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Use of Productive Aprons among Small Scale Welders in Industries to Reduce Occupational Hazard

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Abstract:
Workers in informal small-scale industries (SSI) in developing countries involved in welding, spray painting, woodwork and metalwork are exposed to various hazards with consequent risk to health. These occupational hazards faced by workers can result in temporary or permanent physical injury, short- or long-term adverse health effects, discomfort and even death. The objectives of our study were to assess occupational exposures and perceived health risks of workers in unauthorized small-scale industries (SSI) in the informal sector and to identify possible interventions. The study was carried out at different locations in Delhi. Focused group discussions were conducted among SSI workers. Participants were assessed for exposure to occupational and environmental hazards, the use of protective equipment and health complaints by interview. The findings were discussed with participants and potential interventions identified. The results were compared with that of a control group of the same age group, same locality, and the same socioeconomic class. Also, analysis and monitoring of suspended particulate matter (SPM) using personal air sampler in the workplace was done. We observed that the workers had high levels of exposure to multiple health hazards.

Keywords: welding, small scale industry, occupational hazard, health assessment, particulate matter, fume concentration.

1. INTRODUCTION

The process of welding is being used extensively for the last several decades as one of the most commonly used joining techniques for various metallic structures including ships, airplanes, automobiles, bridges, pressure vessels, etc. From performance point of view, it provides better performance in comparison to other joining techniques in terms of joint efficiency, mechanical properties, and applications. Welding, cutting, and brazing are hazardous activities that pose a Unique combination of both safety and health risks to more than 500,000 workers in a wide variety of industries. Welding joins pieces of metal by the use of heat, pressure, or both. There are more than 80 different types of welding and associated processes. Some of the most common types of welding include: arc welding, which includes “stick” or shielded metal arc welding (SMAW), the gas-shielded methods of metal inert gas (MIG) and tungsten inert gas (TIG), plasma arc welding (PAW), and submerged arc welding (SAW). Some of the welding processes may use oxy-acetylene gas, electrical current, lasers, electron beams, friction, ultrasonic sound, chemical reactions, heat from fuel gas, and robots to carry out different operations. On the other hand, brazing or soldering, involves a filler metal or alloy (a combination of metals), which has a lower melting point than the metal pieces to be joined. The filler materials (such as lead and cadmium) can be very toxic. Welding hazards include electric shock, burns, fire and explosions, radiation, heat, noise, fumes and gases. Exposure to any or all of these can be minimized by using an effective combination of control measures. The aim of the present work is to present a holistic overview of the safety and the hazards involved in a welding environment. Some of the research work carried out in this direction has also been highlighted in this article. Although limited number of research articles are available till date, with these factors in consideration a review of hazards and safety aspects in welding is very mandatory. In general, a hazard may be defined as something that has the potential to cause injury or damage to some resource (health). The risk of injury or damage to health occurring depends on how hazards are dealt with or controlled. Some of the frequently encountered hazards as experienced by welders and other related workers include mainly the electricity, radiation, heat, flames, fire, explosion, noise, welding fumes, fuel gases, inert gases, gas mixtures solvents, etc. In order to provide safe working conditions in a manufacturing environment, it becomes mandatory to take into consideration the aspects related to hazards. Risk mitigation or risk assessment therefore needs to be carried out at various levels. In view of these factors, various safety guidelines are issued by some regulatory bodies to deal with the issues of worker’s safety and the hazards prevention system / methodologies. According to the reports from Occupational Safety and Health Administration (OSHA), the risk from fatal injuries alone is more than four deaths per thousand workers over a working lifetime. Therefore, there is a need to understand the hazards and the risks involved while carrying out the welding operations. It also involves the understanding of ways and means to control these hazards. Various preventive measures have been outlined by welding experts in this direction. This includes avoiding eye injury, respiratory protection, and ventilation of the work area, protective clothing, and having safe equipment to use

2. PROBLEM IDENTIFICATION

Most of the small and medium enterprises (SMEs) have poor working conditions contributing to worker’s safety and health problem. Most welders who work in construction, factories, mining, manufacturing, metallurgy, railroad, petrochemical, ironworks, shipbuilding or steel industries, suffer from some kind of respiratory illness or pulmonary infection. Toxic gases like nitric oxide, carbon monoxide, ozone and nitrogen dioxide are produced from welding processes. These toxic gases can cause headache, pulmonary edema and drowsiness. Phosphine and phosgene are the other gases which are a health hazard. Ozone, a colorless gas produced during welding, is a powerful irritant which attacks the cell membrane and the mucous membrane. Ordinarily safe gases become too concentrated if welders work in confined space, and cause edema, filling lungs with water. Nitrous gases (nitrogen oxides) form when the nitrogen and oxygen in the air react with the hot arc and the hot base metal. NO2 is present in workplaces where combustion processes or gas welding is in use. The exposure limit for NO2 for an 8 hour work shift in most Asian countries is 2 parts per million, and the peak exposure limit for workplaces is 5 parts per million. Concentrations up to these levels occur and are sometimes exceeded. These nitrous gases affect the lungs. Carbon monoxide forms during MAG welding as a result of the atomization of carbon dioxide in the shielding gas. Carbon monoxide affects the ability of the blood to absorb oxygen.

