INDIAN WELDING JOURNAL Volume 56 No. 1, January 2023

Occupational Hazards and Safety Challenges in Welding Activity

Vyom Saxena
Industrial Hygiene and Safety Section, Health, Safety & Environment Group
Bhabha Atomic Research Centre, Trombay, Mumbai, India 400085
Corresponding author email: vyomsaxena2@gmail.com

ORCID: Vyom Saxena : https://orcid.org/0000-0001-9550-9528.

DOI : 10.22486/iwj.v56i1.218496

Abstract

Welding process presents significant occupational health and safety (OHS) challenges due to a number of potential hazards associated with it. The main health hazards are due to welding fumes, radiation, heat and noise while electric current, fire and explosion, dangerous machinery, etc. constitute the major safety hazards. Many types of welding processes are available presently and the severity and nature of hazard depends on multiple factors like process and the composition of materials, ventilation, surroundings and the quantitative magnitude of the material being welded. There are various measures and techniques available to reduce the risks from welding associated occupational hazards. Since there are no safe permissible levels for exposure to welding fumes, it is important to identify the risks and hazards for a proper risk management and apply the control measures accordingly. The recently developed welding processes such as laser and electron beam welding bring in additional challenges for the OHS management. A systematic approach specific to the welding process and the associated parameters can protect the workers and the workplace from the welding hazards.

Keywords: Welding hazards, Occupational health and safety, Welding risk management, Engineering controls.

1.0 INTRODUCTION

The occupational health effects of welding are complex to study because of differences in workplace welding modalities such as industrial setting, welding processes, materials and techniques used, duration of exposure, ventilation, etc. [1]. Welding processes generate welding fumes which are submicron-sized metal containing aerosols, that may cause adverse health effects due to their chemical nature (heavy metals) and likely deposition in the alveolae of the lungs. At present, more than 80 various types of welding and related procedures are being used and the new ones are under development. The common types of welding processes involve arc welding, such as metal arc, metal inert gas, tungsten inert gas, plasma and submerged arc welding and welding with oxy-acetylene gas. The unconventional and recently developed welding processes make use of lasers, electron beams, chemical reactions, friction, ultrasonic sound and robots.

2.0 OCCUPATIONAL HEALTH AND SAFETY RISKS

Welding requires high-temperature heating and evaporation of base metals and electrodes in order to join the metals together. During welding, fumes of the gas and vapor mixtures are formed due to the combination of vaporization, condensation and oxidation processes. Welding procedure, chemical composition of shielding gas, filler metal and base material, presence of coatings are the factors which significantly influence the chemical composition of the aerosol particles [2]. Duration and intensity of exposure and ventilation significantly influence the health risks that could be short or long term. In 2019, the International Agency for Research on Cancer classified all welding fumes, including mild steel welding fume as carcinogenic. It has upgraded the classification of welding fumes as Group 1 (carcinogenic to humans) from their prior class Group 2B (possibly carcinogenic to humans) given in 1989 [3]. Apart from chronic respiratory health risks such as cancer, chronic obstructive pulmonary diseases, occupational asthma, pneumosiderosis or welder's lung, exposure to welding fumes may also cause acute respiratory health risks such as pneumococcal pneumonia, irritant-induced asthma, irritated throat or metal fume fever. Cadmium fumes cause serious respiratory ailments and the galvanized iron is a common source of metal fume fever. The hexavalent nickel chromium and nickel fumes are possible carcinogens. Systemic poisoning may result from inhalation or ingestion of substances such as fluorides, chromium, lead, barium, etc. if present in the fume [4].

Other possible occupational health effects from welding process could be due to heat, radiation (U.V., Visible, IR), arc-eye (injury to the cornea), noise, burns, electric shock, heat stress and heat exhaustion, neurological damage, hearing loss, ocular melanoma, skin damage, contact dermatitis, asphyxiation and musco-skeleton or ergonomic injuries. Occupational safety hazards of welding arise from electrical current, fire and explosion, dangerous machinery, trips and falls, compressed gasses, confined space, etc. All these health and safety risks present mammoth challenges to the occupational health and safety (OHS) professional in ensuring safety of workers and workplaces involved in the welding process. A systematic approach towards risk management can protect and prioritize employee health and safety of workplace.

