Health & Safety Guide
Arc Welding

This guide is intended to provide information on the health and safety hazards associated with arc welding for millwrights and other associated construction trades such as pipe fitters and sheet metal workers.

Safety awareness is the first step to health and safety. Prevention is our ultimate goal.

The contents of this publication are for general information only. This publication should not be regarded or relied upon as a definitive guide to government regulations or to safety practices and procedures. The contents of this publication were, to the best of our knowledge, current at the time of printing.

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Welding Hazards

Welding is a method of joining metal parts together by heating them. Arc welding is the most common type of welding process used in construction. Arc welding uses intense heat to melt metal, causing the molten metal to intermix, usually with a filler metal from an electrode. Once the liquid metal cools, a bond is formed, joining two pieces of metal together.

Although welding is a common work practice in many construction trades, welding tasks can expose workers to numerous hazards such as

- Breathing in toxic fumes and gases
- Starting a fire or explosion
- Getting serious burns from hot metal
- Receiving electric shocks from welding cable.

Welding hazards must be recognized, evaluated, and controlled or eliminated to prevent injury to workers and damage to property. Control measures for welding hazards include

- Ventilation
- Wearing protective equipment.
Toxic Fumes and Gases

The process of heating certain base metals and surface coatings can release toxic fumes into the air. Breathing in toxic welding fume, especially over time, can have serious health effects, ranging from mild irritation to death.

Arc welders are at increased risk because the high temperatures generated by the electric arc can release heavy concentrations of contaminants into the air. In addition, the electrode is coated with a complex mix of chemicals that release a shielding gas such as carbon dioxide to keep air out of the arc zone and protect the weld from oxidation (Figure 1).

The health effects of toxic fumes and gases depend on a number of factors including

- the type of welding process
- the base metal
- the shielding gas
- the concentration of the contaminants.

Chemical contaminants from welding can enter the body through inhalation, skin absorption, or ingestion. The type of contaminant can affect different organs (e.g., the lungs, kidneys, and brain) and damage different systems (e.g., respiratory, digestive, nervous, and reproductive systems).

Figure 1: Arc Welding
Symptoms of overexposure to chemicals may include
• nosebleeds
• headaches
• nausea
• fainting
• dizziness.

Welding and cutting of lead or lead-coated materials releases lead fumes into the air. Inhaling these fumes is the primary source of lead poisoning for welders. Symptoms of lead poisoning include
• loss of appetite
• anemia
• abdominal pains
• kidney and nerve damage.

Lead is a designated substance requiring special precautions for use and handling under Ontario law. Lead-based coatings should be stripped from the base metal at least four inches on both sides of the weld. (Refer to the Ministry of Labour’s guideline: Lead on Construction Projects.)

In addition, hexavalent chromium, a substance that is commonly found in welding fume, has been linked to lung cancer and brain cancer.*

*For more info, refer to the Chromium (Hexavalent) web page on the Carex Canada website.
Arc welders use an electric arc or flame and produce a lot of sparks, so there is a high risk of fires and explosions. Even sparks from cutting and grinding may be hot enough to cause a fire.

Fires may also result from chemicals reacting with one another. During the arc welding process, chemicals can form explosive or flammable mixtures. Even chemicals by themselves can have low ignition points and will be subject to burning or exploding if exposed to the heat, sparks, slag, or flame common in welding.

Work that produces a source of ignition, such as a spark or open flame, is called “hot work”. Hot work, including welding, grinding, and cutting on containers, can cause serious explosions if the proper procedures are not followed.

Before performing hot work, welders may need to obtain a hot work permit to make sure the welding area is free of flammable and explosive material.

*Remember: sparks and molten metal from the welding process can spray up to 35 feet from your work area.*
Follow these safe work practices when welding to prevent fires and explosions:

- Weld only in fire-safe areas and take proper precautions to prevent fires.
- Watch where the sparks are travelling and where metals are falling from your work.
- Keep a suitable fire extinguisher nearby at all times and ensure that the fire extinguisher is in operable condition before you start welding.
- If there are flammable materials including fuel or hydraulic lines in your work area, move those materials away from your area.
- If you can’t move either your work or the combustible substances, put a fire-resistant blanket or shield in place to cover the materials completely.
- Designate a second person as a fire watch (i.e., spark watch) to monitor this area if required.
- If you are welding in upper levels of a structure, make sure that there are no combustible materials underneath.
Serious Burns

Burns are the most common injury reported in the welding trade. They may be caused by hot metal, flying sparks, hot slag, or heat radiation. If you receive a burn, seek first aid immediately and report it to your supervisor.