3. WELDING AND WELDING METHODS

Welding, cutting and allied operations take place in a wide variety of locations under many different conditions. These operations are carried out in factories, building construction sites, pits, vats, mines, tanks, ship compartments and literally everywhere that metals are joined or cut. It is a major industrial process, which uses heat and / or pressure to join metals. Among the different welding techniques, arc welding has become the most widely used. The accidents happening during the welding process are very typical and involve number of injuries. Hot metal slag and spatter often can be dangerous to the operator and to the surroundings. Many welding, cutting and allied processes produce fumes and gases which may be harmful to workers health. In confined spaces the gases might displace breathing air and cause asphyxiation. Excess noise is a known health hazard in welding, cutting and allied operations. Arc welding emits harmful rays like ultraviolet rays and infrared rays and fumes which may cause unpleasantness. This article will focus on some of the hazards involved in welding & cutting operations and precautions to be taken to mitigate them. Before we discuss the various hazards involved in welding & cutting operations, it will be worthwhile to discuss briefly on some of the popular methods followed for welding & cutting operations.

3.1 WELDING AND WELDING METHODS

Welding is an ancient art that has been practiced since man begun to extract and refine iron. Welding is a process that involves the joining of metal pieces by means of a molten flux produced by heat or pressure or both. The process remains the most common method of joining metals in the industry today and is a part of the art of metal fabrication that involves the building of metal structures by cutting, bending and joining. Polishing, painting or coating of the metal pieces also goes along with the other processes to finish the article. Welding types are classified based on the source of heat for melting the metal or filler. The three common sources of heat upon which the classification is grounded are; combustion of a fuel gas with air or oxygen to produce a flame; an electric arc produced by an electrode between the electrode and work piece; and lastly, electric resistance offered to passage of current between two or more work pieces.

Manual Metal Arc (MMA) welding is a type of welding that involves the use of a consumable welding rod coated with a flux; the rod decomposes upon heating and releases shielding gases for the arc - melting the rod and work piece in the process to form a pool of molten metal. The flux on the rod then decomposes to form gases and slag which solidifies and is chipped off the welding upon completion of the task. MMA welding is the most commonly used welding method in the electric arc welding category and is also the most commonly used method in small scale enterprises for reasons that the cost of equipment and maintenance is low compared to other methods. In addition, MMA welding equipment is very portable which serves well for small scale welders who at times have to carry their equipment when called for repair jobs - and may also have to move their equipment at the end of a working day. Furthermore, only moderate skills are required to use the equipment, favouring well with most of the workers in small scale enterprises who lack the technical skills required for more specialised welding methods. Although MMA welding may be more preferable by the small scale welders, it is associated with greater risks of exposure to welding health hazards in comparison to other welding methods. For instance, the amount of fumes and gases produced in MMA welding is higher than other methods such as Gas Metal Arc Welding (GMAW) or Shielded Arc Welding (SAW). When compared to other general-purpose welding electrodes, MMA welding electrodes produce fumes that contain more chemical elements in more than trace (i.e. 1%) amounts. These fumes are largely from the vaporised and decomposed filler and coating. Also because the process of welding using MMA welding if slower compared to other welding methods such as Metal Inert Gas (MIG) welding, the welder may have to spend more 4 time working on the work piece, thereby increasing their exposure time to fumes and gases

3.2 METHODS OF WELDING

The methods of welding can be classified mainly into two viz.: (i) Oxy-Acetylene Welding and (ii) Arc Welding, which are dealt in brief below.

3.2.1 Oxy-Acetylene Welding

Oxy-acetylene welding is a very common welding process. The combination of oxygen and acetylene produces a flame temperature over 3100^{O} C making it ideal for welding & cutting. Oxy-acetylene welding is also known as oxy-fuel welding or oxy welding or gas welding and oxy fuel cutting in which fuel gases and oxygen are used to weld and cut metals. In recent decades, oxy-acetylene has been less widely utilized in industrial operations as other specially devised technologies have been adopted. However, it is widely used for welding pipes and tubes, as well as repair work. It is also frequently well suited, and favoured for fabricating some types of metal-based art work. It may be kept in mind that oxy-acetylene welding has an advantage over electric welding and cutting processes, in situations where accessing electricity would present difficulties. In oxy-acetylene welding, the flame produced by the combination of the gases, melts the metal faces of the work pieces to be joined, causing them to flow together. A filler metal alloy is normally added and sometimes be used to prevent oxidation and facilitate the metal union. The apparatus used in gas welding consists basically of an oxygen source and fuel gas source (usually cylinders), two pressure regulators and two flexible hoses (one of each for each cylinder) and a torch. Usually welding tip is mounted on the end of the torch handle and fuel & gas mixture pass through it to feed the flame. Welding tips have only one hole, while cutting tips have a centrally located hole with a number of smaller holes located around it, in a circular pattern. During cutting, the oxygen comes from the centre hole and preheat flames come from the holes around the centre hole. Now torches are available in various designs incorporating many safety devices