3.0 RISK MANAGEMENT

In the absence of a safe level of exposure to welding fumes, a proper risk management approach is critical to deal with their associated occupational health and safety hazards [5]. Identification and assessment of hazards for the particular welding process is the first step where factors such as type of welding, materials used (eg., base metals, electrodes and surface coatings), and ambient environment and ventilation need to be considered. Material Safety Data Sheets (MSDSs) can help in identifying the hazards associated with each welding flux or filler metal materials used in the process. The hierarchy of controls is a step-by-step approach used to minimize or eliminate exposure to hazards. NIOSH defines five levels of the hierarchy of controls, namely, elimination, substitution, engineering controls, administrative controls and personal protective equipment [6]. The hierarchy begins with the most effective controls, i.e., elimination and goes down till the least effective control, i.e., Personal Protective Equipments (PPEs).

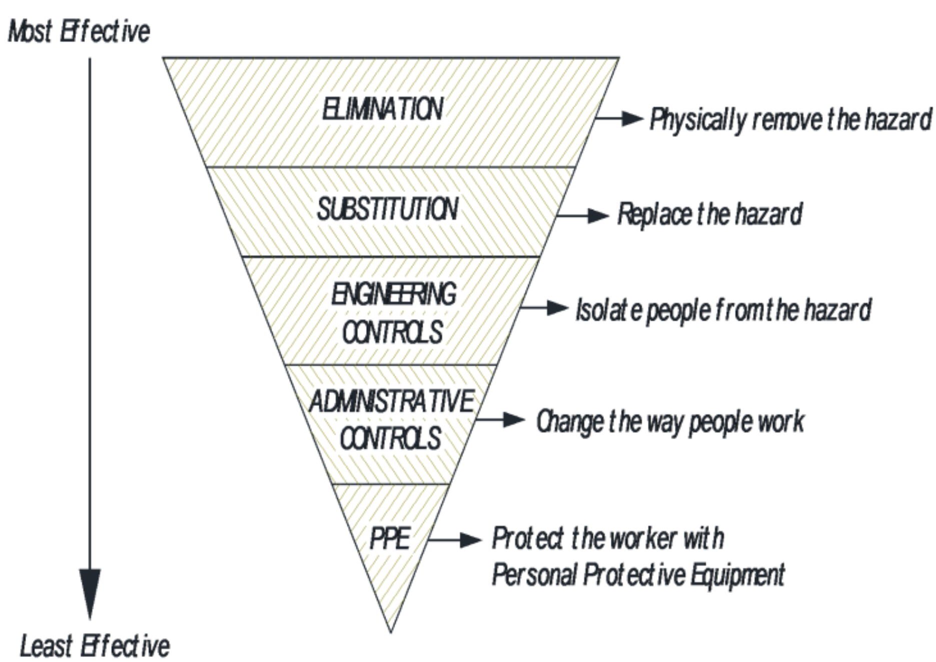

Fig. 1 : Hierarchy of controls

3.1 Elimination and Substitution

The first efforts in the risk management should be towards eliminating the risk if that is practically achievable. This could involve eliminating the hazardous process, source or any cause by measures such as mechanization, automation, use of cold joining technique, etc. If it is not possible to eliminate the risk, then it must be minimised as much as is reasonably achievable. This requires application of adequate and appropriate measures such as substitution or swapping with something that has a lower risk, e.g., less fume producing process like MIG welding in place of MMA stick welding.

3.2 Engineering and Administrative Controls

If elimination and substitution are not feasible then engineering controls should be considered that isolate the hazard by detaching workers from the source of risk or by effecting requisite modifications in physical components of the plant, equipments, structures, lay outs or work area ergonomics. Adequate ventilation is an essential prerequisite during the welding operation. Local Exhaust Ventilation (LEV) that removes the fumes and gases at their source remains a very useful engineering control for indoor welding. It may be achieved by using a non-torch extraction or partial enclosure extraction benches, hoods or booths that capture fume at its source to halt its spreading. Fume extraction gun and vacuum nozzles very close to the plume source can reduce worker exposure to welding fumes by as much as 70 percent [7]. A good general ventilation, however, must supplement local ventilation.

