

Welding Guideline



June 2000

Table of Contents

Summary	3
What is Welding	4
Electric Arc Welding	5
Three Basic Types of Electrodes	6
Gas Welding	6
Common Types of Welding Processes	7
1) Electric Arc Welding	7
2) Combustion Gas Welding	12
Airborne Hazards from Welding Processes	13
1) Fumes	13
2) Gases	13
3) Particulate Matter	14
Welding Fume Composition	15
Primary Health Effects of Exposure	17
Sampling Methodology and Allowable Guidelines	24
a) Welding Fumes	24
b) Welding Gases	24
Basic Welding Control Measures	26
1) Substitution	26
2) Ventilation	26
Personal Protective Equipment for Welders	36
Special Welding Situations	40
Checklist	43
References and Additional Reading	49

Figure 1 - Welding Circuit	5
Figure 2 - Shielded Metal Arc Welding	7
Figure 3 - Gas Tungsten Arc Welding	8
Figure 4 - Gas Metal Arc Welding	9
Figure 5 - Fluxed Cored Arc Welding	10
Figure 6 - Submerged Arc Welding	11
Figure 7 - Resistance Welding	11
Figure 8 - Standing Workbench Design and Seated Workbench Designs	21
Illustration VS-90-01 - Welding ventilation bench hood	28
Illustration VS-90-02 - Welding ventilation movable exhaust hoods	29
Illustration VS-90-03 - Production Line Welding Booth	30
Illustration VS-90-10 - Torch Cutting Ventilation	31
Illustration VS-90-20 - Robotic Application	33
Figure 9 - Welding Gun Mounted on Exhaust Hood	22 & 32
Figure 10 - Portable Fume Extractor	34
Figure 3.3 - Direction of Air Flow	34
Figure 11 - Examples of Respiratory Protection for Welding	37
Table 1 - Minimum Respiratory Protection Recommendations for Welding Processes . . .	38
Figure 12 - Welder's Helmet	39
Table 2 - Shade Numbers for Arc Processes	41
Table 3 - Shade Numbers for Cutting	42

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Figures 1 to 12 and Tables 1 to 3

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SUMMARY

The intent of this **WELDING GUIDELINE** is to serve as a resource for employers and workers to safely perform welding activities. The guideline will provide information on:

- the types of welding processes
- the hazards (noise, smoke characteristics, metal contents, ultraviolet light, ozone, carbon monoxide & other gases)
- health effects of exposure
- current allowable guidelines
- ventilation guidelines
- PPE requirements
- special welding situations
- checklist
- references

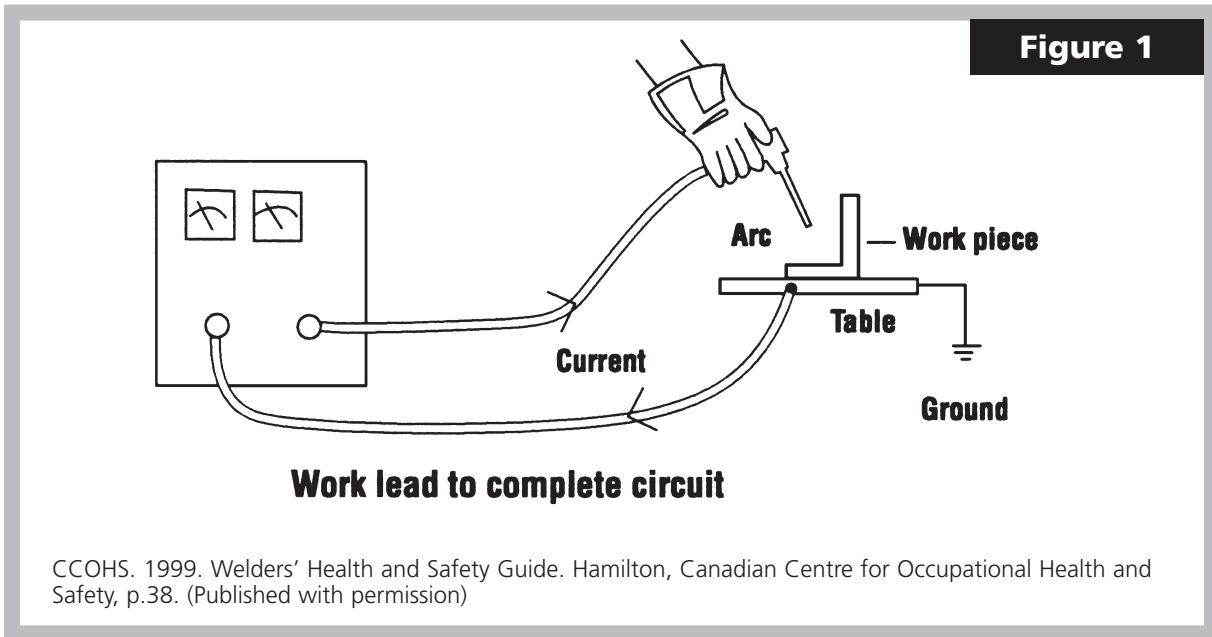
WHAT IS WELDING?

The welding process joins metals together using pressure, heat, flame or electric arc. In the welding process, a filler metal and the work piece are heated to form the weld using an electric arc or combustion gas. Arc welding is the most common form of welding. As the metal is heated, vaporization occurs and a fine metal fume condenses usually with visible smoke. Inhalation is the primary route of exposure for the welder.

Ninety per cent of the welding fumes come from the melting of the consumable electrode (rod) or wire. In the weld, the filler metal used is similar to the metal being welded. Some electrodes are coated and some wire consists of a metal sheath filled with a flux (flux-cored wire). The coating and flux contribute towards the chemical composition of the airborne fumes generated. Fume composition is a mix of the base metal, flux and consumable wire or electrode used in the weld. Refer to the Material Safety Data Sheets (MSDS's) provided by the supplier.

ELECTRIC ARC WELDING

WELDING CIRCUIT FIG. 1



A cable to the welding gun connects the welding machine. An electrical current flows through the cable and the electrode/wire creating an arc, which then passes the current to the work piece being welded. The closed loop in the current system allows the current to be returned to the power supply via the work-return-lead.

THREE BASIC TYPES OF ELECTRODES

- 1) **SOLID ELECTRODES** produce less fumes, compared with flux-cored wire or coated electrodes. Fume production is directly related to the amount of consumed electrode. Electrodes are **consumable** (composed of steel, copper, aluminum, various alloys and other metals) or **non-consumable** (primarily tungsten).
- 2) **COVERED & COATED ELECTRODES** are the largest group of electrodes used in welding. The covering provides the flux for the weld. Major metals from the coatings include fluoride, nickel, iron, chromium, manganese, copper and molybdenum. Fluoride tends to be the major component ranging from 10–20% of the fume composition.
- 3) **BARE RODS OR WIRE** are immersed in the flux material and fume generation is greatly reduced. Bare rods or wire are typically composed of copper alloys, steel, nickel alloys, nickel or chromium-steel alloys.

GAS WELDING

Gases Used in Welding & Cutting Processes

- shielding gases, e.g. argon, carbon dioxide, helium
- fuel gases, e.g. propane, acetylene, butane
- oxygen (used with fuel & shielding gases)

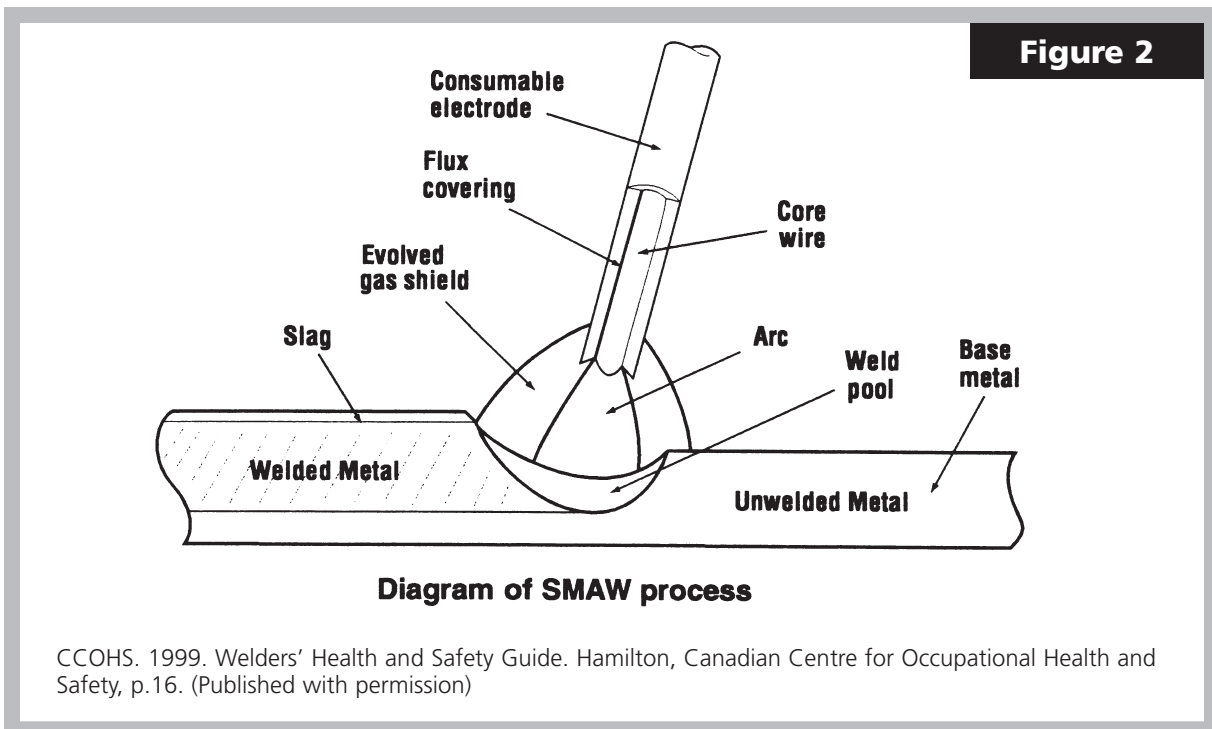
COMMON TYPES OF WELDING PROCESSES

1. ELECTRIC ARC WELDING

ELECTRIC ARC WELDING: uses an electric arc (a continuous electrical discharge) to generate high temperatures of 3,000° to 30,000°C. The electric arc is maintained at the gap between the work piece and the electrode. The arc is manipulated such that molten metal from the work piece and the electrode or wire form a common puddle which then cools forming the weld.

The various types of electric arc welding include:

a) SHIELDED METAL ARC WELDING (SMAW) FIG. 2



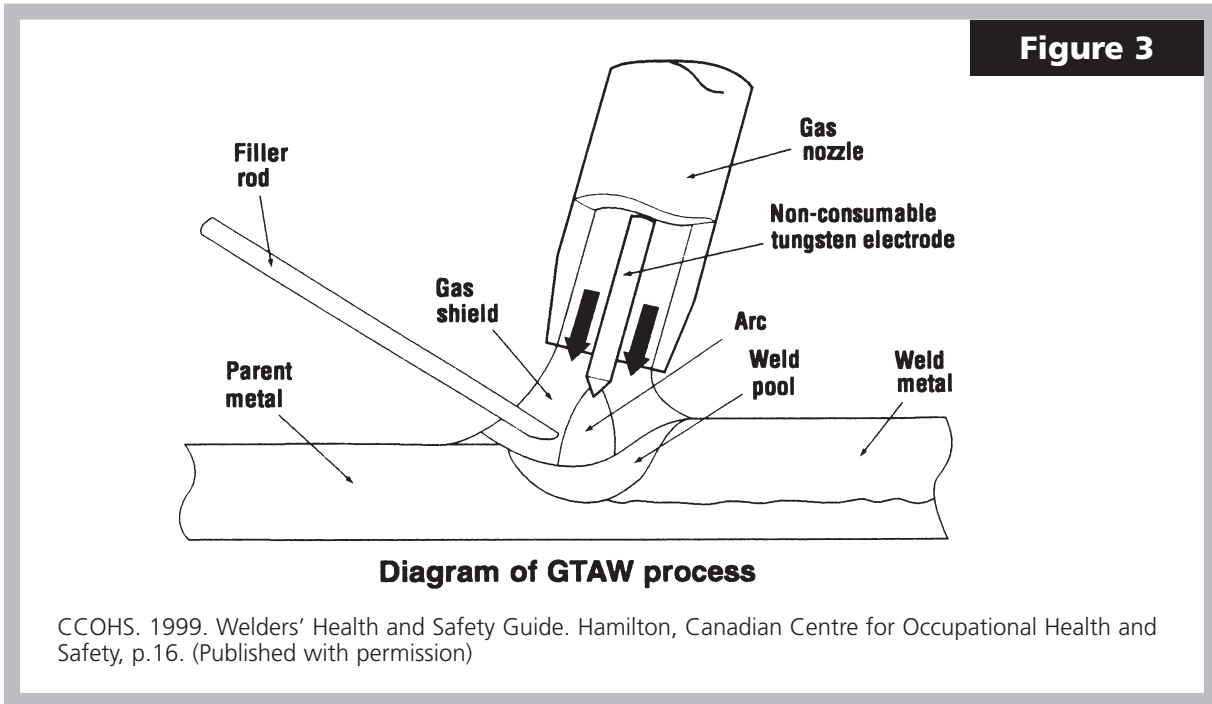
Shielded Metal Arc Welding (SMAW) is the most common type of welding used in maintenance and repair work. SMAW is also referred to as **manual, electrode or stick welding**.

