THE INDIAN INSTITUTE OF WELDING

Monograph # TM-07

WELDING SAFETY

The Indian Institute of Welding - Foundation

ISWP

A SUBSIDIARY OF TATA STEEL LTD.

The Indian Steel & Wire Products Limited (A subsidiary of Tata Steel Limited) was established in the year 1920 as the first wire drawing plant, located at Jamshedpur, India. The Company set up its Wire Rod Mill in the year 1935 and was officially incorporated as a company in the same year. The Jamshedpur Engineering & Machine Manufacturing Company (JEMCO), a division of ISWPL established in the year 1934, has been an eminent name in the Roll Manufacturing Industry.

Accredited with ISO and CII certifications, ISWPL is continuously focusing on TPM & TBEM to drive business excellence through better production with quality initiatives.

ISWPL has three different products marketed under the brand name SPARK:

SPARK WELDING ELECTRODES *SPARK Welding Electrodes are available in various variants i.e. Spark Silver, Spark Gold, Spark Diamond, Spark Platinum, Spark SS types, Spark HF and Spark CI. Armed with the latest technology, ISWPL welding products are uniquely positioned to meet the most exacting needs of the industry.*

SPARK MIG Welding Wires conform to AWS specifications and boast of controlled wire tensile strength. They also have perfect layer winding in all sizes on virgin spools for trouble-free feeding with no entanglements.

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THE INDIAN STEEL & WIRE PRODUCTS LIMITED
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PREFACE

The Indian Institute of Welding (IIW-India) was incorporated on the 22nd April, 1966 at Kolkata to foster the development of welding science, technology and engineering in India.

Since then IIW India has been serving the cause of the welding industry through its 13 branches / Centres throughout India through its various activities and programes and is recognised as the premier Institute related to welding in the country with over 4500 Individual and Corporate Members.

Further, as a member society of the International Institute of Welding, it is helping to project the importance and achievements of the Indian Welding Industry to the global community.

With a mission to be the Premier Professional Institute in India for the advancement of Welding Science & Technology and related activities, IIW-India has been continuously developing itself for achievement of the following objectives.

- ***Human resources development in Welding in India.***
- ***Technology diffusion to Industry and the individual.***
- ***Foster R&D in welding.***
- ***Promote health & safety in welding.***
- ***Promote education, training and qualification in welding in India in line with international standards.***
- ***Establish International standards of quality for the Indian fabrication industry.***

As one of the steps to Promote Health and safety in Welding this Monograph on "Welding Safety" prepared and compiled by Mr Samir Gupta , an eminent Practitioner written this book and authorized us to publish the Monograph and this Monograph is being published by IIW India Foundation by IIW. We are thankful to Mr S K Gupta, Very Senior Member of IIW for his contribution to Welding Professional

We hope, this Monograph will be helpful to Welders, Welding Technicians, Practicing Welding Engineers, Quality control personnel in their operating practices.

Parimal Biswas,
Secretary General,
The Indian Institute of Welding

R Srinivasan
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IIW India Foundation Committee

INTRODUCTION

Welding is used extensively as a major process in fabrication and manufacturing products ranging from Nano components to massive steel structures. As in other processes of manufacture Welding has also specific Hazards which are to be mitigated for the safety of all concerned to create a Productive environment.

Welding Safety is primarily important for a hazard free workplace where the welders can feel secure to work for productivity. This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

SAFETY

Every manufacturing factory using machineries and equipment impose Hazards which are to be mitigated by all concerned. In order to make the working environment as much safe as possible we must understand, evaluate and mitigate dangers and hazards arising out of the process and associated tools, plant and equipment. At the same time we must formulate the safety rules to follow.

HAZARDS OF WELDING

- ***Gases and Fumes***
- ***Fire and Explosion hazards.***
- ***Electric shock.***
- ***Radiation from Arc.***
- ***Work-Related Musculoskeletal Disorders***

The Indian Institute of Welding is committed to promote knowledge and skill in all areas of Welding and publication of this guideline is laudable.

CHAPTER – I
SAFETY – Personal Protective Equipment

Welding Safety is primarily important for a hazard free workplace where the welders can feel secure to work for productivity. This part is particularly focused on the Safety Aspects by using Personal Protective Equipment especially for Fusion Welding Processes to obtain the best possible Accident free shop floor operation.

This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

PERSONAL PROTECTIVE EQUIPMENT

To mitigate HAZARDS effectively, compulsory use of PERSONAL PROTECTIVE EQUIPMENT is absolutely necessary. Personal Protective Equipment are those which protect our body from the Hazards and Dangers arising out of Materials, Tools, Machineries and Process used in and working environment at our work place.

The most commonly used PPE are :

- *Overall or Boiler Suit*
- *Apron*
- *Hand Gloves*
- *Elbow Guards.*
- *Safety Helmets / Head Guard.*
- *Hand Shield.*
- *Goggles.*
- *Leg Guards*
- *Safety Shoes.*
- *Ear Plugs/ Ear Muffs*

Protective Clothing to the Body

Welders must wear clothing to protect them from burns. Burns are the most common injuries to welders due to sparks landing on bare skin. Welding arcs are very intense and can cause burns to skin and eyes with just a few minutes of exposure.

The actual safety clothing varies with the job being performed, but generally protective clothing must be not loose, nor tight to allow freedom of movement while providing adequate coverage against burns from sparks, weld spatter, and arc radiation. Many types of clothing will protect welders from ultra-violet radiation exposure, which appears as a skin burn (much like sunburn). Under the worst conditions, however, severe burns and skin cancer may result from excessive radiation.

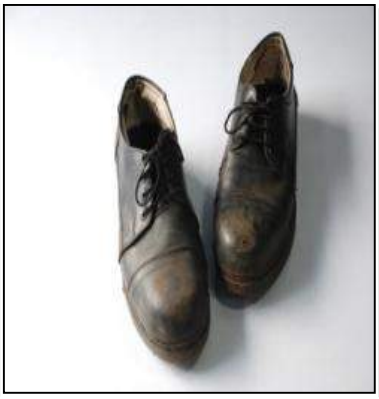
Because of its durability and resistance to fire, wool clothing is suggested over synthetics (which should never be worn because it melts when exposed to extreme heat). Thick cotton, specially treated for fire protection is equally good. All types of safety clothing must be cleaned to be free from of grease and oil, as these substances may ignite and burn uncontrollably in the presence of oxygen.

Sleeves and pant-cuffs must not be rolled up, because sparks or hot metal could deposit in the folds; also, trousers to be worn in such a way that the legs are outside work boots, not tucked in, to keep particles from falling into the boots. Leather high-tops with steel toes is better to wear (especially when doing heavy work).

OVERALL *APRON* *LEG GUARDS*



HELMET *HEAD SHIELD* *HAND SHIELD*


HAND GLOVES ***SAFETY SHOES*** ***SAFETY GLASS***

Other protective wear for heavy work or especially hazardous situations includes: flame-resistant suits, aprons, leggings, leather sleeves/shoulder capes, and caps worn under the helmet. As to preventing electric shock, the key word is dry! It must be kept in mind that moisture can increase the potential for and severity of electric shock. When working in wet conditions, or when perspiring heavily, welders must be even more careful to insulate the body from electrically "live" parts and work on grounded metal.

FOOT PROTECTION

All safety footwear should conform to EN ISO 20345

Foot Protection. When work endangers feet or requires special foot protection, employees must wear protective footwear that meets the requirements in ANSI Z41, "Protective Footwear."

HAND PROTECTION

Heavy, flame-resistant gloves, such as leather, should always be worn to protect hands from burns, cuts, and scratches. In addition, as long as they are dry and in good condition, they will offer some insulation against electric shock. Always wear dry, hole-free, insulated welding gloves in good condition. They will help protect the welder's hands from burns, sparks, heat, cuts, scratches, and electric shock. ANSI Z49.1 requires all welders to wear protective flame-resistant gloves, such as leather

welder's gloves. They generally provide the heat resistance and general hand protection needed for welding.

EYE AND FACE PROTECTION

Eye and face protection required Protective eyewear, which includes safety goggles, protective glasses and face visors and spectacles are regulated by European directives and require a minimum protection level of EN166. Further classifications include EN169 which are filtered for welding, brazing, plasma cutting, etc., EN170 for protection against sources of UV light (sunlight for instance), and EN172 for protection against sun glare.

ARC RAYS can cause burn. Eye, ear and body must be protected with proper PPE. It is essential that the eyes are protected from radiation exposure. Infrared radiation has been known to cause retinal burning and cataracts. And even a brief exposure to ultraviolet (UV) radiation can cause an eye burn known as "welder's flash." While this condition is not always apparent until several hours after exposure, it causes extreme discomfort, and can result in swelling, fluid excretion, and temporary blindness. Normally, welder's flash is temporary, but repeated or prolonged exposure can lead to permanent injury of the eyes.

Other than simply not looking at an arc, the primary preventive measure the welder can take is to use the proper shade lens in the Head and Hand Shield. For various arc welding processes the welder must refer to the lens shade selector chart for the recommended shade numbers. The general rule is to choose a filter too dark to see the arc, then move to lighter shades without dropping below the minimum rating. The filters are marked as to the manufacturer and shade number, the impact-resistant variety are marked with an "H."

Head Shields and hand-held Face Shields offer the most complete shielding against arc radiation. The shade slips into a window at the front of the shield so that it can be removed and replaced easily. The shields are made from a hard plastic or fiberglass to protect head, face, ears, and neck from electric shock, heat, sparks, and flames. The welders should also use safety glasses with side shields or goggles to protect the eyes from flying particles.

Visible light can also be harmful, but it is easy to tell if the light is dangerous: if it hurts to look at, then it's too bright. The same is true for infrared radiation: it can usually be felt as heat. However, there's no real way to predict if the welder or the onlookers being over exposed to UV radiation, so no chances should be taken and welders must always take eye protection with recommended lens for the process.

Filter Lens Shade Numbers

- *SMAW – 1/16 - 5/32 Electrodes = #10*
- *SMAW – 3/16 – ¼ - Electrodes = #12*
- *SMAW - 5/16 & 3/8 Electrodes = #14*
- *GMAW - 1/16 - 5/32 Electrodes = #11 (nonferrous)*
- *GMAW – 1/16 – 5/32 Electrodes = #12 (ferrous)*

- *GTAW – All Electrodes = # 11*
- *Plasma Arc welding – All = # 12*
- *Carbon Arc Gouging – Light # 12, Heavy # 14*
- *Atomic Hydrogen Welding = #10 - #14*
- *Carbon Arc Welding CAW = #14*
- *Soldering = #2*
- *Torch Brazing = #3 or #4*
- *Light cutting up to 1 inch = #3 or #4*
- *Medium cutting 1 inch to 6 inches = #4 or #5*
- *Heavy cutting over 6 inches = #4 or #6*
- *Light gas welding up to 1/8" = #4 or #5*
- *Medium gas welding 1/8" to ½ " = #5 or #6*
- *Heavy Gas Welding over ½ " = #6 or #8*
- *Plasma Arc Cutting – Light <300 amp = #9,*
    - *Medium 300 – 400 amp = #12*
    - *Heavy > 400 amp = #14*

NOISE

There are two good reasons to wear ear muffs or plugs:

I. *To keep out flying sparks or metal from entering into the ears; and*

II. *To prevent hearing loss as a result of working around noisy arc welding equipment, power sources, and processes (like air carbon arc cutting or plasma arc cutting).*

As with radiation exposure to the eyes, the length and number of times that the welders are exposed to high levels of noise determine the extent of the damage to the hearing. It must therefore to be ensured to avoid repeated exposure to noise. If it is not possible to reduce the level of noise at the source (by moving either the welding site or the equipment, utilizing sound shields, etc.), then welders should wear adequate ear protection. If the noise in the work area becomes uncomfortable, causing a headache or discomfort of the ears, everybody working in that area could be damaging their hearing and should immediately put on ear muffs or plugs.

In fact, the use of ear protection at all times is a good idea, as hearing loss is both gradual and adds up over time. Damage to hearing is difficult to notice as it is a slow process and can be noticed only after a complete hearing test, and then it could be too late.

The following table summarizes the differences between ear plugs and ear muffs.

Comparison of Hearing Protection

Ear Plugs	*Ear Muffs*
Advantages: ➢ *small and easily carried* ➢ *convenient to use with other personal protection equipment (can be worn with ear muffs)* ➢ *more comfortable for long-term wear in hot, humid work areas* ➢ *convenient for use in confined work areas*	*Advantages:* ➢ *less attenuation variability among users* ➢ *designed so that one size fits most head sizes* ➢ *easily seen at a distance to assist in the monitoring of their use* ➢ *not easily misplaced or lost* ➢ *may be worn with minor ear infections*
Disadvantages: ❖ *requires more time to fit* ❖ *more difficult to insert and remove* ❖ *require good hygiene practices* ❖ *may irritate the ear canal* ❖ *easily misplaced* ❖ *more difficult to see and monitor usage*	*Disadvantages:* ❖ *less portable and heavier* ❖ *more inconvenient for use with other personal protective equipment.* ❖ *more uncomfortable in hot, humid work area* ❖ *more inconvenient for use in confined work areas*

	❖ *may interfere with the wearing of safety or prescription glasses: wearing glasses results in breaking the seal between the ear muff and the skin and results in decreased hearing protection.*

Steps to take care for hearing protection device

- *Follow the manufacturer's instructions.*
- *Check hearing protection regularly for wear and tear.*
- *Replace ear cushions or plugs that are no longer pliable.*
- *Replace a unit when head bands are so stretched that they do not keep ear cushions snugly against the head.*
- *Disassemble ear muffs to clean.*
- *Wash ear muffs with a mild liquid detergent in warm water, and then rinse in clear warm water. Ensure that the sound-attenuating material inside the ear cushions does not get wet.*
- *Use a soft brush to remove skin oil and dirt that can harden ear cushions.*
- *Squeeze excess moisture from the plugs or cushions and then place them on a clean surface to air dry. (Check the manufacturer's recommendations first to find out if the ear plugs are washable.*

RESPIRATORY PROTECTIVE EQUIPMENT

Respiratory protection equipment falls under the BS EN 149:2001 and BS EN 140:1999 classifications. Protective equipment provides basic breathing defence, such as filtering half masks to protect against dust and dangerous particles. Respiratory protection devices are often referred to by their differing levels of protection, for instance: Type 1, 2 or 3 or P1, P2 or P3. For information on respirators, ANSI Z49.1 and Fact Sheet 37. Also OSH and NIOSH regulations can be referred.

USE OF SAFETY BELTS.

Often welders are required to work at a height. Use of safety belts with a connection of a life line is essential. It is imperative that both the hands of the welder working at a height is essential for manipulation of the welding cable, torch, head shield etc. and therefore a platform with a good width to stand and work must be provided when working at a height.

CONCLUSION.

When working for quality of weld welders must feel comfortable and safe from working hazards. Providing Safety Apparel and making it a habit to use this is by the welders a management responsibility in addition to make the working area hazard free.

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Welding Safety FAQs - Personal Protective Equipment

Clothing

Q: What is the most common injury to a welder?
A: Burns are the most common injury to welders due to sparks landing on the skin. Welding arcs are very intense and can cause burns to skin and eyes with just a few minutes of exposure.
Q: What protective clothing is needed in arc welding?
A: Protective clothing needed for welding includes general fire resistant clothing, safety glasses, shoes, gloves, helmet and leathers.
Q: Can oxy-fuel tinted goggles be used to protect your eyes while arc welding?
A: No, oxy-fuel goggles do not protect your eyes from the intense ultraviolet radiation (UV) produced by the welding arc. A welding helmet with the proper shaded lens must be used whenever welding.
Q: What types of fabric are recommended for clothing worn when arc welding?
A: Because of its durability and resistance to fire, wool clothing is suggested over synthetics. Synthetics should never be worn because it melts when exposed to extreme heat. Cotton can be worn if it is specially treated for fire retardation.
Q: What are steps that you can take to prevent hot sparks from being trapped in your clothing?
A: Avoid rolling up your sleeves or pant cuffs, because sparks or hot metal could deposit in the folds. Also, wear your pants outside your work boots, not tucked in, to keep particles from falling into your boots.

Safety Glasses

Q: Is it necessary to wear safety glasses if you are already wearing a welding helmet?
A: Even when wearing a helmet, Z87.1 approved safety glasses with side shields, or goggles, should always be worn to protect your eyes from flying particles.

Shoes

What types of footwear are recommended for welders?
A: Leather boots with six- to eight-inch ankle coverage are the best foot protection. Where heavy work is done, safety-toe protection boots should be worn. Metatarsal guards over the shoe laces can protect them from falling objects and sparks.

Gloves

Q: What types of gloves are suitable for protecting your hands while welding?
A: Heavy, flame-resistant gloves (from materials such as leather) should always be worn to protect your hands and wrists from burns, cuts and scratches. As long as they are dry and in good condition, they will offer some insulation against electric shock.

Helmets and Arc Rays

Q: What are the two forms of radiation given off by the welding arc?
A: The two types of radiation are Infrared (IR) and Ultraviolet (UV) radiation. IR radiation can cause retinal burning and cataracts. IR can usually be felt as heat. UV radiation, which cannot be felt, can cause an eye burn known as "Welder's Flash."
Q: How can exposure to IR and UV radiation injure your eyes?
A: It is essential that your eyes are protected from radiation exposure. IR radiation can cause retinal burning and cataracts. IR can usually be felt as heat. UV radiation, which cannot be felt, can cause an eye burn known as "Welder's Flash." This condition may not be apparent until several hours after exposure. It can cause extreme discomfort and can result in swelling, fluid excretion and temporary blindness. Normally, "Welder's Flash" is temporary, but repeated or prolonged exposure can lead to permanent injury of the eyes.
Q: Is it safe to weld without a welding helmet for a brief period of time, such as during tack welding?
A: Even brief exposure to UV rays can result in a burn to the eyes known as "Welders Flash" which may not be evident until several hours after exposure. It causes extreme discomfort and can result in swelling, fluid excretion from the eyes and even temporary blindness. Normally, this condition is temporary, but repeated overexposure to UV radiation can result in permanent eye damage.
Q: How do you select the proper filter lens for your welding helmet?
A: The general rule of thumb is to choose a filter too dark to see the arc and then move to the next lighter setting without dropping to below the minimum recommended rating.
Q: How can you tell that you are being overexposed to radiation from the welding arc?
A: Infrared (IR) radiation cannot be seen but is felt as heat. And there is no way to sense if you are being overexposed to Ultraviolet (UV) radiation – so just do not take any chances and always wear eye and face protection with the proper protective shading.
Q: How can overexposure to the UV radiation from the welding arc injure you?
A: UV radiation can also burn exposed skin. This process is similar to getting sunburn from overexposure to the sun. Long exposure to arc rays without protection can lead to second and third degree skin buns. Repeated overexposure to ultraviolet radiation is a known cause of skin cancer.
Q: Is it safe to wear contact lenses while arc welding?
A: Welders should be able to wear contact lenses safely in most situations – provided they wear appropriate industrial eye wear and use the protection we've already discussed with respect to protection against arc rays. Anyone wearing contacts on the job should consult with their company medical staff and their own ophthalmologist.

