WELDING AND ALLIED PROCESSES

Draft Code of Practice

Suggestions for changes

by:

Alex Iwanow
Principal Consultant
AI & OHS Consultants
B.Admin., Grad. Dip. OHM.,
M.H.F.E.S.A., C.P.M.S.I.A. & R.S.P. (Aust),
M.A.S.S.E. (USA), C.M.I.O.S.H. (UK)
Table of Contents

FOREWORD .................................................................................................................................3

SCOPE AND APPLICATION ....................................................................................................3

1. INTRODUCTION .................................................................................................................4
   1.1 What are welding and allied processes? .............................................................................4
   1.2 Who has health and safety duties in relation to welding and allied processes? ............4
   1.3 What is involved in managing the risks associated with welding and allied processes? 4

2. HOW TO MANAGE THE RISKS .........................................................................................6
   2.1 Identify the hazards ...........................................................................................................6
   2.2 Assess the risks ................................................................................................................6
   2.3 Control the risks ...............................................................................................................7
   2.4 Review control measures ...............................................................................................8
   2.5 Information, training, instruction and supervision .........................................................9

3. SPECIFIC HAZARDS AND RISK CONTROL ......................................................................10
   3.1 Radiation .........................................................................................................................10
   3.2 Electrical hazards ..........................................................................................................10
   3.3 Fire and explosion .........................................................................................................12
   3.4 Burns and exposure to heat ............................................................................................14
   3.5 Compressed and liquefied gases ....................................................................................14
   3.6 Compressed air .............................................................................................................15
   3.7 Noise ..............................................................................................................................16
   3.8 Airborne contaminants ....................................................................................................16
   3.9 Other hazards .................................................................................................................18

4. WELDING AND ALLIED PROCESSES EQUIPMENT .........................................................20
   4.1 Ventilation ......................................................................................................................20
   4.2 Personal protective equipment (PPE) ............................................................................22
   4.3 Maintenance of equipment ............................................................................................23

APPENDIX A – BY-PRODUCTS OF WELDING ......................................................................25

APPENDIX B – OTHER SOURCES OF INFORMATION .............................................................27
FOREWORD

This Code of Practice on managing health and safety risks associated with welding and allied processes is an approved code of practice under section 274 of the Work Health and Safety Act (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the Work Health and Safety Regulations (the WHS Regulations).

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and Regulations. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the WHS Act and Regulations may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

This Code of Practice has been developed by Safe Work Australia as a model code of practice under the Council of Australian Governments’ Inter-Governmental Agreement for Regulatory and Operational Reform in Occupational Health and Safety for adoption by the Commonwealth, state and territory governments.

A draft of this Code of Practice was released for public consultation 26 September 2011 and was endorsed by the Select Council on Ministers Council on [to be completed].

SCOPE AND APPLICATION

This Code of Practice provides practical guidance for persons conducting a business or undertaking on how to eliminate or minimise the hazards and risks associated with welding and allied processes. It applies to all workplaces covered by the WHS Act where welding and allied processes are carried out and to all persons involved in these activities.

How to use this code of practice

In providing guidance, the word ‘should’ is used in this Code to indicate a recommended course of action, while ‘may’ is used to indicate an optional course of action.

This Code also includes various references to provisions of the WHS Act and Regulations which set out the legal requirements. These references are not exhaustive. The words ‘must’, ‘requires’ or ‘mandatory’ indicate that a legal requirement exists and must be complied with.
1. INTRODUCTION

1.1 What are welding and allied processes?
Welding is the process of permanently joining two or more materials together, usually metals, by heat or pressure or both. When heated, the material reaches molten state and may be joined together with or without additional filler materials being added. Thermoplastics can also be welded together in permanent joins.

Allied processes include metal preparation processes, metal cutting, gouging, brazing and soldering.

Various methods are used to develop heat required for welding and cutting, for example:
- Electric arc – uses an electric arc between an electrode and workpiece or between electrodes
- Gas – uses a flame usually created by igniting a mixture of compressed oxygen with a fuel gas
- Plasma arc – uses compressed air for plasma gas transferred from torch to workpiece

The main hazards and risks associated with welding and cutting are electric shock, radiation, burns, hazardous fumes and noise.

1.2 Who has health and safety duties in relation to welding and allied processes?

A person conducting a business or undertaking has the primary duty under the WHS Act to ensure, so far as is reasonably practicable, that workers and other persons are not exposed to health and safety risks arising from the business or undertaking. This duty requires eliminating risks associated with welding and allied processes, or if that is not reasonably practicable, minimising the risks so far as is reasonably practicable.

The WHS Regulations include more specific requirements to manage the risks of hazardous chemicals, atmospheric contaminants and plant, as well as other hazards that may be associated with welding and allied processes such as noise.

Designers, manufacturers, suppliers and importers of plant or substances that are used in welding and allied processes must ensure, so far as is reasonably practicable, that the plant or substance is without risks to health and safety. This duty includes carrying out testing and analysis and providing specific information about the plant or substance.

Officers, such as company directors, have a duty to exercise due diligence to ensure that the business or undertaking complies with the WHS Act and Regulations. This includes taking reasonable steps to ensure that the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks that arise from welding and allied processes.

Workers carrying out welding and allied processes have a duty to take reasonable care for their own health and safety and must not adversely affect the health and safety of other persons. Workers must comply with any reasonable instruction and cooperate with any reasonable policy or procedure relating to health and safety at the workplace. If personal protective equipment (PPE) is provided by the person conducting the business or undertaking, the worker must use it in accordance with the information, instruction and training provided on its use.

1.3 What is involved in managing the risks associated with welding and allied processes?

Identifying all reasonably foreseeable hazards associated with welding and allied processes and understanding the level of risk associated with those hazards will help you make the right decisions about what to do to eliminate or minimise the risks.
This process is known as risk management and involves the following steps:
- identifying hazards
- if necessary, assessing the risks associated with the hazards
- controlling the risks, and
- maintaining and reviewing the effectiveness of control measures.

Guidance on the general risk management process is available in the *Code of Practice: How to Manage Work Health and Safety Risks.*

**Consulting your workers**

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

The WHS Act requires that you consult, so far as is reasonably practicable, with workers who carry out work for you who are (or are likely to be) directly affected by a work health and safety matter. If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation with workers and their health and safety representatives is required at each step of the risk management process. By drawing on the experience, knowledge and ideas of your workers you are more likely to identify all hazards and choose effective risk controls.

For example, metal surfaces need to be cleaned prior to welding to remove debris and hazardous materials. When considering how to safely prepare metal using chemical treatments, you should consult with workers to better understand the work practices and the potential hazards they face. Consultation with workers can also help you select appropriate control measures, including any personal protective equipment they may require.

**Consulting, co-operating and co-ordinating activities with other duty holders**

The WHS Act requires that you consult, co-operate and co-ordinate activities with all other persons who have a work health or safety duty in relation to the same matter, so far as is reasonably practicable.