In this welding process, an electric arc is drawn between the tip of an electrode and the metal being welded. The electrode has a metal core, which is covered with a flux or coating. In the **consumable electrode process**, the electrode is used up as the work piece is welded.

The flux shields metal ions in the arc from the atmosphere and ensures arc stability. As the flux decomposes, it produces airborne gases and a slag blanket is formed to protect the hot weld metal from the atmosphere as it cools.

SMAW is widely used in maintenance and repair applications on mild & stainless steel, aluminum and non-ferrous metals. SMAW has limited application in the workplace, since the welding must stop to replace the consumed electrode. SMAW is replaced in the welding industry with the continuous wire processes.

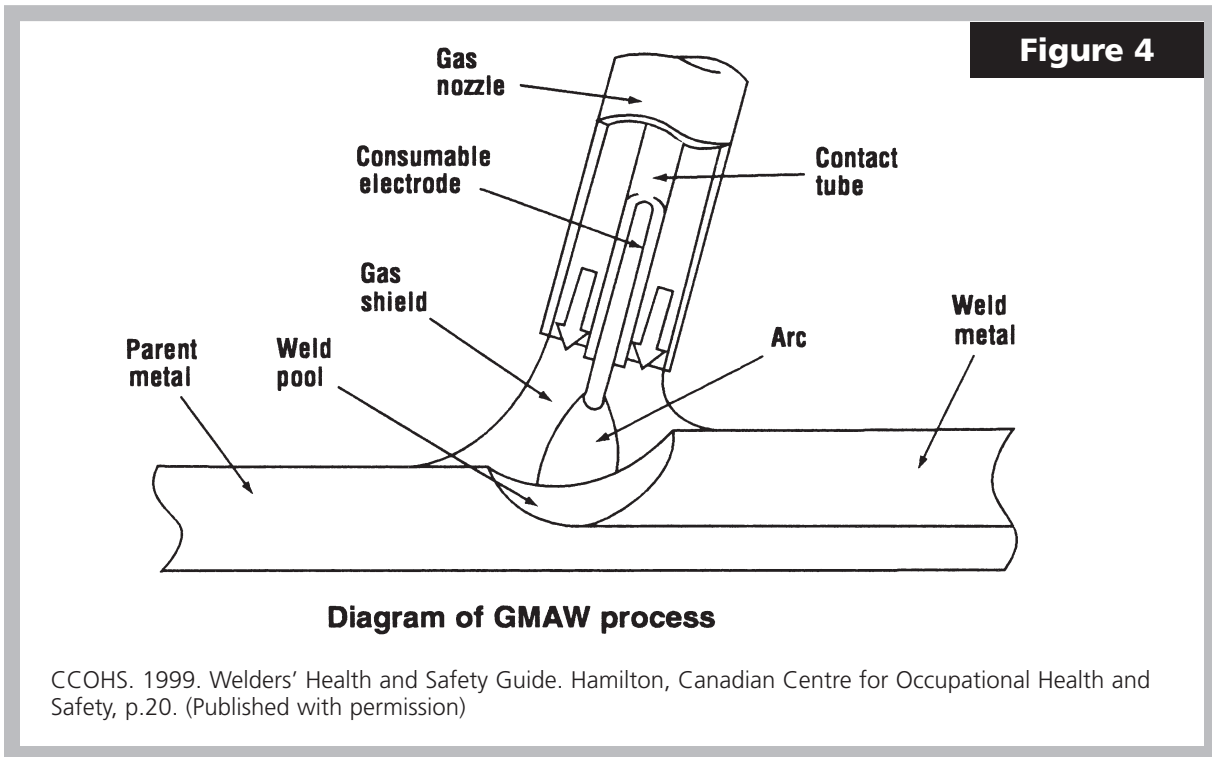
b) GAS TUNGSTEN ARC WELDING (GTAW) FIG. 3



Gas Tungsten Arc Welding (GTAW) is also referred to as **TUNGSTEN INERT GAS (TIG) Welding**. In GTAW, an electric arc is established between the work piece and the tungsten electrode. In contrast to SMAW, this is a **non-consumable electrode** process. The arc is protected by a flow of a shielding gas, commonly argon (also helium or mixtures of these two gases), which displace atmospheric gases from the weld zone. The arc can fuse two metals together without the use of a filler metal. A hand-held filler rod can be placed near the arc and melted to fill any gaps. GTAW is commonly used to weld aluminum. It also has application to mild & stainless steel.

Ultraviolet (UV) light from the electric arc is intense and ozone gas is produced. GTAW produces no slag and produces small amounts of fume. The tungsten electrodes contain small amounts of thorium (<4%), readily burning in air to thorium oxide. Thorium is a radioactive metal and poses an inhalation and ingestion hazard.

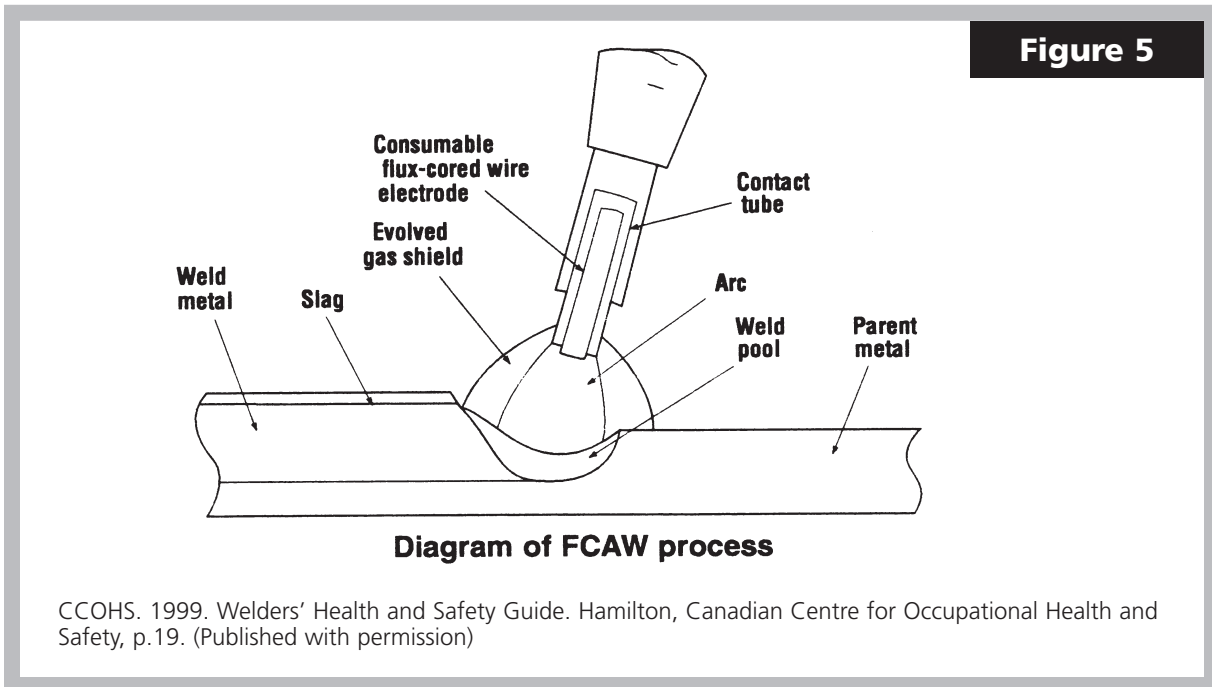
c) GAS METAL ARC WELDING (GMAW) FIG. 4



The Gas Metal Arc Welding (GMAW) process is referred to as **“hard wire”** or **METAL INERT GAS (MIG)**. In this type of welding, a **continuous solid wire** is supplied through the welding gun from the wire feeder. Shielding is provided by an inert gas, commonly argon (also helium or a mix of these with carbon dioxide). There is no slag produced because no flux is used in this type of welding.

GMAW is used throughout the industry primarily for welding mild steel, but also copper, nickel, stainless steel, magnesium and aluminum.

d) FLUXED CORED ARC WELDING (FCAW) FIG. 5



The Fluxed Cored Arc Welding (FCAW) process is also referred to as **“fluxed cored”**.

In FCAW, a **continuous solid wire** is fed through the welding gun from a wire feeder. The wire consists of a metal sheath filled with a flux. The flux helps to establish the arc, provides additives to the weld, and produces a slag.

In gas-shielded FCAW, the shield gas (mix of carbon dioxide & inert gas) is used to protect the arc. In self-shielded FCAW, the flux decomposes to produce the shielding gas and slag. FCAW is used to weld mild and alloy steel and generates large amounts of fumes.

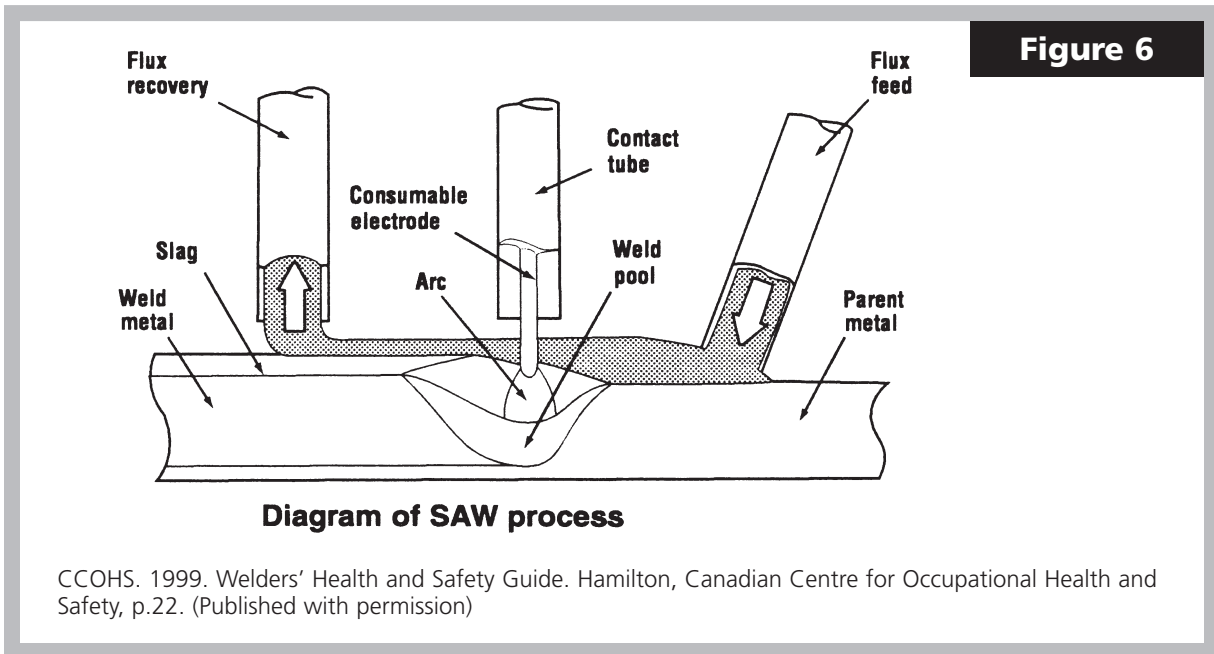
e) PLASMA ARC WELDING (PAW) & PLASMA ARC CUTTING (PAC)

The plasma processes use a **non-consumable tungsten electrode** and a shielding gas, similar to TIG welding. The plasma torch uses a constriction cup, which forces the arc out into a narrow jet. When the diameter of the constriction cup is reduced, a finer arc jet is produced which can be used for cutting or gouging applications.

Arc cutting is the general process in which the cutting or removal of metals is completed by melting with the heat of an arc between the base metal and the electrode. In plasma Arc Cutting (PAC), the metal is cut by melting a localized area with a constricted arc and removing the molten material with a hot high-velocity jet of ionized gas. PAC can be conducted under a water blanket on a water table, which traps noise, arc light, gases, and fumes.