Noise and Hearing Protection

Q: How can you protect your hearing when arc welding?
A: Earplugs and earmuffs keep metal sparks and airborne particles from entering your ear canal and protect your hearing from the effects of excessive noise.
Q: How do you know when the noise level to which you are exposed is potentially hazardous?
A: Levels of noise over 85 decibels, averaged over an eight-hour workday, are potentially hazardous to your hearing. When noise levels are painful or are loud enough to interfere with your ability to hear others speaking at a normal conversational volume this is an indication that levels are potentially hazardous.
Q: How does exposure to high noise levels damage your hearing?
A: The length and number of times you are exposed to high levels of noise determines the extent of the damage to your hearing. High noise levels cause damage to the ear drum and other sensitive parts of your inner ear.
Q: In addition to wearing hearing protection, what measures can you take to protect yourself from high noise levels?
A: If it is not possible to reduce the level of noise at the source by moving either yourself or the equipment, or by using sound barriers, then you should wear adequate ear protection.

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CHAPTER – II

Gases and Fumes.

The hazards imposed by the Gases and Fumes generated by Welding Processes must be safe guarded for welders to work safely to obtain the best possible Accident Free shop floor operation resulting high productivity.

This is a Working Guideline for Supervisors and Operators working in any Engineering Fabrication Plant using welding as a manufacturing process to initiate awareness for observing Safety Rules and regulations.

In all the Welding operations Gases and Fumes are generated in large volume. Generally it is termed as "Welding Smoke." Welding "smoke" is a mixture of very fine particles (fumes) and gases. *The sources of Gas and Smoke generated in Welding are from :*

- ***Base material*** *being welded,*
- ***Filler material*** *that is used,*
- ***Coatings*** *covering the electrode,*
- ***Coatings*** *and* ***paints*** *on the metal being welded,*
- ***Shielding gases*** *supplied from cylinders,*
- ***Chemical reactions*** *which result by the action of ultraviolet light from the arc and heat,*
- ***Process*** *and* ***consumables*** *used,*
- ***Contaminants in the air,*** *for example vapors from cleaners and degreasers.*

Hazards from welding gases include:

- ***asphyxiation (lack of oxygen)***
- ***fire or explosion***
- ***toxicity***

The effects of exposures to the Gases and Fumes generated by the welding processes to the welder and the coworkers are multi directional because the fumes may contain so many different substances that are known to be harmful to different parts of the body including the lungs, heart, kidneys and central nervous system.

Welders are at the highest risk for exposure to welding gases and fumes, but anyone who works near a welder can also inhale welding fumes. This is especially true indoors or in confined spaces. In those areas, fumes can't dissipate and hazardous levels can build up. Workers in an enclosure or confined space with a welder should assume that they are at the same level of risk as the welder. Welding fumes are made of many different metallic components. Each fume will be different depending on the material being welded, the electrode, and the type of welding. The airborne gases and fumes produced or present during welding can include:

- *Nitrous oxide*
- *Carbon dioxide*
- *Carbon monoxide*
- *Shielding gases like argon or helium*

- *Ozone*
- *Metal fumes such as manganese and chromium*

Many of the substances in welding smoke, such as chromium, nickel, arsenic, asbestos, manganese, silica, beryllium, cadmium, nitrogen oxides, phosgene, acrolein, fluorine compounds, carbon monoxide, cobalt, copper, lead, ozone, selenium and zinc, can be extremely toxic.

Welders who smoke may be at greater risk of health impairment than welders who do not smoke, although all welders are at risk.

Gases

All welding processes produce GASES. Gasses are also formed from the decomposition of the shielding gases and fluxes and from interaction of ultraviolet light or high temperatures with atmospheric gases and the shielding gas. In general ozone, nitrogen oxides and carbon monoxide are the most common gases formed. Phosgene gas produced from chlorinated solvents decomposing in the welding arc can react with moisture in the lungs to form hydrochloric acid which is extremely toxic. To prevent this, use of solvent or storage near welding should be prohibited. At normal concentration in use, these gases are not visible to the eye and, in the case of carbon monoxide, not detectable by smell also. The concentration of gases from welding may potentially reach toxic levels in confined spaces or in areas with little or no ventilation for which care must be taken to ensure dilution with proper ventilation.

A regulation adopted by Oregon Occupational Safety and Health Administration (Oregon OSHA) titled: OAR 437 Division 2 Subdivision Q: Welding, Cutting, and Brazing can be followed on such situations.

Fumes

All welding processes produce fumes. Fumes are very fine solid particles produced by the condensation from the gaseous state. Welding fumes often contain metals, metal oxides and other compounds volatilized from either the base metal, electrode, or flux material. The quantity varies widely depending on the welding process. Welding fume particles are very tiny almost all are less than one micro milimeter in diameter, so that fumes will be present during welding whether a smoke plume is visible or not. Also, due to their small size, fumes are able to penetrate deep into the respiratory system to the alveoli.

In determining the degree of the hazard of fumes, the presence of certain toxic metals in fumes will be the more important factor than the total quantity of fumes. The parent metal to be welded containing manganese, chromium, nickel, cadmium, zinc, and copper may be present as small fractions of the total fume, but may impose as the major hazard of the job. The major sources of the fume come from the electrode metal, flux material and coatings on the base metal. Prolonged and repeated overexposure to these metals may cause respiratory and/or neurological problems. Welding fumes have also been classified as "possibly carcinogenic" by the International Agency for Research on Cancer (IARC Group 2B). Fume generation rates can be altered by voltage, arc length, current, electrode diameter, electrode polarity, shielding gas, base metal, fluxes, fillers, wire feed speed, humidity, and position of the weld. As the voltage, arc length, current, wire feed speed, and humidity increases, more fumes

are generated. 30% more fumes are generated by welding DC positive compared to DC negative or AC.

Materials used in welding producing Gases and Fumes

Core and filler metals

Core and filler metals are usually made of alloy similar in chemical composition to the materials being welded. The most commonly used material is mild steel. Special steels may contain chromium, nickel, molybdenum, aluminium, cobalt, vanadium or tungsten. Stainless steel electrodes may contain up to 26 per cent chromium and 21 per cent nickel. Manganese as high as 14 per cent may also be present in certain types of steel electrodes, for example, high-manganese hardfacing electrodes. High-chromium hardfacing electrodes may contain up to 30 per cent chromium, present as chromium metal and chromium carbide.

Electrode coatings (fluxes)

MMAW electrodes are coated with a complex mixture of materials which, by melting and chemical decomposition, provide the following functions:

- *a non-oxidising atmosphere (cellulose, carbonates);*
- *optimum weld and weld pool metallurgy (various metals or their oxides, calcium*
- *fluoride);*
- *slag formers (clays and oxides of titanium, silicon, manganese and magnesium); and*
- *additional charge carriers to the plasma (readily ionisable elements such as sodium,*
- *potassium and calcium from their compounds).*

Electrode coatings may also include ferro-manganese, ferro-vanadium and ferro-silicon. In addition, the following agents are used in manufacturing MMAW electrodes:

- *Moulding agents, such as aluminium and magnesium silicate;*
- *Extruding agents, such as starch, glucose and methyl cellulose;*
- *Binders, such as potassium and sodium silicate; and*
- *Fibrous materials, such as mica (asbestos is not used now).*
- *Coatings of low-hydrogen electrodes have a high fluoride content. Electrode coatings in certain instances may have substantial amounts of metallic constituents added which contribute to the weld deposit, for example, iron, manganese, chromium and nickel.*

Coatings on materials to be welded

Materials being welded may be:

- *metal coated with zinc, lead or tin, which may be achieved by electroplating, hot dipping*
- *or metal spraying;*
  - ✓ *electroplated with cadmium, copper, chromium or nickel;*
  - ✓ *primed, painted with coatings containing lead pigments, zinc chromate, zinc dust or*
- *copper (as in anti- fouling coatings); and*
  - ✓ *coated with resins, such as epoxy, phenol formaldehyde, vinyl, polyurethane, bitumen, oil*
- *modified alkyd and sodium/potassium silicate.*

Fume Formation in welding processes

Welding fume is an extremely complex by-product of certain kinds of welding processes. In MMAW, fume arises by vaporisation of the core metal and flux components of the

electrode. The various constituents of the core metal and flux react at the high temperatures of the welding arc to produce fume particles consisting of a mixture of complex oxides, etc. The extent to which the products of reaction of core and flux components will appear in the welding fume depend on factors such as:

- ❖ *welding conditions, which influence arc and gas temperatures;*
- ❖ *heats of formation, a thermochemical factor; and*
- ❖ *relative volatilities, that is, vaporisation behaviour, of the metal oxides, etc.*
- ➢ *In certain cases, materials other than the welding consumables may represent a significant source of atmospheric contamination. Some examples are:*
- ➢ *where the workpiece itself contains volatile constituents, such as beryllium in copper;*
- ➢ *where ferrous alloys have a surface coating (see the section on welding processes and*
- ➢ *materials), or*
- ➢ *where non- ferrous metals, such as copper and nickel or their alloys, are cut,heated or welded; and*
- ➢ *where painted metal surfaces are used, metal fumes may result from the paint pigment and organic pollutants from the paint binder.*

Fume production in different welding processes

As a rough guide, it may be noted that among the arc processes, SAW has the lowest fume formation rate. Then, in ascending order, come

GTAW,
GMAW,
MMAW and
FCAW.

***NOTE** : In GMAW, carbon dioxide-shielding results in much higher fume formation rates than argon or helium gas-shielding. Oxygen or carbon dioxide additions to the inert shield gas stabilise the arc, but usually result in increased fume formation rates. However, small additions of carbon dioxide to argon or helium have been found to result in spray transfer at low arc voltages, accompanied by very low spatter rates and low fume formation rates.*

Welding: fumes

Grinding and abrasive blasting are known to produce large amounts of fume and dust. In SAW there may be a dust problem due to flux handling but, since there is no open arc, fume and gas problems are minimal. The arc-air gouging process represents environmental hazards of both noise and atmospheric contaminants showing not only high total fume levels but also high copper in the fume from the copper coating on the graphite electrode, and significant concentrations of nitrogen oxides, ozone and carbon monoxide.

The amount of fume given off during plasma welding or cutting is, in general, greater than that encountered in GMAW. Microwelding and specialist processes such as friction welding, electron beam, and laser welding generally produce very little fume.

Fume formation rates and fume composition

Both the fume formation rate and the chemical composition of the fume are affected by the welding parameters and the type of application. Listed below are the most important factors which have been shown to affect the rate of fume formation and the fume composition:

- ✓ *voltage drop across the welding arc which is related to the arc length being maintained;*

- ✓ *welding mode, that is, AC, DC electrode positive (DCEP) or DC electrode negative (DCEN);*
- ✓ *arc current;*
- ✓ *angle between electrode and workpiece;*
- ✓ *position and type of weld, that is, fillet, bead-on-plate, etc.; and*
- ✓ *heat input, which is related directly to arc power (arc voltage **x** arc current) and inversely to welding speed.*

Fume formation rates may vary critically with arc length, which in turn may be affected by the degree of skill of the welder. In general, fumes increase with increasing current, with increasing voltage and with longer arc lengths.

Fume formation rates may be expressed as:

- ✓ *g/min;*
- ✓ *g/kg electrode; or*
- ✓ *g/kg weld deposit.*

Note: Fume (g/min) = fume (g/kg electrode) x electrode melting rate (kg/hr) 60

Fume particle size

Welding fume particles are less than 1 µm, that is, 0.001 mm in diameter, when produced, but they appear to grow in size with time due to agglomeration, that is, particles sticking together. Particles in the size range 1-7 µm thus develop with time. The 1-7 µm diameter particles constitute the greatest health hazard because of their ability to penetrate deep into the lungs and because they are not readily cleared by the cilia lining the respiratory tract. The particles visible in the fume plume are usually the heavier, that is, larger, particles which will rapidly precipitate onto adjacent surfaces as 'dustfall'. Particles in the welder's breathing zone are usually 2 µm or less - these lighter, smaller, particles may remain in the air for some hours if they are not removed by ventilation.

Source and Health Effect of Welding Fumes

Table 1: Source and Health Effect of Welding Fumes

Fume Type	Source	Health Effect
Aluminum	Aluminum component of some alloys, e.g., Inconels, copper, zinc, steel, magnesium, brass and filler materials.	Respiratory irritant.
Beryllium	Hardening agent found in copper, magnesium, aluminum alloys and electrical contacts.	"Metal Fume Fever." A carcinogen. Other chronic effects include damage to the respiratory tract.
Cadmium Oxides	Stainless steel containing cadmium or plated materials, zinc alloy.	Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.

Chromium	Most stainless-steel and high-alloy materials, welding rods. Also used as plating material.	Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium).
Copper	Alloys such as Monel, brass, bronze. Also some welding rods.	Acute effects include irritation of the eyes, nose and throat, nausea and "Metal Fume Fever."
Fluorides	Common electrode coating and flux material for both low- and high-alloy steels.	Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs.
Iron Oxides	The major contaminant in all iron or steel welding processes.	Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.
Lead	Solder, brass and bronze alloys, primer/coating on steels.	Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning.
Manganese	Most welding processes, especially high-tensile steels.	“Metal Fume Fever.” Chronic effects may include central nervous system problems.
Molybdenum	Steel alloys, iron, stainless steel, nickel alloys.	Acute effects are eye, nose and throat irritation, and shortness of breath.
Nickel	Stainless steel, Inconel, Monel, Hastelloy and other high-alloy materials, welding rods and plated steel.	Acute effect is irritation of the eyes, nose and throat. Increased cancer risk has been noted in occupations other than welding. Also associated with dermatitis and lung problems.
Vanadium	Some steel alloys, iron, stainless steel, nickel alloys.	Acute effect is irritation of the eyes, skin and respiratory tract. Chronic effects include bronchitis, retinitis, fluid in the lungs and pneumonia.
Zinc	Galvanized and painted metal.	Metal Fume Fever.

Table 2: Source and Health Effect of Welding Gases		
Gas Type	**Source**	**Health Effect**
Carbon Monoxide	Formed in the arc.	Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death
Hydrogen Fluoride	Decomposition of rod coatings.	Irritating to the eyes and respiratory tract. Overexposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.
Nitrogen Oxides	Formed in the arc.	Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems such as emphysema.
Oxygen Deficiency	Welding in confined spaces, and air displacement by shielding gas.	Dizziness, mental confusion, asphyxiation and death.
Ozone	Formed in the welding arc, especially during plasma-arc, MIG and TIG processes.	Acute effects include fluid in the lungs and hemorrhaging. Very low concentrations (e.g., one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function.

Table 3: Source and Health Effect of Organic Vapours as a result of Welding		
Gas Type	**Source**	**Health Effect**
Aldehydes (such as formaldehyde)	Metal coating with binders and pigments. Degreasing solvents	Irritant to eyes and respiratory tract.
Diisocyanates	Metal with polyurethane paint.	Eye, nose and throat irritation. High possibility of sensitization, producing asthmatic or other allergic symptoms, even at very low exposures.
Phosgene	Metal with residual degreasing solvents. (Phosgene is formed by reaction of the solvent and welding radiation.)	Severe irritant to eyes, nose and respiratory system. Symptoms may be delayed.

Phosphine	Metal coated with rust inhibitors. (Phosphine is formed by reaction of the rust inhibitor with welding radiation.)	Irritant to eyes and respiratory system, can damage kidneys and other organs.

There are health effects for both short-term and long-term exposure to these gases and fumes. Some of these are stated below:

Short-term exposure

- *Eye, nose, and throat irritation*
- *Dizziness*
- *Nausea*

Long-term exposure

- *Occupational asthma*
- *Pneumonia*
- *Metal fume fever*
- *Reduced lung function*
- *Stomach ulcers*
- *Kidney damage*
- *Nervous system damage*
- *Prolonged manganese exposure can cause Parkinson's-like symptoms*
- *Cancer of the lungs, larynx and urinary tract*

Short-Term (Acute) Health Effects

Metal Fume Fever

*Exposure to metal fumes (such as zinc, magnesium, copper, and copper oxide) can cause **metal fume fever.** Symptoms of metal fume fever may occur 4 to 12 hours after exposure, and include chills, thirst, fever, muscle ache, chest soreness, coughing, wheezing, fatigue, nausea and a metallic taste in the mouth.*

Irritation to Eyes, Nose, Chest, and Respiratory tract

Welding smoke can also irritate the eyes, nose, chest, and respiratory tract, and cause coughing, wheezing, shortness of breath, bronchitis, pulmonary edema (fluid in the lungs) and pneumonitis (inflammation of the lungs).

Gastrointestinal effects

Gastrointestinal effects, such as nausea, loss of appetite, vomiting, cramps, and slow digestion, have also been associated with welding.

Cadmium Fumes effects

Some components of welding fume, for example cadmium, can be fatal in a short time.

Utraviolet Radiation Effect

Gases given off by the welding process can also be extremely dangerous. For example, ultraviolet radiation given off by welding reacts with oxygen and nitrogen in the air to

*form ozone and nitrogen oxides. These gases are deadly at high doses and can also cause irritation of the nose and throat and serious lung disease**.***

Ultraviolet rays given off by welding can react with chlorinated hydrocarbon solvents, such as 1, 1, 1-trichloroethane, trichloroethylene, methylene chloride, and perchloroethylene, to form phosgene gas. Even a very small amount of phosgene may be deadly, although early symptoms of exposure -- dizziness, chills, and cough -- usually take 5 or 6 hours to appear. ***Arc*** *welding should never be performed within 200 feet of degreasing equipment or solvents.*

Long-Term (Chronic) Health Effects

- *Studies of welders, flame cutters, and burners have shown that welders have an increased risk of lung cancer, and, possibly cancer of the larynx (voice box) and urinary tract.*
- *These findings are not surprising in view of the large quantity of toxic substances in welding smoke, including cancer-causing agents such as cadmium, nickel, beryllium, chromium, and arsenic.*
- *Welders may also experience a variety of chronic respiratory (lung) problems, including bronchitis, asthma, pneumonia, emphysema, pneumoconiosis (refers to dust-related diseases), decreased lung capacity, silicosis (caused by silica exposure) and siderosis (a dust-related disease caused by iron oxide dust in the lungs**).***
- *Other health problems that appear to be related to welding include: heart disease, skin diseases, hearing loss and chronic gastritis (inflammation of the stomach**),** gastroduodenitis (inflammation of the stomach and small intestine) and ulcers of the stomach and small intestine. Welders exposed to heavy metals such as chromium and nickel have also experienced kidney damage.*
- *Welding also poses reproductive risks to welders. A recent study found that welders, and especially welders who worked with stainless steel, had poorer sperm quality than men in other types of work. Several studies have shown an increase in either miscarriages or delayed conception among welders or their spouses. Possible causes include exposure to: (1) metals, such as aluminum, chromium, nickel, cadmium, iron, manganese, and copper, (2) gases, such as nitrous gases and ozone, (3) heat and (4) ionizing radiation (used to check the welding seams).*
- *Welders who perform welding or cutting on surfaces covered with asbestos insulation are at risk of asbestosis, lung cancer, mesothelioma and other asbestos-related diseases. Employees should be trained and provided with the proper equipment before welding near materials that contain asbestos.*

NEVER weld on or near anything that's been cleaned with a chlorinated hydrocarbon like brake-cleaner. When combined with UV light, chlorinated hydrocarbons can create phosgene gas, which can cause serious injury or death. Ventilation will not prevent poisoning.