Engineering controls and work practices may involve substitution with less hazardous materials like using silver solders which are cadmium-free and use of electrodes, gloves, and hot pads which are asbestos-free [8]. Use of fire-resistant material in construction especially for hoods and duct work is recommended. Other engineering controls involve use of acoustic shields for protection from noise hazard and dull finishes in the welding booths to not reflect U.V. radiation.

Modification in process may involve removal of surface coatings before welding, use of water table to reduce fumes and noise in plasma arc cutting, use of sub arc instead of visible arc process to reduce radiation and fumes, safe distancing from or removal of any flammable / explosive materials. The modification in practices may involve steering clear of cluttering to prevent trips, using lowest practicable current and working in ergonomically right positioning.

If engineering controls are not practicable then the risk has to be minimized by applying appropriate administrative controls such as safe working methods and procedures, job breaks, job rotations or working time limits, etc. Administrative controls involve thorough safety training of workers on safe work practices, emergency procedures and handling of equipments, materials, processes. Standard labels, area notifications and warning signs that warn workers of hazards are also essential administrative controls.

The control measures must be decided, applied, reviewed and modified (if required) in consultation with the workers. Exposure monitoring, air monitoring, health monitoring and bioassay help in assessing the effectiveness of control measures in place.

3.3 Personal Protective Equipment (PPE)

Personal Protective Equipments (PPEs) which constitute the last line of defence should always complement engineering and administrative controls. The use of personal protective equipment is the most practicable measure to reduce the occupational health and safety risk to workers.

3.3.1 Respiratory protective equipment (RPE)

Respiratory protective equipment (RPE) specific to the hazard are essential PPE to protect workers against welding fumes. The workers must be trained to select and use the right RPE. The National Institute for Occupational Safety and Health (NIOSH), USA makes use of respirators mandatory if a carcinogen or any substance immediately dangerous to life or health (IDLH) is present in the working environment. A self-contained breathing apparatus (SCBA) is essential during the operations in confined spaces due to possible reduction in the oxygen content in the air with time.

3.3.2 Eye protection

Eye protections such as face shields or helmets and goggles are required for all types of welding operations to protect the eyes from intense U.V. - visible radiation, heat and flying sparks. Arc and oxyfuel gas welding, brazing or cutting processing additionally require special filter plates or lenses conforming to OSHA specifications in the eye protectors. Auto-darkening welding glasses are new developments in this field which are very useful and convenient for eye protection.

3.3.3 Protective clothing

Protective clothings such as fire-resistant helmets, headcap, safety glasses, face shield, high-top, gauntlet gloves, leather apron, flame-retardant coveralls, hard-toed shoes, leggings or high boots are commonly used during the welding process. Protective clothing like apron or overalls should be made of wool or specially-treated cotton fabrics that can resist fire and corrosive substances. Noisy operations such as air arcing and grinding require use of hearing protection devices such as ear plugs or ear muffs. Ear plugs may also protect from sparks or hot spatter entering the ears [9].

4.0 OHS STANDARDS IN WELDING

American Occupational Safety and Health Association (OSHA) gives standards and regulations that can apply to welders and welding operations [10]. OSHA Standard 29 CFR 1910.252 contains detailed requirements for ensuring safety during welding, cutting, and brazing operations. These include wide ranging aspects of welding work, welding safety, handling of hazardous materials, electrical and fire safety, ventilation, PPEs and training. Bureau of Indian Standards code IS:818–1888 specifies code of practice for safety and health requirements in electric and gas welding and cutting operations. Other codes such as IS code 816 and IS 1179 specify equipment for eye and face protection during welding [11]. OSHA has set permissible exposure limits for different constituents of welding smoke but NIOSH recommends that welding emissions should be kept as low as possible with the help of engineering controls since welding smoke can harm even at concentrations of the different constituents within permissible limits [12].

5.0 NEW WELDING TECHNOLOGIES

Recent technological developments in the welding field like Laser Welding and Electronic Beam Welding present additional sets of safety related risks that are unique and call for special protective measures and safety obligations. This necessitates special precautionary measures during the operation of these welding techniques.

5.1 Laser Welding

In order to achieve very precise welds, laser welding uses a focused light beam that remains very powerful even after reflection. The hazards include eye and skin burns as a result of laser beam shining on a person's body. The major hazard, however, remains to the eyes and a direct strike from the beam can cause partial or full blindness that can be temporary or permanent. Special eye protection measures are required with both the original and reflected beam, since both are very hazardous.