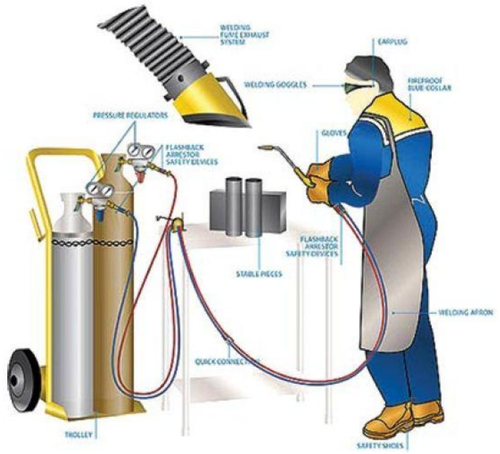

Figure 3.1 A Typical Oxy-Acetylene Welding Station

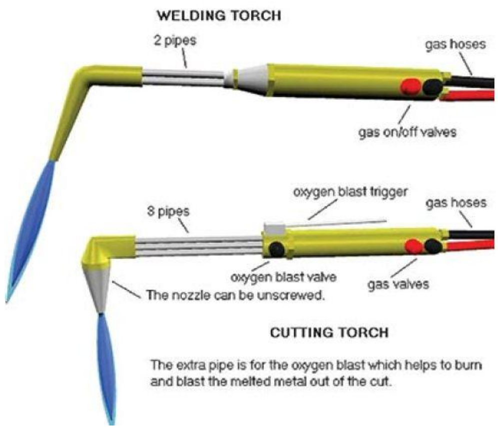

Figure 3.2 Graphical representations of a Welding Torch and Cutting Torch

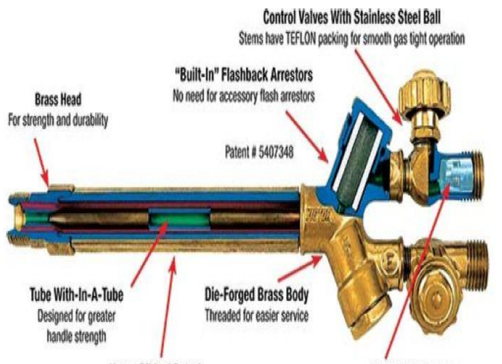

Figure 3.3 A typical torch incorporating many safety devices such as flash back arrestor and flow check valve

❖ **Oxygen Cylinders**

The gaseous oxygen is normally compressed into cylinders. The cylinder when full, normally contain oxygen at a pressure of 139.2 Kg/cm2. Oxygen is colourless and odourless. It supports and promotes combustion, but is not flammable. For identification, oxygen cylinders are painted black

❖ **Acetylene Cylinders**

Acetylene is the fuel gas normally used for welding and cutting. It is produced by the chemical reaction between water and calcium carbide. It is a highly combustible gas having an explosive range when mixed with air or oxygen in the proportion from 2% to 82%. Acetylene may be readily identified by its characteristic pungent smell. Acetylene cylinders are painted maroon for identification. When acetylene is mixed with oxygen from cylinder in the ratio of one to one, a flame having a temperature of approximately 3140O C, is obtained on ignition of the mixed gases at a blow pipe nozzle. The acetylene cylinders are charged at a pressure of 17.57 Kg/m2. At the base of the cylinder and on the cylinder valve, a bursting disk safety plug device is fitted to guard against excessive built up of pressure within the cylinder. It may be kept in mind that the user should under no circumstances tamper with these fittings. Copper pipe must never be used for coupling, because, the copper in contact with acetylene may form a dangerously explosive compound of copper acetylide.

3.2.2 Arc Welding

There has been a tremendous growth in the field of arc welding. Resistance spot welding is one of the oldest of the electric welding process in use by Industry today. The weld is made by a combination of heat, pressure and time. In arc welding, the arc is struck between an electrode and work pieces connected to an AC or DC supply. The temperature is around 4000^{O} C when the work pieces fuse together. Usually molten metal is added to the joint, either by melting the electrode itself or by melting a separate filler rod, which is not carrying current. Conventional arc welding is done manually by means of covered or coated consumable electrode hand-held in an electrode holder. However, many fully automatic electronic welding process are also carried in industry. Arc welding use a continuous electrical discharge (an electric arc) to generate high temperature of 3000^{O} C to $30{,}000^{O}$ C. The electric arc is maintained at the gap between the electrical conductors, i.e. the electrode and the work piece. The arc can be maintained and moved to melt part of the work piece and fill on filler metals as required to form a weld. Welding fumes and gases are produced during the welding process as by products in the form of a welding plume. The heat and ultraviolet radiation from the welding arc also generate potentially harmful gases in the surrounding air. Welders and other workers nearby are exposed to all of these substances.