Section 25 of the Regulations for Construction Projects (213/91) covers skin protection.

25. A worker shall use protection appropriate in the circumstances when there is a risk of injury on a project from contact between the worker’s skin and,

(a) a noxious gas, liquid, fume or dust;

(b) an object that may puncture, cut or abrade the skin;

(c) a hot object, hot liquid or molten metal; or

(d) radiant heat.

Wear flame-resistant clothing when welding. Manufacturers of welding PPE now produce lightweight clothing from flame-resistant cloth, pigskin leather, and combinations of these materials. They not only offer better protection from burns but also increased ease of movement.
Follow these safe work practices when welding to prevent burns:

- Wear clothing made of non-synthetic materials such as wool. It is less likely to ignite.
- Wear flame-proof gauntlet gloves, aprons, leggings, shoulder and arm covers, skull caps, and ear protection.
- Only wear gloves that are made and designed for welding to protect your hands from burns, cuts, and scratches. However, do not use welding gloves to pick up recently welded material. To prevent burns, use pliers instead.
- Choose tight-fitting work wear. Loose-fitting clothes can trap sparks caused by welding.
- Keep sleeves and collars rolled down and buttoned up to prevent sparks from being trapped and causing burns to your skin. Wear shirts with flaps over pockets and pants with no cuffs.
- Cover up all exposed skin areas to avoid the painful and damaging effects of ultraviolet light and infrared rays caused by welding.
- Remove rings, watches, and other jewelry.
- Never carry matches or lighters in your pockets. They may be ignited by sparks, splatter, or high heat.
- Make sure your clothing is free from oil and grease.
- Wear high-cut CSA Grade 1 footwear laced to the top to keep out sparks and slag.
Electrical shock is the effect produced by current on the nervous system as it passes through the body. Electrical shock may cause violent muscular contractions, leading to falls and injuries. It may also have fatal effects on the heart and lungs.

Electrical shock may occur as a result of improper grounding or contact with current through damp clothing, wet floors, and other humid conditions. Even if the shock itself is not fatal, the jolt may cause welders to fall from their work positions.

Electrical burns are an additional hazard. These burns often occur below the surface of the skin and cause damage to muscle and nerve tissue. In severe cases, the results can be fatal.

The extent of injury due to electrical shock depends on the voltage and the body’s resistance to the current passing through it. Even low voltages used in arc welding can be dangerous under damp or humid conditions. Welders should keep clothing, gloves, and boots dry and stay well-insulated from work surfaces, the electrode, the electrode holder, and grounded surfaces.

Welding gloves will offer some insulation against electric shock as long as they are dry and in good condition.
Ventilation

Ventilation is the use of air movement to:

- reduce concentrations of airborne contaminants below the acceptable limits in the worker’s breathing zone and the work area
- prevent the accumulation of combustible gases and vapours
- prevent oxygen-deficient or oxygen-enriched atmospheres.

When welding in poorly ventilated areas, toxic fumes may accumulate or shielding gases might replace breathable air, causing a dangerous health hazard to you and others.

Respiratory protection will not be required for most welding operations if proper ventilation is provided. However, when ventilation or other measures are not adequate, or when the welding process creates toxic fumes (as with stainless steel and beryllium), respiratory protection must be worn.

Natural dilution ventilation

The majority of construction projects depend on natural dilution ventilation (i.e., welding outside in a light breeze or inside with doors and windows open). When using natural dilution ventilation, you must make sure to “keep your head out of the fume”.

Figure 2: Natural Dilution Ventilation

NOTE: Welder must stay to one side of fume.
**Mechanical dilution ventilation**

When welding in confined spaces or spaces containing structural barriers that restrict natural air movement, you should use mechanical dilution ventilation (e.g., smoke eaters and industrial fans) or local exhaust ventilation (i.e., an exhaust fan, air cleaner, and duct system that removes airborne contaminants and exhausts them outdoors).