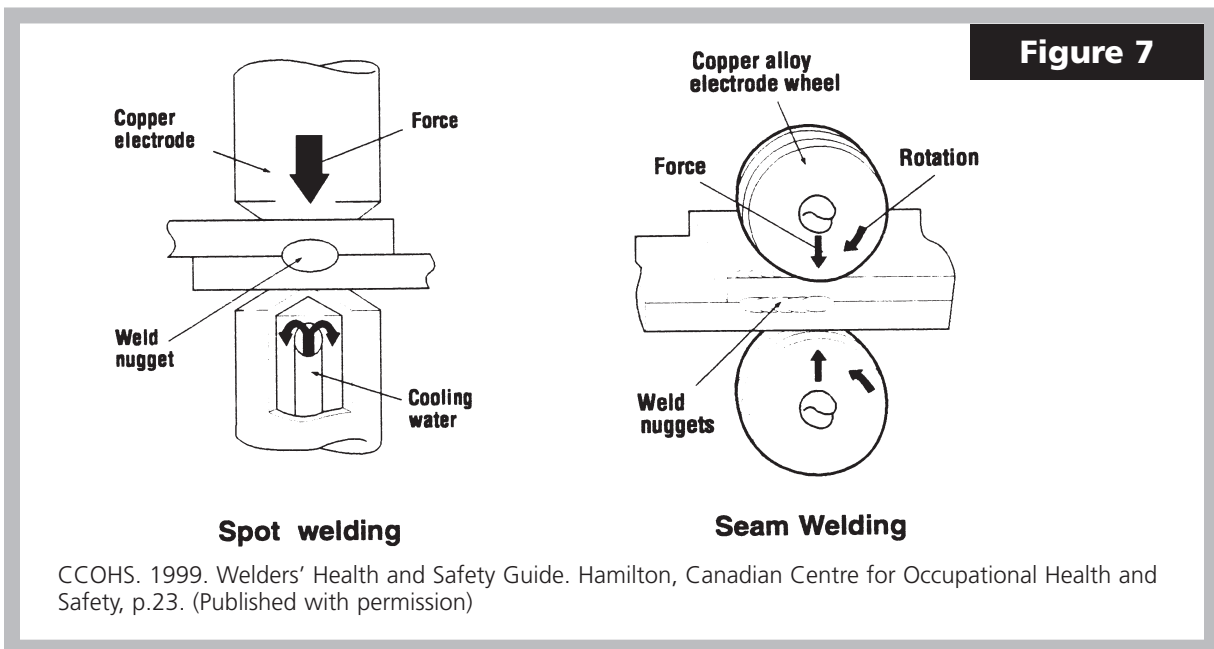
During the PAC and PAW processes, the arc jet released into the air produces ozone and nitrogen oxides, and high frequency noise (range 95 to 100dBA). These noise levels are in excess of the current Manitoba noise standard of 90 dBA (Manitoba Regulation 227/94, W210). **PAW generates low amounts of fumes** compared with other processes. **PAC generates higher amounts of fumes, noise and ozone levels than PAW** except when cutting is done under a water blanket.

f) SUBMERGED ARC WELDING FIG. 6



In Submerged Arc Welding (SAW), the arc is buried under a granular flux bed. The flux traps noise, light, gases and fumes. SAW uses a **consumable electrode**. The tip of the electrode and the welding zone are surrounded and shielded by the molten flux and layer of unused flux in the granular state. No visible evidence of the passage of the current between the electrode and the work surface is evident. Fumes are generated, but in lesser quantities compared with other welding processes.

g) RESISTANCE WELDING FIG. 7



Resistance welding is also referred to as **spot, flash or seam welding**. The weld is produced by pressure applied at the electrode contact points and heat from the electric current. The electrodes are commonly copper or copper-beryllium alloy. No filler metal or flux is used.

2. COMBUSTION GAS WELDING

Gas welding uses the heat from the combustion of oxygen and one of the following gases: acetylene, propane, hydrogen and butane. In this welding process, the filler electrode is manually introduced. It is used for repair work and light sheet metal. The flame temperature in combustion gas welding is lower than in electric arc and is considered less hazardous.

AIRBORNE HAZARDS FROM WELDING PROCESSES

1. FUMES

Fumes are very fine solid particulates formed when a metal is heated above its boiling point. Fumes are created by the condensation from the metal vapour state. Welding fume particles are generally less than **1 micron (u) in diameter, (one millionth of a meter – 1u)**. Welding fume particles penetrate into the alveoli region of the lung. All welding processes produce fumes, but the quantity varies widely depending on the process.

NOTE: Fumes may be present during welding whether a smoke plume is visible or not. Welding smoke is an example of visible fumes.

The health hazard of fumes depends on:

- **amount** of fume produced
- presence of **specific metals & gases**

Two basic mechanisms of fume generation:

- vaporization of the elements & oxides from the arc area (near the electrode tip)
- rapid condensation of the vapours to form solid particles

Major sources of fume:

- electrode metal
- flux material
- coatings, residues, oils, rust inhibitors, solvent-based paints, primers on the base metal

a) Consumable electrode process: Here the electrode is consumed in the weld. Fumes generated originate from the electrode, electrode coating or fluxes. The base metal being welded contributes a small portion.

b) Non-consumable electrode process: Here the amount of fumes generated is less, compared with the consumable electrode process. Fumes generated originate from the base metal being welded and the filler rod.

2. GASES

The following gases are produced from the:

- decomposition of shielding gases & fluxes
- interaction of ultraviolet light or high temperatures with atmospheric gases
- shielding gas

a) OZONE, due to the ionization of oxygen by ultraviolet light

b) CARBON MONOXIDE, from the ultraviolet effects on carbon dioxide in the shielding gas

c) SHIELD GASES, such as helium, argon and carbon dioxide

d) FLUORIDE GASES and other thermal decomposition products of fluxes and electrode coatings

e) FLAMMABLE GASES, such as acetylene

3. PARTICULATE MATTER

- originating from the grinding process required in some welding applications.

SOME WELDING PROCESSES GENERATE MORE WELDING FUMES THAN OTHERS

HIGHEST

Flux Core Arc Welding (FCAW)
Shielded Metal Arc Welding (SMAW)
Gas Metal Arc Welding (MIG)

LOWEST

Gas Tungsten Arc Welding (TIG)

- **BE AWARE** that a lower fume concentration may result in higher concentrations of ozone & nitrogen oxide gases.
- plasma arc cutting (PAC) produce less fumes, due to the finer cuts which remove less base metal material

FUME GENERATION RATE CAN BE ALTERED BY:

- a) Voltage** – as the voltage increases, more fumes are generated
- b) Arc Length** – as the arc length increases, more fumes are generated
- c) Current** – as the current increases, more fumes are generated
 - the exception is GMAW of aluminum where higher currents generate less airborne fume
- d) Electrode Diameter** – a smaller diameter electrode which results in more fumes generated
- e) Electrode Polarity** – 30% more fumes are generated by welding DC positive, compared with DC negative or AC
- f) Shielding Gas**
 - The composition of the shielding gas can significantly affect the fumes generated. An argon and carbon dioxide mix reduces fume generation up to 25%, compared with using only carbon dioxide.
- g) Composition of the base metal, fluxes and fillers** (refer to MSDS's)
 - A system has been developed by the American Welding Society to classify all consumable welding electrodes and rods. Every manufactured welding rod and electrode is referenced back to an MSDS. Encourage all welders to refer to the information contained on the MSDS.
- h) Effectiveness of the existing ventilation system** (general dilution vs local)
- i) Welder's work practices and years of experience**
 - when the distance between the work piece & electrode tip is increased, more fumes are generated (more vaporized metal is exposed to the environment)
- j) Wire feed speed:** as the feed speed increases, more metal is used and fume generation increases
- k) Humidity:** in humid environments, the amount of fume generated increases due to absorption by fluxes
- l) Position of weld:** a flat horizontal position produces less fume, compared with an overhead or vertical position

WELDING FUME COMPOSITION

Welding fumes are a complex mixture of metallic oxides, fluorides and silicates. A summary of the common gases & metals for the most frequently encountered welding processes in Manitoba welding workplaces are:

1. SHIELDED METAL ARC WELDING (SMAW)

a) Mild steel welding (MIG)

Welding fumes generated from mild steel welding were found to contain primarily iron and manganese. In addition, small amounts (less than the ACGIH current guidelines) of aluminum, calcium, copper, magnesium, sodium and zinc were determined. Trace amounts of chromium, potassium, nickel and lead were also determined.

METALS: iron oxide & manganese

Welding mild steel generates more fumes compared with stainless steel or nickel alloys, but has lower concentrations of chromium and nickel.

GASES: ozone & nitrogen oxides

b) Stainless steel

METALS: nickel, chromium & manganese

GASES: fluorides

Welding fumes from stainless steels have higher amounts of chromium and/or nickel, but less iron compared with MIG mild steel welding.

2. GAS METAL ARC WELDING (MIG)

MIG for STAINLESS STEEL

METALS: nickel, chromium & manganese

GASES: ozone, nitrogen oxides

3. GAS TUNGSTEN ARC WELDING (TIG)

TIG for ALUMINUM

METALS: aluminum oxide

GASES: ozone & nitrogen oxides

Aluminum vaporizes more readily than mild steel, thereby producing more fumes.

4. SUBMERGED ARC WELDING (SAW)

SAW for MILD STEEL

METALS: metal fumes (depends on composition of work piece being welded)

GASES: fluorides

Submerged arc welding is used mostly for welding low alloy steel and carbon. Fume generation is reduced, compared with other welding processes. Fluorides generated pose a significant hazard.

5. PLASMA ARC WELDING

Involves various base metals

METALS: metal fumes (depends on composition of work piece being welded)

GASES: ozone & nitrogen oxides

NOISE: Excessive noise levels (levels > 90dBA) pose a significant hazard (at 90dBA+ mandatory hearing protection is required as per Manitoba Regulation 227/94, W210)

6. PLASMA ARC CUTTING

Plasma arc cutting produces a higher volume of fumes & gases, compared with plasma arc welding.

METALS: metal fumes (depends on composition of work piece being welded)

GASES: high levels of ozone & nitrogen oxides

NOISE: excessive noise levels (levels > 90 dBA) pose a significant hazard

OTHER: produces heat, metal sparks & hot spatters

NOTE: Underwater plasma cutting provides greater noise reduction, compared with the water shroud, because the entire working end of the torch & the arc are completely submerged in water.

PRIMARY HEALTH EFFECTS OF EXPOSURE

1. The primary **short-term effects** are:
 - metal fume fever
 - welder's flash (ultraviolet radiation)
2. The **long-term effects** are less well-understood.

1. METAL FUME FEVER:

- metal fume fever occurs after exposure to high concentrations of magnesium (Mg), copper (Cu) & zinc (Zn)
- this acute condition occurs when a freshly formed fume is inhaled
- symptoms develop: 8 – 12 hours after exposure & tend to subside after 24 – 48 hours
- symptoms include: fever, headache, cough, chest pains, chills, muscle aches & metallic taste

Zinc is the major component of the galvanized coatings used on steel and is the more frequently encountered metal.

SOME IDENTIFIED HEALTH EFFECTS from metal exposure:

- a) **Siderosis** is a benign lung condition due to exposure from **iron oxides**.
- b) Chronic exposure to **Manganese** results in central nervous system problems similar to **Parkinson's disease**.
- c) **Cadmium** affects respiratory system (chest pain & difficulty breathing). The chronic effect includes **kidney damage** – Biological Exposure Index (BEI) 5ug/g creatinine.
- d) **Chromium** has been associated with skin ulceration, perforated nasal septum & an increased risk of lung cancer.
- e) **Fluorides**: acute effects – eye, nose & throat irritation
Long-term effects – pulmonary edema
- f) **Lead**: blood lead level – 30 ug/100 ml (ACGIH BEI 1997 - 98).
Chronic effects – anemia, fatigue, abdominal pain & kidney damage
- g) **Nickel**: acute effects – eye, nose, throat & skin irritation
Long term effects – increased risk of nasal & lung cancer
- h) **Lung cancer**: a 40% higher than normal lung cancer rate among welders has been reported in the literature. Some of these reports are from studies conducted 10+ years ago when welding processes had no (or limited) engineering controls in the workplace.

2. RADIATION

Welding arcs emit intense ultraviolet (UV) radiation. UV radiation in the welding arc will tan and burn the skin, similar to UV radiation from sunlight. Long-term exposure to UV radiation can cause skin cancer.

UV radiation to the eye injures the cornea and mucous membrane and is referred to as “**welder’s flash or arc eye or arc flash**”. The medical term for this condition is **photokeratitis and photoconjunctivitis**.

WELDER’S FLASH: The cornea of the eye becomes inflamed when exposed to **ultraviolet (UV) light**.

Symptoms:

- sensation of “sand in the eyes”
- ranging from a feeling of pressure in the eyes to intense pain
- tearing & reddening of the eye membranes
- photophobia: inability to look at a light source

Symptoms develop: 4-6 hours after exposure & tend to subside after 24 hours

UV EXPOSURE IS:

HIGHEST Plasma Arc Welding (PAW)
Gas Metal Arc Welding (MIG)
Shielded Metal Arc Welding (SMAW)

LOWEST Gas Tungsten Arc Welding (TIG)

Visible and **infrared** light are also emitted and present a hazard to the welder and other non-welders. The associated hazards with these two forms of radiation are considered to be less hazardous to the eye. Visible light, if intense, may cause eye fatigue and infrared light may be felt as heat.

3. GASES

a) **OZONE (O₃)** – due to ionization of oxygen (O₂) by the ultraviolet light (UV) from arc welding.



Ozone is classified as a pulmonary irritation & can cause pulmonary edema.

b) **CARBON MONOXIDE (CO)** – from the ultraviolet effects on carbon dioxide (CO₂) in the shielding gas.



Carbon monoxide is classified as a chemical asphyxiant resulting in anemic hypoxia. Hemoglobin has a 220 times greater affinity for carbon monoxide, compared with oxygen, with the resultant carboxyhemoglobin complex formation in the blood.

Carbon monoxide is an odourless and colourless gas. Acute symptoms include dizziness, headache & mental confusion. The airborne concentration of carbon monoxide generated from the welding process was determined to be < 5 ppm (measured at source) as per the WSH Branch welding proactive study 1998-99.