HAZARDS AND RISKS.

In every work place there will be "hazards". When considering the hazards associated with any workplace, it is essential to understand the relationship between 'hazard', 'exposure' and 'risk'.

- *'Hazard' is the potential for an agent or process to cause injury or harm.*
- *'Risk' is the likelihood that an agent will produce injury or disease under specified conditions.*
- *Health effects can only occur if a worker is actually exposed to the hazard.*

The risk of injury or disease usually increases with the duration and frequency of exposure to the agent, and the intensity/concentration and toxicity of the agent or process.
Toxicity refers to the capacity of an agent to produce disease or injury.
The evaluation of toxicity takes into account the route of exposure and the actual concentration of an agent in the body.

In cases of welders exposed to Gases and Fumes a prior study on Hazards, Exposure and Risks involved will be the determinant of the degree of Preventive measures to be taken especially for Ventilation, use of Respirators and work to "Safe Exposure Time."

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tract. The particles visible in the fume plume are usually the heavier, that is, larger, particles which will rapidly precipitate onto adjacent surfaces as 'dustfall'. Particles in the welder's breathing zone are usually 2 µm or less - these lighter, smaller, particles may remain in the air for some hours if they are not removed by ventilation.

Ventilation

Ventilation refers to changes of room air as often as necessary to prevent welders and other workers from breathing high levels of airborne contaminants. Ventilation is a means of providing adequate breathing air, and it must be provided for all welding, cutting, brazing and related operations. Adequate ventilation depends on the following factors:

- *Volume and configuration of the space where the welding operations occur*
- *Number and type of operations that are generating contaminants*
- *Natural air flow rate where operations are taking place*
- *Location of the welders' and other workers' breathing zones in relation to contaminants or sources.*

Two types of ventilation can be used to reduce fume exposures; local exhaust and dilution ventilation. Local exhaust ventilation is the preferred method of ventilation, where the fumes are captured at the source and are removed from the workplace. Dilution ventilation provides large amounts of air into the workplace to dilute the contaminant. Dilution does not remove the contaminant. Fume hoods are not recommended as the fume is generally passed through the workers breathing zone.

Proper ventilation can be obtained either naturally or mechanically. Natural ventilation is considered sufficient for welding and brazing operations if the work area meets these requirements:

- *Space of more than 10,000 square feet is provided per welder*
- *A ceiling height of more than 16 feet*
- *Welding is not done in a confined space*
- *Welding space does not contain partitions, balconies or structured barriers that obstruct cross ventilation*

If the specific welding operation does not fall within the natural ventilation guidelines, mechanical ventilation will be required. Mechanical ventilation options generally fall into two basic categories.

- *The first is a low-vacuum system, which takes large volumes of air at low velocities. This system consists of hoods positioned at a distance from the work area. The hood and housing may have to be repositioned by the worker to get maximum benefit from this means of ventilation. Hoods generally remove the fumes and contaminated air through ducting and exhaust the contaminants to the outdoors. Hoods should be placed as near as practical to the work and should provide effective air flow with a velocity of 100 linear feet (30 meters) per minute at its most remote distance from the point of welding. Processes where low-vacuum systems work best are arc air gouging and arc cutting.*

- *Another category of mechanical ventilation is a high-vacuum system. This system consists of a close-range extractor aimed at capturing and extracting fumes as near to the work as possible. Fume extractors often have an immediate area of welding. By removing a small volume of air at a high velocity, the potentially hazardous materials are effectively removed before reaching the welder's breathing zone. These systems often are equipped with a fan that pulls the contaminants into a filtration system, with a high-efficiency particulate absolute (HEPA) filter or combination of HEPA filter and prefilter and then recirculates the clean air back into the work area. Advantages of high-vacuum systems are greater flexibility for job adaptation, more efficient means of fume removal and greater visibility to the welder due to reduced clouds of fumes and vapors being created.*

Fumes and gases from welding and cutting cannot be easily classified. The quantity of fumes and gases is relative to the metal being worked and the processes and consumable material being used, such as coatings (like paint, galvanizing and platings), along with contaminants in the atmosphere, such as halogenated hydrocarbon vapors from cleaning and degreasing activities. Air sampling to verify the concentration levels of toxic fumes and gases is necessary. Respiratory protection is required along with mechanical ventilation in the cutting and/or welding of certain metals and compounds.

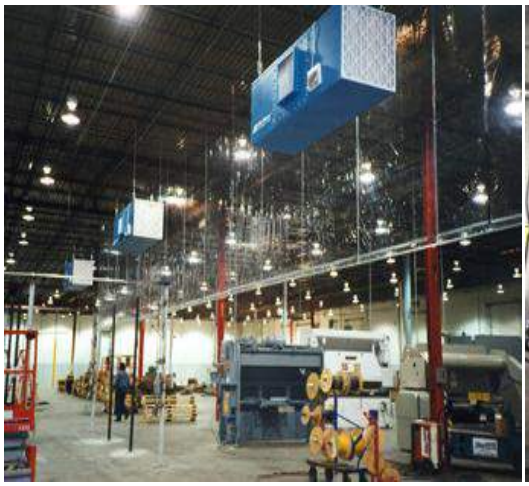
The welder should be located in an area with adequate ventilation. In general, when welding is being done on metals not considered hazardous, a ventilation system that will move a minimum of 2000 cubic feet per minute (CFM) of air per welder is satisfactory. However, many materials are considered very hazardous and should be welded only in adequately ventilated areas to prevent the accumulation of toxic materials or to eliminate possible oxygen deficiency not only to the operator but to others in the immediate vicinity. Such ventilation should be supplied by an exhaust system located as close to the work as possible. When welding or cutting metals with hazardous coatings such as galvanized metal the operator should use a supplied-air type respirator or a respirator specially designed to filter the specific metal fume. Materials included in the very hazardous category are welding rod fluxes, coverings, or other materials containing fluorine compounds, zinc, lead, beryllium, admium, and mercury. Some cleaning and degreasing compounds as well as the metals they were cleaned with are also hazardous. Always follow the manufacturers precautions before welding or cutting in the presence of these materials.

FUMES and GASES can be hazardous to your health.
Keep your head out of the fumes. Do not breathe fumes and gases caused by the arc. Use enough ventilation.

Provide enough ventilation wherever welding and cutting are performed. Proper ventilation will protect the operator from the evolving noxious fumes and gases. The degree and type of ventilation will depend on the specific welding and cutting operation. It varies with the size of work area; on the number of operators; and on the types of materials to be welded or cut. Potentially hazardous materials may exist in certain fluxes, coatings, and filler metals. They can be released into the atmosphere during welding and cutting.

In some cases, general natural-draft ventilation may be adequate. Other operations may require forced-draft ventilation, local exhaust hoods or booths, or personal filter respirators or air-supplied masks. Welding inside tanks, boilers, or other confined spaces require special procedures, such as the use of an air supplied hood or hose mask.

TYPICAL METHODS FOR VENTILATION AND RESPIRATORY PROTECTION.



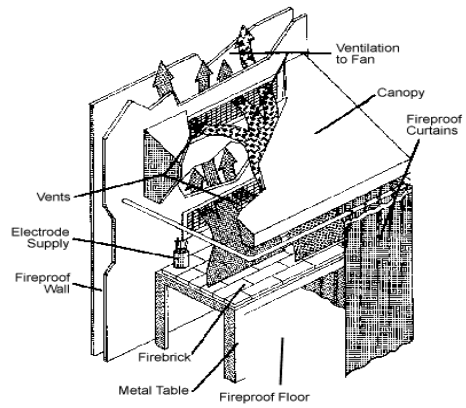
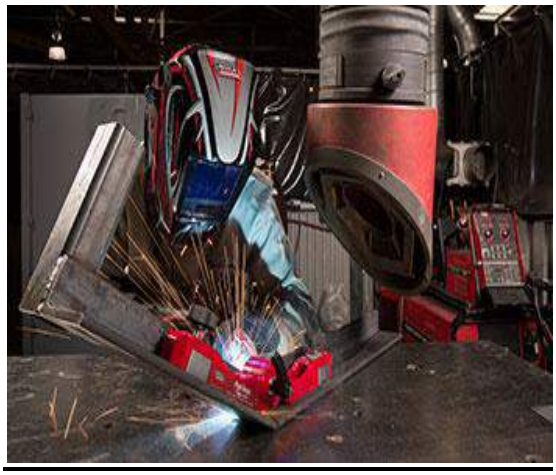
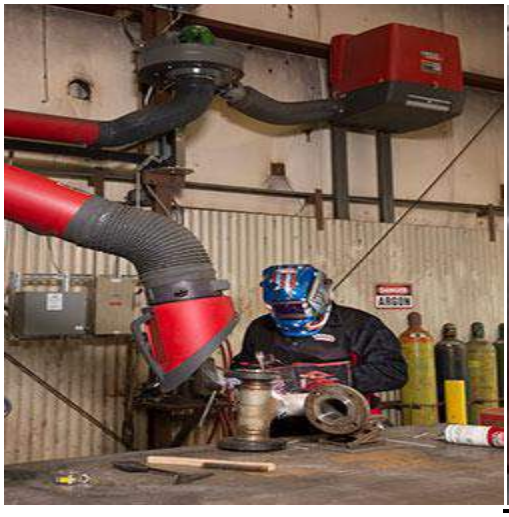


Figure 2. Typical welding area showing proper ventilation and screening





Respiratory Protection

Respiratory protection equipment falls under the BS EN 149:2001 and BS EN 140:1999 classifications. Protective equipment provides basic breathing defence, such as filtering half masks to protect against dust and dangerous particles. Respiratory protection devices are often referred to by their differing levels of protection, for instance: Type 1, 2 or 3 or P1, P2 or P3.

Lungs (breathing)	***Respirators***		***Protects against:*** ***fumes and oxides***

Respiratory protection is needed when ventilation is not sufficient to remove welding fumes or when there is risk of oxygen deficiency. Select and use respirators in compliance with applicable regulations. Seek expert advice, conduct a hazard assessment, and initiate an appropriate respiratory protection program.
The process of selecting appropriate respiratory protection is also outlined in CSA standard Z94.4 and ANSI (American National Standards Institute) standard Z88.2 "Respiratory Protection".

Breathe Freely. Fumes and smoke emitted during welding pose a health hazard. When welding in confined spaces, toxic fumes may accumulate, or shielding gasses may replace breathable air. Use an exhaust hood to remove fumes from the area and ensure enough clean breathing air is available. Some materials specifically require respirators when welding, so consult the manufacturers welding electrode's data sheet, your welding engineer or industrial safety specialist for proper procedures.

Respirator masks filter weld fumes and particles from the air and increase operator comfort and safety. Miller welding respirators are designed to fit under the welding helmet or integrate airflow into the helmet system for maximum comfort and portability. Choose from disposable respirators, half mask respirators or disposable respirators.

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HALF MASK RESPIRATOR *The large valve help to reduce the user's breathing resistance and prevents condensations from the breath from building up inside the mask. This mask is oil proof and protects against particles. There are 4 different positions that the mask can be adjusted to for customizing fit even further.*	

REUSABLE RESPIRATOR GAS MASK

This is one of the cheapest quality masks on the market.
The mask not only comes in 3 different sizes, it also has adjustable elastic head straps that do not lose their elasticity with continued use thanks to the lightweight headpiece
The mask is oil-proof and this even includes protection against oil-based aerosol particles.
The filters are affordable and easy to replace.




COMMONLY ASKED QUESTIONS

Q. What is a fume plume?
A. A fume plume is the clearly visible column of fume that rises directly from the spot of welding or cutting. Welders and cutters should take precautions to avoid breathing this area directly. Ventilation can direct the plume away from the face. (Fume removal is most effective when the air flow is directed across the face of the welder, rather than from behind.)

Q. How do I know what hazardous materials I may be using?
A. Check the Safety Data Sheet (SDS). The suppliers of welding materials must provide an SDS or equivalent documentation identifying the hazardous materials, if any, used in welding and cutting products.

Q. What are the storage requirements for oxygen and acetylene and other fuel gas cylinders?
A. Oxygen cylinders should be stored 20 feet or more from fuel gas cylinders or separated by a noncombustible barrier at least five feet high with a one-half-hour fire resistance rating.

Q. What is Mapp gas?
A. Mapp gas is a product that was developed as a fuel for welding, brazing, cutting, flame hardening and metallizing operations. It has many of the physical properties of acetylene, but lacks its shock sensitivity, and therefore, can be stored and shipped in lighter containers. Mapp gas is the result of rearranging the molecular structure of acetylene and propane. It also has a very distinct odor so any leakage can readily be detected.
Health Effects: Fumes

Q: What compounds are found in common welding fume?
A: The most common compounds in arc welding fume mild steel are iron, manganese and silicon although other compounds in the electrode or on the base metal may be in the welding fume.

Q: What types of electrode products are likely to have chromium or nickel in the welding fume?
A: Fumes from the use of stainless steel and hardfacing products contain chromium or nickel.

Q: What are the potential health effects that may result from long-term overexposure to chromium or nickel?
A: Asthma has been reported and some forms of these metals are known or suspected to cause lung cancer in processes other than welding. Therefore, it is recommended that precautions be taken to keep exposures as low as possible.

Q: What are the potential health effects that may result from sustained overexposure to manganese?
A: Manganese overexposure may affect the central nervous system, resulting in poor coordination, difficulty in speaking and tremor of arms or legs. This condition is considered irreversible.

Q: What are the long-term health effects associated with exposure to welding fume?
A: Check an LH70 MSDS sheet, including comments on siderosis and irritation of nose and throat.

Q: What are the potential health effects that may result from overexposure to zinc?
A: Overexposure to zinc may cause fume fever with symptoms similar to the common flu.

Q: What is a common source of zinc in welding fume?
A: Zinc in welding fume usually comes from welding on galvanized steel.

Warnings

Q: Where can you find safety instructions regarding welding products that you use?
A: Each welding power source and container of consumable product has a warning label which contains specific safety instructions regarding the arc welding product you have chosen to use.

Q: What information is contained on a material safety data sheet (MSDS)?
A: An MSDS contains additional information including a summary of the Hazardous Materials used to manufacture the product, a summary of Fire and Explosion Hazard Data, Health Hazard Data and Reactivity Data, and information on the precautions to observe for the Safe Handling and Use of the product.

Q: Where can you find the MSDS for the consumable product you are using?
A: Inside each Lincoln Electric consumable container. It can also be found on the Lincoln Electric website, on the AWS website and from your supervisor.

Q: Since fumes and gases can be dangerous to your health, what three steps should you take to protect yourself?

A: 1) Keep fumes and gases from your breathing zone and general area 2) Keep your head out of the fumes 3) Use enough ventilation or exhaust at the arc, or both, to keep fumes and gases from your breathing zone and general area.

Q: What additional precautions should be followed for products that require special ventilation?
A: If special ventilation products are used indoors, use local exhaust. If special ventilation products are used outdoors, a respirator may be required.

Q: What types of products generally require special ventilation?
A: Hardfacing and stainless products.

Health Effects: Gases

Q: What are the potential health hazards related to shielding gases used in arc welding?
A: Most of the shielding gases (argon, helium and carbon dioxide) are non-toxic, but they can displace oxygen in your breathing air causing dizziness, unconsciousness and possible death. Carbon monoxide can also be present and may pose a hazard if levels are excessive.

Adequate Ventilation

Q: What is the one of the most basic safety precautions that a welder can take to protect themselves from overexposure to welding fume?
A: Keep your head out of the fume plume!

Q: Where is the concentration of fumes and gases greatest?
A: Concentration of fumes and gases is greatest in the plume.

Q: How can you keep fumes and gases away from your breathing zone?
A: Keep fumes and gases from your breathing zone and general area using natural ventilation, mechanical ventilation, fixed or moveable exhaust hoods, or local exhaust at the arc.

Q: What precautions must be taken if adequate ventilation cannot be provided?
A: It may be necessary to wear an NIOSH approved respirator if adequate ventilation cannot be provided.

Q: Does OSHA require engineering or workplace controls be installed before respirators can be used?
A: OSHA requires that engineering and workplace controls be installed first and if the controls alone do not keep exposures below applicable limits, use respirators.

Q: How can a welder determine if there is adequate ventilation?
A: As a practical rule of thumb for welders, for many mild steel electrodes, if the welder is comfortable and the air is visibly clear, the welder has adequate ventilation.

Q: What method is used to accurately measure a welder's exposure to welding fume?
A: A welder's exposure can only be determined by having a qualified professional take a sample of the welder's breathing air during the workday.

Q: When is it most important to measure a welder's exposure to welding fume?
A: Measuring a welder's exposure to welding fume is essential if you are welding with stainless, hardfacing or other special ventilation products (see the product label).

Q: What precautions should be taken when welding a base metal which is plated or painted?
A: If the base metal cannot be cleaned before welding, the composition of the coating should be evaluated.

Q: What should you do if you feel overexposed to welding fume?
A: Stop welding and get some fresh air immediately. If you continue to feel the symptoms, see your doctor. Notify your supervisor and co-workers so the situation can be corrected and other workers are aware of and can avoid the hazard. Be sure you are following safe practices, as stated upon the consumable labeling and MSDS, and improve the ventilation in your area. Do not continue welding until the situation has been corrected.

Q: What does adequate ventilation mean?
A: Your work area has adequate ventilation when there is enough ventilation and exhaust to control worker exposure to the hazardous materials in the welding fumes and gases (so the applicable exposure limit for those materials is not exceeded).

Q: What are the most commonly used exposure limits?
A: The two most common U.S. exposure limits are established by OSHA in the form of permissible exposure limits or PEL and by the ACGIH in the form of Threshold Limit Values or TLV.

Q: What exposure limit is mandatory in the United States?
A: Your employer must keep exposures below the PEL.

Q: Where can you find the applicable limits for the PEL and TLV for substances in welding fume?
A: The PEL and TLV are listed on the first page of the MSDS for compounds in each electrode or flux.

Evaluating the Welding Environment

Q: What steps can you, the welder, take to identify hazardous substances?
A: There are also steps that you should take to identify hazardous substances in your welding environment. Read the product label to review the warnings, safety precautions and to determine if special ventilation is needed. Obtain and review the material safety data sheet (MSDS) for the electrode which your employer or supervisor has posted in the work place or that

you find inside the electrode or flux container. You should review the complete MSDS to determine specifically what compounds you may be exposed to when using the product.

Q: Where can the welder find information about materials in the base metal or any coating on the base metal?
A: Obtain a copy of the supplier's MSDS for the base metal being welded, as this should be reviewed as well.

Welding Fume Control

Q: What is natural ventilation?
A: Natural ventilation is the movement of air through the workplace caused by natural forces. Outside, this is usually the wind. Inside, this may be the flow of air through open windows and doors.