Sections 46 and 47 of the Regulations for Construction Projects (213/91) deals with ventilation.

46. (1) A project shall be adequately ventilated by natural or mechanical means, 

(a) if a worker may be injured by inhaling a noxious gas, vapour, dust or fume or from a lack of oxygen; or

(b) if a gas, vapour, dust or fume may be capable of forming an explosive mixture with air.

(2) If it is not practicable to provide natural or mechanical ventilation in the circumstances described in clause (1) (a), respiratory protective equipment suitable for the hazard shall be provided to and used by the workers.

**Figure 3: Mechanical Dilution Ventilation**

- Air forced into and out of work area
- Roof exhaust fans
- Wall fans

NOTE: Air volume should deflect fume out of welders breathing zone.
Welding machines are typically AC/DC, 240-volt transformer types that use electricity as the energy source. However, when portable welders are powered by diesel, gasoline, or propane engines, welders must follow section 47 of the regulations.

47. No internal combustion engine shall be operated,

(a) in an excavation unless provision is made to ensure that exhaust gases and fumes will not accumulate in the excavation; or

(b) in a building or other enclosed structure,

(i) unless the exhaust gases and fumes from the engine are discharged directly outside the building or structure to a point sufficiently remote to prevent the return of the gases and fumes, or

(ii) unless there is an adequate supply of air for combustion and adequate natural or mechanical ventilation to ensure exhaust gases and fumes will not accumulate.

Note: Ventilation guidelines for different welding processes are spelled out in CAN/CSAW117.2-12—Safety in Welding, Cutting, and Allied Processes. In addition, refer to the NIOSH Certified Equipment List for respiratory equipment considered adequate protection for various types of hazards, which is downloadable from the CDC website (www.cdc.gov).
Personal Protective Equipment (PPE)

Welders and any workers near the welding area should wear proper eye protection and any other protective equipment required. In addition, signs should be posted to warn others of the welding hazards in the area and requiring protective equipment to be worn.

Welding helmets provide radiation, thermal, electrical, and impact protection for face, neck, forehead, ears, and eyes. Welding hand shields are designed to provide radiation and impact protection for the eyes and face. Safety glasses with full side shields are designed to protect against UV radiation and flying objects.

Welders should always wear safety glasses with side shields and use hearing protection under their welding helmet. This will keep flying sparks or metal from causing injury to eyes and ears and prevent hearing loss as a result of working around noisy arc welding equipment, power sources, and processes (e.g., air carbon arc cutting or plasma arc cutting).
Section 24 of the Regulations for Construction Projects (213/91) covers eye protection.

24. A worker shall use protection appropriate in the circumstances when there is a risk of eye injury to the worker.

Welding arcs are intensely bright light sources that can emit ultraviolet (UV) light, which may cause eye damage. **Remember: Never look at the welding arc with the naked eye.**

The filtered or shaded plate in the welding helmet acts as a barrier to the harmful UV light rays and reduces them to a safe intensity. For general welding up to 200 amps, the filter plate should be at least a #10 shade. However, certain operations such as carbon-arc welding and higher current welding operations require darker shades.

Use a welding shield with a filter plate and a replaceable cover plate at all times when welding. And never use a welding helmet if the filter plate or cover lens is cracked or broken.

**Note:** This section on protective equipment complies with the intent of CAN/CSA Z94.3-07 (R2014)—Eye and Face Protectors.

**Figure 4: Typical Lens Assembly for Arc Welding**

The arc welding lens assembly consists of 3 parts. The outside lens is clear plastic or tempered glass. It protects the shades lens from damage. The centre lens is a shade lens that filters out the harmful light. The inner lens is clear and must be plastic.
# Controls for Arc Welding Hazards