It is estimated that about 80% of all welding is accounted for by three major arc welding methods, viz.

(i) Shielded Metal Arc Welding
(ii) Metal Inert Gas Welding and
(iii) Tungsten Inert Gas Welding.

Figure 3.4 arc welding

These methods are used to weld four major types of metals, viz.

(i) Mild Steel
(ii) Stainless Steel & High Alloy Steels and
(iii) Aluminium & Galvanised Steel.

3.2.2.1 Shielded Metal Arc Welding

Shielded Metal Arc Welding (SMAW) is the most common arc welding process. It is also known as Manual Metal Arc Welding. It uses a short length of consumable electrode, which melts as it maintains the arc. Metal with characteristics similar to the metal being welded is melted off the electrode and carried across the arc to become the filler metal of the weld. The electrode is fed into the arc as fast as it melts to maintain a constant arc length. The electrode is coated with a complex mixture of chemical compounds, which perform important functions in the welding process. The principal role of the coating is to release a blanket of inert gas such as carbon dioxide to keep air out of the arc zone to prevent oxidation and contamination while welding is in progress. The composition of the coatings varies with the metal being welded.

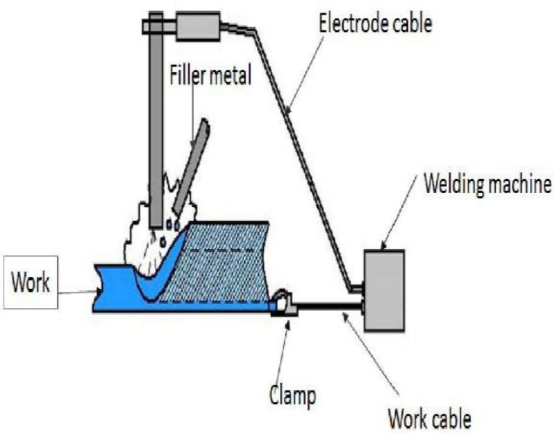

Figure 3.5 Shielded Metal Arc Welding

3.2.2.2 Metal Inert Gas Welding

Metal Inert Gas Welding (MIG) uses an uncoated consumable wire that is fed continuously down the middle of the welding torch. A ring like tube around the wire transports an inert gas such as argon, helium or carbon dioxide from an outside source to the arc zone to prevent oxidation of the weld. Flux Cored Arc Welding (FCAW) is a variation of MIG welding. This process uses a hollow consumable wire, the core of which contains various chemicals that generate shielding gases and strengthen the weld.

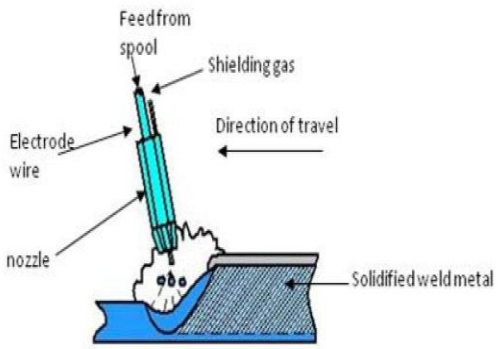

Figure 3.6 Metal Inert Gas Welding

3.2.2.3 Tungsten Inert Welding

Tungsten Inert Gas Welding (TIG) uses a non-consumable tungsten electrode, which maintains the arc and provides sufficient heat to join the metals. If filler metal is needed, it is added in the form of a rod held close to the arc, so it will melt and be deposited at the weld. Externally supplied shielding gases may or may not be used in TIG, depending on the metal being welded.

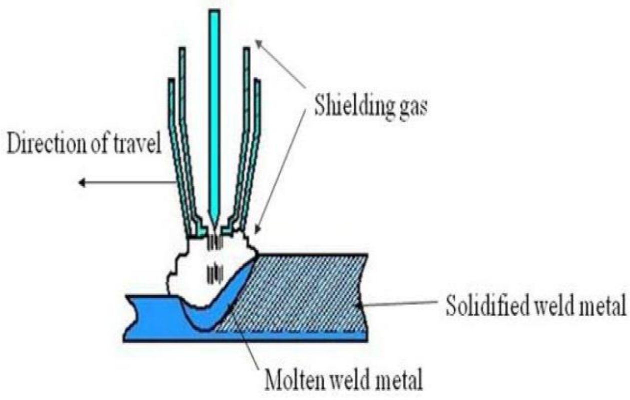

Figure 3.7 Tungsten Inert Welding

3.3 OTHER WELDING PROCESSES USED IN INDUSTRY

3.3.1 Plasma Arc Welding (PAW)

This process is similar to TIG. A non-consumable electrode is used in this process. Arc plasma is a temporary state of gas. The gas gets ionized after the passage of electric current and becomes a conductor of electricity. The plasma consists of free electrons, positive ions, and neutral particles. Plasma arc welding differs from GTAW welding in the amount of ionized gas which is greatly increased in plasma arc welding, and it is this ionized gas that provides the heat of welding. This process has been illustrated.