Q: What is mechanical ventilation?
A: Mechanical ventilation is the movement of air through the workplace caused by an electrical device such as a portable fan or permanently mounted fan in the ceiling or wall.

Q: What is local exhaust?
A: Local exhaust is a mechanical device used to capture welding fume at or near the arc and remove contaminants from the air.

Q: What factors need to be considered when determining the exhaust requirements for your application?
A: The ventilation or exhaust needed for your application depends upon factors such as:

Workspace volume
Workspace configuration
Number of welders
Welding process and current
Consumables used (mild steel, hardfacing, stainless, etc.)
Allowable levels (TLV, PEL, etc.)
Material welded (including paint or plating)
Natural airflow

Q: Name several types of local exhaust that can be used to control exposure to welding fume?
A: Local exhaust of welding fumes can be provided by any of the following: adjustable "elephant trunk" exhaust systems, fume extraction guns or fixed enclosures, or booths with exhaust hoods.

Q: Which system is more effective and economical: general ventilation or local exhaust systems?
A: Local exhaust systems are more effective and economical to operate than a general ventilation system, particularly in the winter, because they require less replacement air to be

brought into the room and heated.

Q: What is the minimum air velocity (speed) required near the welding arc?
A: Minimum required air velocity at the welding arc is 100 fpm.

Q: When should an employee's exposure to welding fume be obtained?
A: Exposure should be checked when new ventilation equipment is installed, when the process is modified or when the welder feels uncomfortable. Periodically, exposure should be re-checked to be sure it is still working properly and is adequate.

Special Ventilation Reminder

Q: What must be done to insure that there is adequate ventilation when welding with electrodes that require special ventilation (such as stainless or hardfacing, or other products which require special ventilation - see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings like galvanized steel, which produce hazardous fumes?
A: Keep exposure as low as possible and below exposure limit values (PEL and TLV) for materials in the fume using local exhaust.

Q: When should a respirator be used?
A: In confined spaces or in some circumstances, for example outdoors, a respirator may be required if exposure cannot be controlled to the PEL or TLV (see MSDS).

Q: When does OSHA consider natural ventilation sufficient?
A: According to OSHA regulations, when welding and cutting (mild steels), natural ventilation is usually considered sufficient to meet requirements, provided that:

The room or welding area contains at least 10,000 cubic feet (about 22' x 22' x 22') for each welder
The ceiling height is not less than 16 feet
Cross ventilation is not blocked by partitions, equipment or other structural barriers
Welding is not done in a confined space
Regardless of the whether the ventilation meets these requirements, the welder's exposure must be controlled to below the PEL or TLV (if applicable) exposure limit to be adequate

Sources
ANSI Z49.1-2012, American National Standards Institute: Safety in Welding, Cutting and Allied Processes 29 CFR Subpart Q – Welding, Cutting and Brazing

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CHAPTER – III.

FIRE & EXPLOSION

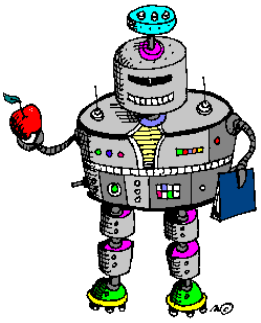
Safety Aspects especially the issues of Fire and Explosion hazards in Fusion Welding Processes must be safe guarded for welders to work safe to obtain the best possible Accident free shop floor operation resulting high productivity.

This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

Fire and Explosion Hazards

➲ *Intense heat and sparks can cause fires or explosions if in the vicinity of combustible or flammable materials. Heat from flames and arcs can start fires. Hot slag or sparks can also cause fires and explosion.*






➲ *Welding and cutting should be performed in areas free of combustible materials such*

as trash, wood, paper, textiles, plastics, chemicals, and flammable dusts, liquids and gases. All combustible materials must be removed well away from the work area. All such materials may also be covered with a protective nonflammable covering.

➲ *Hot sparks or hot metal can fall through cracks or crevices in floors or wall openings and cause a hidden smoldering fire or fires on the floor below. Such openings should be protected from hot sparks and metal.*

➲ *Welding, cutting or other hot working to be performed only when the work piece has been completely cleaned so that there are no substances on the work piece which might produce flammable or toxic vapors.*

➲ *Welding or cutting must not be done on containers that have held a flammable or combustible material unless the container is thoroughly cleaned or filled with an inert gas*

➲ *Use of equipment beyond its ratings must be restricted. For example, overloaded welding cable can overheat and create a fire hazard.*

➲ *Fire extinguishers of proper size, type and number for the hazards involved must be placed in stands near the weld site. Fire extinguishing equipment handy for instant*

use, such as a garden hose, water pail, sand bucket, or portable fire extinguisher are of great help in case of an emergency.

➲ *A fire inspection should be performed prior to leaving a work area and for at least 30 minutes after the operation is completed. After completing operations, inspect the work area to make certain there are no hot sparks or hot metal which could cause a later fire. Use fire watchers when necessary*

➲ *Fire Watch lasting at least 30 min after welding or cutting operations is required if more than a minor fire might develop and if certain combustible materials are present*

➲ *Authorization: A responsible individual must inspect the area and designate precautions, preferably by written permit.*

➲ *Floors: Combustible materials must be swept 35 feet away; combustible floors must be wetted or protected (while preventing arc welding shock)*

Prohibited areas for welding:

- *Unauthorized by management*
- *Where sprinklers are impaired*
- *Explosive atmospheres*
- *Near storage of large quantities of readily ignitable materials*

Relocation of Combustibles

- *Combustibles shall be moved 35 feet away or properly protected or*
- *shielded*
- *Ducts: Ducts & conveyor systems that might carry sparks must be shut*
- *down.*
- *Combustible walls must be shielded or guarded.*
- *Noncombustible walls, partitions or ceilings (when welded) require*
- *opposite-side moving of combustibles or a fire watch.*
- *Combustible cover: No welding on certain metal building components*
- *having combustible covers or layers.*
- *Pipes (or any metal) close enough to combustibles to cause ignition by conduction may not be cut or welded.*

➲ *Management responsibilities:*

- *Establish proper areas and procedures*
- *Designate responsible individual*
- *Ensure training*
- *Advise contractors of hazards*

➲ *Supervisor responsibilities:*

- *Safety of equipment & procedures*
- *Determine combustibles & hazardous areas*
- *Protect combustibles from ignition through moving, shielding and scheduling*
- *Secure authorizations*
- *Give go-ahead to cutter or welder*
- *Ensure fire protection*
- *Ensure fire watches if required.*

- *General Requirements*
  - *Used containers must be cleaned of flammable materials or other materials that could release toxic of flammable vapors when heated.*
  - *Venting & purging is required for hollow spaces or cavities.*
  - *Railing or other suitable fall protection must be provided as required.*
  - *Welding cable and other equipment must be kept clear of passageways, ladders and stairways.*
  - *Flammable mixtures of fuel gases and air or oxygen must be guarded against.*
  - *Maximum pressures of 15 psi for acetylene must be observed (with certain rare exceptions).*
  - *Approved apparatus.*
  - *Competent personnel in charge of supply equipment*

- *<u>CYLINDER HANDLING</u>*

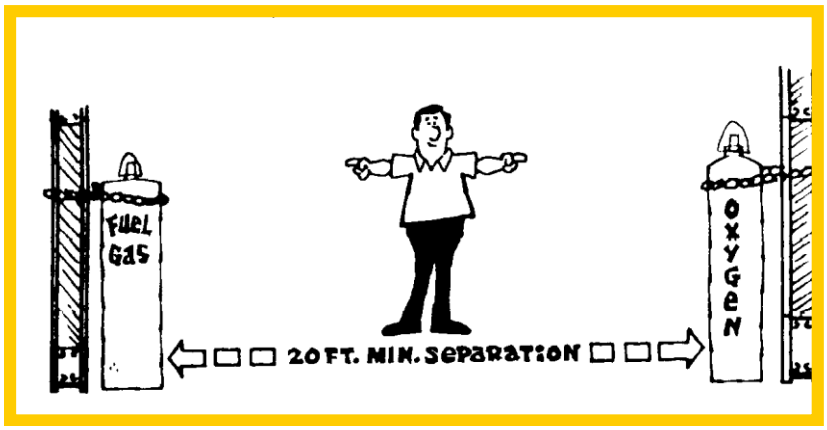
Cylinders, if mishandled, can rupture and violently release gas. Sudden rupture of cylinder, valve, or relief device can injure or kill. Therefore:

- *Use the proper gas for the process and use the proper pressure reducing regulator designed to operate from the compressed gas cylinder. Do not use adaptors. Maintain hoses and fittings in good condition. Follow manufacturer's operating instructions for mounting regulator to a compressed gas cylinder.*
- *Always secure cylinders in an upright position by chain or strap to suitable hand trucks, undercarriages, benches, walls, post, or racks. Never secure cylinders to work tables or fixtures where they may become part of an electrical circuit.*
- *When not in use, keep cylinder valves closed. Have valve protection cap in place if regulator is not connected. Secure and move cylinders by using suitable hand trucks. Avoid rough handling of cylinders.*

- *Locate cylinders away from heat, sparks, and flames. Never strike an arc on a cylinder.*

Cylinders & Containers

- *Approval & Marking:*
- *DOT compliant*
- *Legibly marked*
- *ANSI compliant connections*
- *Valve protection*
- *Away from heat sources (such as radiators)*
- *When inside buildings:*
  - *Well-protected, ventilated, dry location at least 20 ft from combustibles*
  - *Assigned storage spaces, protected from damage & tampering*
- *When empty: closed valves*
- *When not in use: hand-tight valve protection caps*



- *Protect oxygen cylinders from fire hazards such as acetylene:*
- *Distance: ≥20 ft from fuel-gas cylinders or combustibles, or*
- *Barrier: ≥5 ft high noncombustible partition with half-hour fire-resistance rating*
- *Cylinders, cylinder valves, couplings, regulators, hose, and apparatus kept free from oily or greasy substances*
- *Oxygen cylinders shall not be handled with oily hands or gloves*
- *A jet of oxygen must never be permitted to strike an oily surface, greasy clothes, or enter a fuel oil or other storage tank*

➲ *When transporting cylinders by a crane:*

- *Use a cradle or suitable platform*
- *Never use slings or electric magnets*
- *Valve-protection caps always in place*

- *Never use valve-protection caps to lift cylinders from one vertical position to another*
- *Never use bars under valves or valve-protection caps to pry cylinders loose may use warm (not boiling) water*

➲ *Before cylinders are moved:*

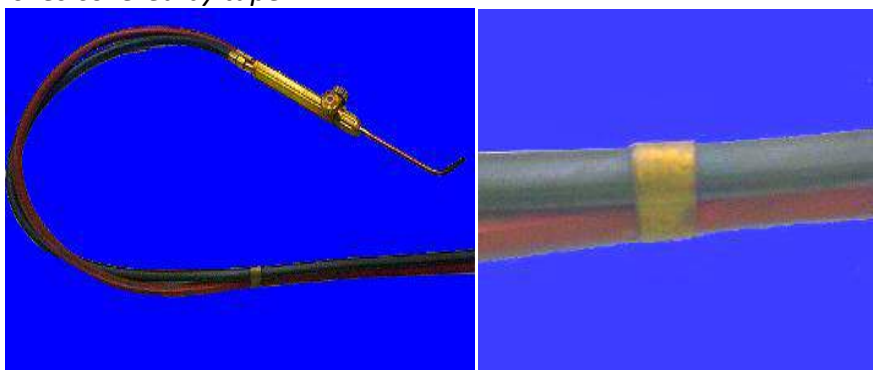
- *Regulators shall be removed*
- *Valve-protection caps, when provided for, shall be put in place*
- *Unless cylinders are secured on a special truck*



- *Cylinders without fixed hand wheels shall have keys, handles, or nonadjustable wrenches on valve stems while cylinders are in service*
- *Fuel-gas cylinders shall be placed with valve end up whenever they are in use*
- *Liquefied gases shall be stored and shipped with the valve end up*

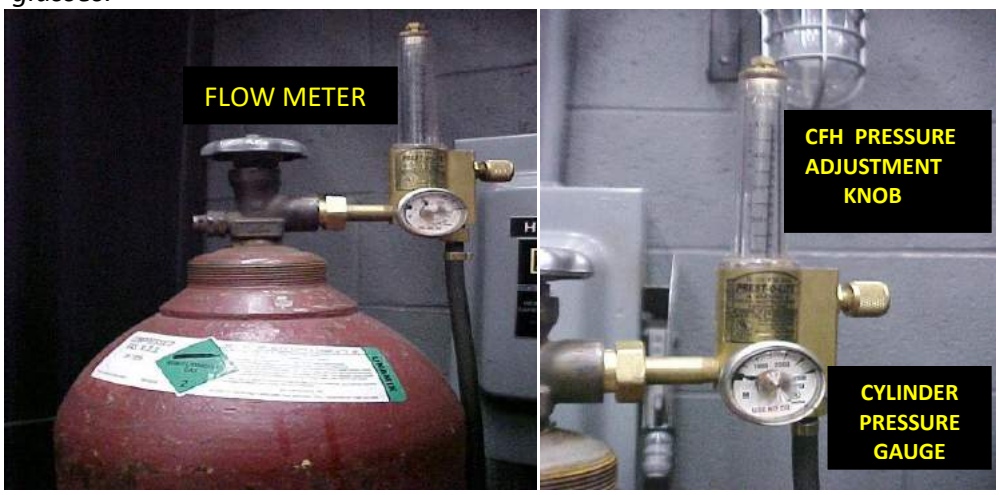
- *Before connecting a regulator to a cylinder valve:*
  - *Open the valve slightly; close immediately*
  - *Open the valve while standing to one side of the outlet; never in front of it*
  - *Never crack a fuel-gas cylinder valve near other welding work or near sparks, flame, or other possible sources of ignition*
  - *Always open the cylinder valve slowly*
  - *Never open an acetylene cylinder valve more than 1.5 turns of the spindle, and preferably no more than 3/4 of a turn*

- *Replace hose with leaks, burns, worn places, defects*
- *When parallel lengths of oxygen and fuel hose are taped together, not more than 4 of 12 inches covered by tape*

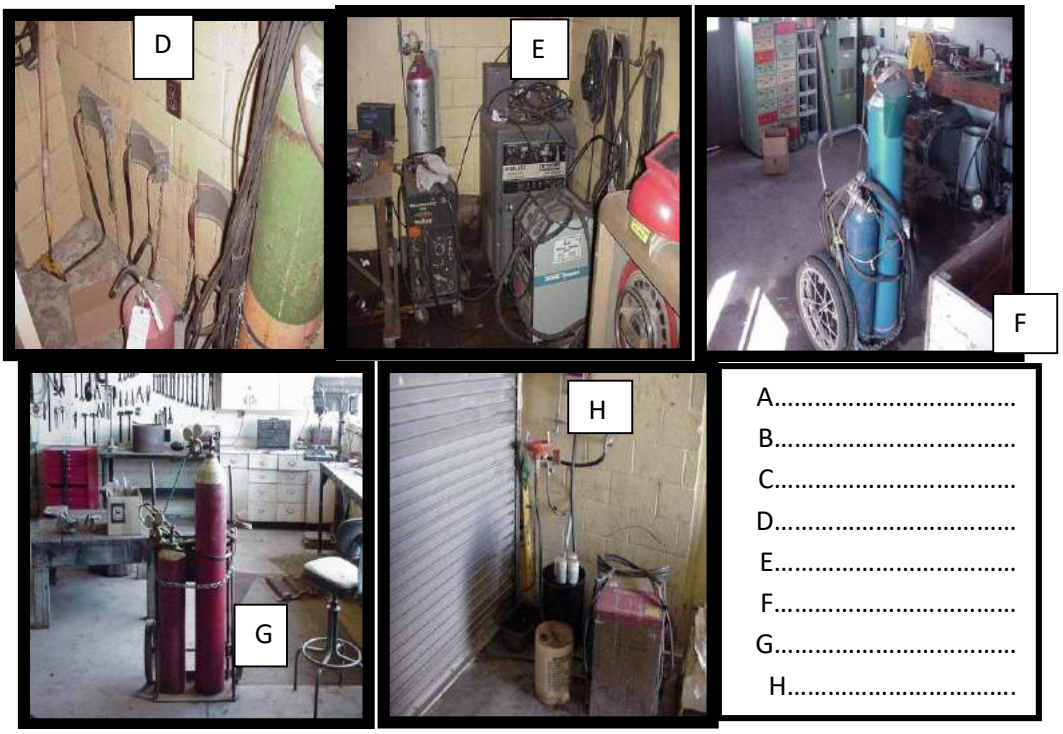


- *<u>Check</u>*
  - *How long must a fire watch continue?*
  - *At least 30 minutes*
  - *How far away must combustible materials be kept from welding?*
  - *A radius of 35 feet*
  - *Who is responsible for making fire watchers available?*
  - *Supervisor.*
  - *During work in confined spaces, what must be left outside?*
  - *Gas cylinders & welding machines.*

- *Wear flameproof gauntlet type gloves, heavy long-sleeve shirt, cuffless trousers, high-topped shoes, and a welding helmet or cap for hair protection, to protect against*
  arc rays and hot sparks or hot metal. A flameproof apron may also be desirable as protection against radiated heat and sparks.
- *Hot sparks or metal can lodge in rolled up sleeves, trouser cuffs, or pockets. Sleeves and collars should be kept buttoned, and open pockets eliminated from the front of clothing.*
- *Protect other personnel from arc rays and hot sparks with a suitable non flammable partition or curtains.*
- *Use goggles over safety glasses when chipping slag or grinding. Chipped slag may be hot and can fly far. Bystanders should also wear goggles over safety glasses.*



Examples & Diagnosis : What is wrong ? Which is right ?



CONCLUSION

A burn injury in the size of a PALM only can be fatal. By all means Fire and Explosions must be avoided in all working areas. Apart from making the working area safe it is again a management responsibility to train the workmen in Fire Drills for making them safety conscious.

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CHAPTER – IV.

ELECTRIC SHOCK

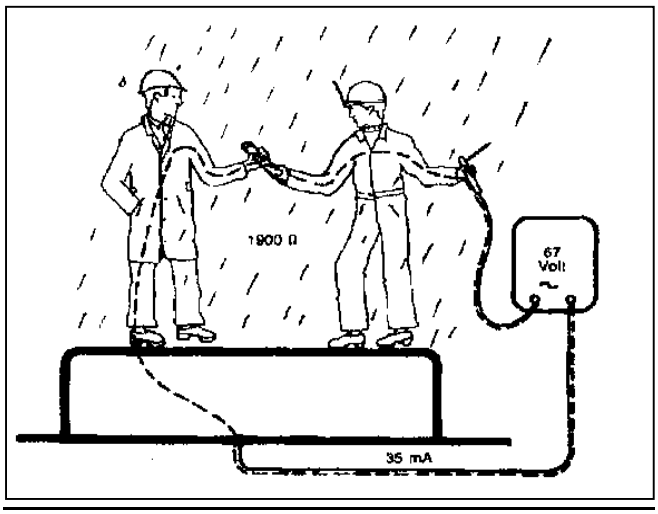
Safety Aspects regarding Electric Shock must be carefully looked into and all precautionary measures to prevent electrocution are to be maintained strictly to obtain the best possible Accident free shop floor operation.