5.2 Electronic Beam Welding

A focused beam of electrons is utilized to produce high precision and deep penetration welds in electronic beam welding process. X-rays are produced as a by-product during the electron beam welding necessitating complete enclosing and shielding of the process and equipment for preventing x-ray exposure. All openings, doors and ports must be properly sealed and regularly checked to find out any breach of integrity in order to prevent x-ray leakage. For the purpose of measuring any accidental radiation exposure operators must wear film badges. The high voltages used for the generation of electron beam present electrical safety hazard.

5.3 Robot Welders

Use of robots as substitutes for welders on the assembly line in many industries is a recent development and is gaining momentum. Although it obviates many of the health risks that a human worker can face, but it presents additional and rather unforeseen sets of workplace safety challenges since the primary aim of robotics remains job elimination instead of workplace improvements. In addition to the anomalies arising from the incompatibility of ergonomics that are more suited to a robot's requirement rather than of a human worker, the possibility of workers getting injured by welding robots can also not be ruled out. For example, a misguided movement of a robot may result into serious safety consequences.

6.0 CONCLUSION

There are several health and safety hazards associated with the welding process. More than 80 types of welding processes are in use today with each having its own potential health and safety hazard. Managing occupational health and safety risks arising out of welding processes becomes more challenging due to a myriad of factors, the main being the absence of any safe exposure limits of welding fumes. A proper systematically structured risk management approach after identification and assessment of the hazards associated with the welding process can ensure realization of occupational health and safety objectives for workers and the workplace. The hierarchical controls defined by NIOSH, if applied properly, can help meet the OHS challenges. Many types of engineering controls and personal protective equipments are available to deal with the hazards associated with specific welding processes and a combination of right choices often determines the OHS outcomes. The new technologies pose new challenges and innovative solutions are required to deal with these challenges.

REFERENCES

[1] Antonini MJ, Badding MA, Meighan TG, Keane M, Leonard SS and Roberts JR (2014); Evaluation of the pulmonary toxicity of a fume generated from a nickel-, copper-based electrode to be used as a substitute in stainless steel welding, Environmental Health Insights, 8s1. DOI: https://doi.org/10.4137/EHI.S15260.

[2] Paul K (2021); Chapter 9 - Welding safety and training in Advancements in Intelligent Gas Metal Arc Welding Systems: Fundamentals and Applications, Science Direct, pp.353-362.

[3] International agency for research on cancer: welding, molybdenum trioxide, and indium tin oxide (2018); IARC monographs on the evaluation of carcinogenic risks to humans, Vol. 118, World Health Organization (Ed.), Lyon, France, pp.36–265.

[4] Antonini MJ (2014); Health effects associated with welding in comprehensive materials processing, Vol. 8, Bassim N (ed.), Elsevier Ltd., Oxford, UK, pp.49–70.

[5] Guide for Safety at Work Electric Shock Hazard of Manual Electric Arc Welding Work (2008); Occupational Safety and Health Branch, Labour Department., U.K., p.8.

[6] Guide for safety at work: electric shock hazard of manual electric arc welding work (2008); Occupational Safety and Health Branch, Labour Department, U.K.

[7] https://www.cdc.gov/niosh/topics/hierarchy/default.html (updated 2023).

[8] https://www.worksafe.govt.nz/topic-and-industry/welding/health-safety-in-welding (updated 2017).

[9] Zimmer AT (2002); The influence of metallurgy on the formation of welding aerosols, J. Environ Monit, 4(5), pp.628–632.

[10] Vaz MRC, Bonow CA, Sant'Anna CF, Cardoso LS, Almeida MCV (2015); Identification of thermal burns as work-related injury in welders, Acta Paul Enferm, 28(1), pp.74-80. DOI: http://dx.doi.org/10.1590/1982-0194201500013.

[11] https://www.osha.gov › regulations › standards.

[12] Indian Standard: code of practice for safety and health requirements in electric and gas welding and cutting operations (revised 2003).

[13] Mgonja C (2017); The effects of arc welding hazards to welders and people surrounding the welding area, International Journal of Mechanical Engineering and Technology, 8, pp.433-441.