Sometimes you may have responsibility for health and safety together with other business operators who are involved in the same activities or who share the same workplace. In these situations, you should communicate with each other to find out who is doing what and work together in a co-operative and co-ordinated way so that all risks are eliminated or minimised as far as reasonably practicable.

For example, if you hire a welder to repair an item of machinery at your workplace, then you should work together with the welder to plan the work, discuss any safety issues that may arise and how the risks associated with the welding work, such as exposure to fumes and noise, will be controlled.

Further guidance on consultation is available in the *Code of Practice: Work Health and Safety Consultation, Co-operation and Co-ordination.*
2. HOW TO MANAGE THE RISKS

2.1 Identify the hazards

Identifying hazards involves finding all of the things and situations that could potentially cause harm. The major hazards associated with welding and allied processes are listed in Table 1.

Table 1: Common hazards associated with welding

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Potential harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Ultra violet, welding arc flashes, infrared, electromagnetic radiation, lasers can cause burns, cancer and blindness</td>
</tr>
<tr>
<td>Compressed and liquefied gas, compressed air</td>
<td>Asphyxiation, fire and explosion hazards arising from gas leaks, hearing damage from sudden release of compressed air</td>
</tr>
<tr>
<td>Electricity</td>
<td>Potential ignition source. Exposure to live electrical wires or electrodes can cause shock, burns or death from electrocution</td>
</tr>
<tr>
<td>Fire and explosion</td>
<td>Potential ignition source, serious burns and potential death, flashback, dust explosion</td>
</tr>
<tr>
<td>Metal fumes</td>
<td>Metal Fume Fever, heavy metals such as Cadmium, Chromium in stainless steel and hardfacing can cause respiratory illnesses, cancers and dermatitis</td>
</tr>
<tr>
<td>Hazardous chemicals</td>
<td>Chemicals such as acids, pickling and passivation chemicals can cause burns, solvents, ozone and heavy metals can cause respiratory illnesses, cancers and dermatitis</td>
</tr>
<tr>
<td>Airborne contaminants</td>
<td>Fumes, mists, dust, vapour and gases may be toxic, asphyxiant, and cause respiratory illnesses, metal fume fever</td>
</tr>
<tr>
<td>Extreme temperatures</td>
<td>Exposure to hot objects and hot environment can cause burns, heat stroke, fatigue</td>
</tr>
<tr>
<td>Noise</td>
<td>Exposure to loud noise can cause permanent hearing damage</td>
</tr>
<tr>
<td>Confined spaces</td>
<td>Exposure to hazardous substances, unsafe oxygen levels, potential for fire, explosion and engulfment, electrocution</td>
</tr>
<tr>
<td>Working at height</td>
<td>Falls and falling objects can cause fractures, bruises, lacerations, dislocations, concussion, permanent injuries or death</td>
</tr>
<tr>
<td>Manual tasks</td>
<td>Overexertion or repetitive movement can cause muscular strain</td>
</tr>
</tbody>
</table>

Potential hazards may be identified in a number of different ways, including:

- talking to workers and observing the work
- inspecting the materials and equipment that will be used during the welding process
- reading product labels, safety data sheets and manufacturer’s instruction manuals
- talking to manufacturers, suppliers, industry associations and health and safety specialists, and
- reviewing incident reports.

2.2 Assess the risks

A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening. A risk assessment can help you determine:

- how severe a risk is
- whether any existing control measures are effective
- what action you should take to control the risk, and
- how urgently the action needs to be taken.
It is necessary to estimate the likelihood of each hazard actually causing harm in a specific situation, for example welding being carried out in a confined space. The following questions may help to assess the risk:

- How often, and for how long, will exposure to the hazard occur?
- In the event of exposure to the hazard, will the outcome be severe, moderate or mild?
- What are the conditions under which welding is carried out?
- What are the skills, competence and experience of the welder?

Different welding and cutting processes also influence the risk. For example, the risk of electric shock or electrocution is lower using gas metal arc welding (MIG) than manual metal arc welding because the open circuit voltages are low, only direct current is used and the power is switched at the torch.

2.3 Control the risks

The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of risk control. Duty holders must work through this hierarchy when managing risks under the WHS Regulations.

**Eliminate the risk**

By designing-in or designing-out certain features, hazards may be eliminated. For example, fabrications may be designed to include many pre-cast components or extruded shapes to eliminate a considerable amount of welding.

**Minimise the risk**

If it is not reasonably practicable to eliminate the risks, you must minimise the risk so far as is reasonably practicable by choosing one or more of the following measures:

- **Substitution** – Replace a hazardous process or material with one that is less hazardous, for example using submerged arc welding instead of flux-cored wire welding will reduce the risk of exposure to radiation and fumes. In welding, such types of substitution are not always practical or technically suitable.
- **Isolation** – Removing the welder from the hazard or isolating or screening the hazard from the welder, for example ancillary processes like plasma cutting, gouging, grinding, fettling and guillotining can be carried out in specified areas away from general fabrication, to reduce risk of exposure to loud noise at the welding station.
- **Engineering** – Use engineering control measures to minimise the risk, for example, ventilation systems to remove welding fumes, VRD attached to arc welders to prevent electrocution from contacting live electrode or flash back arrestors to prevent gas cylinders exploding.

If there is a remaining risk, it must be minimised so far as is reasonably practicable by implementing administrative controls, and if a risk still remains, then suitable personal protective equipment must be provided and used. These two types of control measures, when used on their own, tend to be least effective in minimising risks because they rely on human behaviour and supervision.

- **Administrative** – For example, if a welding operation takes place in a very hot environment, then allowing the welder to weld for a limited time followed by a suitable rest and cooling-off period, will reduce the risk of heat exhaustion.
- **Personal protective equipment (PPE)** – For example, if the welder has to stand on metallic surfaces that form part of the electric circuit and so may become live, then the use of rubber-soled boots will reduce the risk of electrocution.

You should check that your chosen control measure does not introduce new hazards.
2.4 Review control measures

The controls that are put in place to protect health and safety should be monitored and reviewed regularly to make sure they work as planned. This may involve, for example, atmospheric monitoring to measure the amount of welding fume in the welder’s breathing zone following introduction of fume extraction equipment. If the control is not working effectively it must be revised.

Control measures implemented under the WHS Regulations for hazardous chemicals must be reviewed and, if necessary revised:
- when the control measure is not effective in controlling the risk
- before a change at the workplace that is likely to give rise to a new or different health and safety risk that the control measure may not effectively control
- if a new hazard or risk is identified
- if the results of consultation indicate that a review is necessary
- if a health and safety representative requests a review
- if a safety data sheet or register of hazardous chemicals is changed
- if a health monitoring report for a worker identifies adverse health effects
- if air monitoring indicates that the airborne concentration of a hazardous chemical at the workplace exceeds the relevant exposure standard, and
- at least once every 5 years.

You can use the same methods as in the initial hazard identification step to check controls.