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<tr>
<th>Hazards</th>
<th>Controls</th>
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</thead>
<tbody>
<tr>
<td><strong>Toxic fumes and gases</strong></td>
<td>• Use ventilation or exhaust to keep breathing zone clear and comfortable.</td>
</tr>
<tr>
<td>• Confined spaces</td>
<td>• Use helmet and positioning of head to minimize fume in breathing zone.</td>
</tr>
<tr>
<td>• Position of welder’s head</td>
<td>• Read warnings on electrode container and MSDS for electrode.</td>
</tr>
<tr>
<td>• Lack of ventilation</td>
<td>• Provide additional ventilation/exhaust where special ventilation requirements exist.</td>
</tr>
<tr>
<td>• Electrode types (manganese, chromium, etc.)</td>
<td>• Use special care when welding in a confined area.</td>
</tr>
<tr>
<td>• Base metal coatings (galvanized metal, lead, paint, etc.)</td>
<td>• Do not weld unless ventilation is adequate.</td>
</tr>
<tr>
<td><strong>Fire or explosion from welding sparks</strong></td>
<td>• Do not weld on containers that have held combustible materials. (Check CAN/CSAW117.2-12 - Safety in Welding, Cutting, and Allied Processes before welding.)</td>
</tr>
<tr>
<td>• Flammable materials</td>
<td>• Remove flammable materials from welding area or shield workers from sparks and heat.</td>
</tr>
<tr>
<td>• Containers that have held combustibles</td>
<td>• Keep a fire watch (i.e., spark watch) in area during and after welding.</td>
</tr>
<tr>
<td><strong>Electric shock</strong></td>
<td>• Keep a fire extinguisher in the welding area.</td>
</tr>
<tr>
<td>• Wetness</td>
<td>• Wear flame-resistant clothing and head protection. Use earplugs when welding overhead.</td>
</tr>
<tr>
<td>• Welding in or on workplace</td>
<td>• Insulate welder from the workpiece and ground using dry insulation, rubber mat, or dry wood.</td>
</tr>
<tr>
<td>• Confined spaces</td>
<td>• If wet area and welder cannot be insulated from the workpiece with dry insulation, use a semiautomatic, constant-voltage welder or stick welder with a voltage-reducing device.</td>
</tr>
<tr>
<td>• Electrode holders and cable insulation</td>
<td>• Wear dry, hole-free gloves. (Change as necessary to keep dry.)</td>
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<tr>
<td></td>
<td>• Do not touch electrically “hot” parts or electrodes with bare skin or wet clothing.</td>
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<tr>
<td></td>
<td>• Keep electrode holder and cable insulation in good condition. Do not use if insulation is damaged or missing.</td>
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<tr>
<td>Hazards</td>
<td>Controls</td>
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<tr>
<td><strong>Serious burns</strong></td>
<td><strong>Wear flame-resistant clothing, gauntlet gloves, aprons, leggings, shoulder and arm covers.</strong></td>
</tr>
<tr>
<td>• Hot metal</td>
<td><strong>Wear clothing made of non-synthetic materials.</strong></td>
</tr>
<tr>
<td>• Flying sparks</td>
<td><strong>Wear gloves designed for welding.</strong></td>
</tr>
<tr>
<td>• Hot slag</td>
<td><strong>Choose tight-fitting work wear.</strong></td>
</tr>
<tr>
<td>• Heat radiation</td>
<td><strong>Keep sleeves and collars rolled down and buttoned up.</strong></td>
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<td></td>
<td><strong>Wear shirts with flaps over pockets and pants with no cuffs.</strong></td>
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<td></td>
<td><strong>Cover up all exposed skin areas.</strong></td>
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<td><strong>Remove rings, watches, and other jewelry.</strong></td>
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<td></td>
<td><strong>Never carry matches or lighters in pockets.</strong></td>
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<td></td>
<td><strong>Make sure clothing is free from oil and grease.</strong></td>
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<td></td>
<td><strong>Wear high-cut CSA Grade 1 footwear laced to the top.</strong></td>
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<tr>
<td><strong>Arc rays</strong></td>
<td><strong>Select a protective shade lens that complies with CAN/CSAW117.2-12 – Safety in Welding, Cutting, and Allied Processes.</strong></td>
</tr>
<tr>
<td>• Arc rays can burn eyes and skin</td>
<td><strong>Always use helmet when welding.</strong></td>
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<tr>
<td>• Gas-shielded arc is the most severe</td>
<td><strong>Provide non-flammable shielding to protect others.</strong></td>
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<tr>
<td></td>
<td><strong>Wear clothing that protects the skin while welding.</strong></td>
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<tr>
<td><strong>Confined spaces</strong></td>
<td><strong>Ensure a Confined Space Program is in place and a plan executed in accordance with Regulation 632/05.</strong></td>
</tr>
<tr>
<td>• Metal enclosures</td>
<td><strong>Assess whether the ventilation is adequate, as per Regulation 632/05, especially where the electrode requires special ventilation or where gas may displace breathing air.</strong></td>
</tr>
<tr>
<td>• Restricted entry</td>
<td><strong>Provide welder with a helper and a method of welder retrieval from outside the enclosure.</strong></td>
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<tr>
<td>• Gases that are heavier than air</td>
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<tr>
<td>• Welding inside or on workpiece</td>
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</table>
# Controls for General Work Area Hazards