Note: A poorly adjusted flame will result in higher amounts of carbon monoxide.

c) CARBON DIOXIDE – from the decomposition of fluxes

Carbon dioxide is classified as a simple asphyxiant. It displaces oxygen, reducing the amount of oxygen available in the air. Oxygen depletion may cause dizziness, disorientation, inattention, unconsciousness or even death if the level of oxygen drops too low. The minimum acceptable oxygen content in the air is 19.5%.

d) NITROGEN OXIDES are formed from the heating of atmospheric oxygen & nitrogen (in the presence of ultraviolet light). The oxide usually consists of nitrogen dioxide (NO₂) and nitric oxide (NO). NO₂ is the predominant oxide present in the fume. NO₂ is irritating to the eyes, nose & throat at low concentrations (10-20 ppm) and at higher concentrations results in pulmonary edema.

e) HYDROGEN CHLORIDE & PHOSGENE are produced by the reaction between ultraviolet light and vapours from chlorinated hydrocarbon de-greasing solvents. Both of these gases irritate and can damage the respiratory system.

4. LUNG IRRITATION/INJURY/CANCER:

- lung, nose & throat irritation, bronchitis, emphysema & asthma
- welders suffer a greater incidence of bronchitis, compared with the general population
- 40% increase of lung cancer reported among welders, compared with the general population
- most welders also tend to be smokers & in many Manitoba workplaces welders were allowed to smoke on the shop floor

5. NOISE:

- noise originating from the metal fabrication processes (e.g. metal to metal impacts, materials handling, metal working, grinding/drilling)

Noise levels in Manitoba welding workplaces determined from the WSH Branch welding proactive study 1998-99 were found to be:

- > 80dBA in shops that were continuously welding & also in the smaller shops that were spot welding (> 80 dBA requires the implementation of a Hearing Conservation Program)
- most welding shops were > 90 dBA requiring mandatory hearing protection

Some methods of noise control in the workplace include:

- administrative controls: e.g. relocate welders away from noisy areas to reduce excessive noise levels

- engineering controls: replace noisy operations with quieter equipment, quieter processes or quieter materials
- reduce the driving force in mechanical equipment: decrease speed, maintain dynamic balance, provide vibration isolation and increase the duration of impact while reducing the force
- reduce the response of vibrating surface
- increase sound absorption
- use of equipment noise enclosures
- use of personnel noise enclosures
- use of some form of shield(s) or barrier(s)

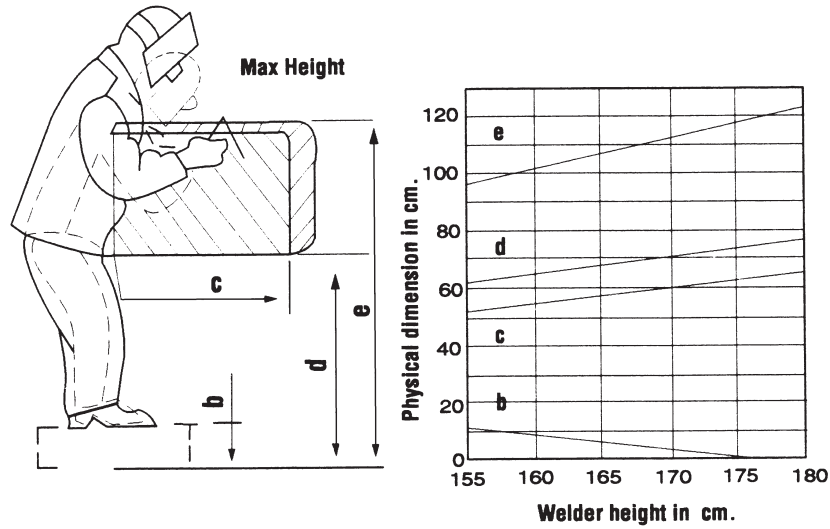
6. ERGONOMIC: REPETITIVE STRAIN INJURIES

The welding process places physical demands on the wrist, elbows, arms, shoulders & neck of the welder, due to the awkward postures and forceful exertions required by the job. Musculoskeletal injuries are common among welders, with female welders being placed at additional risk (often) due to poor design of equipment. The following ergonomic factors are prevalent in the welding process:

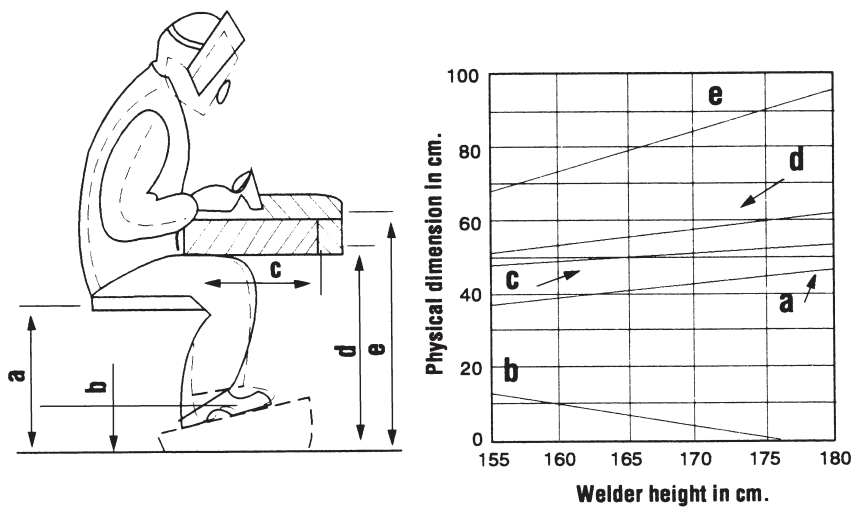
POSTURE

- equipment design – welder must adjust his/her body to make the tools work
- product design – welder must adopt to the product they are working on - low back pain is also common among welders due to the nature of having to bend over the work piece being welded
- workbench design (seated or standing) & the use of positioning aids to accommodate work posture are provided in Fig. 8

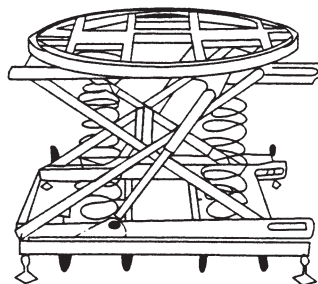
Standing Workbench Design



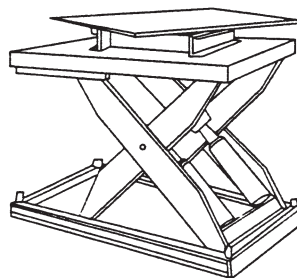
Seated Workbench Designs



USE positioning aids to accommodate work posture.



Turntable

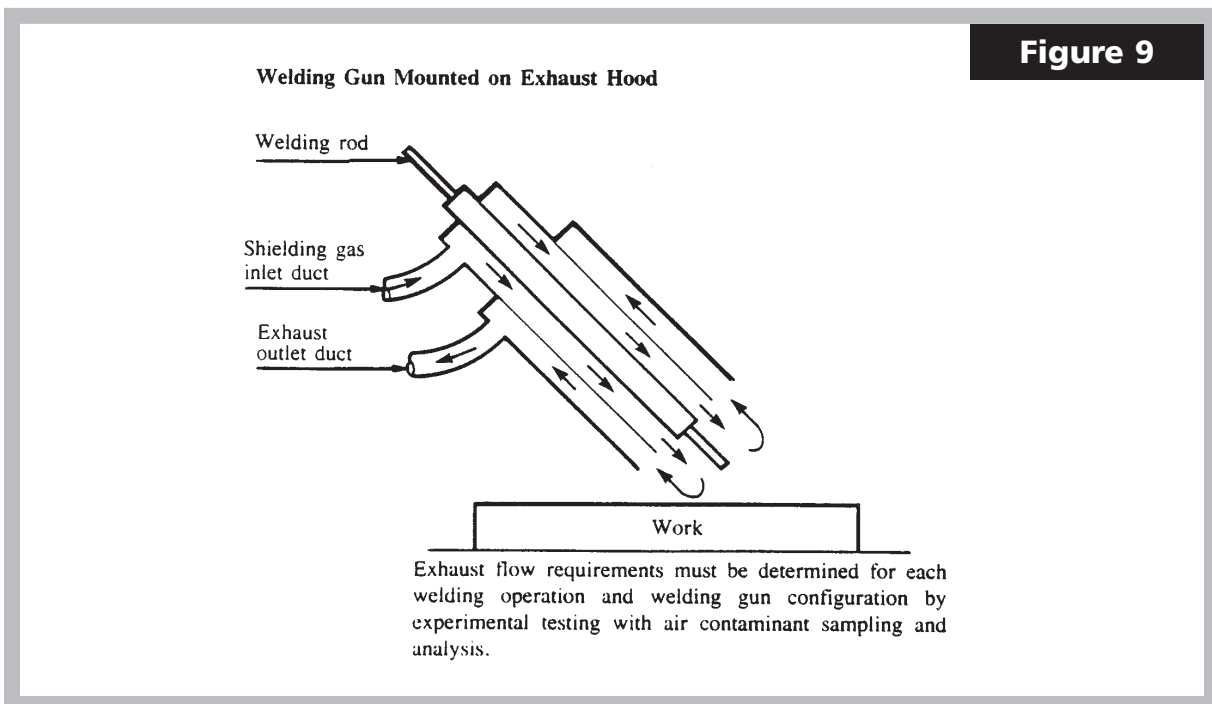


Scissor Lift

FORCE

- grip size (affects how hard you need to grip the tool)
- tool weight: the introduction of the smokeless-gun (Fig. 9) which has a fume extraction nozzle that covers the welding gun capturing the welding smoke – the disadvantage of the smokeless gun is the additional weight, placing an additional strain on the welder's wrist, elbow & shoulder (especially among female welders)
- manipulating the work piece(s) – when jigs or cranes are not readily available

NOTE: The use of appropriate welding techniques requires that the welder's head be as far away from the welding plume as possible. It was commonly observed that welders tend to work very closely to the work piece being welded.



7. ELECTRICAL INJURIES:

An electric arc supplies the energy required for bonding the work piece and the metal. The electricity is generated from welding machines, which are designed to use either alternating current (AC) or direct current (DC). DC machines may be powered by a rotating generator or by a transformer/rectifier. AC machines are powered by transformers using line voltage.

- Electricity used in welding is available as:
 - single phase, 120 V or 240 V
 - triple phase, 575 V
 - the voltage drops to 15 – 30 V once the arc is established & the current is flowing
- Typical welding currents are between 150 Amperes (A) and 500 A for manual welding & higher for semi-automated and robotic welding.

- The common electrical hazard is electrical shock. Spasms, burns, muscle paralysis or death can result depending on the amount of current flowing through the body.
- Ensure that the welding machine is grounded to the electrical panel input into the building & ground the work piece separately, preferably at the work piece itself or at the welding machine.
- Continuous welding wires are on a spool (wire which is advanced by a wire feeder) & the current is conducted through the electrode. The wire spool is “live” while the wire is being fed.

ARC WELDING, which requires high electrical currents, is also a source of:

- **magnetic fields** (strength of the magnetic field increasing as the electrical current increases)
- **strong magnetic fields may affect pacemakers**
- the long term effects of magnetic fields are less well-understood

WELDERS should all be trained on electrical safety procedures. All equipment maintenance & inspection should be conducted daily/regularly as required.

8. BURNS

Burns in the welding process are caused by two sources:

- **thermal:** skin burns from hot metal, spattering slag and from handling hot tools or electrodes
- **erythema:** skin burns primarily by ultraviolet light

9. EXPLOSION OR FIRE HAZARD

- oxyfuel processes involve the use of oxygen & fuel gases
- some fuel gases (e.g. acetylene) tend to be lighter than air & rise to the ceiling
- other fuel gases (e.g. butane & propane) tend to be heavier than air & settle to the floor
- flammable mixtures of fuel gases can ignite & cause a fire
- any oxygen leak can enrich the atmosphere, making a fire/explosion difficult to extinguish

Adequate Ventilation in the workplace is a safety requirement to prevent the displacement or enrichment of oxygen & accumulation of other flammable gases.

SAMPLING METHODOLOGY AND ALLOWABLE GUIDELINES

A. WELDING FUMES

There are two sampling methods for assessing the airborne concentration of welding fumes.

1. The simpler & less expensive method is the gravimetric (weight) method. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends an exposure limit of **5 mg/m³** TLV-TWA (threshold limit value-time weighted average) for welding fumes – total particulate (not otherwise classified) that can be inhaled.

The gravimetric method determines the total particulate weight of all aerosols including metals in the smoke generated from the welding process. **NIOSH Method # 0500 is used.**

2. The various welding processes such as stainless steel & mild steel generate varying amounts of specific metals. The individual metal concentration of the welding fume requires an assessment of the welding processes. This includes the alloy being welded, the process, the electrodes/wire being used, and the appropriate use of the National Institute of Occupational Safety & Health (NIOSH) analytical method.

