SAFE WORK PRACTICE **SWP-43**

Revised: April, 2023 **WELDING, CUTTING AND ALLIED PROCESSES**

PURPOSE/APPLICATION

This SWP provides guidance to those involved in welding, cutting and other allied processes. There are over 70 different welding processes all of which require various controls. A proper risk assessment using a HIAC is critical to identifying and mitigating the hazards and providing a safe working environment. References to Strike's Code of Practices (COP), Safe Work Practices (SWP) and Safe Job Procedures (SJP) are provided to offer further guidance on performing the work safely.

Welding, cutting, and allied processes take place in a wide variety of locations under many different conditions. Among the different welding techniques, arc welding is the most widely used. Hot metal slag and spatter often can be dangerous to the workers and surroundings. Many welding, cutting and allied processes produce fumes and gases which can be harmful to workers' health. Excess noise is also a known health hazard in welding, cutting and allied processes. Arc welding emits harmful rays like ultraviolet rays and infrared rays and fumes which may cause unpleasantness.

PPE

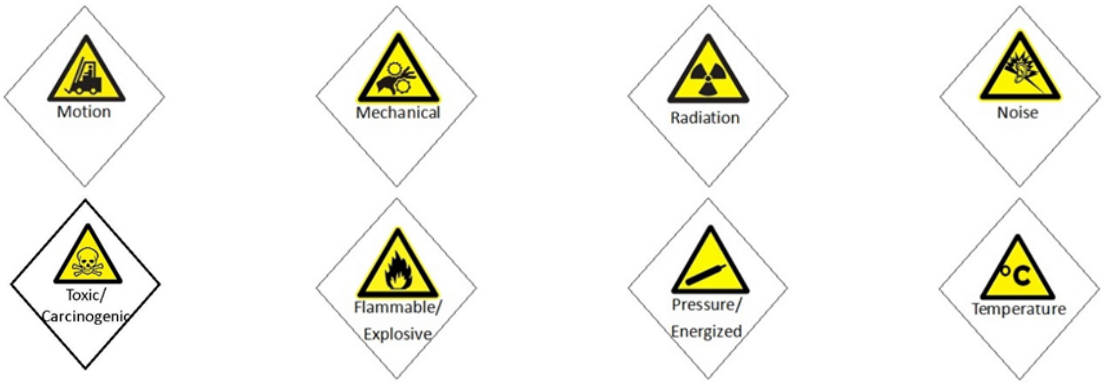
- Strike Minimum Requirements
- Job/Task Specific PPE as required, determined by Hazard Assessment or SJP/SWP
- Welders Helmet, Respiratory Protection (where required), Hearing Protection (where required)

TRAINING

- Strike and Task/Site Specific Requirements
- WHIMS, Required Trade Training

HAZARDS & CONCERNS

- Personal injury
- Occupational Illness
- Property Damage
- Compressed Gases
- Rotating Equipment
- Flying Debris
- Equipment Failure
- Concurrent Operations
- Motion (Pinch/Crush Points)
- Welding Fumes
- Gravity
- Sparks, Fire, Explosion
- Entanglement
- Radiation
- Noise



PRECAUTIONS:

- Inspect work area prior to welding, cutting, or grinding to ensure the area is safe to work in.
- Prior to any work commencing, a thorough hazard assessment is required to be conducted. All workers involved in the work need to be made aware of the hazards and sign off on the hazard assessment. **ALL IDENTIFIED CONTROLS NEED TO BE IN PLACE BEFORE WORK BEGINS.**
- If the scope of work changes, the hazard assessment needs to be revised with proper controls put in place to address the new hazard(s).
- The use of welding screens and tents are required to protect workers and prevent hot materials or UV rays from impacting co-workers.
- Proper ventilation is required when welding. Shielding gases (carbon dioxide and argon) used to protect the welding process present significant risks; they are colourless and odorless and can displace oxygen in the work area. Continuous monitoring may be required if identified on by the task hazard assessment.
- **Chlorinated Brake Clean, (Trichloroethylene) may decompose through exposure to heat and the effects of ultraviolet rays. This decomposition results in the formation of phosgene, a highly toxic gas**. Metal parts should be thoroughly decontaminated before welding to remove all traces of trichloroethylene from their surfaces. Inert gas metal-arc welding should not be conducted in the same area where there are degreasing tanks containing chlorinated solvents.
- No workers are allowed to work directly beneath a welding, cutting, or grinding operation where there is a risk of sparks, debris, or other falling hazards.
- Identify systems within your work area that require protection from the by-products of welding cutting and grinding. Take necessary measures to protect them (i.e., fire blanket, welding screens, etc.).
- Stage an appropriately sized fire extinguisher in the immediate area.
- Eye protections should be selected according to the recommended lens shade numbers for workers performing welding or cutting activities (see Appendix 1).