3.3.2 Oxyfuel Gas Welding (OFW)

This process is also known as oxy-acetylene welding. Heat is supplied by the combustion of acetylene in a stream of oxygen. Both gases are supplied to the torch through flexible hoses. Heat from this torch is lower and far less concentrated than that from an electric arc.

3.3.3 Resistance welding

Resistance welding is a group of welding process in which coalescence is produced by the heat obtained from the resistance of the work to the flow of electric current in a circuit of which the work is a part and by the application of pressure. No filler metal is needed in this process.

3.3.4 Electron-Beam Welding (EBW)

Electron beam welding is defined as a fusion welding process wherein coalescence is produced by the heat obtained from a concentrated beam of high velocity electron. When high velocity electrons strike the workpiece, kinetic energy is transformed into thermal energy causing localized heating and melting of the weld metal. The electron beam generation takes place in a vacuum, and the process works best when the entire operation and the workpiece are also in a high vacuum of 10-4torr or lower. However, radiations namely ray, infrared and ultraviolet radiation generates and the welding operator must be protected.

3.3.4 Laser Beam Welding (LBW)

Laser beam welding is defined as a fusion welding process and coalescence is achieved by utilizing the heat obtained from a concentrated coherent light beam and impinging upon the surface to be joined. This process uses the energy in an extremely concentrated beam of coherent, mono-chromatic light to melt the weld metal. This process is illustrated in Figure

3.3.5 Friction Welding (FRW)

In friction welding (solid state welding process) coalescence is produced by utilizing the heat obtained from the mechanically induced rotating motion between the rubbing surfaces. When the temperature at the interface of the two parts is sufficiently high, the rotation is stopped and increased axial force is applied. This fuses the two parts together. The rotational force is provided through a strong motor or a flywheel. In the latter case the process may be called inertia welding.

3.3.6 Other Welding Processes

Other processes used in the industry are following:

1. Diffusion bonding (DB): Parts are pressed together at an elevated temperature below the melting point for a period of time.
2. Explosion welding (EXW): The parts to be welded are driven together at an angle by means of an explosive charge and fuse together from the friction of the impact.
3. Ultrasonic welding (USW) for metals: This process utilizes transverse oscillation of one part against the other to develop sufficient frictional heat for fusion to occur.
4. Electro slag (ESW) and Electro gas (EGW) processes: In these processes a molten pool of weld metal contained by copper "shoes" is used to make vertical butt welds in heavy plate.

4. CAUSES OF WELDING ACCIDENTS AND INJURIES

Many industrial projects, including vehicles, ships, rail cars, and buildings, require the skills of welders. Welders are extremely important to our nation's infrastructure, but they also are in an extremely dangerous profession. According to the Occupational Safety & Health Administration (OSHA), 500,000 workers perform welding, brazing, and cutting annually in a variety of industries, and the risk of suffering fatal injuries is more than four deaths per thousand workers.

4.1 CAUSES OF WELDING ACCIDENTS

Electrical shock is one of the most common accidents welders face. It can be caused when two metal parts that have a voltage between them touch or by secondary voltage shock where the welder touches part of the welding or electrical circuit at the same time his body touches a part of the metal he is welding. Exposure to fumes and gases. Welders are exposed daily to toxic welding fumes and gases, such as harmful metal oxide compounds, base metals, and base metal coatings, and minerals like manganese that can cause respiratory illnesses and worse. Excessive noise. Welders can be exposed to dangerous noise levels—above 85 decibels averaged during their workday—and flying debris that can penetrate their ear canals, resulting in permanent hearing loss. Fires and explosions. Because of the high heat of the welding arc and the hazardous fumes, gases, and chemicals welders work with, they face a serious risk of being injured or killed in a fire or other explosion. Optical hazards. Sparks and hot metal drops can saturate the air and injure welder's eyes. In addition, welders risk welder's flash, eye arc, and flash burns—caused by ultraviolet and infrared radiation from the electrical arc in the welding process. Difficult work environments. Welders must often work long hours in cramped working environments where their bodies must be in awkward positions for lengthy periods of time. Hot metals. Welders are exposed to extremely hot metals, such as molten metals and hot slag, causing them to suffer serious burns.