<table>
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<tr>
<th>Hazards</th>
<th>Controls</th>
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<tbody>
<tr>
<td><strong>Cluttered areas</strong></td>
<td>• Keep cables, materials, and tools neatly organized.</td>
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<td></td>
<td>• Protect cables that must be laid on the floor or ground from damage and entanglement.</td>
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<tr>
<td></td>
<td>• Keep cables dry and free of grease to prevent premature breakdown of insulation.</td>
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<tr>
<td><strong>Indirect work</strong> (welding ground connection)</td>
<td>• Connect work cable as close as possible to area where welding is being done.</td>
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<td></td>
<td>• Do not allow alternate circuits through scaffold cables, hoist chains, and ground leads.</td>
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<tr>
<td><strong>Electrical equipment</strong></td>
<td>• Always disconnect power to equipment before servicing.</td>
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<td>• Report any faulty or defective equipment to your supervisor.</td>
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<td></td>
<td>• Use only double-insulated or properly grounded equipment.</td>
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<td></td>
<td>• Use equipment that is specifically designed for welding and cutting and that can safely handle the maximum-rated current capacity required.</td>
</tr>
<tr>
<td><strong>Engine-driven equipment</strong></td>
<td>• Use only in open, well-ventilated areas.</td>
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<tr>
<td></td>
<td>• Keep enclosure complete and guards in place.</td>
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<td></td>
<td>• Refuel with the engine off.</td>
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<td></td>
<td>• If using auxiliary power, a ground-fault circuit interrupter (GFCI) may be required.</td>
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<tr>
<td></td>
<td>• Read and follow the equipment manufacturers’ instructions carefully.</td>
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<tr>
<td><strong>Gas cylinders</strong></td>
<td>• Never touch a cylinder with the electrode.</td>
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<td></td>
<td>• Never lift a machine with a cylinder attached.</td>
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<td></td>
<td>• Keep cylinders upright and chained to a support.</td>
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<tr>
<td></td>
<td>• Always regard cylinders as full and handle accordingly.</td>
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</tbody>
</table>
Resources

• *Occupational Health and Safety Act* (RSO 1990, c.01)
• Regulation for Construction Projects (213/91)
• Confined Spaces Regulation (632/05)
• CAN/CSA W117.2 – *Safety in Welding, Cutting, and Allied Processes*
• CAN/CSA Z94.3 – *Eye and Face Protectors*
• NIOSH Certified Equipment List
• MOL Guideline: *Lead on Construction Projects*
  www.labour.gov.on.ca/english/hs/pubs/lead/
• Chromium (Hexavalent) web page:
  www.carexcanada.ca/profile/chromium_hexavalent/
• Health and Safety Advisory: *Toxic Exposure to Manganese in Welding Fume* (W156)
  www.ihsa.ca/PDFs/Products/Id/W156.pdf
• Diagnostic ToolKit: *Occupational Health Risks—Millwrights and Similar Trades* (W102)
  www.ihsa.ca/PDFs/Products/Id/W102.pdf
• Safety Talks:
  - *Welding – Inhalation Hazards*
  - *Lead-based Paint – Welding and Cutting*
  - *Welding – MSDs*
  www.ihsa.ca/resources/safetytalks.aspx
More information on welding-related hazards and controls is available in the **Welding and Cutting** chapter of our **Construction Health and Safety Manual** (M029).

Order or download it from our website. It's free to IHSA members.

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