Health monitoring

If welders and workers who perform allied processes are exposed to a hazardous chemical, such as cadmium, chromium or lead, health monitoring may be required to assess the status of their health.

A person conducting a business or undertaking must provide workers with health monitoring where there is a significant risk to their health because of exposure to a hazardous chemical.

Health monitoring must be done by or under the supervision of a registered medical practitioner with relevant skills and experience. Health monitoring, which may include biological monitoring, can assist in:
- establishing whether an identifiable disease or health effect known to be linked to exposure to dust or other chemicals has occurred, and
- determining levels of toxic substances in the body so that informed decisions can be made about the effectiveness of controls and whether any further action needs to be taken (e.g. a reduction in or cessation of exposure).

While air monitoring is the primary workplace monitoring technique, if hazardous chemicals may have been absorbed through the skin, ingested or inhaled, biological monitoring techniques should also be used. For example, workers that weld using lead may require biological monitoring to measure the level of lead in their blood.

Biological monitoring has the specific advantage of being able to take into account individual responses to particular hazardous chemicals. Individual responses are influenced by factors including size, fitness, personal hygiene, work practices, smoking and nutritional status.

Health monitoring should not be used as an alternative to proper implementation and maintenance of control measures designed to prevent exposure. For more information on health monitoring techniques required (e.g. x-ray, respiratory function tests), see Schedule 14 of the WHS Regulations.
Health monitoring report

A report must be obtained from the medical practitioner who supervised the health monitoring as soon as possible after the monitoring is carried out and a copy provided to the worker as soon as reasonably practicable. The report must include:

- any test results that indicate the worker has been exposed to a hazardous chemical
- any advice indicating an injury or illness as a result of carrying out the work that triggered the health monitoring
- any recommendations about the remedial measures the person conducting the business or undertaking should take, including whether the worker can continue the work, and
- whether any medical counselling is required for the worker.

If a recommendation is provided in the health monitoring report, the person conducting the business or undertaking must ensure:

- a copy of the report is given to the relevant regulator as soon as practicable, and
- risk assessment and control measures are reviewed and, if necessary, revised.

All health monitoring reports must be kept as confidential records for at least 30 years after the record is made. The details of the record must not be disclosed to any person other than the worker unless that worker has provided their written consent or they are being disclosed to a person under a duty of professional confidentiality.

2.5 Information, training, instruction and supervision

Workers who are involved in welding or allied processes require relevant information, training, instruction or supervision to enable them to carry out the work without risk to health and safety. This should include providing training and information on:

- symptoms of health affects from welding e.g Welding Fume Fever, etc
- the nature of the hazard and the control measures implemented to eliminate or minimise exposure to radiation, fire, explosion, hazardous chemicals, burns, heat and noise
- the use of welding equipment, including how to handle and store compressed air and compressed and liquefied gases safely
- how and where to access relevant information including safety data sheets
- the information in safety data sheets and manufacturers’ manuals
- the selection, use and maintenance of PPE
- working in hazardous environments like confined spaces or working at heights.
- the nature of, and reasons for, any health monitoring required, and
- first aid and emergency procedures.
3. SPECIFIC HAZARDS AND RISK CONTROL

3.1 Radiation

Electric arc, flame and laser welding emit ultraviolet, visible light and infra-red radiation while gas welding and cutting emits visible light and infra-red radiation. Electron beam welding emits X-rays. The effects of ultraviolet and infra-red radiation are not normally felt until some time after exposure. Radiation from lasers and from electron beam processes are less obvious than from electric welding arcs but both are serious hazards.

Radiation may also be emitted during non-destructive testing of welds, mainly when radiographic examinations are conducted which use either an X-ray or gamma ray source.

Eye disorders and skin burns may be caused by exposure to intense ultraviolet and infra-red radiation in welding operations. Exposure to the eyes causes ‘arc eye’ or ‘welders flash’ which is a painful inflammation of the cornea. The cornea can repair itself in one to two days, however, if the cornea becomes infected it may lead to some loss of vision. Workers directly involved in the welding are at greatest risk, however, other workers in the workplace and passers-by could also be exposed to radiation.

**Control measures**

- Install non-flammable screens and partitions
- Use signs to warn that welding is occurring and that entry into the work area is not permitted unless personal protective equipment is worn
- Provide personal protective equipment including filter shades for goggles and face shields to protect the eyes from radiation. Gloves and other protective clothing should be worn to cover exposed skin.

3.2 Electrical hazards

Using electrical welding equipment involves a risk of electric shock or electrocution. Exposure to electromagnetic fields is also a potential hazard for workers with some medical conditions.

**Electric shock**

Electric shock can result in serious burns and death by electrocution. Electric shock can occur through direct contact with the electrode, live parts, the work piece, or through contact with a device such as an unearthed cable, lead or tool.

---

A person conducting a business or undertaking must manage risks associated with electrical hazards. This includes ensuring that any unsafe electrical equipment is disconnected from its electricity supply.

All portable electrical equipment and electrical equipment that is used in an environment that could damage the equipment (through moisture, heat, vibration, mechanical damage, corrosive chemicals or dust) requires earth leakage current protection by means of a residual current device (RCD).

The output of electrical welder should be protected by a voltage reduction device (VRD) to reduce the risk of electrocution.
Control measures

- De-energise the power source when removing or changing an electrode by:
  - installing a safety cut-out switch
  - disconnecting the handpiece powers supply cables, or
  - switching off the welding machine (for example, caddy type machine)
- Use fully insulated electrode holders. The holder should never be dipped into water to cool, or be placed on conductive surfaces
- Prevent electricity passing through the body while changing the electrode by not leaning or contacting the structure being welded.
- Prevent contacting electrodes or welding wire with bare hands or moist leather gloves when in the holder or welding gun (wear dry welding gloves), and ensure that holders or welding guns are never held under the armpits
- Prevent holders or electrodes coming into contact with any other person
- Ensure the working area does not have any potentially live structures, components or wet areas
- Maintain all equipment in good condition, including power switches, terminals, connections, cables and insulation. Only competent people, such as licensed electricians, should carry out electrical repairs.

The working environment should be designed to minimise the risk of electric shock. For example, welding workspaces can be insulated and air-conditioned to prevent workers from perspiring as perspiration is a conductor of electricity. The working environment should be classified in regard to the risk as specified by Section 2.2 of AS1674.2 2007.

Table 2 below lists several ways to reduce the risk of electric shock when carrying out welding and allied processes.