This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

Welding Circuit Shock Hazards

The welding circuit consists of all conductive material through which the welding current is intended to flow. Welding current flows through the welding machine terminals, welding cables, workpiece connection, gun, torch, electrode holder and workpiece. The welding circuit is not connected to ground within the welding machine, but is isolated from ground

ELECTRIC SHOCK Can Kill



Assistant hands welder a metal object.
Resultant current is 35 mA
I = V/R = 67/1900 = 35 mA
Result = Assistant survived but welder died

Different Values of Electric Current and corresponding Reactions on the Body are given in the Table below :

Current.	***Current Reaction on Body***
1 ma	*Just a faint tingle*
5 ma	*Slight shock felt. Disturbing, but not painful. Most people can "let go."However, strong involuntary movements can cause injuries.*
6 – 25 ma (women)	*Painful shock. Muscular control is lost. This is the range where "freezing currents" start. It may not be possible to let go.*
9 – 30 ma (men)	*Painful shock. Muscular control is lost. This is the range where "freezing currents" start. It may not be possible to let go.*
50 -150 ma	*Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible*
1,000– 4,300 ma	*Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles (1–4.3 amps) contract; nerve damage occurs. Death is likely.*
10,000 ma	*Cardiac arrest and severe burns occur. Death is probable. (10 amps)*
15,000 ma	*Lowest overcurrent at which a typical fuse or circuit breaker opens a circuit! (15 amps)*

Dangers of Electrical Shock

1. The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. For example, 1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death.

The amount of internal current a person can withstand and still be able to control the muscles of the arm and hand can be less than 10 milliamperes (milliamps or mA). Currents above 10 mA can paralyze or "freeze" muscles. When this "freezing" happens, a person is no longer able to release a tool, wire, or other object. In fact, the

electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, handheld tools that give a shock can be very dangerous. If the welder can't let go of the tool, current continues through the body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). The person will stop breathing for a period of time. People have stopped breathing when shocked with currents from voltages as low as 49 volts. Usually, it takes about 30 mA of current to cause respiratory paralysis.

Currents greater than 75 mA cause ventricular fibrillation (very rapid, ineffective heartbeat). This condition will cause death within a few minutes unless a special device called a defibrillator is used to save the victim. Heart paralysis occurs at 4 amps, which means the heart does not pump at all. Tissue is burned with currents greater than 5 amps.

2. The table shows what usually happens for a range of currents (lasting one second) at typical household voltages. Longer exposure times increase the danger to the shock victim. For example, a current of 100 mA applied for 3 seconds is as dangerous as a current of 900 mA applied for a fraction of a second (0.03 seconds). The muscle structure of the person also makes a difference. People with less muscle tissue are typically affected at lower current levels. Even low voltages can be extremely dangerous because the degree of injury depends not only on the amount of current but also on the length of time the body is in contact with the circuit.

The electrode and work (or ground) circuits are electrically "hot" when the welding power source is on. In semiautomatic or automatic MIG/MAG welding, the electrode, electrode spool, welding head, nozzle or semiautomatic welding gun are also electrically "hot".

The hazard of electric shock is one of the most serious and immediate risks facing a welder. Contact with metal parts which are "electrically hot" can cause injury or death because of the effect of the shock upon the body or a fall which may result from the reaction to the shock.

The electric shock hazard associated with arc welding may be divided into two categories which are quite different:

– Primary Voltage Shock (i.e., 230, 460 volts); and

– Secondary Voltage Shock (i.e., 20-100 volts).

The primary voltage shock is more hazardous because it is much greater voltage than the secondary voltage of the Power Source. The Welder can receive a shock from the primary (input) voltage if he touches a lead inside the welding power source with the power to the welder "on" while the Welder has his body or hand on the welding power source case or other grounded metal. The Welder must remember that turning the welding power source's power switch "off" does not turn the power off inside the welding power source. To turn the power inside the welder "off", the input power cord must be unplugged or the power disconnect switch turned off. The fixed panels from the welder should never be removed; in fact, it is better to have a qualified technician repair the welder if it isn't working properly. Also, the welding power source should be installed by a qualified electrician so it will be correctly wired for the primary voltage which supplies it power and so the case will be connected to an earth ground.

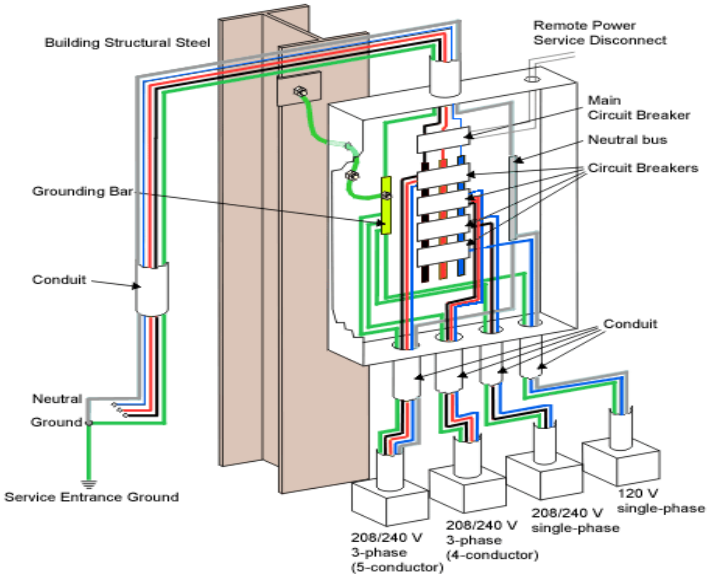
Utilizing proper grounding in the welding environment must be done, though it does not remove all possibility of electrical shock. The welding circuit is energized by welding voltage. A person will receive a shock if he becomes a part of the electrical path across the welding circuit. Precautions must be taken to insulate the Welder from the welding circuit by using Personal Protecting Equipment and definitely dry insulating gloves and other insulating means and maintaining insulation on weld cables, electrode holders, guns and torches to provide protection.

Similarly, electric shock originating from the electrical supply system must be prevented. Proper maintenance of electrical equipment and extension cords will insulate the welder from electrical sources. These "hot" parts in touch with bare skin or wet clothing of a welder cause shock.

<u>Grounding and Arc Welding Safety</u>

What does Grounding have to do with Arc Welding Safety?

Grounding of electrical circuits is a safety practice that is documented in various codes and standards (see Additional Safety Information). A typical arc welding setup may consist of several electrical circuits. Applying and maintaining proper grounding methods within the welding area is important to promote electrical safety in the workplace. Associated processes such as plasma cutting will also benefit from proper grounding.



<u>Welding Machine Ground</u>

Welding machines that utilize a flexible cord and plug arrangement or those that are permanently wired into an electrical supply system contain a grounding conductor. The grounding conductor connects the metal enclosure of the welding machine to ground. If we could trace the grounding wire back through the electrical power distribution system we would find that it is connected to earth, and usually through a metal rod driven into the earth.

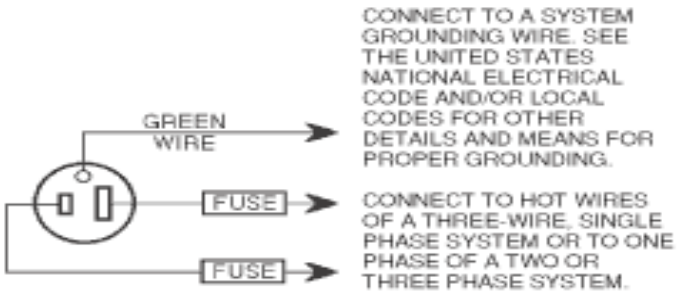
The purpose of connecting the equipment enclosure to ground is to ensure that the metal enclosure of the welding machine and ground is at the same potential. When they are at the same potential, a person will not experience an electrical shock when touching the two points. Grounding the enclosure also limits the voltage on the enclosure in the event that insulation should fail within the equipment. The current carrying capability of the grounding conductor is coordinated with the over current device of the electrical supply system. The coordination of ampacity allows the grounding conductor to remain intact even if there is an electrical fault within the welding machine.

Some welding machines may have a double insulated design. In this case, a grounding conductor connection is not required. This type of welding machine relies on extra insulation to protect the user from shock. When double insulation is present it is identified by a "box within a box" symbol on the rating plate.

For small welding machines that utilize a plug on the end of a power cord, the grounding conductor connection is made automatically when the welding machine is plugged into the receptacle. The grounding pin of the plug makes a connection within the receptacle. The use of adapters that effectively remove the grounding pin connection at the plug is not recommended.

Receptacle circuit testers will easily check the continuity of the grounding conductor. Receptacle circuit testers for 120-volt circuits are available at electrical supply or hardware stores; these inexpensive test devices plug into an electrical outlet. Indicator lights show whether the grounding circuit is available at the outlet, as well as other circuit tests. If the test device shows the absence of a ground connection or other circuit problem, call a qualified electrician for assistance. This is a simple test and should be done periodically. Consult with a qualified electrician to test circuits greater than 120 volts.

Receptacle Diagram



Workpiece Ground

The welding circuit consists of all conductive material through which the welding current is intended to flow. Welding current flows through the welding machine terminals, welding cables, workpiece connection, gun, torch, electrode holder and workpiece. The welding circuit is not connected to ground within the welding machine, but is isolated from ground. How do we ground the welding circuit?

According to ANSI Z49.1, "Safety in Welding, Cutting and Allied Processes," the workpiece or the metal table that the workpiece rests upon must be grounded. We must connect the workpiece or work table to a suitable ground, such as a metal building frame. The ground connection should be independent or separate from the welding circuit connection.

Grounding the workpiece has similar benefit to grounding the welding machine enclosure. When the workpiece is grounded, it is at the same potential as other grounded objects in the area. In the event of insulation failure in the arc welding machine or other equipment, the voltage between the workpiece and ground will be limited. Note that it is possible to have an ungrounded workpiece, but this requires the approval of a qualified person.

The Workpiece Connection is not a Ground Clamp

"Ground clamp" and "ground lead" are common terms used by many welders. The workpiece is connected to a welding cable typically by means of a spring loaded clamp or screw clamp. Unfortunately, a workpiece connection is often incorrectly called a "ground clamp" by many welders and the workpiece lead is incorrectly called "ground lead." The welding cable does not bring a ground connection to the workpiece. The ground connection is separate from the workpiece connection.

High Frequency Ground

Some welding machines utilize starting and stabilizing circuits that contain a high frequency voltage. This is common on Tungsten Inert Gas (TIG) welding machines. The high frequency voltage may have frequency components that extend into the megahertz region. In contrast, the welding voltage may be as low as 60 Hertz.

One method to minimize the radiation of high frequency signals is to ground the welding circuit.

Portable and Vehicle Mounted Welding Generator Grounding

Portable and vehicle mounted arc welding generators often have the capability to supply 120 and 240 volt auxiliary power. These generators are used in remote locations away from an electrical power distribution system. A convenient earth ground is not usually available for connection. Should the generator frame be grounded?

The rules for grounding depend on the specific use and design of the auxiliary power generator. Most applications fall into one of the two categories summarized below:

1. *If all of these requirements are met, then it is not required to ground the generator frame:*

- *The generator is mounted to truck or trailer*
- *The auxiliary power is taken from receptacles on the generator using a cord and plug arrangement*
- *The receptacles have a grounding pin*
- *The frame of the generator is bonded, or electrically connected, to the truck or trailer frame*

2. If neither of these conditions are met, then the generator frame must be grounded:

- *The generator is connected to a premises wiring system. For example, to supply power to a house during a blackout.*
- *The auxiliary power is hard wired into the generator without the use of cords and plugs.*

<u>Extension Cord Grounds</u>

Extension cords should be periodically tested for ground continuity. Extension cords lead a rough life while lying on the ground; they are under foot and prone to damage. The use of a receptacle circuit tester will confirm that all of the connections are intact within the cord, plug and receptacle

- *Before starting any arc welding operation, you should make a complete inspection of your equipment.*
  - *Have you read the instruction manual and do you understand the instructions?*
  - *Have you read the warnings and instructions on the equipment nameplates and decals as well as the consumables labels and material safety data sheets?*

- *For the welding power source:*
  - *Are all the connections tight, including the earth ground?*
  - *OSHA regulations require output terminals to be insulated. Rubber boots are available for that purpose.*
  - *Are the electrode holder and welding cable well insulated and in good condition?*
  - *Are the settings correct for the job you're about to begin?*

- *For an engine-driven welder:*
  - *Is it running OK?*
  - *Are the cables the right size for your job? Be sure any damaged cable insulation is repaired.*
  - *Are they spread out and run neatly to prevent overheating?*
  - *Is the Work Lead connected securely?*
  - *Is there enough dry insulation between your body and the work piece?*
  - *Is there adequate ventilation in your work area?*

TEN COMMANDMENDS

- *BE SURE you are insulated from live electrical parts.*
- *BE SURE equipment is adequate for the job.*
- *BE SURE equipment is installed according to prevailing codes.*
- *BE SURE damaged parts are repaired or replaced.*
- *BE SURE welding machine is properly grounded.*
- *BE SURE gloves have no holes.*
- *BE SURE to stay dry; do not weld when you are wet.*
- *BE SURE equipment is turned OFF when not in use.*
- *DO NOT use cables that are too small, damaged, or poorly spliced.*
- *DO NOT wrap cables around your body.*

Electric and Magnetic Fields

Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding current create EMF fields around welding cables and welding machines. EMF fields may interfere with some pacemakers, and welders having a pacemaker should consult their physician before welding.

All welders should use the following procedures in order to minimize exposure to EMF fields from the welding circuit:

- *Route the electrode and work cables together – Secure them with tape when possible.*
- *Never coil the electrode lead around your body.*
- *Do not place your body between the electrode and work cables. If the electrode cable is on your right side, the work cable should also be on your right side.*
- *Connect the work cable to the workpiece as close as possible to the area being welded.*
- *Do not work next to welding power source.*

HIGH VOLTAGE CAN KILL.

- *Do not operate with covers removed.*
- *Disconnect input power before servicing.*
- *Do not touch electrically live parts.*
- *When electrical supply lines are connected to a welder, check the welder capacity nameplate and connection instructions to be sure the input is the correct phase (single phase or three phase) and voltage. Many welders may be set up for single phase or three phase and for multiple input voltages.*
- *Be certain the welder is set up for the electrical supply to which it is connected. Only a qualified electrician should connect input power. The case must be grounded so that if a problem develops inside the welder a fuse will blow, disconnecting the power and letting you know that repair is required. Never ignore a blown fuse because it is a warning that something is wrong.*

➢ *If welding must be performed under electrically hazardous conditions (in damp locations or while wearing wet clothing; on metal structures such as floors, gratings or scaffolds; when in cramped positions such as sitting, kneeling or lying, if there is a high risk of unavoidable or accidental contact with the work piece or ground) use the following equipment:*

- ❖ *Semiautomatic DC Constant Voltage Welder*
- ❖ *DC Manual (Stick) Welder*
- ❖ *AC Welder with Reduced Voltage Control*

➢ *A secondary voltage shock occurs when you touch a part of the electrode circuit — perhaps a bare spot on the electrode cable — at the same time another part of your body is touching the metal upon which you're welding (work). To receive a shock your body must touch both sides of the welding circuit — electrode and work (or welding ground) — at the same time. To prevent secondary voltage shock, you must develop and use safe work habits.*

➢ *Remember the voltage at the electrode is highest when you are not welding (open circuit voltage).*

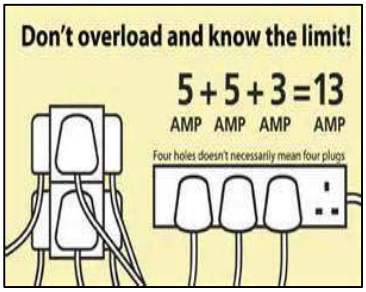
- ❖ *Wear dry gloves in good condition when welding.*
- ❖ *Do not touch the electrode or metal parts of the electrode holder with skin or wet clothing.*
- ❖ *Keep dry insulation between your body (including arms and legs) and the metal being welded or ground (i.e., metal floor, wet ground).*
- ❖ *Keep your welding cable and electrode holder in good condition. Repair or replace any damaged insulation.*

PRE-OPERATIONAL SAFETY CHECKS

- ❖ *Locate and ensure you are familiar with all machine operations and controls.*
- ❖ *Check workspaces and walkways to ensure no slip/trip hazards are present.*
- ❖ *Ensure the work area is clean and clear of grease, oil and any flammable materials.*
- ❖ *Keep the welding equipment, work area and your gloves dry to avoid electric shocks.*
- ❖ *Ensure electrode holder and work leads are in good condition.*
- ❖ *Ensure other people are protected from flashes by closing the curtain to the welding bay or by erecting screens.*


<u>Use Miniature Circuit Breakers in all the Incoming Power Terminals for each Power source</u>

OPERATIONAL SAFETY CHECKS



- *Keep welding leads as short as possible and coil them to minimise inductance.*
- *Ensure work return earth cables make firm contact to provide a good electrical connection.*
- *Ensure the electrode holder has no electrode in it before turning on the welding machine.*
- *Ensure current is correctly set according to electrode selection.*

ENDING OPERATIONS AND CLEANING UP

- *Switch off the machine and fume extraction unit when work is completed.*
- *Remove electrode stub from holder and switch off power source.*

Hang up electrode holder and welding cables. Leave the work area in a safe, clean and tidy state.

SAFETY PRECAUTIONS

ELECTRIC SHOCK

Disconnect the power cord from the mains before working on the cables or opening the machine.

- *Never touch live parts*
- *Never use the machine without the safety guards.*
- *Insulate yourself from the part to be cut/welded and from the earth by wearing insulating gloves and clothing.*
- *Keep all clothing (gloves, shoes, headgear) and your body dry at all times.*
- *Do not work in damp or humid environments*
- *Should you notice even the slightest sensation of electric shock, stop cutting/welding immediately. Do not use the equipment again until the problem has been identified and resolved.*
- *Include an automatic wall switch of adequate capacity placed near the equipment, to allow it to be shut off immediately in case of emergency.*
- *Inspect the power cord, torch cable, grounding cable and the torch itself often. Never use the machine if any of these parts are damaged.*
- *Make sure the power supply line is fitted with an efficient grounding socket.*
- *Plasma cutting equipment requires dangerous voltages to strike the arc (approximately 250/350 V DC). It is therefore recommended to take the following precautions during use.*
- *Never disable the safety devices on the torch and machine.*
- *If using the system for plasma cutting, always turn off the machine before replacing the nozzle, isolating diffuser, electrode or nozzle holder.*
- *Only screw the nozzle holder onto the head with the electrode, the isolating diffuser and the nozzle mounted.*

If these parts are not present, the machine will not function properly and operator safety will be endangered.

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CHAPTER – V.

ARC RADIATION

Arc Radiation Safety especially in all Fusion Welding Processes must always be taken for the co workers of a welder engaged in welding as it causes temporary work stoppage and suffering at home.