4.2 INJURIES WELDERS COULD SUFFER

The dangers that welders are exposed to daily can cause them to suffer many life-altering injuries that will affect their lives forever or result in their deaths. Some of these injuries include:

- Eye damage, vision loss, and blindness
- Electrical shocks and burns
- Severe burns that can be life-threatening
- Hearing loss and deafness
- Lung damage
- Brain damage
- Nerve damage
- Skin lacerations
- Musculoskeletal injuries
- Crushed toes and fingers
- Welders' Parkinson's Disease

5. IMPACTS OF WELDING ON ENVIRONMENTAL AND HEALTH PROBLEMS

5.1 ENVIRONMENTAL CONSEQUENCES CAUSED BY WELDING

In these years, companies' managers compete with their competitors in order to gain more profit; so, gaining more profit is the first priority of the most companies. To achieve this goal, workers should perform difficult, onerous and dangerous tasks, in this is an unfortunate fact that the first priority of the companies belongs to more profit instead of human health. According to the working environment and conditions, serious dangers and diseases threat workers. For example, welders are working in construction, mine, metallurgy industry, petrochemical and metal industry, faced with respiratory diseases more than others due to the contaminated workplace and significant height difference relative to sea level. There are different methods for welding, which all of these methods produce toxic and hazardous gases. Produced and dangerous gases in welding processes include carbon dioxides, nitrogen dioxides and ozone. The most important feature of these gases is toxic and suffocating effects, and officials are extremely concerned about this feature. Breathing and lung problems and severe headaches are other symptoms of these gases inhalation. Of course, other gases produced in welding processes too. Use of inappropriate raw materials or impurities on the metal surface leads to produce other gases like phosgene. Ozone produced in all the welding methods. In welding operation UV radiation forms because of welding arc, this radiation leads to oxygen ionization; thus, ozone gas produces finally. In welding operation, bluish color belongs to produced ozone, and the inhaling smell in the electric sparks is the ozone smell. As mentioned, produced gases in welding are toxic and hazardous, and ozone is not the exception too. This gas is very strong and creates problems in trace amounts such as cough, nausea, bronchitis and drowsiness, and in large quantities lead to death. Produced ozone in welding can make breathing problems because of its nature (low solubility in water). Nitrogen oxides include nitrogen monoxide and nitrogen dioxide is other produced gases with dangerous effects. These oxides produced in the presence of UV radiation and nitrogen of atmosphere warming. Nitrogen dioxide produced during the welding process, without a doubt; the amount of this gas is more than other gases. This gas has different colors at different temperatures. These kinds of oxides have very dangerous effects upon human life. These gases create problems even in trace amounts such as headache, cough, and shortness of breath, eye irritation and insomnia. The important note about these oxides is exposed time. For example, very short exposed time with 50 ppm nitrogen monoxide leads to acute respiratory problems. According to the mentioned notes, this issue is a serious challenge. In this regard, some protocol should be ratified in all the countries, which determine the allowed exposed time and the allowable amount of these compounds in order to minimize the risks. Carbon monoxide is another toxic and hazardous gas, which produces in the welding process. This gas is the result of UV radiation on carbon dioxide, and leads to chemical suffocation and interferes in natural absorption of oxygen by blood. Therefore, the released gases in welding operation are toxic and hazardous gases, and lack of knowledge and safety tips leads to irreparable effects.

5.2 DAMAGING EFFECTS OF WELDING ON THE HEALTH

On welding operation, metals converted to the molten state, and they evaporated due to the very high temperature, and this produced vapor is called fume. The production of this metal vapor is with oxidation reactions; therefore, metal oxides such as aluminum, chromium, copper and cadmium produced according to the metal nature of fumes. Medical investigations proved constituent compounds of fume have negative effects upon the health. However, the influence of fume on the health is depended upon several factors such as the amount of produced fume, special metal and gas presence near the electrode tip, type of metal in welding operation and constituent compounds of the electrode. Each company or factory managed by different sectors and workers. Workers group are more vulnerable, because they are more evolved with toxic and hazardous substances; unfortunately, workers don't have appropriate and adequate training to deal with the risks in many countries and developing country, especially. As mentioned, fume threat the health, and its impacts categorized into short-term and long-term effects. As the name implies, short-term effects appear immediately, a few hours and days after inhalation; these impacts include problem such as metal fume fever. On the other hand, long-term effects make a problem after several years, and lead to chronic disease, normally. Of course, workers can be safe at short-term effects by attention to the simple and basic rules. While, these simple and basic rules don't guarantee the safety of long-term effects of these toxic fumes and gases. Another important note is effectiveness of various fumes. A fume with special compound may create irreparable problems with very low concentration; while, another fume may have fewer impacts in high concentration. Therefore, awareness from different compounds is very important. For example, operation threshold and effectiveness of aluminum is 1 milligram per cubic meter in every 8 hours of work, while this amount is 0.00005 milligram per cubic meter in every 8 hours of work for beryllium. Therefore, if a fume with beryllium compound produce in welding is more dangerous from a fume with aluminum compound. This amount called threshold limit value in safety standards. Threshold limit value determines the allowable concentration of a compound for application and inhalation, and it is specified with exact investigations and analysis by experts. Therefore, exceed this amount associated with damaging effects. Produced fume in the welding process, composed of fine and man-sized particles. These particles diameter is about 0.2 – 0.3 micron; therefore, they can effect on the human respiratory tract easily. According to the investigations, effective diameter of fume particles and welding ash is in the range of 0.0005 – 5000 micrometers. Therefore, tiny particles of pollutants increased their destructive power. It is concluded, pollutant inhalation in welders is 4 times more than other people according to the analysis and comparison between welders and others. Disadvantages of fine metal particles in fume consideration required several researches, because this is a very detailed topic. Briefly, some of the disadvantages can be noted; for example, aluminum compound in fumes leads to respiratory tract irritation, copper compound leads to acute problems such as irritation to the eyes, nose and throat, nausea and metal fume fever, manganese compound can cause problems such as metal fume fever and chronic problems in central nervous system and zinc oxides may lead to metal fume fever too. Many other problems can occur due to inhaling these pollutants.