GENERAL DOS AND DON'TS

THE DOs

DO Inspect all equipment prior to use
DO Make sure the welding machine is properly grounded
DO Keep guards and/or shields in place
DO Refer to appropriate SWP/SJP for the job you are doing
DO Confirm the area is free of flammable material or gases prior to welding
DO Ensure there is adequate ventilation or determine if Respiratory Protection Equipment (RPE) is required
DO Ensure your ground is secured into place to prevent arc burn or sparking
DO Monitor supporting stands for "walking" of the pipe it ensures pipe stands do not fail
DO Check the tightness as the pipe heats and cools when using chucks on welding tables or on positioners, to prevent release from the chuck (see SWP 71 Chucks, Positioners, and Power Rollers for more information)
DO Wear double eye protection when welding or grinding
DO Review SWP 26 Grinder Operations before starting work
DO Use appropriate hand protection (as per HSEMS Section 6 PPE).
DO Make sure clothing is in good repair and made from natural fibers that will not melt. Worn or tattered clothing may be more prone to ignition or become caught in grinders or other equipment
DO Make sure clothing and tools are dry. Use of wet gloves or clothing can result in electrical shock

- **DO** Make sure you have an appropriate rod pail (won't melt or ignite) to contain the hot rod stubs
- **DO** Verify that you have all required hot work permits. Verify that Spark Watch is in place as required (see COP 09 for more information)
- **DO** Use hearing protection whenever grinding or buffing (see COP 04 for more information)
- **DO** Keep sparks, hot slag, rod stubs and other hot material away from dry flammable material
- **DO** Clean debris from welding helmets and hard hats before putting them on

THE DON'Ts

- **DON'T** Store torches or regulators inside a toolbox or cabinet unless they have been disconnected from the hoses
- **DON'T** Pile material on the hoses
- **DON'T** Wear clothing that is contaminated by oil or grease
- **DON'T** String hoses or cables across walk/roadways or high traffic areas, they can create tripping hazards
- **DON'T** Run electrical cables thought puddles or standing water.
- **DON'T** Use compressed air to clean debris off yourself
- **DON'T** Leave a torch unattended
- **DON'T** Lubricate the regulators or introduce hydrocarbons on the bottles
- **DON'T** Ignite a torch with a lighter, always use a striker
- **DON'T** Store Oxygen and Acetylene in the same rack

GENERAL PRECAUTIONS

Although low voltage is used in normal arc welding, welding currents are high. The risk of electric shock should not be ignored, especially in cramped spaces. Therefore, before welding commences, the grounding installation on arc welding equipment should always be checked. Cables and connections should be in good repair and of adequate capacity. A proper grounding clamp or bolted terminal should always be used. Where two or more welding machines are grounded to the same structure, or where other portable electric tools are also in use, proper grounding is critical.

The work area for welding and cutting operations should be dry, secure, and free of hazards and obstructions. A well-arranged, well lighted, properly ventilated, and organized workplace is important. If the work is carried out in confined spaces or dangerous positions, additional electrical protection can be installed in the welding circuit, ensuring that only extremely low voltage current is available at the electrode holder, when welding is not taking place.

Jaws and connections of electrode holders should be cleaned and tightened periodically to prevent overheating. Provision should also be made to accommodate the electrode holder safely when not used by an insulated hook or a fully insulated holder. Plastic tubes and PVC-covered cables should be used for all supplies from the transformer to the electrode holder.