This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

RADIATION FROM WELDING ARC.

INTRODUCTION

Most arc welding and cutting processes, laser welding, and torch welding, plasma cutting, resistance welding and brazing, or soldering produce substantial radiation requiring precautionary measures for safety of operators of the processes. Some cold pressure welding, ordinarily produce negligible quantities of radiant energy.

DEFINITION

Radiation is electromagnetic energy given off arc or flame that can injure eyes by the UV Rays and burn skin. An operator sees visible light radiation. However, he does not see ultraviolet or infrared radiation. Radiation is often silent and undetected, yet injury occurs.

TYPES OF RADIATION

There are two types of radiation associated with welding operations:

- *Ionizing (such as X-rays). .*
- *Non ionizing (such as ultraviolet, visible light, or infrared)*

EFFECTS OF RADIATION

The effects of radiation depend on the wavelength, intensity, and length of time one is exposed to the radiant energy. Although a variety of effects is possible,

UV radiation is known to cause adverse health effects over both the short and long term. UV radiation is normally absorbed in the skin and the adverse health effects are mostly confined to the skin and eyes. In most cases it is considered that shorter wavelengths (UVB) are more harmful than longer wavelengths (UVA).
Ultraviolet (UV) radiation is a known cause of the following most common injuries:

- *skin cancer,*
- *skin ageing,*
- *eye damage, and*
- *may affect the immune system.*

Effects of UV radiation on the skin.

Short-term exposure to UV radiation causes reddening of the skin, sunburn and swelling, which may be very severe. In some people this sunburn is followed by increased production of melanin, and is recognised as a suntan. Tanning is a sign that damaged skin is attempting to protect itself from further harm. The most serious long-term effect of UV radiation is the induction of skin cancer. The non-melanoma skin cancers (NMSCs) are basal cell carcinomas and squamous cell carcinomas.

Effects of UV radiation on the skin

Effects of UV Radiation on the Eyes.

Responses of the human eye to acute over exposure of UV radiation include photokeratitis and photoconjunctivitis (inflammation of the cornea and the conjunctiva, respectively), more commonly known as snow blindness or welder's flash. Symptoms range from mild irritation to sever pain and possibly irreversible damage. There is evidence that chronic exposure to intense levels of solar radiation is a contributory factor in the development of age-related macular degeneration of the retina and cortical cateracts, both are causes of blindness.

UV RAYS AND YOUR EYES.

Extended exposure to UV Rays could lead to a host of Eye Problems.

- *UV Radiation can be categorized into three sets of invisible rays :*
- *UVC Rays which are most dangerous, but so far blocked by the atmospheric Ozone Layer.*
- *UVB Rays which can cause dangers ranging from a simple skin tan to even skin cancer.*
- *UVA Rays which have been linked to the formation of certain types of cataracts.*

ARC EYE.

Arc Eye also known as Arc Flash or Welder's Flash or Corneal Flash Burns is a painful condition sometimes experienced by Welders who have failed to use adequate eye protection.
It can also occur due to light from Sun Beds, light reflected from snow (known as Snow Blindness), water or sand.

The intense Ultraviolet light emitted by the Arc causes a superficial and painful KERATITIS. Symptoms tend to occur a number of hours after the exposureand typically resolve spontaneously within 36 hours. It has been described as sand poured into the eyes

ULTRAVIOLET RADIATION AS A HAZARD IN THE WORKPLACE

I. SUN RAYS

Welders who work outdoors are the most likely of all workers to suffer health damage from exposure to UV radiation in addition to UV Rays from the welding arc. Other people may be exposed to UV radiation at indoor work from non-solar sources such as arc welding, the curing of paints, inks etc.

In relation to non-solar sources of UV radiation, well designed engineering and administrative controls and in the case of arc welders, personal protective equipment can keep the risks to a minimum. However with outdoor welders who are regularly exposed to the sun for long periods of time, a more comprehensive strategy is required to minimize risks. This is because the sun (exposure source) cannot be controlled like other workplace exposure hazards. Factors that affect Solar UV radiation include the following;

- *Sun elevation: The higher the sun in the sky, the more intense the UV radiation. Therefore the UV radiation levels are highest around solar noon and in summer*
- *Latitude: The closer to equatorial regions, the higher the UV radiation levels.*
- *Cloud cover: Solar UVR can penetrate through light cloud cover, and on lightly overcast days the UV radiation intensity can be similar to that of a cloud-free day. Heavy cloud can reduce the intensity of UV radiation. Scattered cloud*

has a variable effect on UV radiation levels, which rise and fall as clouds pass in front of the sun.

- *Altitude: At higher altitudes, the atmosphere is thinner and absorbs less UV radiation.*
- *Ozone: Ozone absorbs some of the UV radiation that would otherwise reach the Earth's surface.*
- *Ground reflection: Grass, soil and water reflect less than 10% of UV radiation; fresh snow reflects as much as 80%; dry beach sand about 15% and sea foam about 25%.*

As UV radiation can neither be seen nor felt, it is important therefore that workers who have the potential to be exposed to intense levels of UV radiation are aware of the risks and are regularly reminded to take prompt, appropriate protective action.

II. ELECTRIC WELDING ARC.

Very high Welding arcs can exceed the UV radiation guidelines in seconds within a few meters of the arc. Workers, bystanders and passers-by can be overexposed to UV from the arcs if engineering controls are inadequate.

The arcs associated with arc welding emit high levels of ultraviolet radiation (UVR), and this often causes acute injuries in the workplace, particularly photokeratoconjunctivitis. It is important to know the level of UVR emitted by arc welding under various conditions, as this information will help in evaluating potential UVR hazards in welding workplaces and taking protective measures against it.

A STUDY

A study made for the ACGIH effective irradiance for UVR was measured experimentally for CO2 arc welding in order to evaluate its UVR hazards. A welding robot was used in the experiment in order to realize reproducible and consistent welding operations.

The effective irradiance at 1 m from the arc was in the range 0.28-7.85 W/m2 (28-785|xW/cm2) under the study conditions. The coefficient of variation (standard deviation/mean) for repeated measurements was 15% on average for the solid wire and 10% on average for the flux-cored wire The corresponding permissible exposure time per day is only 4-100 s, suggesting that UVR from.CO2 arc welding is actually hazardous for the eye and skin. It was found that the effective irradiance is inversely proportional to the square of the distance from the arc, is strongly dependent on the direction of emission from the arc with a maximum at 50-60° from the plate surface, and tends to increase with welding current.

(2001 British Occupational Hygiene Society. Published by Elsevier Science Ltd.)

The UVR level at the position of welders will be several times higher, because the welder is usually less than 1 m away and the effective irradiance is inversely proportional to the square of the distance, as shown in this study. Thus, welders should always wear an appropriate face protector (welding helmet or shield) and appropriate clothing to protect eyes and skin against UVR when conducting CO2 arc welding. UVR may also be hazardous at greater distances from the arc. For

example, at 10 m, although the UVR level decreases to 1 % of the level at 1 m, the permissible time per day is still only 6 min to 3 h. exposure

HOW TO MANAGE RADIATION HAZARDS IN THE WORKPLACE

There are a number of measures that can be put in place to control risks in the workplace. This would involve;

1. Engineering controls . for outdoor workers this would include the provision of shade cover or canopies. In the context of non-solar sources of UV radiation, suitable engineering controls measures would include opaque barriers, UV radiation blocking filters and door interlocking power supplies.

2. Administrative controls . for outdoor workers this would include rescheduling outdoor work programs where possible to be performed outside the peak UV radiation period (2 hours either side of solar noon), Training of supervisors and employees should be undertaken for workers exposed to solar and non-solar sources of radiation.

3. Personal protective equipment (PPE) . Outdoor workers should be provided with protective clothing that is loose fitting, made of close weave fabric and provides protection to the neck and preferably to the lower arms and legs. Welding Head Shields / Handshields must be worn. Sunscreen should be a minimum SPF 15, and be broad-spectrum, that is block UVA and UVB, and be applied regularly and liberally to exposed skin.

4. Training should be offered to all employees exposed to medium to very high levels of UV radiation at work so that they understand the risks and what is expected of them while at the workplace.

EYE AND FACE PROTECTION

Eye and face protection require Protective eyewear, which includes safety goggles, protective glasses and face visors and spectacles regulated by a minimum protection level of EN166. Further classifications include EN169 which are filtered for welding, brazing, plasma cutting, etc., EN170 for protection against sources of UV light (sunlight for instance), and EN172 for protection against sun glare.

ARC RAYS can cause burn. Eye, ear and body must be protected with proper PPE. It is essential that the eyes are protected from radiation exposure. Infrared radiation has been known to cause retinal burning and cataracts. And even a brief exposure to ultraviolet (UV) radiation can cause an eye burn known as "welder's flash." While this condition is not always apparent until several hours after exposure, it causes extreme discomfort, and can result in swelling, fluid excretion, and temporary blindness. Normally, welder's flash is temporary, but repeated or prolonged exposure can lead to permanent injury of the eyes.

Other than simply not looking at an arc, the primary preventive measure the welder can take is to use the proper shade lens in the Head and Hand Shield. For various arc welding processes the welder must refer to the lens shade selector chart for the recommended shade numbers. The general rule is to choose a filter too dark to see the arc, then move to lighter shades without dropping below the

minimum rating. The filters are marked as to the manufacturer and shade number, the impact-resistant variety are marked
With an "H".

Head Shields and hand-held Face Shields offer the most complete shielding against arc radiation. The shade slips into a window at the front of the shield so that it can be removed and replaced easily. The shields are made from a hard plastic or fiberglass to protect head, face, ears, and neck from electric shock, heat, sparks, and flames. The welders should also use safety glasses with side shields or goggles to protect the eyes from flying particles.

Auto-Darkening Helmets. The sensors on an auto-darkening helmet darken the lens in a fraction of a second. All auto-darkening helmets must meet ANSI standards, the most recent being ANSI Z87.1-2003.

Visible light can also be harmful, but it is easy to tell if the light is dangerous: if it hurts to look at, then it's too bright. The same is true for infrared radiation: it can usually be felt as heat. However, there's no real way to predict if the

welder or the onlookers being over exposed to UV radiation, so no chances should be taken and welders must always take eye protection with recommended lens for the process.

Filter Lens Shade Numbers

- *SMAW – 1/16 - 5/32 Electrodes = #10*
- *SMAW – 3/16 – ¼ - Electrodes = #12*
- *SMAW - 5/16 & 3/8 Electrodes = #14*
- *GMAW - 1/16 - 5/32 Electrodes = #11 (nonferrous)*
- *GMAW – 1/16 – 5/32 Electrodes = #12 (ferrous)*
- *GTAW – All Electrodes = # 11*
- *Plasma Arc welding – All = # 12*
- *Carbon Arc Gouging – Light # 12, Heavy # 14*
- *Atomic Hydrogen Welding = #10 - #14*
- *Carbon Arc Welding CAW = #14*
- *Soldering = #2*
- *Torch Brazing = #3 or #4*
- *Light cutting up to 1 inch = #3 or #4*
- *Medium cutting 1 inch to 6 inches = #4 or #5*
- *Heavy cutting over 6 inches = #4 or #6*
- *Light gas welding up to 1/8" = #4 or #5*
- *Medium gas welding 1/8" to ½ " = #5 or #6*
- *Heavy Gas Welding over ½ " = #6 or #8*
- *Plasma Arc Cutting – Light <300 amp = #9,*
  - *Medium 300 – 400 amp = #12*
  - *Heavy > 400 amp = #1*

Plasma cutting protection

ANSI Z49.1:2005 Recommendations		
Arc Current (Amperes)	Minimum Protective Shade	Suggested Shade Numbe
Less than 20	4	4
20 – 40	5	5
40 – 60	6	6
60 – 80	8	8
80 – 300	8	9
300 – 400	9	12
400 – 800	10	14

TO PROTECT YOURSELF AS A WELDER

1.As a rule of thumb, start with a shade that is too dark to see the arc zone. Then go to a lighter shade which gives sufficient view of the arc zone without exerting a strain on your eyes.
2. Protect against arc flashes, mechanical injury, or other mishaps. Wear spectacles or goggles with No. 2 shade filter lens and side shields inside the welding helmet or hand shield. Helpers and observers should wear similar protection-Be sure "lift front" welding helmet has plastic plate inside and safety glass cover on the outside.
3. Wear protective clothing such as heat resistant jackets, aprons, and leggings. Exposure to prolonged or intense arc radiation can cause injury. Thin cotton clothing is inadequate protection. Cotton deteriorates with this type of radiation.
4. Wear high, snug fitting shoes. Avoid wearing low or loose shoes which would allow hot spatter to get inside.
5. Wear cuffless pants. By wearing pants with no cuffs, you eliminate a dangerous spark and spatter trap- Pants legs should overlap shoe tops to prevent spatter from getting into your shoes.
6. Wear clean clothes. Do not wear clothing that has been stained with oil and grease. It may burn if ignited by the heat of the arc.
7. Wear ear protection, not only where there is noise, but where there is a chance that spatter or sparks could get into your ears.
8. Wear a leather cap or other protection to protect the head from sparks or spatter.
9. Protect neighboring workers from exposure to arc radiation. Shield your station with metal or heat resistant shields. If your station cannot be shielded, everyone within about 75 ft. should wear eye protection when welding or cutting is in progress.
10. Keep your pockets, sleeves and collars buttoned. Sparks may lodge in them and cause fires or bums. Be sure your pockets are emptied of combustibles such as matches and other flammables.

WELDING CURTAINS.

Fitters, Gas Cutters, Grinders and other operators working in and around the welding workplace must also be protected from the Arc Radiation. Welding curtains complying with EN1598 to block out welding light. The curtains are provided with seams all around with snap fasteners on both sides for joining. Portable curtain frame for use when welding are ideal for moving to and from work areas. Supplied complete with reinforced holes and steel suspension rings can be set up in the frames very quickly.

CONCLUSIONS.

All Arc Welding Processes emit UV rays which cause harmful effects on skin and eyes of the welders and associated operators if exposed for prolonged periods. Preventive and Protective actions can and must be taken in a planned way to reduce these to minimum.

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CHAPTER – VI

WELDING ERGONOMICS

Ergonomical Safety Aspects regarding Work-Related Musculoskeletal Disorders are important especially for Fusion Welding Processes to prevent worker discomfort, injuries forcing the welder to leave work and sometimes absence from work.

This is a Working Guideline for Supervisors and Operators working in an Engineering Fabrication Plant using welding as the main manufacturing process to initiate awareness for observing Safety Rules and regulations.

INTRODUCTION.

The word Ergonomics has several meanings. The first is literal. Derived from two Greek words: Ergo = work; and Nomos = laws. Therefore ergonomics literally means the laws of work.

But the practical meaning of Ergonomics is fitting the task and work environment to theHuman limitations. Ergonomists try to design tasks and workplaces to suit the capability of the human. In most of our workplace layout design and selection of production processes there are many tasks, work environments, and even products, which do not take human capabilities into consideration.

Ergonomics is the science of designing and arranging plant, machinery. equipment and positioning of job for efficient and effective workout by operators. It is also named as Human Factors Engineering. It is the science and relationship interaction between worker and workplace environment.

Ergonomics attempts to make the workplace comfortable to the operators to work with minimum fatigue of body and limbs. Ergonomics focuses on designing Process and Method to suit worker capabilities and not changing worker. It does not try to make workers adjust to the workplace. When a workplace is designed properly, the worker feels comfortable. Quality and production increase. Everyone benefits.

OBJECTIVES OF ERGONOMICS

- *Reduce injuries and disorders.*
- *Ensure worker Safety.*
- *Ensure worker Health.*
- *Reduce Absenteeism.*
- *Ensure worker Productivity.*

CAUSES OF THE PROBLEMS

- *Reaching.*
- *Bending.*

SYMPTOMS OF MSDS.

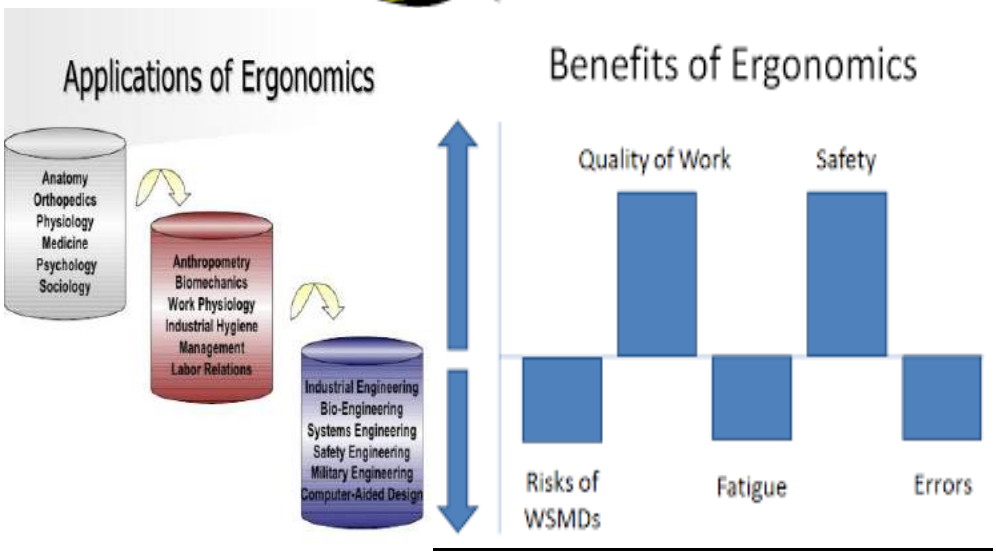
- *Less Gripping strength.*
- *Less Range of Motion.*
- *Loss of Muscle function.*
- *Painful Joints.*
- *Pain, Numbness in body Limbs.*
- *Shooting or Stabbing Pains.*
- *Swelling or Inflammation.*
- *Stiffness or Burning sensation.*

- *Heavy Lifting.*
- *Using continuous Force.*
- *Working with Vibrating Equipment.*
- *Repetitive Motions.*
- *Awkward Postures. Temperature.*

PROBLEMS FROM POOR ERGONOMICS.

- *Musculoskeletal Disorders (MSD)*
- *Repetitive Motion Injury.*
- *Worker Dissatisfaction.*
- *Increased Absenteeism.*
- *Increased Turnover rates.*

Ergonomics includes many different scientific disciplines such as : physiology, biomechanics, psychology, anthropometry, industrial hygiene and kinesiology.



MUSCULOSKELETAL DISORDERS.

Discomfort and pain are common in human-work activities and workers working in the industrial sector are prone to be exposed to the risk of injuries. Occupational risk factors are the most common entity to cause health problems. Exposure to occupational hazards adversely affect the functioning of human body and in turn reduce worker productivity and product/work quality and increase musculoskeletal problems.