Commonly the **NIOSH METHOD # 7300** is used. The current ACGIH TLV-TWA guidelines (1997-98) are provided. The **26 metal scan** includes:

Silver (TLV-TWA = 0.1 mg/m³), aluminum (TLV-TWA = 5 mg/m³), arsenic (TLV-TWA = 0.01 mg/m³), barium (TLV-TWA = 0.5 mg/m³), beryllium (TLV-TWA = 0.002 mg/m³), calcium (TLV-TWA = 2 mg/m³), cadmium (TLV-TWA = 0.01 mg/m³), cobalt (TLV-TWA = 0.02 mg/m³), chromium (TLV-TWA = 0.5 mg/m³), copper (TLV-TWA = 0.2 mg/m³), iron (TLV-TWA = 5 mg/m³), potassium (TLV-TWA = not assigned), magnesium (TLV-TWA = 10 mg/m³), manganese (TLV-TWA = 0.2 mg/m³), molybdenum (TLV-TWA = 5 mg/m³), sodium (TLV-TWA = not assigned), nickel (TLV-TWA = 1 mg/m³), lead (TLV-TWA = 0.05 mg/m³), antimony (TLV-TWA = 0.5 mg/m³), selenium (TLV-TWA = 0.2 mg/m³), tin (TLV-TWA = 2 mg/m³), strontium (TLV-TWA = not assigned), vanadium (TLV-TWA = 0.05 mg/m³), tungsten (TLV-TWA = 5 mg/m³), zinc (TLV-TWA = 5 mg/m³) and zirconium (TLV-TWA = 5 mg/m³).

B. WELDING GASES

- a) **OZONE:** **Commercial** Air Sampling Pump with colorimetric sensory tubes
Direct reading Ozone Portable Meter

The ACGIH TLV-TWA guidelines for ozone are:

Heavy work	0.05 ppm
Moderate work	0.08 ppm
Light work	0.1 ppm

- b) **FLUORIDE GASES:** Commercial Air Sampling Personal Pump with filter & Treated pad.
NIOSH
Method #7906 or 7902.

The ACGIH TLV-TWA guideline for fluoride is: 2.5 mg/m³

c) CARBON MONOXIDE/CARBON DIOXIDE/NITROGEN OXIDES/HCL/PHOSGENE:

Commercial Air Sampling Pump with colorimetric sensory tubes. Direct instrumentation exists for some of the gases.

The ACGIH TLV-TWA guidelines for:

carbon monoxide = 25 ppm
carbon dioxide = 5000 ppm
nitrogen oxides = varies
hydrochloric acid = 5 ppm C
phosgene = 0.1 ppm

- d) DUST:** Commercial dust track analyzers, i.e. DUST TRAK
Commercial Air Sampling Personal Pumps & PVC filters
– NIOSH Method # 0500

The ACGIH TLV-TWA guideline for respirable dust is 3 mg/m³ and for inhalable dust is 10 mg/m³.

- e) NOISE:** Sound Level Meter and/or Noise Dosimeter

Standard as per W210, M.R. 227/94 – Respecting Hearing Conservation and Noise Control.

- f) RADIATION:** Commercial UltraViolet Radiation Meter

Refer to the current ACGIH TLVs and BEIs Booklet for the recommended ultraviolet exposures.

BASIC WELDING CONTROL MEASURES

1. SUBSTITUTION

Substitution implies the use of welding electrodes with a less hazardous composition, but without altering welding or metallurgical characteristics. Some manufacturers are introducing a new **“low smoke welding wire”**, which they claim meets the requirements for a given electrode class and generates less fume & smoke compared with the conventional consumable rods.

2. VENTILATION

GENERAL RECOMMENDATIONS:

- the hood design(s) should be chosen based on their level of effectiveness.
(e.g., enclosing hoods are the most effective in controlling welding contaminants. Dilution – or general – ventilation is the least effective ventilation technique, but was the most commonly encountered in Manitoba welding shops.)
- integrate the planning for the ventilation systems with materials handling
- place welding curtains or other barriers to prevent cross-drafts
- avoid recirculating filtered air from the welding hoods back into occupied spaces – most filtering devices do not adequately remove gases
- face velocity for enclosing hoods ranges from 100-130 fpm – higher face may be required where cross-drafts exist
- capture velocities for non-enclosing hoods range from 100-170 fpm

GENERAL VENTILATION:

In general ventilation, large amounts of air are introduced into a workplace by mechanical intervention, (e.g., installation of exhaust fan(s)). General ventilation dilutes the contaminant in the workplace, but does not remove it. This type of ventilation is commonly installed when the contaminants are not considered to be toxic and contaminants are generated at a uniform rate. MIG welding of mild steel primarily produces iron oxide fumes, which are not considered as toxic as other welding by-products.

The Industrial Ventilation Manual, A Manual of Recommended Practice, recommends the following requirements for installations when a local exhaust ventilation system(s) cannot be applied:

ROD DIAMETER	CFM/WELDER
5/32	1000
3/16	1500
1/4	3500
3/8	4500

OR

- A) for open areas where welding fume can rise away from the breathing zone:
cfm required = 800 X lb/hour rod used
- B) for enclosed areas or positions where fume does not readily escape breathing zone:
cfm required = 1600 X lb/hour rod used

LOCAL EXHAUST VENTILATION:

This is the preferred method of ventilation since welding processes tend to generate high concentrations of fumes and gases in localized areas. In contrast to general ventilation, local exhaust ventilation captures contaminants at their source and removes them from the workplace.

The common types of a local exhaust welding ventilation system, installed as recommended from The Industrial Ventilation Manual, A Manual of Recommended Practice, are:

1. **ventilation bench hood** Fig. VS-90-01

Q = 350 cfm/ft of hood length
Hood Length = required working space
Minimum duct velocity = 2000 fpm

2. **movable exhaust hoods** – several hood types are recommended, Fig. VS-90-02

- A) flexible exhaust connections with swivel attachments and/or galvanized hood
- B) plain or cone or flanged hood

Face velocity = 1500 fpm
Minimum duct velocity = 3000 fpm

NOTES:

- a) locate work as close as possible to hood
- b) hoods perform best when located to the side of the work
- c) ventilation rates may be inadequate for toxic materials
- d) capture velocities above 100 – 200 fpm may disturb shield gas

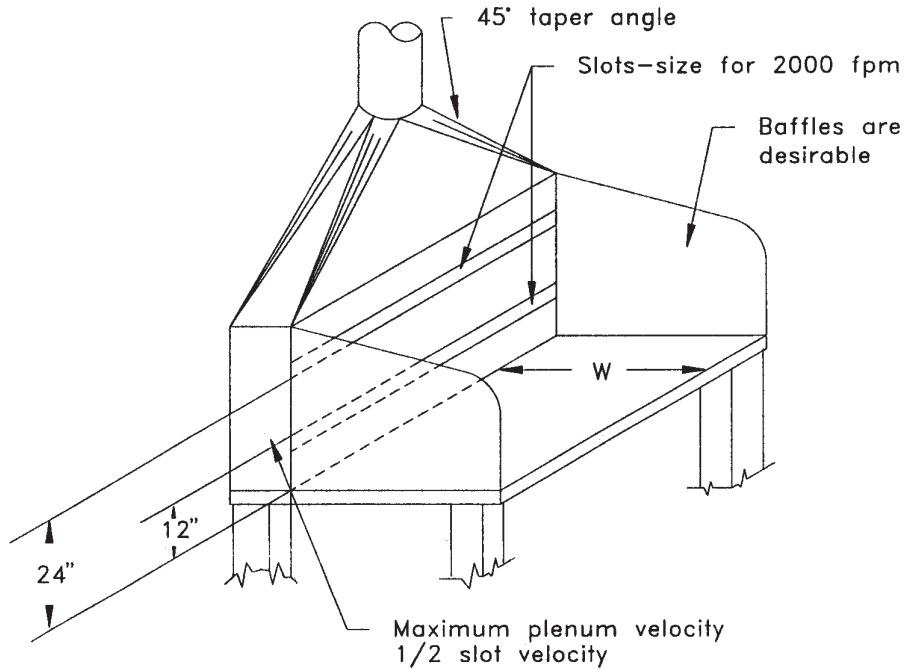
3. **production line welding booth** Fig. VS-90-03

Q = 1000 – 1200 cfm/linear ft of booth
Minimum duct velocity = 3500 fpm

4. **torch cutting ventilation** Fig. VS-90-10

enclosed bench with slot design

Q = 150 cfm/ft² of gross bench area
Minimum duct velocity = 4000 fpm
Slot sized for 2000 fpm



$Q = 350 \text{ cfm/ft of hood length}$
 Hood length = required working space
 $W = 24''$ maximum, if $W > 24''$ see chapter 3
 Minimum duct velocity = 2000 fpm
 $h_e = 1.78 VP_s + 0.25 VP_d$

General ventilation, where local exhaust can not be used:

Rod, diam.	Cfm/welder
5/32	1000
3/16	1500
1/4	3500
3/8	4500

or

- A. For open areas, where welding fume can rise away from the breathing zone:
cfm required = 800 x lb/hour rod used
- B. For enclosed areas or positions where fume does not readily escape breathing zone:
cfm required = 1600 x lb/hour rod used

For toxic materials higher airflows are necessary and operator may require respiratory protection equipment.

Other types of hoods

Local exhaust: See VS-90-02

Booth: For design see VS-90-30

$Q = 100 \text{ cfm/ft}^2$ of face opening

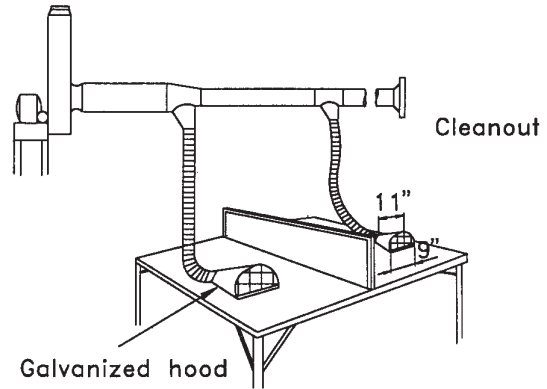
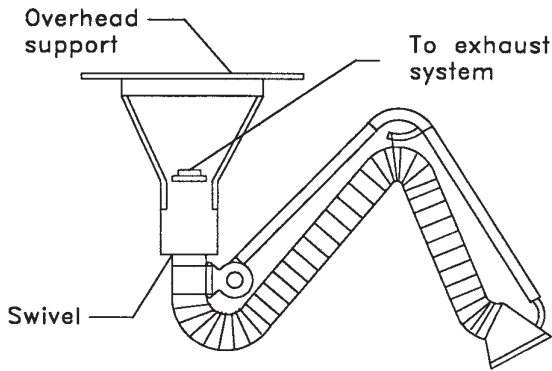
MIG welding may require precise air flow control

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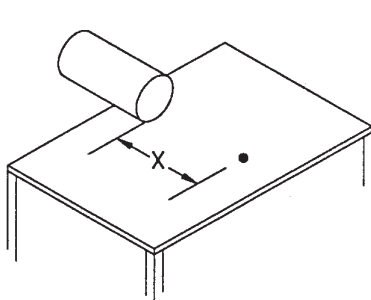
WELDING VENTILATION
BENCH HOOD

DATE 1-91

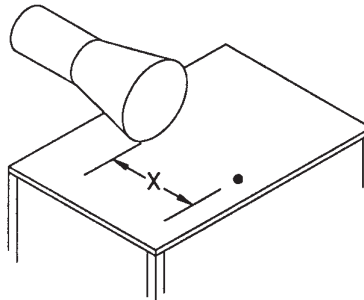
FIGURE VS-90-01



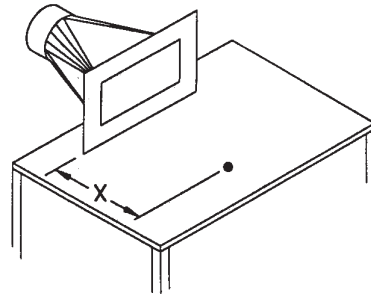
FLEXIBLE EXHAUST CONNECTIONS



PLAIN DUCT



CONE HOOD



FLANGED HOOD

RATE OF EXHAUST

X, inches	Plain duct cfm	Flange or cone, cfm
Up to 6	335	250
6-9	755	560
9-12	1335	1000

Face velocity = 1500 fpm
 Minimum duct velocity = 3000 fpm
 Plain duct entry loss = $0.93 VP_d$
 Flange or cone entry loss = $0.25 VP_d$

Notes:

1. Locate work as close as possible to hood.
2. Hoods perform best when located to the side of the work.
3. Ventilation rates may be inadequate for toxic materials.
4. Velocities above 100-200 fpm may disturb shield gas.

GENERAL VENTILATION, where local exhaust cannot be used :

Rod, diam.	cfm/welder
5/32	1000
3/16	1500
1/4	3500
3/8	4500

OR

- A. For open areas, where welding fume can rise away from the breathing zone:
 cfm required = $800 \times \text{lb/hour rod used}$
- B. For enclosed areas or positions where fume does not readily escape breathing zone:
 cfm required = $1600 \times \text{lb/hour rod used}$

For toxic materials higher airflows are necessary and operator should use respiratory protection equipment.