Table 2: Procedures to reduce the risk of electric shock

<table>
<thead>
<tr>
<th>Work phase</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before welding or allied process:</td>
<td>Become familiar with the procedures and emergency plans for your workplace and make sure you understand how to perform welding and allied processes safely and what you need to do if a person suffers an electric shock</td>
</tr>
<tr>
<td></td>
<td>Avoid working in an environment that is damp, humid or wet or where a worker may be exposed to rain</td>
</tr>
<tr>
<td></td>
<td>Check the condition of the equipment is well maintained. For example, conductors should be well insulated to prevent contact with live conductors</td>
</tr>
<tr>
<td>During welding or allied process:</td>
<td>Avoid working alone</td>
</tr>
<tr>
<td></td>
<td>Avoid leaning against the material or structure during the welding process</td>
</tr>
<tr>
<td></td>
<td>Wear personal protective equipment such as both welding gloves and rubber insulated shoes while working</td>
</tr>
<tr>
<td></td>
<td>Stand, lay or sit on non-conducting material while carrying out welding or allied processing work</td>
</tr>
<tr>
<td></td>
<td>Always keep the welding machine terminals and cable connections clean and tight and only use welding cables that are fully insulated for their entire length</td>
</tr>
<tr>
<td></td>
<td>Avoid perspiration by allowing time to dry equipment and clothing during breaks, changing clothing, using ventilators and using an air fed welding mask</td>
</tr>
<tr>
<td></td>
<td>Do not change electrodes with bare, perspiring hands or touch either the bench or the work piece</td>
</tr>
</tbody>
</table>
Do not connect or change welding cables before switching off the power at the mains.

Use shut down mechanisms such as fuses, low voltage safety switches or residual current devices on equipment. Where devices have an earth (ground) connection, it is essential it is connected at all times.

After welding or allied process:

Use a voltage reducing device to reduce the open circuit voltages to a safe level.

Check the condition of all equipment after use and report any hazards.

Further information about electrical safety is available in *Welding Electrical Safety*, WTIA Technical Note No. 22, published by the Welding Technology Institute of Australia.

**Electromagnetic fields**

Electric arc welding and cutting produce strong electric and magnetic fields close to the power source and around the current-carrying cables. Electromagnetic fields can disrupt the operation of pacemakers, permanent defibrillators or other medical devices which could cause the heart to stop or slow down. A worker will not be aware of a magnetic field hazard unless a heart pacemaker or other device is behaving irregularly.

Electromagnetic fields can also occur wherever power is being generated and near transmission lines. Before work near these facilities begins, you should check with the electricity supply company to ensure work will not affect the supply of power or if there are any special precautions welders need to take when working in those areas.

You should determine what equipment generates strong electromagnetic fields and find out if workers have pacemakers or other medical devices that may be affected by electromagnetic fields. When assessing risk, consider how workers use equipment and how close the worker will be to equipment that can generate strong electromagnetic fields. The further the magnetic field is from the body, the weaker it will be.

**Control measures**

- Use barriers to isolate people who are not directly involved in welding from the working area.
- Signs indicating there are strong electromagnetic fields should be used to alert people to risks.
- Workers should not stand close to the power source or drape the welding cable around their body.
- Workers with pacemakers or other susceptible devices should be able to substitute work that involves exposure to electromagnetic fields for another type of welding process, such as performing oxy-fuel welding instead of electric arc welding. Seek medical advice before exposing a worker wearing such a device to welding related electromagnetic fields.
- If arc cutting is being performed, it should be carried out at a safe distance from sensitive electronic equipment with the cutting power source appropriately grounded.

### 3.3 Fire and explosion

Welding and allied processes generate heat, flames and sparks—all of which are sources of ignition. When combined with sources of fuel and oxygen, sources of ignition present a significant risk of fire and explosion.
You must identify all sources of ignition, such as other processes associated with welding, for example grinding, which can also generate heat, flames and sparks.

Common sources of fuel that can be found in workplaces include flammable and combustible materials such as, flammable gases, (for example, hydrogen, methane (natural gas), liquefied petroleum gas (for example, barbeque gas), flammable liquids (for example, mineral turpentine, petrol), combustible liquids (for example, oils) and materials such as wood, leaves, cardboard boxes and flammable metal or self-burning dusts. Neighbouring properties may have containers of fuel, flammable liquids and dried grass or leaves which also can present a hazard to your workplace if these sources ignite.

The risk of fire and explosion could be increased by exposure to dust or an oxygen rich atmosphere at your workplace. Fires in oxygen rich atmospheres are very difficult to extinguish. When oxygen comes in contact with oil, grease, other hydrocarbons or oil based substances, it can spontaneously ignite and result in a fire or explosion. For example, containers with potentially flammable materials and pressurised cylinders, pipes or vessels should never be cut.

A workplace atmosphere is considered hazardous if the concentration of a flammable gas, vapour, mist or fume is more than five per cent of the lower explosive limit for the gas, vapour, mist or fume. The criteria for classification of hazardous areas are described in AS/NZS 60079 (series) - Explosive atmospheres and AS/NZS 61241.10 - Electrical apparatus for use in the presence of combustible dust – classification of areas where combustible dusts are or may be present. You may need to develop specific procedures for welding work in a hazardous atmosphere or hazardous area. For example, the WHS Regulations requires a ‘confined spaces entry permit’ for work in a confined space. When welding in an area that is not a confined space, you should still document specific procedures which should include the issue of a ‘hot work permit’.

Control measures

- Isolate ignition sources from fuel sources.
- Drums, vessels and tanks which are to be welded must be purged of all traces of flammable or combustible material prior to welding, or filled with an inert substance such as nitrogen gas or water.
- Use fire resistant barriers to prevent welding sparks accidently reaching flammable and combustible materials when welding indoors or outdoors.
- Ensure work areas are well ventilated to prevent accumulation of flammable vapours in the work area.
- Use flash back arrestors on gas hoses to prevent the flame travelling back and igniting the gas in the cylinders.
- Drain and purge equipment, such as gas hoses, immediately after use.
- Do not store flammable and combustible materials near the welding work area.
- Keep fire fighting equipment near the welding work area.
- Ensure that the area where the welding is being undertaken does not contain material that could produce a dust explosion e.g. grain, etc.
3.4 Burns and exposure to heat

Burns are one of the most common injuries in welding. The temperature of a welding arc can reach 6000 degrees Celsius. The intense ultraviolet and infra-red rays can be harmful to both the welder and anyone else nearby. Burns occur frequently on hands and skins, but also in eyes from sparks and metal fragments. The symptoms of exposure to this level of heat are similar to extreme sunburn.

Control measures
Isolate workers from contacting hot work pieces, for example, carrying out post-weld heat treatment in areas where work pieces cannot be accidently touched.

Equipment, metals, plates or items likely to be hot in the welding area should be marked or labelled as hot to minimise accidental burns. Contact with heated surfaces can be avoided by using thermal insulating materials and wearing personal protective equipment.

Heat

Welding and allied processes can often produce heat at a level that creates an uncomfortable and hazardous working environment. Exposure to extreme heat is particularly hazardous when working outdoors in direct sunlight, on hot days and in confined spaces. Wearing personal protective equipment can also restrict air movement and sweat evaporation which can make a worker’s immediate environment hot.

Working in a hot environment can be hazardous and can cause heat rash, heat stress, heat stroke and result in permanent injury or death. Heat stress can occur gradually and has a range of symptoms. While discomfort, dehydration and sweating can be easily noticed by a worker, symptoms such as lack of concentration, fatigue, lethargy and confusion are less noticeable.