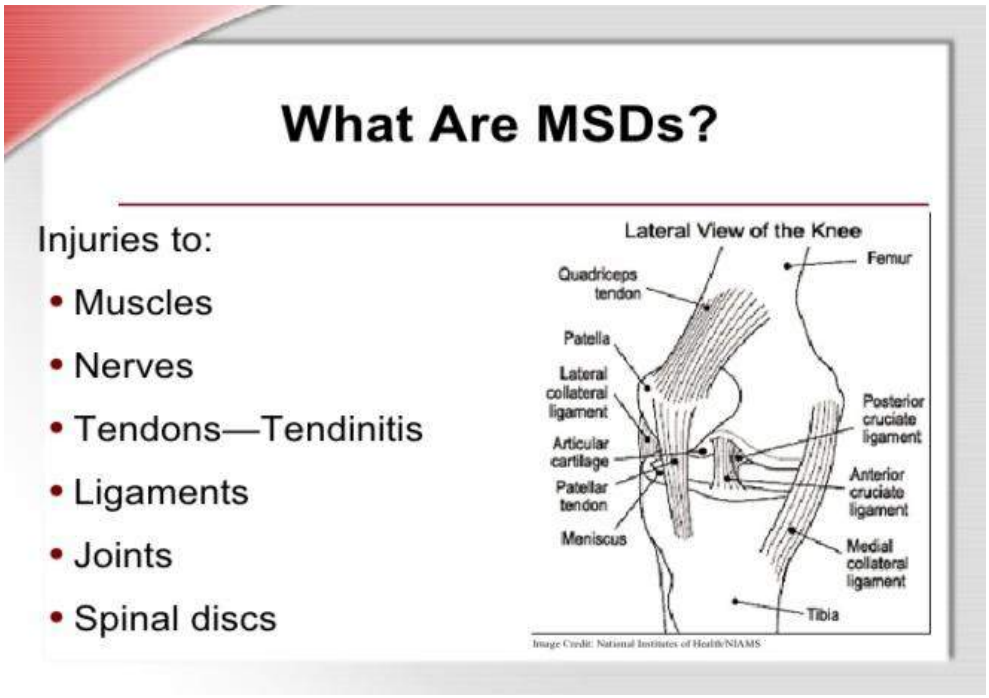
MSDs, or musculoskeletal disorders, are injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) including the nerves and tendon sheaths, and most frequently involve the arms and back. Occupational safety and health professionals have called these disorders in variety of names :

- *Cumulative trauma disorders,*
- *Repeated trauma,*
- *Repetitive stress injuries,*
- *Occupational overexertion syndrome.*

These are painful and often disabling injuries generally developing gradually over a period of weeks, months and years. MSDs usually result from exposure to multiple risk factors that can cause or accelerate the disorders MSDs can cause a number of conditions, including pain, numbness, tingling, stiff joints, difficulty moving, muscle loss, and sometimes paralysis .These disorders include :

- *Carpal tunnel syndrome,*
- *Tendinitis,*
- *Sciatica,*
- *Herniated discs, and*
- *Low back pains.*

Frequently, workers lose time from work to recover; some never regain full health. MSDs are not caused from a single event or trauma such as a fall, collision, or entanglement.



The Nature of Welding

In any metal fabrication industry, welding plays a vital role; it is a versatile manufacturing process and its application covers almost all the Engineering products including Nano-Technology. Welding is said to contribute to 50% of the nation's gross national product. Welding often requires awkward body positions and time are key factors in causing injuries. Welders have a high prevalence of musculoskeletal complaints, including back injuries, shoulder pain, tendonitis, and reduced muscle strength. In this background, there is lot of scope for improvement in the operating (welding) postures which in turn helps in increased productivity, worker safety and quality of work in welding-industry. Problems are mismatches between man and machine, improper layout design, unhealthy work environment and mainly illiteracy among workers. Small scale industries face serious occupational health and safety challenges. Workers working in a shop floor throughout the day will experience a certain level of discomfort in their body parts; this in turn affects quality, and productivity.

Welding is a precise task that requires the welder to maintain static postures for relatively long periods of time. In almost all cases welding in the field requires the welder to adapt to the workplace, rather than adapting the workplace to the welder. This is because metal is heavy and it is easier to have the welder assume an awkward posture, than move a ship. Welding also is hot work and generates metal fumes that can contain many relatively harmful metals.

The use of proven ergonomic principles can improve the way a particular task is performed, thereby reducing welder exposure to risk factors. This generally translates to a healthier workforce, improved morale, greater productivity and increased product quality.

Most of the tasks welders perform are dictated by the design of the item being worked. In many cases, the materials are big, heavy, and might be covered with dirt, rust, and/or grime.

Work Related Musculoskeletal Disorders in Welding

Many injuries can develop when there is a mismatch between the capabilities of the workforce and the demands of the task. These injuries are generally called Work Related Musculoskeletal Disorders or WMSDs. These have also been called Cumulative Trauma Disorders (CTDs) or Repetitive Stress Injuries (RSIs)

In general, these conditions develop because of micro-traumas that occur to the
body over time. Consider lower back vertebral disk degeneration. The vertebral disk is made of flexible cartilage and contains a semi-liquid gel. The cartilage is in the form of rings. When a person performs lifts beyond their capability, these rings can degrade. If the person continues performing such lifts the disk can rupture. When it ruptures it bulges out and can place pressure on a spinal nerve causing severe pain.

Work situations and conditions that are likely to cause MSD problems include the following:

- *Exerting excessive force more than normal ;*

- *Continuous and excessive repetition of movements that can irritate tendons and increase pressure on nerves;*
- *Forced awkward postures, or unsupported positions that stretch physical limits, can compress nerves and irritate tendons;*
- *Static postures, or positions that a worker must hold for long periods of time, can restrict blood flow and damage muscles;*
- *Abrupt motion, such as increased speed or acceleration when bending and twisting, can increase the amount of force exerted on the body;*
- *Compressive forces from grasping sharp edges like tool handles, can concentrate force on small areas of the body, reduce blood flow and nerve transmission, and damage tendons and tendon sheaths;*
- *Inadequate recovery time for tissue repair due to overtime, lack of breaks, and failure to vary tasks.*
- *Continuous and excessive vibration, usually from vibrating tools, can decrease blood flow, damage nerves, and contribute to muscle fatigue.*
- *Vibration of the whole-body such as from driving trucks or operating subways, or continuous chipping can affect skeletal muscles and cause low-back pain; and*
- *Working in extreme hot or cold temperatures can adversely affect a worker's coordination and manual dexterity and cause a worker to use more force than necessary to perform a task.*

These risk factors, either alone or in combination, can subject the muscles, tendons, cartileges of the workers' shoulders, arms, hands, wrists, backs, and legs to thousands of repetitive twisting, forceful, or flexing motions during a typical workday. MSDs, however will result from these risk factors when present for a sufficient duration, frequency, or magnitude.

The many possible causes of injury are not limited to one industry or to specific occupations, but result from a pattern of usage. Physical Work Place Risk Factors with common causes of injury are:

- *Repetitive gripping / twisting*
- *Repetitive reaching*
- *Repetitive moving*
- *Static postures*
- *Lack of rest to overcome fatigue*

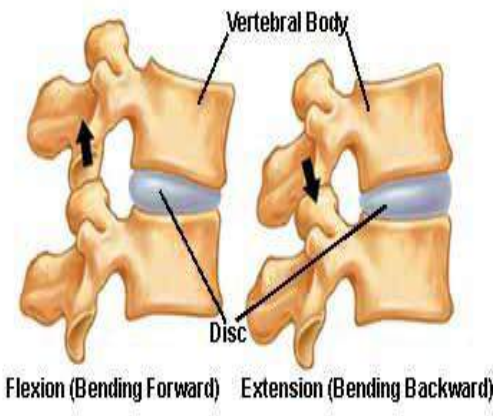
These causes fall into six major physical workplace risk factors:

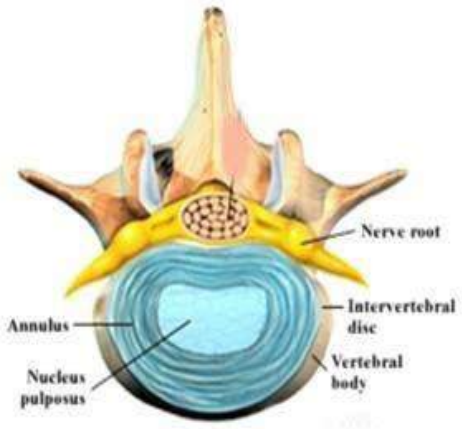
- *Force to perform the task*
- *Highly repetitive tasks*
- *Poor, awkward or static postures*
- *Pressure points or compression*
- *Vibration*
- *Duration*

When present with sufficient frequency, magnitude, or in combination, these risk factors may cause Work-related Musculoskeletal Disorders (WMSDs) – injuries and illnesses that affect muscles, nerves, tendons, ligaments, joints, spinal discs, skin, subcutaneous tissues, blood vessels, and bones.

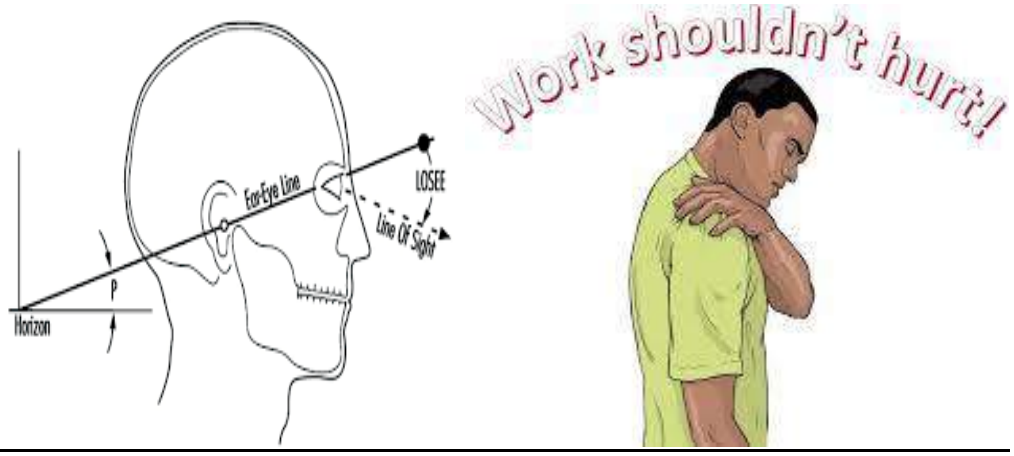
Additionally, environmental conditions such as working in temperature extremes may contribute to the quick development of WMSDs. Personal risk factors, such as physical conditioning, preexisting health problems, gender, age, work technique, hobbies and organizational factors (e.g., job autonomy, quotas, deadlines) may also contribute to, but do not cause, development of WMSDs. Common WMSDs for welders include:

- *Back Injuries – From strains and sprains to degradation of the vertebral disks*
- *Bursitis – Inflammation of a saclike bodily cavity, containing a viscous lubricating fluid located between a tendon and a bone or at points of friction between moving structures (i.e. inflammation of a bursa)*
- *Carpal Tunnel Syndrome – A complex disorder that starts with the inflammation of the tendon sheaths in the wrist and progresses into the degradation of median nerve*
- *Tendonitis – Inflammation of the tendons*
- *Tenosynovitis – Inflammation of tendon sheath*
- *Thoracic Outlet Syndrome – A disorder in which blood vessels and nerves in the*
- *upper shoulder region are compressed and cause pain. This condition is sometimes caused by chronic postures associated with overhead work.*
- *Trigger Finger – Tendons in the fingers "lock down" due to injury to the tendons*





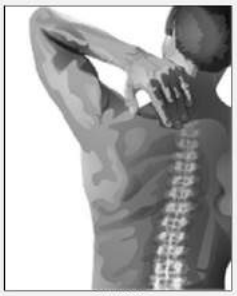
Spinal disc and vertebra



Effects of Exposure to Ergonomic Hazards

Musculoskeletal Disorders (MSDs)

- **Mild**
  - Joint pain
  - Swelling
  - Sciatica
  - Acute lower back pain
- **Serious**
  - Epicondylitis (Tennis Elbow)
  - Raynaud's Phenomenon (White finger)
  - Thoracic Outlet Syndrome
  - Carpal Tunnel Syndrome
  - Chronic lower back pain
  - Tears (Rotator cuff is common)



Source: OSHA

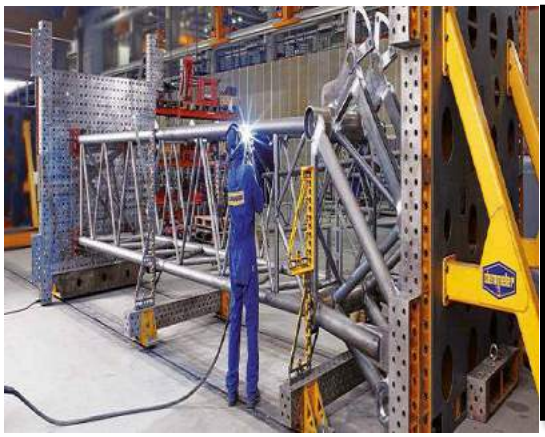
Ergonomics Stressors Compression: **Leaning on a hard surface**
Awkward & Static Posture: **Holding the arms away from the body for long durations**


Welding with the hands in front of the body

Ergonomics Stressors: ***Awkward & Static Posture:*** **Extension of the neck, static loading in the arms and shoulders**


Welding at ground level

Ergonomics Stressors: ***Awkward & Static Posture:*** **Extension of the neck, static loading in the arms and shoulders**




Welding above shoulder height

Ergonomics Stressors: *Awkward & Static Posture:* Hot work in a static posture caused by the constrained space *Compression:* Leaning on a hard surface


Welding in constrained spaces

Ergonomics Stressors: *Awkward & Static Posture:* Working with the back bent forward and wrist in extension *Compression:* Leaning on a hard, sharp surface


Welding with back bent forward

Ergonomics Stressors: *Awkward & Static Posture:* Working with the back bent


Working with the back bent forward

Ergonomics Stressors: *Awkward & Static Posture:* Statically Holding a stooped


Working in a stooped posture

Ergonomics Stressors: Awkward & Static Posture: Working with the back bent forward and holding the arms away from the body Compression: Resting the arms on a hard surfaces


Working with the back bent forward

Ergonomics Stressors: Awkward & Static Posture

A few of the following photographs show various awkward and strained body postures during welding which invariably cause ergonomic stresses.



ERGONOMIC SOLUTION APPROACH

The following section on ergonomic solutions for welders describes changes toequipment, work practices and procedures (administrative controls) that can address ergonomics-related risk factors, help control costs, and reduce employee turnover.

These changes may also increase employee productivity and efficiency because they eliminate unnecessary movements and reduce heavy manual work.

However, there are numerous job aids such as fixtures, jigs, and part holders available to aid welders in doing their jobs and reduce the risk of injury. In addition, special chairs and/or creepers are available that provide body support while performing tasks so that an awkward posture is avoided. These types of ergonomic solutions will be presented in the following sections.

Action Plan for Implementing Solutions to Reduce Workplace Risk Factors

Step 1: Look for clues

- *Observe work activities*
- *Risk factors*
- *Worker fatigue*
- *Tool / equipment modifications*
- *Increased absenteeism*
- *Decreased production*
- *Bottlenecks / missed deadlines*
- *Talk to workers (form ergonomics action teams or designate an ergonomic point of contact)*

- *Use assessment tools*
- *Risk factor physical check list.*

Discomfort Assessment Checklist

Questionnaire/ checklist to identify discomfort in various parts of the body with different regions are shown in the below Table. Frequency indicates how many times the body part undergoes discomfort. Evaluation hour indicates level of discomfort as the work progress.

Table : Discomfort Assessment Checklist

Evaluation is done by questioning the worker, whether any sort of pain happening throughout the entire working shifts. The observations are likely to be: that during the first hour discomfort level is very minute (mild) and as the work progress certainly there will be an increase in discomfort level where the workers feels moderate discomfort whereas in some parts of the body, level of discomfort is severe. Finally, when the work reaches its final stage discomfort level increase to peak level i.e., in this condition the worker doesn't able to work anymore because there will be loss of muscle function, painful joints at the end of the working shifts.

However, such an analytical approach will identify the limbs or the joints of welders subjected to maximum discomfort due to postural stress and strain during welding. Remedial measures to prevent MSD can then be taken and then another study undertaken at the same workplace to ascertain that the measured taken have yielded a positive result.

Sl no	Parts of the body	Frequency	Side		Evaluation hour		
			Left	Right	1st	4th	8th
1	Eyes						
2	Head						
3	Neck						
4	Trapeze						
5	Thorax						
6	Lumbar						
7	Shoulder						
8	Upper arm						
9	Elbow						
10	Forearm						
11	Wrist						
12	Hands/fingers						
13	Buttocks						
14	Thigh						
15	Knee						
16	Lower leg						
17	Ankle						
18	Foot/legs						

Sl no	Frequency	Evaluation
1	1-2 times per week	No discomfort
2	3-4 times per week	Mild
3	Every day (once)	Moderate
4	Every day (several times)	Severe
5	Every day (all day long)	Insupportable

Step 2: Prioritize job for improvements : Consider

- *Frequency & severity of the risk factors*
- *Frequency & severity of complaints*
- *Injuries*
- *Workers' ideas*
- *Timeframe for making improvements*
- *Difficulty in making improvements*

Step 3: Make improvements – Improve the fit between task demands & worker capabilities

- *Talk to various employees*
- *Contact other industries*
- *Consult ergonomics experts*
- *Use internet resources*

Step 4: Follow-up:

- *Has each improvement reduced or eliminated the risk factors, fatigue, discomfort symptoms or injury reporting?*
- *Has each improvement been accepted by the workers?*
- *Have any improvements created new risks or other problems?*
- *Have any improvements impacted production or quality?*
- *Are implemented improvements supported by training?*

POSSIBLE SOLUTIONS TO PROBLEMS

- *Recognize that often Repetitive Motion Injury is mistakenly felt to be a type of short-term weakness or fatigue. Actually it is the start of potentially more serious injuries.*
- *Address complaints in a timely manner.*
- *Get employee input.*
- *Interact with the worker. Discuss possible solutions. Give the employee ownership of any new plans. Promote employee acceptance of solutions.*
- *Redesign the workstation with the employees' help. Employees should feel part of the process.*
- *Utilize gravity when it can help move material to the work area or station. This helps to prevent unnecessary material handling.*

PRACTICAL SOLUTIONS—HOW TO AVOID THE HAZARDS

- *Avoid fixed work positions. They reduce the blood supply to muscles.*
- *Keep elbows close to the body.*
- *Avoid positions where arms are raised above shoulder level.*
- *Use lighter hand tools.*
- *Suspend tools.*
- *Support your elbows.*
- *Provide sufficient rest.*
- *Utilize jigs and fixtures.*

WORKSTATION DESIGN FACTORS

Some factors to consider:

- *Position of the work.*
- *Physical ability of the worker.*
- *Design and weight of the tools.*
- *Body mechanics of the operation. of the work.*
- *Physical ability of the worker.*
- *Design and weight of the tools.*
- *Body mechanics of the operation.*
- *Type of protective equipment used.*
- *Workspace / environment (size, lighting, temperature, noise, vibration, etc.).*
- *Physical requirements of the job (lifting, turning, reaching, etc,).*
- *Mental requirements (motivation, alertness, concentration).*
- *Strength and size of the workers.*

Use suggested PRACTICAL SOLUTIONS of the work.