Other types of hoods
 Bench, see VS-90-01
 Booth, for design see VS-90-30
 $Q = 100 \text{ cfm/ft}^2$ of face opening

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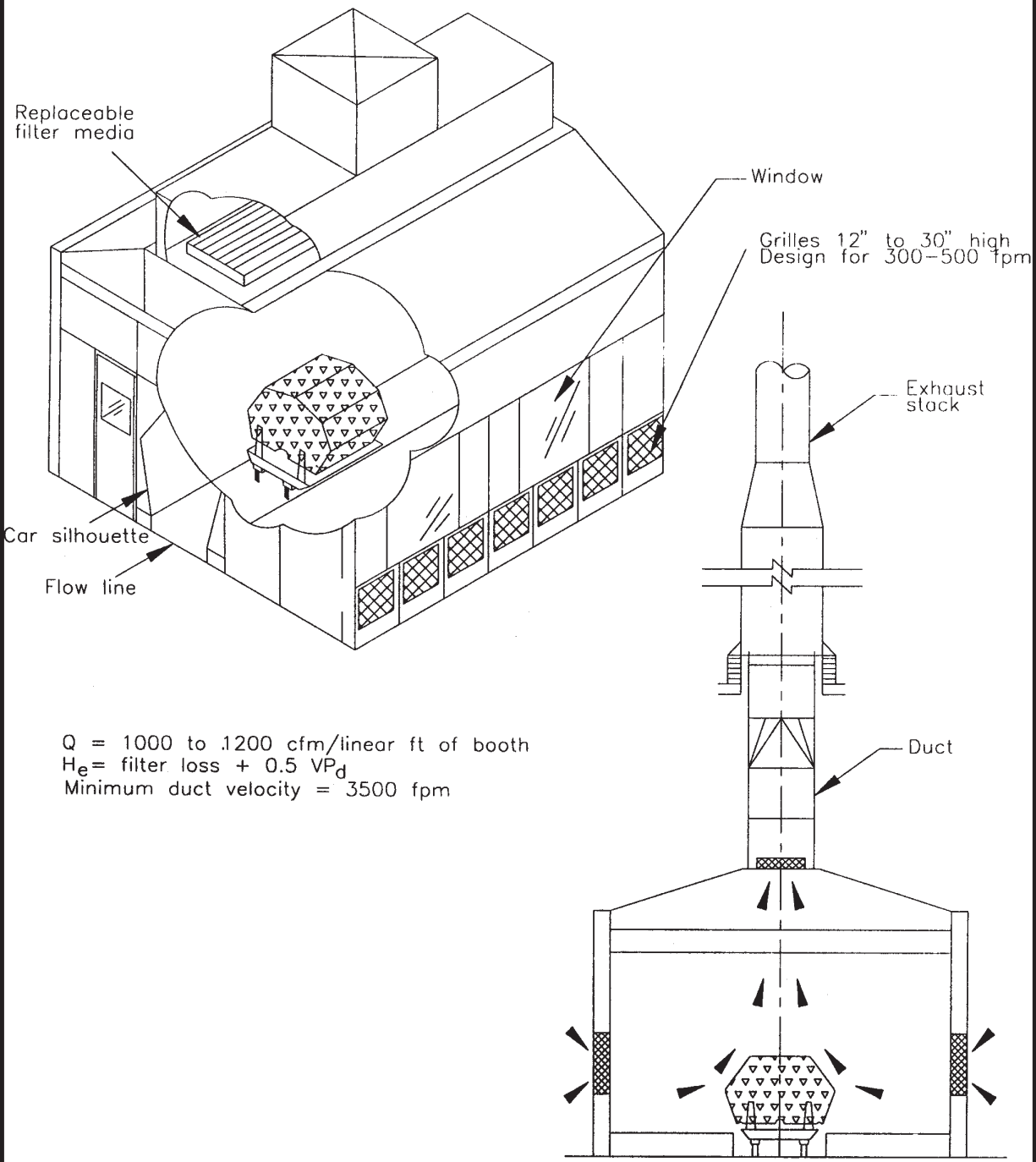
WELDING VENTILATION
 MOVABLE EXHAUST HOODS

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1-91

FIGURE

VS-90-02



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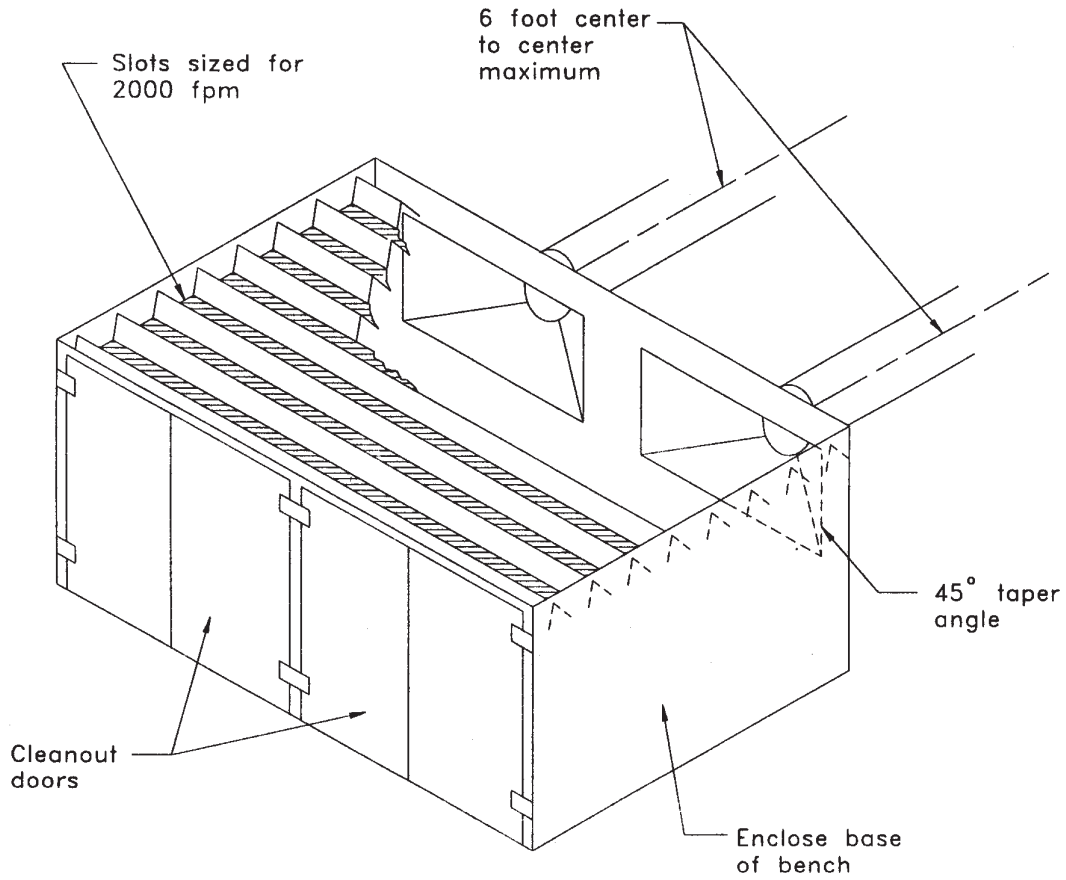
PRODUCTION LINE
WELDING BOOTH

DATE

2-91

FIGURE

VS-90-03



$Q = 150 \text{ cfm/ft}^2$ of gross bench area
 Minimum duct velocity = 4000 fpm
 $h_e = 1.78 VP_s + 0.25 VP_d$

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TORCH CUTTING VENTILATION

DATE 1-91

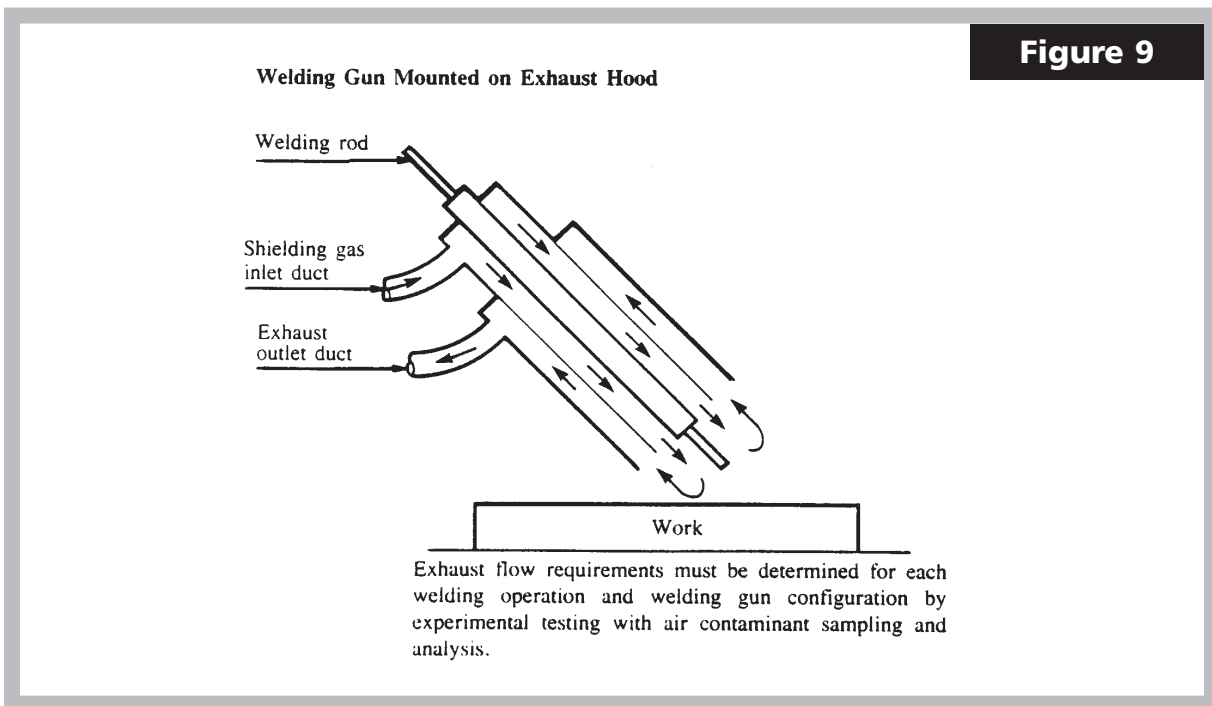
FIGURE VS-90-10

5. **robotic welding application** Fig. VS-90-20

- robot swivel arm with a flexible weld hose
- slot velocity = 2000 fpm
- hood located within 4 inches of source to maintain 200 fpm capture velocity
- minimum duct velocity = 3500 fpm

6. **welding gun with fume extraction nozzle (smoke-less gun)** Fig. 9

- these are welding guns with a fume extraction nozzle attached
- contaminants are removed very close to the source of generation & are drawn into an extraction system
- recommended air flow rates are 30 – 50 cfm/welder (as per manufacturers' guidelines)
- problem is the added weight to the welding gun – usually requires selecting a light weight gun & hose

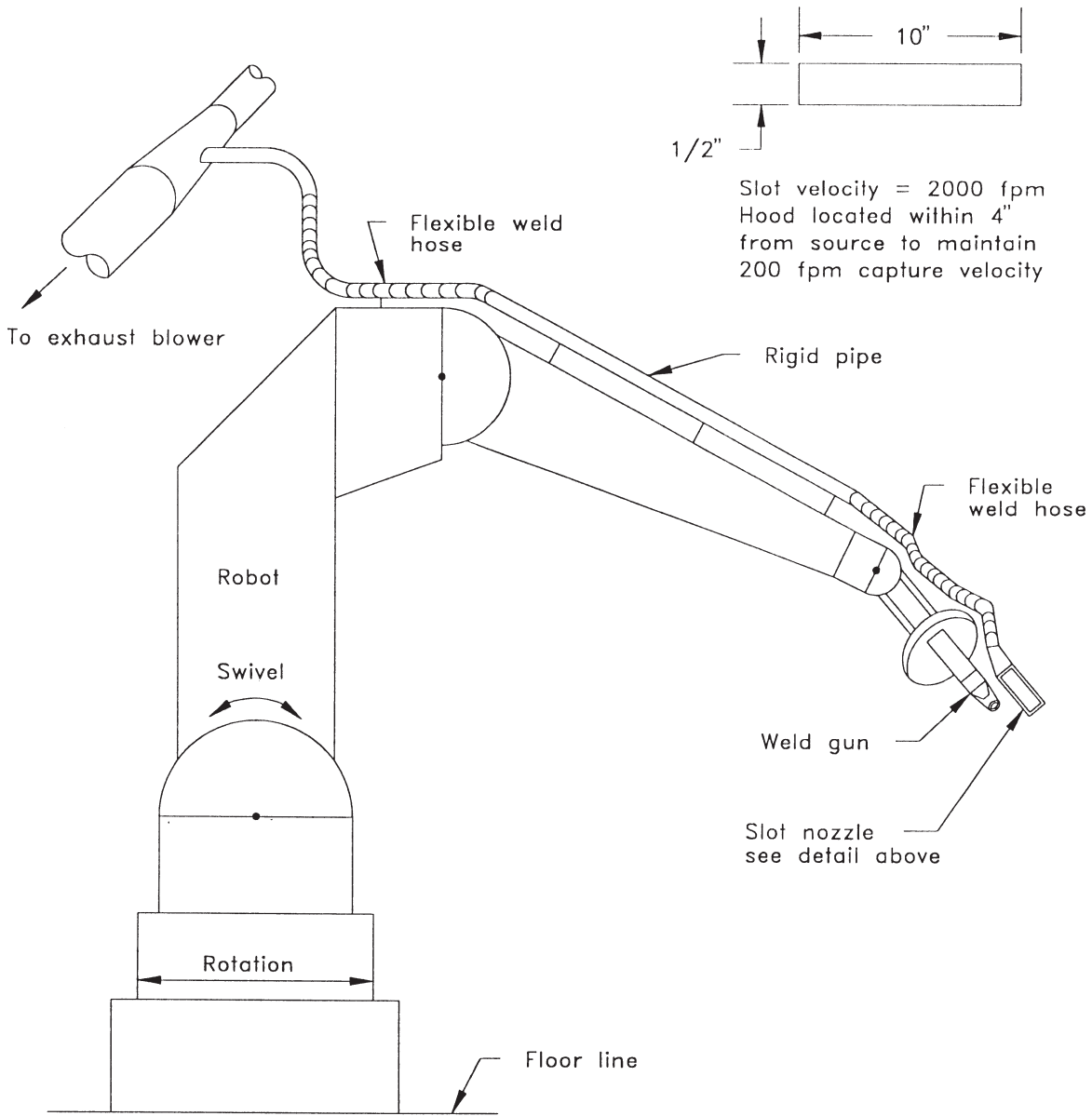


7. **portable fume extractor** Fig. 10

A portable fume extractor unit is most useful on large work pieces, which cannot be moved or moved with great difficulty. This extractor consists of a movable capture hood, duct, air cleaner, fan and motor. The system consists of a series of filters:

- coarse & finer filter (particulates)
- charcoal filter (gases)

The portable fume extraction system is designed to stop the recirculation of air when the filtering system fails. Manitoba welders complained that these units tend to be heavy and cumbersome to move around the work piece being welded.



$$h_e = 1.78 V_p^2 + 0.25 V_D^2$$

Minimum duct velocity = 3500 fpm

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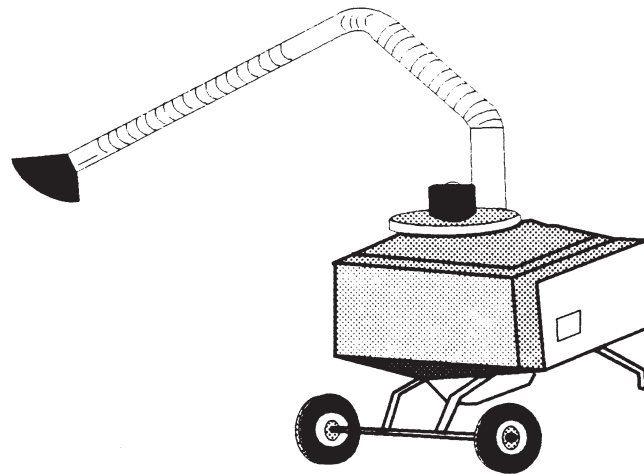
ROBOTIC APPLICATION

DATE 02-91

FIGURE VS-90-20

Portable Fume Extractor

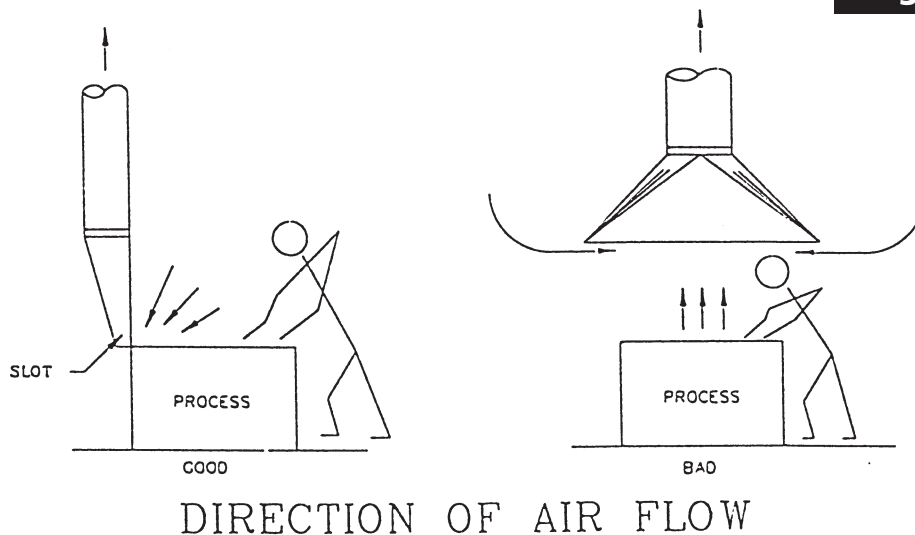
Figure 10



AVOID THE USE OF CANOPY HOODS

A canopy hood located over a welding table is not suitable for capturing welding contaminants. Canopy hoods would, however, provide some relief from heat and humidity. This type of hood design draws the contaminants through the breathing zone of the welder and, in most instances, are located too high above the process to provide any means of exhaust. Refer to Fig. 3.3.

Figure 3.3



LOCATE THE HOOD SO THE CONTAMINANT IS REMOVED AWAY FROM THE BREATHING ZONE OF THE OPERATOR.

SPECIFIC ENGINEERING CONTROLS

OZONE is difficult to control since it is formed at a distance from the welding arc. Local exhaust ventilation tends to be ineffective in controlling ozone exposure.

A stainless steel shroud, which acts as a barrier to the ultraviolet radiation, is one method to capture ozone. By layering the stainless steel mesh, the transmission of radiation and ozone concentration is reduced. Another method is the use of a ventilation enclosure.

REMOVE ANY COATINGS ON THE METAL TO BE WELDED

Removal of coatings, paints, degreasers & rust inhibitors on the metal work piece to be welded will minimize the fume – the removal of any coating will also improve weld quality. Some examples of coatings are listed below.

- metal working fluids, oils & rust inhibitors
- zinc on galvanized steel vaporizes to produce zinc oxide fumes
- cadmium plating
- vapours from paints & solvents
- lead oxide and chromate primer paints
- some plastic coatings can produce “polymer fume fever”
- polyurethane coatings can produce hydrogen cyanide, formaldehyde & toluene diisocyanate
- epoxy coatings can produce hydrogen cyanide & carbon monoxide
- vinyl paints can produce hydrogen chloride
- phosphate rust inhibiting paints can release phosphine

NOTE: Welders are advised to apply stripping products to remove coatings & TO NOT GRIND coatings as the grinding dust will pose an additional health problem. However, caution should be used since stripping products can pose chemical health risks on their own as well as leave a surface residue, which can become airborne when welding heat is applied.

PERSONAL PROTECTIVE EQUIPMENT FOR WELDERS

1. RESPIRATORY PROTECTION

Respiratory protection is the least desirable method of fume and gas exposure control. It should only be used in emergency situations or as a temporary measure until permanent control measures are installed. Appropriate respiratory protection shall be employed as per the current CSA standard (Z94.4 – M1993), Selection, Care and Use of Respirators.

Respiratory protection depends on the selection of the right type of respirator. Other important considerations include proper use by the welder, fit testing, storage, and maintenance/repair of the respirator.

The types of respirators commonly used by welders for capturing metal fumes & dust are: (Refer to Fig. 11 & Table 1 & consult with the supplier)

a) DISPOSABLE SINGLE-USE NIOSH APPROVED AIR PURIFYING FUME/DUST RESPIRATOR

- disposable respirators to protect against metal fumes & dust

b) AIR-PURIFYING, BELT-MOUNTED CARTRIDGE RESPIRATOR

- the facepiece fits over the nose and mouth - not interfering with the functioning of the welding helmet
- a flexible hose draws air through the belt-mounted cartridges

c) POWERED AIR PURIFYING RESPIRATOR

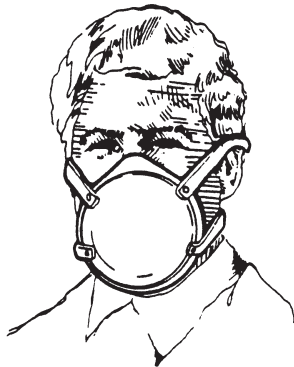
- a compact fan unit, powered by a rechargeable battery pack, draws contaminated air through a series of filters for aerosol protection only (not for capturing gases)
- the filtered air is carried to the helmet by a flexible hose
- the face/head seal maintains positive pressure inside the helmet
- the filtered air enters the welding helmet at the top of the helmet
- exhaled air exits through the bottom of the welding helmet

d) SUPPLIED AIR RESPIRATOR

- protect against metal fumes/dust/gases
- operating principle similar to powered air-purifying respirator
- clean air is provided from a compressed air source (air line) and flows into the half mask underneath the helmet
- the length of hose line determines the welder's movement
- this type of respirator should be used in situations where maximum protection is required (e.g. confined entry or enclosed spaces with little or no ventilation)

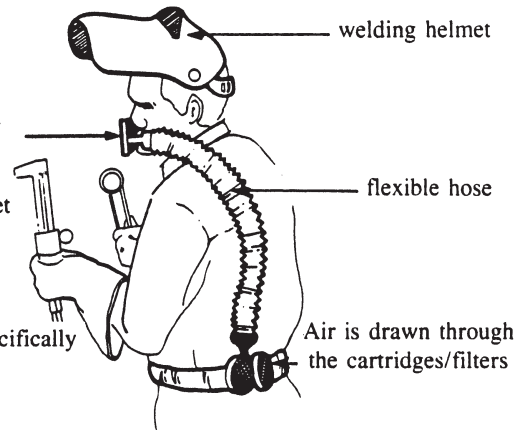
Figure 11

EXAMPLES OF RESPIRATORY PROTECTION FOR WELDING

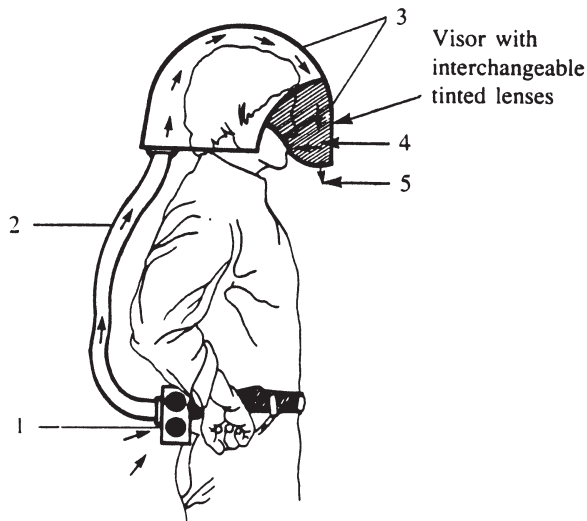


Single-use air purifying respirator (dust/fume mask)

Facepiece fits over nose and mouth, and should not interfere with the functioning of the welding helmet



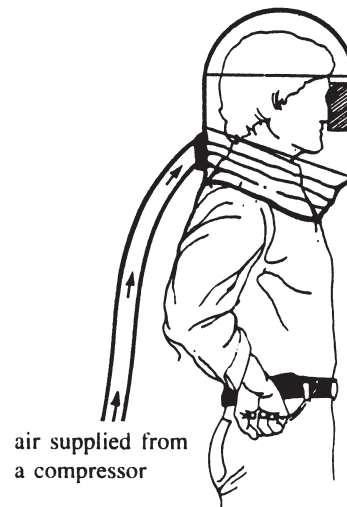
Air purifying, belt-mounted respirator



Powered air purifying respirator

1. a fan powered by a battery pack draws contaminated air through filter cartridges
2. filtered air is carried to the helmet through a flexible hose
3. face/head seal maintains positive pressure inside the helmet
4. filtered air is brought over the face for improved comfort, user breathes normally
5. exhaled air exits through cutout in bottom of faceshield

System is completely portable to allow maximum movement by the worker.



Supplied-air respirator

- operating principle similar to powered air purifying respirator
- clean air is provided from a compressed air source (air line) and flows into the helmet
- worker movement limited by length of hose connected to air line

**Table 3
Minimum Respiratory Protection Recommendations for Welding Processes**

		Shop Welding		Field Welding	
		Ventilation Good: Exhaust vent is used to capture fumes and gases	Ventilation Poor: Vent cannot be used due to physical or process restrictions	Ventilation Good: ^A Open area spark enclosure, or inside vessel with excellent air movement	Ventilation Poor: ^B Spark enclosure or inside vessel with poor air movement
Shielded Metal Arc Welding	Carbon Steel Other Alloys	Not required	Not required	Not required, except for galvanized	Fume mask required
		Not required	Fume Mask required	Not required, except for galvanized	Fume mask required
Arc Cutting or Gouging		Arc cutting is shop not recommended: see field welding requirements		Fume mask required except for open plant areas	Air supplied respirator required Helpers to wear fume mask (minimum)
Oxy-acetylene Torch Cutting		Not required	Not required except for galvanized steel		Air supplied respirator required
Plasma Arc Cutting		Air supplied respirator required for all plasma arc cutting			
Gas Metal Arc Welding		Not required	Air supplied respirator required	Not required	Air supplied respirator required
Gas Tungsten Arc Welding		Not required	Air supplied respirator required	Not required	Air supplied respirator required

^AGeneral criteria to be met:

Spark Enclosures: At least two open sides; no fume accumulation; no more than one welder

Inside Vessels: Directional air flow moving fume away from welder; no more than one welder; no major structural or scaffolding barriers to air flow

^BExamples:

Spark enclosure with all sides enclosed

Vessel with welders working at different elevations

Visible accumulation of fume

Short circuiting of air flow by open manways

Adapted from Table 3, page 15, reference 10

2. EYE SAFETY

WELDER'S HELMET FIG. 12

The helmet is made of a material that is an electrical and thermal insulator, noncombustible, and opaque to visible, ultraviolet and infrared light.

