sheets" brings 45 topics relevant to the health of welding workers, highlighting the importance of prevention.

Literature review on the deleterious effects of exposure to welding fumes by workers in the welding sector

Welding is a highly skilled occupation involved in a large number of production processes. A large number of workers perform some type of welding as part of their jobs. Different epidemiological studies indicate that welders have some type of respiratory disease such as bronchitis, siderosis, asthma, and possibly lung cancer. Lung diseases in these professionals are also of greater severity, duration and frequency (Antonini et al, 2004).

The exposure resulting from the inhalation of welding fumes is variable and is related to the materials used and the processes used. Hazardous agents associated with soldering processes are acetylene, carbon monoxide, oxides of nitrogen, ozone, phosgene, tungsten, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, tin and zinc. Any welding process involves the potential risk of inhalation that will result in acute or chronic respiratory disease (Meo, et al, 2003).

In large part, the materials used in welding are metal alloys that may contain iron, manganese, chromium and nickel, as a result, the properties of the welding fumes resulting from the processes will be very diverse and their deleterious effects on health will involve complex physiological relationships. Experimental animal models indicated that the constitution of the fumes will be a determining factor in the toxicity of this exposure. Fumes resulting from the welding of materials containing stainless steel induce lung inflammation and are more harmful and remain longer in the lung than fumes resulting from carbon steel. In the first case, stainless steel, the fumes have a high concentration of chromium and nickel and in the case of carbon steel the main constituent is iron (Antonini et al, 2004).

A number of conditions have been reported to be associated with occupational exposures to welding fumes such as lung function abnormalities, asthma, chronic obstructive pulmonary disease and pulmonary fibrosis such as pneumoconiosis, chronic disease from exposure to beryllium and cobalt lung, and lung cancer. (Wittczak et al, 2009).

Hartmann et al (2014) investigated the effects of MIG (metal-inert gas) welding of aluminum and zinc-coated steel on the health of healthy individuals. 12 men were exposed for six hours, on different days, to filtered air, aluminum MIG welding smoke and zinc MIG welding smoke with an average

concentration of 2.5mg/m(3). Spirometric and pulse oscillometric measurements were taken, exhalation condensate was collected and blood samples analyzed for markers of inflammation were taken before exposure, immediately after exposure, after 1 day and after 7 days. In MIG welding with zinc, there was an increase in the concentration of highly sensitive C-reactive protein (hsCRP), which is an important marker of inflammation. Exposure to fumes from aluminum MIG welding led to reduced lung function.

In view of the findings indicating that the inflammatory response can be activated by exposure to welding fumes, Markert et al (2016) evaluated which metals would be responsible for this outcome through the exposure of 15 healthy male individuals exposed under controlled conditions to fumes containing zinc, copper or zinc and copper and its derivatives indicated that any of the metals could lead to an increase in C-reactive protein.

In order to assess whether the systemic inflammatory response could be preceded by nasal inflammatory reactions, Baumann et al (2018) exposed 15 non-smoking male subjects for six hours under controlled conditions to welding fumes containing zinc and copper 2.5mg/m (3) or ambient air control. The volunteers were randomly distributed among the groups. Nasal secretions were collected before exposure and 1, 3, 6, 10 and 29 hours after exposure. The authors concluded that short-term exposure to fumes containing zinc and copper significantly increases markers of nasal inflammation.

Gube et al (2013) exposed 12 healthy men to MAG (active metal-gas) welding fumes containing chromium and nickel. Blood and urine samples were collected before and after six hours of exposure. The volunteers were divided into two random groups, one group received pollutant-free ambient air and the other received MAG welding fumes at concentrations of 1 mg/m (3) and 2.5 mg/m (3). Urine samples indicated the presence of metals after exposure to fumes.

The association between work as a welder and the development of lung cancer is unclear as smoking may mask the results of previously conducted studies. Due to this fact, Wong et al (2017) evaluated this association in welding workers who were also heavy smokers (> 30 pack years) in the United States using data from a prospective study, the National Lung Screening Trial, which surveyed 53,454 smokers. heavy. Patients with clinically/ histologically confirmed lung cancer were evaluated for history and duration of activity as a welder. The results indicated that the increase in welding work increases the risk of lung cancer among heavy smokers.

FINAL CONSIDERATIONS

Welding processes represent an important activity in the industrial sector and on them depend the production of countless goods incorporated into the productive system and the way of life of the population, thus constituting an indispensable task. However, exposure to emissions derived from this action predisposes to a series of harm to human health. The forms of prevention are well established in legislation through the use of adequate PPE and standard operating procedures. In this scenario, the deleterious effects recorded indicate the misuse, or even the non-existence of use of the indicated protective equipment. It is up to researchers to better understand this process in order to establish the causes of inappropriate use or lack of use of the necessary equipment for the correct conduct of welding actions.

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