Dragging cables and rubber gas supply hoses across heated surfaces or welds must be avoided. Rubber hoses and rubber covered cables must not be used anywhere near the high-frequency discharge, because the ozone produced will rot the rubber.

Dirt and metallic dust can cause a breakdown in the high-frequency discharge unit, which should be cleaned regularly by blowing out with compressed air.

1. The regulators fitted to the cylinders should be designed for the gas in use
2. Oxygen and acetylene cylinders must be stored separately and only on fire resistant surfaces devoid of flammable materials. In case of fire, they may be readily removed

HAZARDS IN WELDING

The hazards involved in welding and cutting operations may be divided into two groups:

1. Fire and Explosion Hazards
2. Health Hazards

Fire and Explosion Hazards

Welding, cutting, and allied processes produce molten metal, sparks, slag, and hot work surfaces. These can cause fire or explosions if precautionary measures are not followed. Sparks and molten metal from the various processes can travel a significant distance when falling. Keep in mind that sparks can travel up to 36 feet, 12 meters, from the work area. The combustible material inside a workplace or buildings includes wood, paper, rags, clothing, plastic, chemicals, flammable liquids, gases and dusts. Portions of work areas or buildings such as: floors, partitions, and roofs may also be combustible. The typical combustible materials outdoors include dry leaves, dry grass, and brush.

Health Hazards Welding Fumes

All welding processes produce fumes, but the composition and concentration of the fumes can vary widely. Almost all the fumes originate from the filler metal and the coatings contained in the consumable electrodes. The largest component of all welding fumes is iron oxide. Depending on the welding process and the material being welded, the fumes may also contain various combinations of the metals such as aluminum; cadmium; chromium; copper; fluorides; lead; manganese; molybdenum; nickel; tin; titanium; vanadium; and zinc and other chemical compounds. If the metal being welded has been painted or coated with corrosion or rust inhibitors, these coatings may decompose. Welding galvanized steel, for example, generates large amounts of zinc or cadmium in the fume. Welding painted metals may result in elevated levels of lead if the paint contains lead. Another example is that exposure to fumes, containing zinc oxide can lead to a sickness named "metal fume fever" which in extreme cases can be fatal. The greatest concern about potential health effects from welding, centre on cadmium, chromium, iron oxide, nickel, and zinc.

Most welding fumes are very small (less than one thousandth of a millimeter) and therefore can be easily inhaled. When exposed to these fumes, some fume particles may dissolve in the lungs and be transported by the blood or lymphatic system to other parts of the body, where they may have toxic effects. The potential for health effects from welding fumes depends on the total amount of fume that is inhaled, and the specific toxic metals or compounds present in the fume.

Control measures are to be used where required to eliminate or reduce the exposure potential for worker acute and/or chronic injury or illness. This includes:

- Half-mask air-purifying respirator with a P-100 filter and/or combination P-100 and organic vapour cartridge. CSA standard Z94.4 Respiratory protection can be referenced
- Powered Air Purifying Respirator (PAPR) for welding fumes that require a higher protection factor against contaminant hazards
- Workers must be fit-tested and clean shaven to wear a respirator
- Ventilation should be considered for welding activities to either introduce general dilution air or use local exhaust system at the source of the contaminant to capture as much as possible

Welding Gases

The gases generated during welding of unprimed metals include ozone, nitrogen oxides, carbon monoxide, and carbon dioxide. Ozone and nitrogen oxides are formed by the action of ultraviolet radiation from the welding arc. It is difficult to control exposure to these gases because they are formed

at a distance up to several metres from the welding arc. Metal inert gas welding generates higher levels of ultraviolet radiation than shielded metal arc welding, resulting in the formation of greater amounts of ozone and nitrogen oxides.

Carbon dioxide and carbon monoxide generated by melting of the coatings of consumable electrodes in the high temperatures of the welding arc, may be a health hazard, only if welding is carried out in enclosed or confined spaces with inadequate ventilation. Similarly, if gas shielded arc welding is carried out in enclosed areas with insufficient ventilation, then the shielding gases, such as carbon dioxide or argon, may displace the oxygen in the surrounding air.