- *Physical ability of the worker.*
- *Design and weight of the tools.*
- *Body mechanics of the operation.*
- *Type of protective equipment used.*
- *Workspace / environment (size, lighting, temperature, noise, vibration, etc.).*
- *Physical requirements of the job (lifting, turning, reaching, etc,).*
- *Mental requirements (motivation, alertness, concentration).*
- *Strength and size of the workers.*

CONCLUSION

- *It was noticed from the study and findings that in the small scale industries and in the unorganized sector there is very little awareness about safety and ergonomics*
  aspects, workers are unaware of musculoskeletal disorders.

- *Present study is based on workers working in welding section. Among the various work postures, restricted (awkward) postures were found to be associated with occupational risk injuries.*
- *Ergo fellow, a simulation software consisting assessments tools like RULA, REBA, OWAS are carried out to evaluate the awkward welding postures and interpretation of result indicates safe working postures as recommended by OSHA.*
- *A simplified procedure for discomfort identification through standard ergonomic tools and suitable working environment with necessary guidelines is proposed and demonstrated.*
- *Postures adopted during welding are observed through photographs and manikin model in ergonomic design and analysis workbench module of CATIA V5 is developed with necessary tools required for welding.*
- *RULA analyses for various welding postures were evaluated. From the results, it was noticed that the postures carried out during welding were unsafe and objectionable. Suggesting interventions for better working environment to enhance worker productivity.After suggesting suitable guidelines, comparison results shows lot of improvement in welding postures. RULA shows 60% of development in working action; REBA indicates 50% of betterment in posture level. OWAS suggests improvement in workers workload.*
- *Software analysis and ergonomic assessment tools were very best source for identifying the workers discomfort levels and providing possible solutions for the action WMDS'S. It is evident that WMSD are a significant health concern, by implementing and properly following the ergonomic guidelines can reduce WMSD's among the workers. This will benefit the company/industries to achieve better quality and increased productivity*

SCOPE FOR THE FUTURE WORK

- *In developing countries like India, the scale of use of human resources in small and medium entrepreneurs (SME's) in labor-intensive industries is huge. In this situation, it must be obvious that even small improvements in working conditions or working methods can lead to large benefits.*
- *Suggested ergonomic guidelines should be implemented for the workers sake in order to create safe working environment.*
- *This evaluation technique can be applied for any manual material handling activities in manufacturing industry and also in various occupational risk activities to evaluate and improve the work environment.*
- *To provide them proper industrial training, creating ergonomic awareness, industrial*
  hygiene expertise, alternative welding methods.
- *Employee suggestion scheme should be introduced where employees are given free*
  hand to give a suggestion to management for any improvement from quality, cost, delivery, safety and morale point of view.

- *Conduct periodic health assessment to ensure the workers are working in good environment condition.*
- *Workstation renovation also can ensure a safe and comfortable working environment.*
- *Monitoring groups and systematic approach and will help the management in the implementation in order to reduce workplace hazards.*
- *Safety aspects and application of safety equipment's like hand gloves, goggles, positive air powered respirator, auto darkening helmets, heat resistant aprons etc., will ensure the workers safety.*

XXXXXXXXXXXXX

ANNEXURE - I

SAFETY - SPECIFICATIONS / CODES / STANDARDS.

- *** IS 812:1957 Glossary of terms relating to welding and cutting of Sep 2008*
- *IS 818:1968 Code of practice for safety and health Sep 2008 requirements in electric and gas welding and cutting operations (first revision)*
    - *IS 1179:1967 Equipment for eye and face protection during Sep 2008 1 welding (first revision)*
- *IS 8990 : 1978. Code of Practice for maintenance and care of industrial safety clothing.*
- *IS 14489 : 1998 Code of Practice on Occupational Safety and Health Audit.*
- *IS 18001 : 2000. Occupational Health and Safety Management Systems – Specifications and Guidelines for use.*
- *IS 3016:1982 Code of practice for fire precautions in welding and Mar 2006*
- *cutting operations (firstrevision*
- *IS 10811:1984 Oxygen and acetylene manifold regulators for Mar 2006*
- *welding, cutting and related processes*
- *IS 5780 : 1980. Intrinsically safe Electrical Apparatus and Circuits.*
- *IS 5903 : 1970. Safety Devices for Gas Cylinders.*
- *IS 5216 (Part 1) : 1982. Recommendations on Safety Procedures – Practices in Electrical Work.*
- *IS 11006 : 1984. Flash Back Arrester (Flame Arrester).*
- *IS 1641 :1988. Code of Practice for Fire Safety in Buildings (general).*
- *IS 3016 : 1982. Code of Practice for Fire Precautions in Welding and Cutting operations..*
- *IS 5896. Code of Practice for Selection, Operation and Maintenance of Fire Fighting Appliances.*
- *IS 8433 : 1984. Dissolved Acetylene Cylinders.*
- *IS 1179 : 1967. Equipment for Eye and Face protection during welding.*
- *IS 6519 : 1971. Code of Practice for Selection, Care and Repair of Safety Footwear.*
- *IS 8990 :1978. Code of Practice for Maintenance and Care of Industrial Safety Clothing.*
- *IS 816 : 1969. Code of Practice for Safety and Health requirements in Electric and Gas welding and Cutting Operations.*
- *IS 3483 : 1965. Noise reduction in Industrial Buildings, codes of practice.*
- *IS 10224 : 1982. Ergonomic Principles in Design of Work Systems.*
- *IS 7620 (Part 2) :1991. Radiation Safety requirements.operations (first revision)*

STANDARDS AND SPECIFICATIONS FOR PPE.

- *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."*
- *When welding or engaging in similar activities which might produce small splashes of molten metal, safety workwear (Boiler suit/ Overall) and equipment needs to meet the specifications of protection level EN1161.*
- *EN ISO 11612:2008 Protective clothing to protect against heat and flame.*
- *EN ISO 14116:2008 Protective Clothing to protect against heat and flame – limited flame*
  spread (replaces EN 533 – still accepted for garments already certified). Protection for workers against occasional and brief contact with small igniting flames, where there is no significant heat hazard and without the presence of another type of heat.
- *EN 1149 Protective clothing with electrostatic properties.*
- *Industrial safety gloves designed to provide protection EN12477 is the standard for the protective gloves used for welding.*
- *Eye and face protection required Protective eyewear, which includes safety goggles, protective glasses and face visors and spectacles are regulated by European directives and require a minimum protection level of EN166. Further classifications include EN169 which are filtered for welding, brazing, plasma cutting, etc., EN170 for protection against sources of UV light (sunlight for instance), and EN172 for protection against sun glare.*
- *ANSI Z87.1, "Practice for Occupational and Educational Eye and Face Protection."*
- *ANSI Z87.1 : helmet with filter lens and cover plate complies with for protection from radiant energy, flying sparks, and spatter.*
- *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.*
- *A filter lens shade according to the Lens Shade Selector Chart in ANSI Z49.1 or AWS F2.2. Lens Shade Selector.*
- *AWS Fact Sheet 31, Eye and Face Protection for Welding and Cutting Operations.*
- *ANSI Z87.1-2003 : Auto-Darkening Helmets. The sensors on an auto-darkening helmet darken the lens in a fraction of a second. All auto-darkening helmets must meet ANSI standards, the most recent being.*
- *All safety footwear should conform to EN ISO 20345.*
- *ANSI Z41, "Protective Footwear."*

- *ANSI Z49.1 requires all welders to wear protective flame-resistant gloves, such as leather welder's gloves. They should provide the heat resistance and general hand protection needed for welding.*
- *Respiratory protection equipment falls under the BS EN 149:2001 and BS EN 140:1999 classifications.*
- *European legislation for ear defenders and ear plugs requires a minimum protection level of EN352.*

SAFETY INFORMATION –WELDING & CUTTING – AMERICAN WELDING SOCIOETY

The following publications, which are available from the American Welding Society are recommended :

- *ANSI/ASC Z49.1 - "Safety in Welding and Cutting"*
- *AWS C5.1 - "Recommended Practices for Plasma Arc Welding"*
- *AWS C5.2 - "Recommended Practices for Plasma ArcCutting"*
- *AWS C5.3 - "Recommended Practices for Air Carbon Arc Gouging and Cutting"*
- *AWS C5.5 - "Recommended Practices for Gas Tungsten Arc Welding“*
- *AWS C5.6 - "Recommended Practices for Gas Metal Arc Welding"“*
- *AWS SP - "Safe Practices" - Reprint, Welding Handbook.*
- *ANSI/AWS F4.1, "Recommended Safe Practices for Welding and Cutting of Containers That Have Held Hazardous Substances*
- *American Welding Society, ANSI Z49.1:2005 "Safety in Welding, Cutting, and Allied Processes."*
- *National Fire Protection Association, NFPA 70, "National Electrical Code", 2005.*
- *American Welding Society, Safety and Health Fact Sheet No. 29, "Grounding of Portable and Vehicle Mounted Welding Generators", July 2004.*
- *American Welding Society, AWS A3.0-2001, "Standard Welding Terms and Definitions."*
- *ANSI/NFPA 70, "National Electrical Code" for the specifics.*
- *“Precautions and Safe Practices for Arc Welding, Cutting and Gouging", Form 52-529.*

ANNEXURE – II.

REFERENCES / INFORMATION SOURCES

- *Naval Safety Center Ergonomics Success Stories.*
- *Mishap Prevention and Hazards Naval Facilities Engineering Command Ergonomics Abatement Program funding and submittal process ,*
- *Easy Ergonomics: A practical approach for improving the work place:*
- *Occupational Safety and Health Administration & California OSHA Services.*
- *Alexander, D. Ergonomic Design Guidelines, Alabama: Auburn Engineers, 1997.*
- *Johnsen, M. R. 1998. "Ergonomics, the Best Fit for Safety," in Welding Journal, Vol 77, No. 10, October 1998.*
- *McKormick and Sanders. Human Factors in Engineering and Design. New York: McGraw Hill Book Co., 1982.*
- *Konz, Stephen. Workplace Design:*
- *Industrial Ergonomics, Third Edition. Ohio: Horizon Publishing Co., 1990.*
- *Occupational Safety and Health Administration (OSHA). Ergonomics Program Management Guidelines, Washington, DC: U.S. Government Printing Office. Latest Revision*
- *ACGIH. 2000 TLVs and BEIs. Cincinnati: The American Conference of Governmental Industrial Hygienists, 2000.*
- *Bennett AP, Harlen F. Measuring the UV radiation hazard to welders. Weld Metal Fab 1980;October:541-9.*
- *Dennis JH, Mortazavi SB, French MJ, Hewitt PJ, Redding CR. The effects of welding parameters on ultra-violet light emissions, ozone and CrVI formation in MIG welding. Ann Occup*
- *Hyg 1997;41:95-104.*
- *Emmett EA, Horstman SW. Factors influencing the output of ultraviolet radiation during welding. J Occup Med 1976;18:41-4.*
- *Hietanen M, Nandelstadh P. Measurements of optical radiation emitted by welding arcs, In: Matthes R and Sliney D, editors. Measurements of optical radiation hazards. Munich:*
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- *JWES (The Japan Welding Engineering Society). Shakouhogogu no seinouhyouka tou ni kansuru chousa kenkyu seika houkokusho [A research report on the performance of eye*
- *protectors against optical radiation], Sanpo-Sakuma Bid. 9F, 1-11 Kandasakumacho, Chiyoda-ku, Tokyo 101-0025, Japan, 1980.*

- *Lyon TL, Marshall WJ, Sliney DH, Krial NP, Del Valle PF. Non ionizing radiation protection special study No. 42-0053- 77, Evaluation of the potential hazards from actinic ultraviolet*
- *radiation generated by electric welding and cutting arcs. US Army Environmental Hygiene Agency Aberdeen Proving Ground, ADA033768, Maryland, 1976.*
- *Mariutti G, Matzeu M. Measurement of ultraviolet radiation emitted from welding arcs. Health Phys. 1988;54:529-32.*
- *Okuno T. Spectra of optical radiation from welding arcs. Ind Health 1985;23:53-70.*
- *Okuno T. Measurement of ultraviolet radiation from welding arcs. Ind Health 1987;25:147-56.*
- *Sibata Scientific Technology Ltd. Yugaishigaihoshasokuteiki UV-3 kata toriatsukaisetsumeisho [Hazardous ultraviolet radiation meter UV-3 instruction manual], Tokyo, 1997.*
- *Sliney D, Wolbarsht M. Safety with lasers.*
- *Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.*
- *American National Standards Institute*
- *(ANSI). Practice for Occupational and Educational Eye and Face Protection (ANSI Z87.1), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; Web site: www.ansi.org.*
- *Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Web site:*
- *www.osha.gov.*
- *National Fire Protection Association (NFPA). Standard for Fire Prevention during Welding, Cutting, and Other Hot Work (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269–*
- *9101; Web site: www.nfpa.org.*
- *American Welding Society (AWS). Safety and Health Fact Sheet No. 31, Eye and*
- *Face Protection for Welding and Cutting Operations, available from American*
- *Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.*
- *ASTM International Standards, F2412, Test Methods for Foot Protection, and*
- *F2413, Specification for Performance Requirements for Protective Footwear,*
- *available from ASTM International, 100 Bar Harbor Drive, P.O. Box C700, West Conshohocken, PA*.

xxxxxxxxxxxxxxxxxxxxxxxxxx

ANNEXURE - III

A FEW POSTERS TO USE


No Safety
Know Pain
Know Safety
No Pain


DANGER
WELDING
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CAUTION
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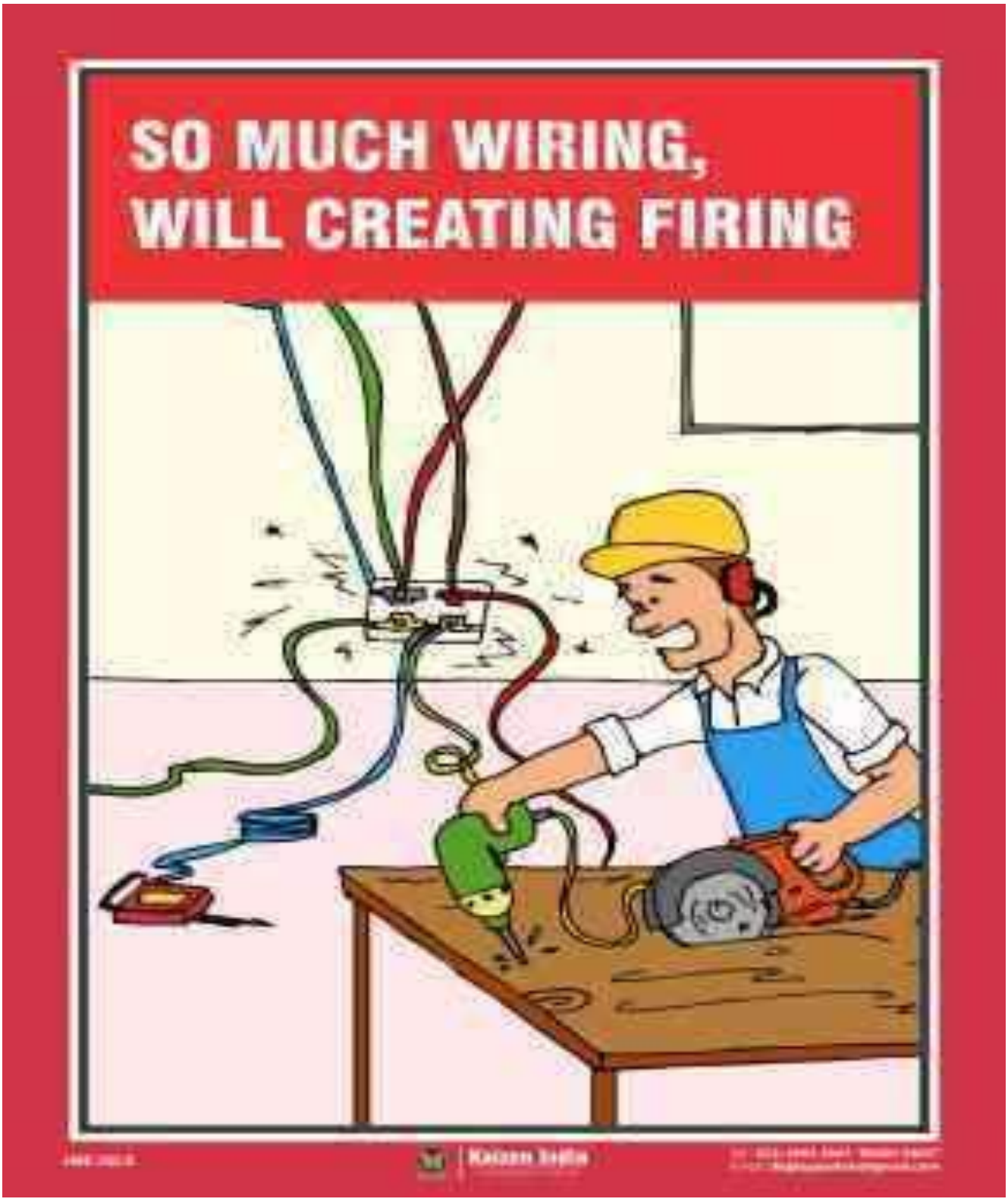
DANGER
WELDING ARC
WEAR PROPER
EYE
PROTECTION


SO MUCH WIRING,
WILL CREATING FIRING

Other Dangers

- Eye damage from flash burns or Ultraviolet (UV) Radiation ("Welder's Eye")
- Flash burns to the welder or surrounding workers
- Inhalation of dangerous fumes ("Metal Fume Fever")
- Heat stress

THE AUTHOR

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He was an Executive Committee Member of National Safety Council, India, West Bengal Chapter. He has taught Safety Management Courses at IISWBM, Ashutosh College, Association of Engineers, Regional Labour Institute, Kolkata, National Productivity Council.

He has a working experience of 38 years in the areas of Manufacturing Rolling Stocks and Foundry Practice with Martin & Burn. Burn Standard, Datre Corporation and now with Jupiter Alloys and Jupiter Wagons as Technical Director.

He has an in-depth experience on Skills Training with Shell International and Ministry of Labour and Social Affairs, Muscat and Oman and now with Quivan Skill Empowerment Pvt.Ltd, Cheu Wren and HTTC as Director.

He has trained welding skill at the operator's level at Railway Workshops at Kharagpur, Kanchrapara, CLW , Indian Oils, Welding Institute at ESAB, Reliance Refinery at Jamnagar, Kolaghat Thermal Power Station. National Productivity Council, Ichapur Gun & Shell Factory.

He has taught Management subjects at Indian Institute of Social Science and Business Management. Annex College of Management, Indian Institute of Coal Management.

He has been serving the Institute of Welding since last 30 years, was a Chairman of Calcutta Branch, served as a Director and now is a Board Member of the ANB, Paper Setter Examiner of AMIIW course and a regular Faculty Member of Courses run by IIW.

He has published more than thirty papers on different welding and management topics.

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