Control measures
Ventilate work areas to reduce the build up of heat in the workplace.

Workers should drink cool drinking water and take regularly scheduled rest breaks.

Workers should also be familiar with safe working practices in order to avoid exposure to extreme heat. For example, when working with a plasma arc, workers should keep away from the torch tip and not grip materials near the cutting path.

3.5 Compressed and liquefied gases

Compressed and liquefied gases are used as fuel, a source of oxygen or as shielding gases in certain types of welding. Cylinders contain large volumes of gas under high pressure and precautions need to be taken when storing, handling and using cylinders.

The hazards associated with compressed and liquefied gases include fire, explosion, toxicity, asphyxiation, oxidisation and uncontrolled release of pressure. Gas leakage is particularly one of
the greatest hazards. Leaking fuel gas is usually recognised by odour; however, oxygen leaks are potentially more dangerous as they are usually not recognised easily.

**Control measures**

- Ensure that cylinders are stored and handled in accordance with AS 4332-2004 – *The storage and handling of gases in cylinders*.
- Maintain cylinders to ensure that there are no leaks or dents
- Store cylinders in an upright position to ensure the safety device functions correctly
- Secure cylinders to prevent dislodgement
- Ensure flashback arrestors on hoses are tested at periodic intervals (at least every 12 months)
- Keep the cylinder valve closed when the cylinder is not being used, and
- Keep all sources of heat and ignition away from gas cylinders, even if the cylinders do not contain flammable material.

If a small leak occurs, close the cylinder valve if possible. The area should be well ventilated and air conditioning systems should be turned off to avoid spreading gas. However, if a large amount of gas escapes, emergency procedures should be implemented.

**Asphyxiation hazards**

Asphyxia is a condition that occurs where there is lack of oxygen. All gases, including fuel gases (for example, hydrogen, acetylene and liquid petroleum gas) and inert gases (for example, argon, helium and nitrogen) are an asphyxiation hazard in high concentrations.

Too little oxygen in the air that we breathe can cause fatigue and in extreme cases death. Using compressed and liquefied gases can result in dangerously low levels of oxygen, either through consumption of oxygen in the air (burning of fuel) or where an accumulation of gases displaces oxygen in air. For example, gases that are heavier than air can accumulate in low lying areas such as pits, wells and cellars and gases that are lighter than air can accumulate in high areas, for example roof spaces and lofts.

In welding and allied processes, asphyxiation commonly occurs from gas slowly leaking in a work area.

**Control measures**

- To prevent leaks, oxygen, hydrogen, carbon dioxide and inert gas cylinders should be fitted with a bursting disc safety device and liquid petroleum gas cylinders should have an operational spring-loaded pressure relief valve.
- Avoid work being carried out in oxygen-enriched (over 23 per cent) or oxygen-depleted (under 19 per cent) atmospheres
- Keep the work area well ventilated, particularly in low lying areas and roof spaces where gases can accumulate
- Use an air supplied respirator, particularly in confined spaces
- Monitor the atmosphere in the confined space to ensure it is free of harmful contaminants and contains an adequate oxygen level
- Ensure cylinder fittings, hoses and connections are not damaged or in poor condition.

### 3.6 Compressed air

Compressed air can be hazardous, for example the sudden release of gas can cause hearing damage or even rupture an eardrum. Compressed air can also deeply penetrate the skin resulting in an air bubble in the blood stream known as an embolism. Even a small quantity of air or other gas in the blood can be fatal.
Control measures

- Train workers to handle compressed air properly and ensure that compressed air is not deliberately misused
- Inspect and maintain equipment regularly, including hoses and air receivers.

3.7 Noise

Exposure to excessive noise levels can cause permanent hearing loss. Equipment for performing welding and allied processes can generate varying levels and frequencies of noise that may exceed exposure standards. Plasma arc welding generally exceeds the noise levels generated by other welding processes and ranges between 98 to 112 dB(A).

A person conducting a business or undertaking must manage the risks of hearing loss associated with noise at the workplace, including ensuring that the noise a worker is exposed to at the workplace does not exceed the exposure standard for noise.

Audiometric testing must be provided to a worker who is frequently required to use personal hearing protectors to protect the worker from hearing loss associated with noise that is above the exposure standard.

The exposure standard for noise in relation to hearing loss, is defined in the WHS Regulations as an L_{Aeq,8h} of 85 dB(A) or an L_{C,peak} of 140 dB(C). There are two parts to the exposure standard for noise because noise can either cause gradual hearing loss over a period of time or be so loud that it causes immediate hearing loss.

The most effective control measure is to remove the source of noise completely, for example, by replacing a noisy welder or exhaust with a quieter one. If this is not possible, modify equipment and processes to reduce the noise, or isolate the source of noise from people by using distance, barriers, welding bays and sound absorbing surfaces (types of engineering controls). If these measures are not reasonably practicable, implement administrative controls which limit the amount of noise people are exposed to and how long they are exposed to it. Lastly, personal hearing protection must be provided to protect workers from any remaining risk.

Further guidance about controlling noise in the workplace is available at Code of Practice: Managing Noise and Preventing Hearing Loss at Work.

3.8 Airborne contaminants

Welding and allied processes can generate fumes, mists, dust, vapours and gases, including ozone. The amounts and types of fumes produced vary greatly depending on the process involved and the materials being used such as metals, solvents, flux, paint and plastics. The health effects of exposure to fumes, dust, vapour and gases can vary. Effects can include irritation of the upper respiratory tract (nose and throat), tightness in the chest, asphyxiation, asthma, wheezing, metal fume fever, lung damage, bronchitis, cancer, pneumonia or emphysema.

A person conducting a business or undertaking must manage the risks associated with using, handling, generating or storing a hazardous chemical at a workplace. This includes ensuring that hazardous chemicals are correctly labelled and that workers can access current safety data sheets.

Some welding fumes are easy to see, however, many gaseous fumes and vapours are invisible. Generally, fewer fumes are generated from gas welding and cutting than from electric welding and cutting processes. Also, intense ultraviolet radiation emitted from arcs may give rise to significant quantities of ozone which can travel significant distances from an arc, especially in reflective
environments. Appendix A contains information about fumes that are commonly released during welding and allied processes.

To determine the risk of exposure to fumes during welding and allied processes you should identify what equipment and materials are being used and the level of fumes, dust, vapour and gases generated. For example, phosphine is generated when steel that is coated with a rust proofing compound is welded. High concentrations of phosphine gas are irritating to the eyes, nose and skin. The substance can have detrimental effects on the lungs and other organs. In order to prevent exposure to phosphine in this circumstance, you would first identify that rust proofed steel in the material that will be welded.

**Exposure standards**

Exposure standards refer to airborne concentrations of a substance (whether as a fume, mist, dust, vapour or gas) under which it is considered nearly all workers can be repeatedly exposed five days a week for eight hours a day throughout their working life, without adverse health effects.