The types of gases released are related to the chemicals contained in the coatings. For example, polyurethane coatings may release substantial amounts of formaldehyde and toluene diisocyanate, whereas welding metals coated with epoxy resins may result in exposure to hydrogen cyanide and carbon monoxide. Degreasing solvents such as trichloroethylene and perchloroethylene are commonly used to clean metals before welding. Ultraviolet radiation or heat from the welding arc breaks down these compounds to form highly toxic gases such as phosgene, phosphine, chlorine or hydrogen chloride. Exposure to these gases may also occur if the degreasing process is carried out close to where the welding is being conducted.

TYPES OF WELDING/CUTTING

The methods of welding can be classified mainly into two:

- Oxy-Acetylene Welding and Cutting,
- Arc Welding, Air/Carbon Arc Gouging, Plasma Arc Cutting, which are dealt in brief below.

Oxy-Acetylene Welding/Cutting

Oxy-acetylene welding is a very common welding process. The combination of oxygen and acetylene produces a flame temperature over 3100 ^{0}C making it ideal for welding & cutting.

Backfires and Flashbacks

Backfires and flashbacks are likely the most concerning hazard with the Oxy-Acetylene welding and cutting processes. Backfire occurs in the torch itself and reaches only into the welding or cutting torch tip and it never travels beyond the torch. However, the flashback is the more dangerous. In a flashback the flame reaches the fuel gas supply source through the cutting torch mixing chamber and could burn back through hoses.

It should be noted here that if a backfire occurs, the torch must be shut off immediately, if the conditions causing the backfire are not corrected, then flashback can occur. In case of flashback, the flame has an explosive reaction. A flashback can occur in oxygen hose as well as in acetylene hose.

When conducting Oxy-Acetylene cutting and welding operations, welders can experience backfires or flashbacks. Check valves and flashback arrestors are required for Oxy acetylene cutting and allied operations. A check valve is a device designed to prevent unintentional back flow of gases. A flashback arrestor (flame arrestor) is a device that prevents the propagation of flame upstream. Note that these devices reduce the volume of gases available at the tip/nozzle which in turn arrest the potential backfires and flashbacks.

Arc Welding

In arc welding, the arc is struck between an electrode and workpieces connected to an AC or DC supply. The temperature is around 4000 ^{0}C when the workpieces fuse together. Usually, molten metal is added to

the joint, either by melting the electrode itself or by melting a separate filler rod, which is not carrying current.

Conventional arc welding is done manually by means a of covered or coated consumable electrode hand-held in an electrode holder. However, many fully automatic electronic welding processes are also carried out. Arc welding uses a continuous electrical discharge (an electric arc) to generate high temperatures of 3000 ^{0}C to 30,000 ^{0}C. The electric arc is maintained at the gap between the electrical conductors (i.e., the electrode and the workpiece). The arc can be maintained and moved to melt part of the workpiece and fill on filler metals as required to form a weld.

Welding fumes and gases are produced during the welding process as byproducts in a welding plume. The heat and ultraviolet radiation from the welding arc also generate potentially harmful gases in the surrounding air. Welders and other workers nearby are exposed to these substances.

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

- Shielded Metal Arc Welding
- Metal Inert Gas Welding
- Tungsten Inert Gas Welding. These methods are used to weld four major types of metals:
    - Mild Steel
    - Stainless Steel & High Alloy Steels and
    - Aluminum
    - Galvanized Steel

Shielded Metal Arc Welding

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

Metal Inert Gas Welding

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

Tungsten Inert Welding

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

Air/Carbon Arc Gouging

Air carbon arc gouging works as follows. An electric arc is generated between the tip of a carbon electrode and the workpiece. The metal becomes molten and a high velocity air jet streams down the electrode to blow it away, thus leaving a clean groove. The process is simple to apply (using the same equipment as MMA welding), has a high metal removal rate, and gouge profile can be closely controlled. Disadvantages are that the air jet causes the molten metal to be ejected over quite a large distance and, because of high currents (up to 2000A) and high air pressures (80 to 100 psi), it can be very noisy.

The electrode is a graphite (carbon) rod which has a copper coating to reduce electrode erosion. The electrode diameter is selected according to the required depth and width of gouge. Cutting can be precisely controlled and molten metal/dross is kept to a minimum.