The eyes are protected from the ultraviolet radiation by a filter shade mounted on the welder's helmet. The shell of the helmet is hinged so that it can be raised and then lowered during welding. Most welders were observed jerking their neck back to raise the helmet, rather than manually raising it. This jerking motion tends to increase the incidence of neck strain.

Eye protection is provided by an assembly of the following:

- outer cover plate (polycarbonate plastic)
- filter lens (glass with a filter to reduce the amount of light)
- clear retainer lens (plastic)
- gasket (heat insulating material)

Safety eyewear should always be worn under the welding helmet to protect against flying debris when the helmet is raised to inspect work and when engaged in other welding activities, e.g. grinding, hammering.

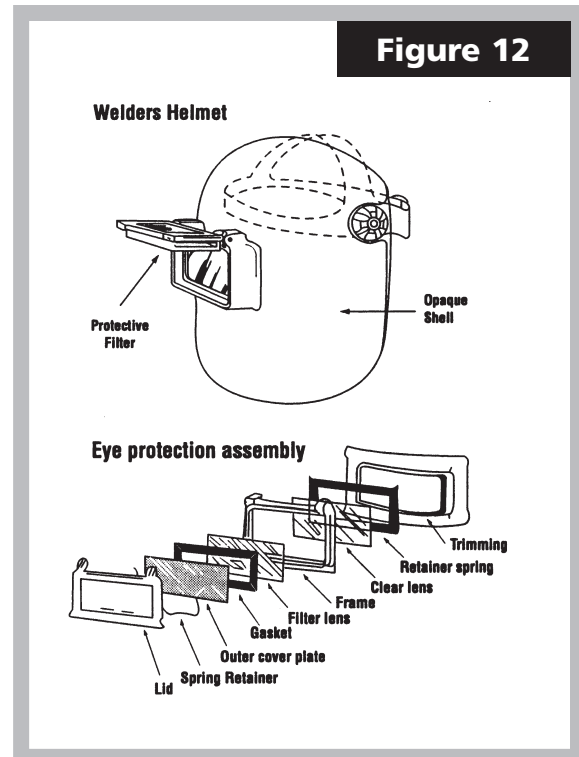
3. PERSONAL PROTECTIVE CLOTHING

Protective clothing is required to be worn to protect the skin from burns (sparks, spatter and radiation). All clothing should be laundered regularly to prevent oil and grease buildup. Ideally, protective clothing should be chemically treated to reduce combustibility. In some Manitoba welding shops, welders were not provided with any protective clothing over their street clothes. These welders wore their street clothes in the workplace, which were then laundered at their home.

Personal Protective Equipment/Clothing should include:

- leather or fibrous glass gloves and protective sleeves to protect forearms – leather is a good electrical insulator
- leather aprons to protect from sparks
- a fire-resistant skull cap under the welding helmet
- safety footwear as per the current CSA Standard (Z195) "Protective Footwear"
- certified industrial safety eyewear with side shields as per the current CSA Standard (Z94.3) to be worn under the welding helmet
- hearing protection: ear plugs and/or muffs

NOT RECOMMENDED are welders wearing contact lenses because any foreign particles in the eye may cause excessive irritation.



PROTECTING ADJACENT WORKERS

BE AWARE THAT:

NON-WELDERS near a welding operation can suffer welder's flash by inadvertently looking directly at an arc struck or by being exposed to reflected light.

1. **WEAR PROPER EYE PROTECTION** if you are within **30 meters (100 feet)** of an unshielded welding area.
 - Use polycarbonate plastic lenses to absorb the UVB & C and most of the UVA light.
 - Wear tinted polycarbonate safety glasses with tinted side shields if you are standing near a welding operation. USE a # 3 or # 5 shade if you are not looking directly at the arc.
 - Use the same shade as the welder, when looking directly at the arc.
 - REFER to Tables 2 & 3.
2. Welding activities should be **SHIELDED BY NON-REFLECTIVE SCREENS, PARTITIONS OR CURTAINS** to minimize the risk of exposing others to arc light.
3. The use of **SPARK OR SPATTER SHIELDS** will assist in preventing the escape of hot material from the welding area into adjacent locations.
4. It was observed in Manitoba welding shops that welders have a tendency to not put on their helmets if the welding job is of short duration, thereby unnecessarily exposing their eyes to the arc struck.

SPECIAL WELDING SITUATIONS

1. CONFINED SPACE:

Any welding operation in a "confined space" is potentially lethal due to oxygen deficiency, flammable gas/vapour buildup and airborne chemical concentrations exceeding the current acceptable guidelines. Confined spaces require continuous ventilation and monitoring. Refer to "Guidelines for Confined Entry Work", Manitoba Labour, WSH Branch publication.

Common Hazards are:

- Shielding gases given off during the welding which can displace oxygen
- flammable gas or vapour buildup (e.g. carbon monoxide)
- electrical hazards
- heat stress
- arc light reflections

In confined entry situations, portable self-contained ventilation systems are required, which include a gas absorbing system and particulate filters.

Shade Numbers for Arc Processes (from CSA W117.2)

Process	Electrode Diameter (mm)	Current (Amperes)	Minimum Shade	Suggested Shade
SMAW	< 2.5	< 60	7	-
	2.5 - 4	60 - 160	8	10
	4 - 6.4	160 - 250	10	12
	> 6.4	250 - 550	11	14
GMAW and FCAW		< 60	7	-
		60 - 160	10	11
		160 - 250	10	12
		250 - 500	10	14
Air Carbon Arc Cutting light heavy		< 500	10	12
		500 - 1000	11	14

**In the United States use ANSI/AWS Standard F2.2 for selecting filter lens shades.*

Shade Numbers for Cutting (from CSA W117.2)

Process	Plate Thickness (in mm)	Minimum Shade #	Suggested Shade #
Light	< 25	3	4
Medium	25 - 150	4	5
Heavy	> 150	5	6

** In the US use ANSI/AWS Standard F2.2 for selecting filter lens shade.*

2. BRAZING & SOLDERING:

Oxyfuel gas equipment used for cutting and heating has been largely replaced by electric arc welding processes. In the oxyfuel process, oxygen gas is combined with a fuel gas to produce a flammable gas mixture, which is ignited to produce an intense burning.

- **BRAZING** joins metals by heating **ABOVE 450°C** with a filler metal
 - Brazing joins metals of different composition
 - Heating by induction heating, torch or brazing furnace
 - Brazing fumes may contain fluorine, chlorine, & boron
- **SOLDERING** is similar to brazing but requires much lower temperatures – **BELOW 450°C**

CHECKLIST

Welding Processes:

- Determine what **type of welding is being done and the frequency throughout the workshift.**

Type of welding _____

Frequency _____

Work Shifts _____

Number of total welders _____

Number of female welders _____

Experience of welder _____

Average age of welders _____

- Are current MSDS's available?
- Do welders understand the hazards?
- If you see a **smoky haze** in the welding area, check that the **existing ventilation system** in the welding area is operating properly and airflow rates are not obstructed. A smoky haze in the workplace is suggestive that the ventilation system is not working properly or that no ventilation system exists.

Note: Fumes may be present during welding whether a visible smoke plume is present or not.

What type of **ventilation** exists in the welding area(s):

- local
- general
- Are welding curtains or other forms of barriers available?

Health Effects Identified:

- Are welders experiencing any **health effects** that may be related to the welding process?
- Welder's flash?
- Eye, nose and/or throat irritation?
- Do they suffer from any respiratory problems, e.g. bronchitis/asthma/emphysema?
- When was their last chest X-ray?
- Other complaints _____

Work Practices:

Check that the welders are adhering to **good work practices**.

- Are welders wearing their helmet when welding?
- Are the welders keeping their head out of the plume?
- Are welders positioning their work to take advantage of existing ventilation to direct the plume away from the breathing zone?

Personal Protective Equipment:

- Do welders have the required PPE?
 - welding helmet?
 - safety eyewear?
 - protective clothing, e.g. coveralls and/or leather apron/jacket?
 - safety footwear?
 - no frayed or loose clothing?
 - is the clothing clean?
 - protective gloves?
 - respiratory protection?
 - hearing protection?
- Is appropriate PPE readily available to welders?
- Is the PPE certified for its intended use by the appropriate standards authority, e.g. ANSI, NIOSH, CSA?
- Does the PPE fit properly?
- Is the PPE maintained/stored properly?
- Is there a written PPE policy for specific jobs?
- Are there rules and/or procedures?
- Are they using the PPE as prescribed?
- Do any welders wear respiratory protection?
- Is there a Respiratory Protection Program?

Program Elements:

- Workplace Survey
 - Selection
 - Fitting & Wearing
 - Maintenance
 - Training Support
 - Auditing the Program
- Are the limitations of the PPE understood by the welders?

Air Monitoring:

Has there been any monitoring of welding fumes in this workplace? _____

What areas were monitored? _____

Who did the air monitoring? _____

What year was it done? _____

Have any welding processes changed since the last monitoring? _____

Has production changed since the last monitoring? _____

What method of air monitoring was used? _____

Was a proper analytical air monitoring conducted? _____

NIOSH METHOD # _____

Ergonomics:

- Have the ergonomic factors in the workplace been assessed?
- Do any of the welders have complaints regarding back, wrist, shoulder, etc. pain?
- Is an ergonomic assessment requested/required?

Noise Levels:

- What are the **noise levels in the workplace?**

- Areas monitored _____

- Have the noise levels been monitored in this workplace?

- Is there a hearing conservation program established in the workplace?

- Are welders wearing hearing protection?

- Is hearing protection being made available to the welders?

- Do any control measures exist to reduce the noise levels?

Safety Training:

- Are welders trained on **electrical safety**?
- Fire safety?**
- Emergency Training?**
- Is all equipment installed in accordance with the CSA Standard C22.1, Canadian Electrical Code Part I – Safety Standard for Electrical Installations?
- Installed by a qualified authority in accordance with the manufacturer’s instructions?
- Is the welding machine grounded?
- Is the work piece grounded to a good electrical ground by locating the work on a grounded metal floor or platen or other satisfactory ground?
- Are repairs made only by qualified personnel?

- Compressed gases:** shall be used from cylinders only with appropriate regulator attached to the cylinder valve. If the cylinder is attached directly to a manifold, the manifold shall be designed to withstand full cylinder pressure.
 - Is there any evidence of gas leakage?
 - Valve leakage?
 - Flashback arresters should be fitted to all oxyacetylene equipment. Oxyacetylene equipment should not be left near hot equipment or metals, which could lead to burns.

Other Training:

- Has there been any training in the workplace provided to welders on safe work practices and/or 2) safety in welding & cutting (e.g. ANSI Z49.1-1993, Safety in Welding and Cutting)
- Is there a training program in the workplace for those newly recruited into the industry, e.g., recent college graduates?
- Does the company only hire experienced welders?

Welding Health & Safety Program:

- Is there a **welding health & safety program established in the workplace?**

Program Elements

- Individual responsibility
 - Joint Occupational H&S Committee
 - Health & Safety Rules
 - Correct Work Procedures
 - Employee Orientation
 - Training
 - Workplace Inspections
 - Reporting & Investigating Accidents
 - Emergency Procedures
 - Medical & First Aid
 - Health & Safety Promotion
- Does the program include hazard identification?
 - Any regular workplace inspections to ensure safe working procedures?
 - Any regular air monitoring of the common contaminants?
 - Any regular assessment of the ventilation system(s)?
 - Any review of lost time injuries?
 - Any regular review of the training program?
 - Is the health & safety program periodically evaluated to ensure that welders are being adequately protected?
 - Are there any training manuals?

Health & Safety Committee:

- Is there a Health & Safety Committee in this workplace? Or a Worker Representative?
- Is the Health & Safety Committee involved in the welding health & safety program(s)?
- Last Committee meeting? _____

Hygiene:

- Are welders provided with adequate hand washing facilities?
- Are welders washing their hands prior to the ingestion of food & smoking?
- Are welders provided with protective clothing (e.g. coveralls) & does the company launder these items?
- Is the lunchroom off the shop floor?
- Are there proper locker facilities?

Housekeeping:

- Is good housekeeping maintained in the workplace?
- Is the work area cleaned up at the end of each shift?
- Is the work kept free of flammable debris, e.g. rags & solvents?

NOTE: Ensure that working areas are free from debris, wastes are removed, areas are free from trip or fall hazards, and walkways are clear of welding cables, air hoses, electrical cords, tools & equipment.

Other Comments:

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