A person conducting a business or undertaking must ensure that no person at the workplace is exposed to a substance or mixture in an airborne concentration more than the exposure standard for the substance or mixture.

Exposure standards are listed in the *Workplace Exposure Standards for Airborne Contaminants*. These do not represent levels at which every worker can be guaranteed protection, therefore you should ensure that the level of exposure to any hazardous chemical is kept as low as is reasonably practicable. This includes exposure to hazardous chemicals that do not have declared exposure standards.

**Air monitoring**

A person who conducts a business or undertaking at a workplace must ensure that air monitoring is carried out to determine the airborne concentration of hazardous chemicals if:

- there is uncertainty whether the airborne concentration of the hazardous chemical is more than the exposure standard, or
- monitoring is necessary to determine whether there is a risk to health.

Air monitoring is the sampling of workplace atmospheres to obtain an estimate of workers’ potential inhalation exposure to hazardous chemicals. Air monitoring can be used:

- to indicate whether exposure standards are being exceeded or approached
- when there is uncertainty about the level of exposure
- to help with the risk assessment process, and
- to test the effectiveness of the control measures.

The air samples should be collected by a competent person, such as an occupational hygienist.

If monitoring identifies that the exposure standard is being exceeded, the control measures must be reviewed and any changes made.

You must ensure that the results of monitoring are recorded and are available to any worker who may have been exposed to the hazardous chemical. The records must be kept for 30 years after the date the record is made. Records must be kept for so long because some diseases, including cancer, can take a long time to develop after exposure.
Control measures

- Eliminate, so far as is reasonably practicable, any exposure to airborne contaminants that are hazardous chemicals.
- If it is not reasonably practicable to eliminate risk, risks can be minimised by:
  1. substituting a hazardous chemical with a less hazardous one
  2. reducing the quantity of a hazardous chemical that is used, handled or stored at the workplace
  3. isolating the source of exposure to the hazardous chemical, for example, welding in isolation booths away from others
  4. using engineering controls, for example, installing ventilation systems to remove airborne contaminants, or
- Implement administrative controls, for example procedures to handle hazardous chemicals safely
- Provide appropriate respiratory protection

Check the safety data sheet for welding rods and wires to identify which gases and fumes are released during welding. Further information about controlling airborne contaminants is available in the Fume Minimisation Guidelines, published by the Welding Technology Institute of Australia.

Lead

Lead can become an airborne contaminant when soldering and welding materials. A welder may be exposed to lead when welding on steel painted with leaded paints, on leaded steel, flame cutting of batteries and materials contaminated with lead (for example, old automotive mufflers). The major risk associated with lead is lead poisoning (plumbism). This affects the blood system and can cause anaemia. Other symptoms include abdominal pain, convulsions, hallucinations, coma, weakness, tremors, possible increased cancer risk, and reduced fertility. Lead exposure during pregnancy is a particular concern.

Where a process by which electric arc, oxyacetylene, oxy gas, plasma arc or a flame is applied for welding, cutting or cleaning, to the surface of metal coated with lead or paint containing more than 1% by dry weight of lead metal, the WHS Regulations requires a person conducting a business or undertaking to provide workers with information about the risks and toxic effects associated with the exposure with lead, monitor the health of the worker and put in place risk control measures.

When lead work is being performed, you should ensure that lead is confined to a process area, the process area is kept clean, workers are provided with changing, washing and laundering facilities and processes. It is also important to ensure that no person eats, drinks or smokes in the lead process area.

3.9 Other hazards

Confined spaces

A person conducting a business or undertaking must manage the risks associated with a confined space including risks of entering, working in, on or near a confined space (including a risk of a person inadvertently entering the confined space).

The WHS Regulations include specific requirements to the control the risks of working in a confined space.
Hazards that may be encountered in a confined space include, but are not limited to:

- chemical agents including combustible gases or vapours, toxic gases or vapours, combustible or toxic liquids or solids, or potentially explosive dusts
- oxygen deficiency or excess, and
- physical agents including thermal extremes, radiation, noise or flooding.

Further guidance on how to work safely in confined spaces is available in the *Code of Practice: Confined Spaces*.

**Working at heights**

A person conducting a business or undertaking must manage the risk of a fall from one level to another that is reasonably likely to cause injury to the person or another person.

In managing the risks of falls, the WHS Regulations require the following specific control measures to be implemented where it is reasonably practicable to do so:

1. eliminate the need to work at heights by performing welding and allied processes at ground level
2. carry out the work on solid construction that includes a safe means of access and egress
3. minimise the risk of fall by providing and maintaining a safe system of work including:
   - using fall prevention devices (for example, temporary work platforms and guard railing) or
   - work positioning systems (for example, industrial rope access systems), or
   - fall arrest systems such as catch platforms.

In some cases, a combination of control measures may be necessary, for example, using safety harnesses while working from an elevating work platform.

Welding and allied processes should not be carried out on ladders. There is a risk of falls due to the limited visibility of the welder and heat from the welding process may damage aluminium ladders.

Further guidance about working at heights is available in the *Code of Practice: How to Prevent Falls at the Workplaces*.

**Manual tasks**

Welding and allied processes may result in back strain from lifting or pushing and muscle strain from working in awkward positions.

A person conducting a business or undertaking must manage the risk of a musculoskeletal disorder associated with hazardous manual tasks.

Ways of reducing the risk of musculoskeletal disorders include:

- designing the layout of the work area and positioning the work piece in a way that allows workers to adopt a comfortable position, and
- reducing the amount of force necessary to perform tasks, such as using rigging to lift heavy work pieces and using trolleys to transport cylinders.

Further guidance on how to manage the risks of hazardous manual tasks is available in the *Code of Practice: Hazardous Manual Tasks*. 
4. WELDING AND ALLIED PROCESSES EQUIPMENT

4.1 Ventilation

Ventilation can remove heat from the environment and reduce exposure to fumes and other atmospheric contaminants in the work area.

There are three main types of ventilation:
- local exhaust ventilation
- forced dilution ventilation, and
- natural dilution ventilation.

The choice of ventilation system should take into account:
- the amount and type of fumes and contaminants produced
- the proximity and location of the welding process relative to the ventilation system
- the level of ventilation, natural or mechanical, both for the whole workplace and the welding area – this will also depend on screens and partitions which may restrict cross-flow at the work area, and
- the proximity of the welder’s breathing zone to the fume source.

**Local exhaust ventilation**

A local exhaust system normally comprises:
- a hood which captures the contaminant close to its point of generation
- a duct system to move contaminant away from the work area
- an air cleaning system to prevent pollution of the general atmosphere
- an exhaust fan to provide air flow, and
- a stack or other means of discharging the decontaminated air into the atmosphere.