6. EXPOSURE STANDARDS FOR WELDING EMISSIONS

6.1 EXPOSURE STANDARDS FOR WELDING EMISSIONS

Usually, exposure standards apply to long term exposure to a substance over an eight hour work per day for a normal working week, over an entire working life. Some organizations like American Conference of Governmental Industrial Hygienists (ACGIH), National Institute for Occupational Safety and Health (NIOSH), and Occupational Safety and Health Administration (OSHA) have published the exposure standards for various components in welding fumes and gases (table 2). According to Work Safe Australia exposure standards cannot be used as a fine dividing line between a healthy and unhealthy workplace. Adverse health effects below the exposure limits might be seen in some people because of individual susceptibilities and natural biological variation. ACGIH, however, recommends a TLV-TWA (Threshold Limit Value- Time Weighted Average) of 5 mg/m3 for total welding fume, assuming that it contains no highly toxic components. Each metal or gas within the welding has its own exposure standard.

As Table 2 indicates, biological media, Biological Exposure Index (BEI), and carcinogenicity class have been proposed for some welding emissions

7. PERSONAL PRODUCTIVE EQUIPMENT

7.1 TYPES OF PERSONAL PROTECTIVE EQUIPMENTS

- Head Protection
- Eye Protection
- Ear Protection Respiratory Protection
- Face Protection
- Hand Protection
- Leg Protection
- Body Protection

7.1.1 Head and Ear Protection

Wear a fire-resistant welder's cap or other head covering under your helmet. It will protect your head and hair from flying sparks, spatter, burns, and radiation. • When working out of position, such as overhead, wear approved earplugs or muffs. They prevent sparks, spatter, and hot metal from entering your ears and causing burns. If loud noise is present, wear approved earplugs or muffs to protect your hearing and prevent hearing loss. Hard hats must be worn in areas around or where there is a potential for falling objects. Hard hats must also be worn where there are low-hanging obstructions. Helmets designed to reduce electrical shock hazards must be worn when your head is exposed to electricity Some tasks require both head & face protection

Figure 7.1 Head and Ear Protection

7.1.2 Eye and Face Protection

Wear a helmet with filter lens and cover plate that complies with ANSI Z87.1 for protection from radiant energy, flying sparks, and spatter. According to ANSI Z49.1 and OSHA 29 CFR 1910.252, "Helmets and hand shields shall protect the face, forehead, neck, and ears to a vertical line in back of the ears, from the direct radiant energy from the arc and from direct weld spatter." Helmets shall be made of material that complies with ANSI Z49.1. Filter lenses and cover plates must meet the tests prescribed in ANSI Z87.1.

Figure 7.2 Eye and Face Protection

7.1.3 Foot Protection

Select boots that meet the requirements of ASTM F2412 and ASTM F2413 (or the older ANSI Z41 which has been withdrawn). Look for a compliance mark inside your boot. Wear leather, steel-toed, high-topped boots in good condition. They will help protect your feet and ankles from injury. In heavy spark or slag areas, use fireresistant boot protectors or leather spats strapped around your pant legs and boot tops to prevent injury and burns. Do not wear pants with cuffs. Wear the bottoms of your pants over the tops of your boots to keep out sparks and flying metal. Do not tuck pant legs into your boots.