The gouging torch is normally operated with either a compressed air line or separate bottled gas supply. Air supply pressure will be up to 100psi from the airline but restricted to about 35psi from a bottled supply. Providing there is sufficient air flow to remove molten metal, there are no advantages in using higher pressure and flow rates.

Plasma Arc Cutting

Plasma cutting is extremely efficient, but is not without its hazards: electricity, gas, ultraviolet light, etc. A plasma arc cutting machine slices through any electricity-conducting metal faster than traditional cutting methods, including saws, snips, or oxy-acetylene torches. The plasma cutting arc, using high pressure air or gas, blows out hot metal and sparks, especially during the initial piercing of the metal. It also heats the workpiece and cutting torch, all of which can cause fire and burns.

Plasma arc cutting requires higher voltages than welding to start and maintain the arc - typically 110 to 400V DC - and touching live electrical parts can cause fatal shocks or severe burns. Poor connections and bare spots on cables increase the possibility of electrical shock. Inspect these items daily and **replace**, not repair, any worn cables or broken connections.

Because water conducts electricity very well, avoid wet working conditions (even body perspiration can lower the body's resistance to electrical shock). Insulate yourself from work and the ground by standing on a dry rubber mat or dry plywood sheet big enough to cover the full area of your contact with the work or ground. Be cautious, as both rubber and wood can ignite. If you can find a dry, non-flammable material to stand on (put between you and ground), use it.

Confined Spaces

Welding activities can create a higher risk for workers working inside the confined space to be exposed to higher concentrations of toxic welding fumes. Where ventilation alone cannot adequately protect the welder’s breathing zone, respiratory protective equipment (RPE) must be used. Refer to Code of Practice 02, Respiratory Protection Equipment and Code of Practice 03, Confined Space Entry.

NOTE: General guidelines for welding ventilation have been published in the CSA standard W117.2 Safety in welding, cutting, and allied processes, and the ANSI (American National Standards Institute) standard Z49.1 Safety in Welding and Cutting.

Appendix 1 - RECOMMENDED LENS NUMBER FOR VARIOUS TYPES OF WELDING/CUTTING

Type of Welding	Lens Number
Atomic Hydrogen Welding	10-14
Carbon Arc	14
Gas Welding (heavy), 12.7 mm (1/2") and over	6 or 8
Gas Welding (light), up to 3.2 mm (1/8")	4 or 5
Gas Welding (medium), 3.2 mm to 12.7 mm (1/8 to 1/2")	5 or 6
Heavy Cutting, 15.2 cm (6") and over	5 or 6
Light Cutting, up to 2.5 cm (1")	3 or 4
Medium Cutting, 2.5 cm to 15.2 cm (1 to 6")	4 or 5
Open Arc (semi-auto hard face with 2.8 mm {7/64"} core wire)	10-14
Plasma Cutting	14
Soldering	2
TIG Welding	12
Torch Brazing	3 or 4

REFERENCES / ADDITIONAL INFORMATION

SJP-29 Tie-in Welding
SJP-31 Pipeline Welding
COP 02 Respiratory Protection Equipment
COP 03 Confined Space Entry
COP 04 Noise Control and Hearing Conservation
Welder's Guide to the Hazards of Welding Gases and Fumes, Work Safe Alberta

Alberta OHS Code

Part 4 Chemical Hazards, Biological Hazards and Harmful Substances
Part 10 Fire and Explosion Hazards
Part 15 Managing the Control of Hazardous Energy
Part 16 Noise Exposure
Part 18 Personal Protective Equipment
Part 20 Radiation Exposure
Part 25 Tools, Equipment and Machinery

British Columbia OHS Regulations

British Columbia OHS Regulation - Part 12 Tools, Machinery and Equipment Welding, Cutting and Allied Processes

Manitoba OHS Regulations

Part 6 Personal Protective Equipment
Part 12 Hearing Conservation and Noise Control
Part 16 Machines, Tools and Robots
Part 17 Welding and Allied Processes
Part 18 Radiation
Part 19 Fire and Explosive Hazards
Part 36 Chemical and Biological Substances

Saskatchewan OHS Regulation

Fire extinguishers 361
Hot Work 370 5.

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