Local exhaust ventilation systems should be designed to provide a minimum capture velocity at the fume source of 0.5m/second away from the welder. Inlets and outlets should be kept clear at all times. Air from a local exhaust ventilation system should not be re-circulated into the workroom. This air should be discharged into the outside air away from other work areas and away from air conditioning inlets or compressors supplying breathing air.

Examples of local exhaust ventilation suitable for welding operations include:
- fixed installations, such as side-draught or down-draught tables and benches, and partially or completely enclosed booths
- portable installations, such as movable hoods that are attached to flexible ducts (for example, see Figure 1), and
- low volume high velocity fume extractors attached directly to the welding gun (for example, see Figure 2).

**Forced dilution ventilation**

An elevated concentration of atmospheric contaminants can be diluted with a sufficient volume of clean air. Successful dilution ventilation depends not only on the correct exhaust volume but also on control of the airflow through the workplace. Although forced dilution ventilation systems are not as effective in controlling atmospheric contaminants as local exhaust ventilation systems, they may be useful to control minor emissions of low toxicity contaminants.
Natural ventilation

Natural ventilation should only be used for general comfort and should not be used as a control for atmospheric contaminants and fumes. This is because natural ventilation is not a reliable way of diluting or dispersing contaminants. For example, if a welder is working in a fixed position and the natural wind direction is mild, the worker may remain exposed to contaminants that have not been removed from the working area.
### 4.2 Personal protective equipment (PPE)

In most cases PPE must be worn by workers when welding to supplement higher level controls such as ventilation.

Remember that PPE worn by workers may increase the risk of a musculoskeletal disorder and other injury due to thermal discomfort, reduced visual and hearing capacity.

If personal protective equipment (PPE) is to be used at the workplace, the person conducting the business or undertaking must ensure that the equipment is:

- selected to minimise risk to health and safety
- suitable for the nature of the work and any hazard associated with the work
- a suitable size and fit and reasonably comfortable for the person wearing it
- maintained, repaired or replaced so it continues to minimise the risk
- used or worn by the worker, so far as is reasonably practicable.

A worker must, so far as reasonably able, wear the PPE in accordance with any information, training or reasonable instruction.

The types of PPE recommended for use in welding are summarised in the table below:

<table>
<thead>
<tr>
<th>PPE type</th>
<th>Hazards</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| Eyes, face and head protection (e.g. goggles, helmets, hand shields and protective filters) | Light, radiation, burns from hot debris and sparks                      | - Workers should always have their eyes, face and/or head protected whenever they are welding.  
- Protection should comply with AS/NZS 1338 (series) - Filters for eye protectors, AS/NZS 1338.1-1992 - Filters for eye protectors - Filters for protection against radiation generated in welding and allied operations and AS/NZS 1336-1997 - Recommended practices for occupational eye protection. |
| Hearing protection (e.g. ear muffs and ear plugs) | Hearing loss                                                            | - Ear plugs or ear muffs may be required to control noise.  
- Protection should comply with AS/NZS 1270-2002 - Acoustics - Hearing protectors. |
| Gloves                                       | Heat, ultraviolet light and burns from hot debris and sparks            | - Gloves should be fire resistant and protect exposed skin on the hands and wrists.  
- Gloves should comply with AS/NZS 2161 (series) - Occupational protective gloves |
| Clothing (e.g. flame resistant long sleeved shirts, long trousers, aprons and leather spats) | Heat, ultraviolet light and burns from hot debris and sparks            | - Avoid clothing that has the potential to capture hot sparks and metals, for example in pockets or other folds. Clothing should be made of natural fibres.  
- Clothing should comply with AS/NZS 4502 (series) - Methods for evaluating clothing for protection against heat and fire. |
| Foot protection (e.g. boots and shoes)       | Hot metal debris, other metal debris and electric shock                 | - Foot protection should be non-slip and be heat and fire resistant. Avoid using foot protection that has the potential to capture hot sparks and metal debris, for example in laces or in open style shoes.  
### PPE type | Hazards | Recommendation
---|---|---
**Screens** | Exposure to the rays of an arc during electric welding operations | - Opaque or appropriate translucent screens can be used to protect the health and safety of people within the vicinity of welding.  
- Screens should comply with AS/NZS 3957-2006 - Light-transmitting screens and curtains for welding operations.

**Respiratory protective devices (face respirators and air supplied respirators)** | Dusts, hazardous fumes, gases and chemicals and oxygen depleted atmospheres | - Respirators must be fitted for each person individually and if one is to be used by another operator, it must be disinfected and refitted before use. The tightness of all connections and the condition of the face piece, headbands and valves should be checked before each use. Air supplied respirators may be required in some situations, e.g. confined spaces.  
- Protection should comply with AS/NZS 1716-2003 - Respiratory protective devices and be selected in accordance with AS/NZS 1715-2009 - Selection, use and maintenance of respiratory protective equipment.

![Figure 3: Welder wearing welding helmet, dry leather welding gloves and leather apron](image)

#### 4.3 Maintenance of equipment

You must ensure that any equipment used in welding and allied processes is adequately maintained.

Electrical equipment such as power sources, generators and welding machines and other devices like ventilation systems and equipment must be properly installed, maintained, repaired and tested.

Equipment used with compressed gases, including regulators, must be properly maintained to prevent hazards such as gas leaks. Persons with management or control of workplaces must ensure that gas cylinders are regularly inspected by a competent person. They should frequently check whether cylinders and regulators are visibly damaged or corroded, and whether they are within test date. Gas pipes, hoses and tubing can easily become damaged over time so these should also be inspected regularly.

PPE must be maintained to be in good working order and kept clean and hygienic. Some types of personal protective equipment have a limited life span and need to be replaced periodically, while other types of personal protective equipment may become damaged or ineffective if stored incorrectly. For example, some respirators and filters can absorb toxins and contaminants in the air.
when stored between use. PPE should be stored in a clean environment to avoid contamination or damage or according to instructions provided by the manufacturer.
This appendix contains information on types of fumes typically released during welding. Some of these substances have national exposure standards. You should refer to the Hazardous Substances Information System database on the Safe Work Australia website to determine if an exposure standard has been set: www.safeworkaustralia.gov.au