Figure 7.3 Foot Protection

7.1.4 Body Protection

Wear oil-free protective clothing made of wool or heavy cotton. Heavier materials work best. They are harder to ignite and resist wear and damage. Choose clothing that allows freedom of movement and covers all areas of exposed skin. Wear long sleeved shirts (no t-shirts), and button the cuffs, pockets, and collar. They will protect your arms and neck from radiation exposure and skin burns (caused by ultraviolet radiation from the arc). Wear heavy, durable, long pants (no shorts) without cuffs that overlap the tops of your boots. Keep clothing dry. Change it when needed (this reduces the possibility of electric shock). Be aware that any cuffs or open pockets can catch flying sparks and start on fire easily. Unroll cuffs and button pockets to prevent spark entry. Keep clothing clean (free of oil, grease, or solvents which may catch fire and burn easily). Keep it in good repair (no holes, tears, or frayed edges). Always follow the manufacturer's directions for their use, care, and maintenance. Remove all flammables and matches and cigarette lighters from your pockets. Do not wear synthetic (man-made) fabrics because they may burn easily, melt, stick to your skin, and cause serious burns. Wear leather aprons, leggings, capes and sleeves as needed for the application. Leather protects better than most materials. Read ANSI Z49.1. It gives a full explanation of the protective clothing needed when welding or cutting. In brief, Z49.1 states that “Clothing shall provide sufficient coverage, and be made of suitable materials, to minimize skin burns caused by sparks, spatter, or radiation.” Full details are in the document.

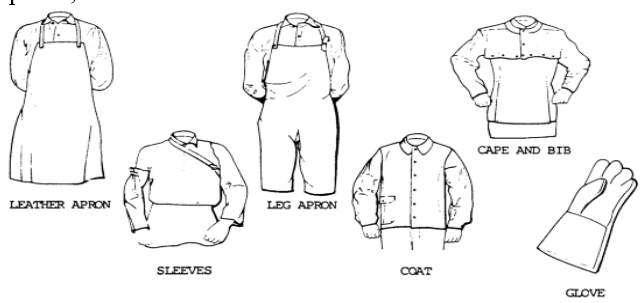

Figure 7.4 Body Protection

8. SURVEYING

8.1 SURVEYING

Working conditions of the welders who were working in the welding shops were studied. This study was done with the help of a questionnaire prepared for the workers keeping in mind the factors which will affect the health of the workers. This questionnaire was based on daily habits of the welders which plays a very important role in the health of the workers. Also similar questionnaire was used for control group (persons in similar economic condition with similar type of work environment). After this, the control study was used to calculate Relative Risk, and Population Attributable Risk (PAR).

Table 8.1 Percentage of workers suffering from health hazards without using personal productive equipment
Total no. of workers: 122 [Welders]

	Percentage of workers suffering from health hazards		
	Type of hazard	**Disease Frequency**	**Percentage**
1	Eye problem	**56**	**45.9**
2	Skin problem	**73**	**59.8**
3	Respiratory problem	**67**	**54.9**
4	Headache	**80**	**65.5**
5	Heart problem	**14**	**11.4**

Table 8.2 Percentage of workers suffering from health hazards based on years

Working years	Percentages of exposures and duration of exposure among 122 male workers in welding shops				
	Eye problem	Skin problem	Respiratory problem	Headache	Heart problem
0-5	02	01	02	06	NIL
5-10	04	05	05	08	NIL
10-15	08	12	07	14	02
15-20	12	20	18	22	05
20-25	30	35	35	30	07

9. RESULT AND DISCUSSION

The study identified the prevalence and correlates occupational health hazards in unauthorized small-scale units. We found that workers in SSI (Small Scale industries) were exposed to a variety of work-related hazards, though most of them were using protective equipment. Workers and employers were both unaware of occupational and environmental health hazards. Workers in SSI perceive themselves to be exposed to many occupational and environmental health hazards. Mostly two categories workers affected by health hazards 15-20 years and 20-25 years welders. Three main health issues occur in welding industries Headache, Respiratory problems and Skin problems.

10. CONCLUSION

Lack of protection from ultraviolet and infrared rays caused severe eye strain and eye damage to welders. An eye injury known as "Arc Eyes" affects those who see the arc without correct type of googles. All welding and cutting operations result in the production of a certain amount of smoke and atmospheric contamination. In most cases these fumes are harmless although sometimes they may be irritating. However, there have been some cases, where welders working inside tanks, the fumes and gases released in welding operations are mainly related to the chemicals contained in the coatings. Although there are vast amount of published literature, the question of the effects on health from many years of exposure to welding fumes and gases is still largely unanswered. A definite link between welding and cancer has not been established, although some research suggests an increased risk of lung cancer among stainless steel welders. Exposures to welding fumes and gases should be controlled as much as possible by following good occupational hygiene practices, such as product substitution, process modifications and ventilation. It is desirable to provide means of good ventilation when welding takes place, especially in confined spaces. It is also desirable to wear appropriate personal protective equipment such as flash goggles, gloves, aprons, boots, spats, welding helmets, welding hoods, appropriate lenses to filter ultraviolet & infrared rays, etc. during the welding and cutting operations. Lack of awareness by operators and supervisors were also observed for safe welding and cutting operations.

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