<table>
<thead>
<tr>
<th>Fume Type</th>
<th>Source</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>Aluminium component of some alloys, e.g., Inconels, copper, zinc, steel, magnesium, brass and filler materials.</td>
<td>Respiratory irritant.</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Hardening agent found in copper, magnesium, aluminium alloys and electrical contacts.</td>
<td>“Metal Fume Fever.” A carcinogen. Other chronic effects include damage to the respiratory tract.</td>
</tr>
<tr>
<td>Cadmium Oxides</td>
<td>Stainless steel containing cadmium or plated materials, zinc alloy.</td>
<td>Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.</td>
</tr>
<tr>
<td>Chromium</td>
<td>Most stainless-steel and high-alloy materials, welding rods. Also used as plating material.</td>
<td>Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium).</td>
</tr>
<tr>
<td>Copper</td>
<td>Alloys such as Monel, brass, bronze. Also some welding rods.</td>
<td>Acute effects include irritation of the eyes, nose and throat, nausea and “Metal Fume Fever.”</td>
</tr>
<tr>
<td>Fluorides</td>
<td>Common electrode coating and flux material for both low- and high-alloy steels.</td>
<td>Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs.</td>
</tr>
<tr>
<td>Iron Oxides</td>
<td>The major contaminant in all iron or steel welding processes.</td>
<td>Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.</td>
</tr>
<tr>
<td>Lead</td>
<td>Solder, brass and bronze alloys, primer/coating on steels.</td>
<td>Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning.</td>
</tr>
<tr>
<td>Manganese</td>
<td>Most welding processes, especially high-tensile steels.</td>
<td>“Metal Fume Fever.” Chronic effects may include central nervous system problems.</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Steel alloys, iron, stainless steel, nickel alloys.</td>
<td>Acute effects are eye, nose and throat irritation, and shortness of breath.</td>
</tr>
<tr>
<td>Nickel</td>
<td>Stainless steel, Inconel, Monel, Hastelloy and other high-alloy materials, welding rods and plated steel.</td>
<td>Acute effect is irritation of the eyes, nose and throat. Increased cancer risk has been noted in occupations other than welding. Also associated with dermatitis and lung problems.</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Some steel alloys, iron, stainless steel, nickel alloys.</td>
<td>Acute effect is irritation of the eyes, skin and respiratory tract. Chronic effects include bronchitis, retinitis, fluid in the lungs and pneumonia.</td>
</tr>
<tr>
<td>Zinc Oxides</td>
<td>Galvanized and painted metal.</td>
<td>Metal Fume Fever.</td>
</tr>
<tr>
<td>Source and Health Effect of Welding Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Gas Type</strong></td>
<td><strong>Source</strong></td>
<td><strong>Health Effect</strong></td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>Formed in the arc.</td>
<td>Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death.</td>
</tr>
<tr>
<td>Hydrogen Fluoride</td>
<td>Decomposition of rod coatings.</td>
<td>Irritating to the eyes and respiratory tract. Overexposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>Formed in the arc.</td>
<td>Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems such as emphysema.</td>
</tr>
<tr>
<td>Oxygen Deficiency</td>
<td>Welding in confined spaces, and air displacement by shielding gas.</td>
<td>Dizziness, mental confusion, asphyxiation and death.</td>
</tr>
<tr>
<td>Ozone</td>
<td>Formed in the welding arc during open arc welding processes including MMAW, FCAW, especially during plasma-arc, MIG and TIG processes.</td>
<td>Acute effects include fluid in the lungs. Very low concentrations (e.g., one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function.</td>
</tr>
<tr>
<td>Phosphine</td>
<td>Metal coated with rust inhibitors. (Phosphine is formed by reaction of the rust inhibitor with welding radiation.)</td>
<td>Irritant to eyes and respiratory system, can damage kidneys and other organs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source and Health Effect of Organic Vapours as a result of Welding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Type</strong></td>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>Aldehydes (such as formaldehyde)</td>
<td>Metal coating with binders and pigments. Degreasing solvents</td>
</tr>
<tr>
<td>Diisocyanates</td>
<td>Metal with polyurethane paint.</td>
</tr>
<tr>
<td>Phosgene</td>
<td>Metal with residual degreasing solvents. (Phosgene is formed by reaction of the solvent and welding radiation.)</td>
</tr>
</tbody>
</table>
**APPENDIX B – OTHER SOURCES OF INFORMATION**

*Health and Safety in Welding*, WTIA Technical Note No. 7, Welding Technology Institute of Australia – provides detailed guidance on managing risks associated with particular welding processes, including electric arc welding, gas welding, plasma arc welding, resistance welding, brazing, soldering, pre- and post-weld material treatments and metal spraying.


<table>
<thead>
<tr>
<th>Australian Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS 1335-1995</td>
<td>Hose and hose assemblies for welding, cutting and allied processes</td>
</tr>
<tr>
<td>AS/NZS 1336:1997</td>
<td>Recommended practices for occupational eye protection</td>
</tr>
<tr>
<td>AS/NZS 1337 (Series)</td>
<td>Personal eye protection</td>
</tr>
<tr>
<td>AS/NZS 1338: (Series)</td>
<td>Filters for eye protectors</td>
</tr>
<tr>
<td>AS/NZS 1596-2008</td>
<td>The storage and handling of liquefied petroleum gas</td>
</tr>
<tr>
<td>AS 1674.1-1997</td>
<td>Safety in welding and allied processes - Fire precautions</td>
</tr>
<tr>
<td>AS 1674.2-2007</td>
<td>Safety in welding and allied processes - Electrical</td>
</tr>
<tr>
<td>AS/NZS 1841(series)</td>
<td>Portable fire extinguishers</td>
</tr>
<tr>
<td>AS 1940-2004</td>
<td>The storage and handling of flammable and combustible liquids</td>
</tr>
<tr>
<td>AS/NZS 1668 (series)</td>
<td>The use of ventilation and air-conditioning in buildings</td>
</tr>
<tr>
<td>AS/NZS 2161 (series)</td>
<td>Occupational protective gloves</td>
</tr>
<tr>
<td>AS 2812-2005</td>
<td>Welding, brazing and cutting of metals - Glossary of terms</td>
</tr>
<tr>
<td>AS 2865-2009</td>
<td>Confined spaces</td>
</tr>
<tr>
<td>AS/NZS 3000-2007</td>
<td>Electrical installations (known as the Australian/New Zealand Wiring Rules)</td>
</tr>
<tr>
<td>AS/NZS 3017-2007</td>
<td>Electrical installations - Verification guidelines</td>
</tr>
<tr>
<td>AS/NZS 3195:2002</td>
<td>Approval and test specification - Portable machines for electric arc welding and allied processes</td>
</tr>
<tr>
<td>AS 3853-2006</td>
<td>Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operator’s breathing zone</td>
</tr>
<tr>
<td>AS/NZS 3957-2006</td>
<td>Light-transmitting screens and curtains for welding operations</td>
</tr>
<tr>
<td>AS 4267-1995</td>
<td>Pressure regulators for use with industrial compressed gas cylinders</td>
</tr>
<tr>
<td>AS 4289-1995</td>
<td>Oxygen and acetylene gas reticulation systems</td>
</tr>
<tr>
<td>AS 4332-2004</td>
<td>The storage and handling of gases in cylinders</td>
</tr>
<tr>
<td>AS 4603-1999</td>
<td>Flashback arresters - Safety devices for use with fuel gases and oxygen or compressed air</td>
</tr>
<tr>
<td>AS 4839-2001</td>
<td>The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes</td>
</tr>
<tr>
<td>AS 60974.1-2006</td>
<td>Arc welding equipment - Welding power sources</td>
</tr>
<tr>
<td>AS/NZS 60079 (series)</td>
<td>Explosive atmospheres</td>
</tr>
</tbody>
</table>