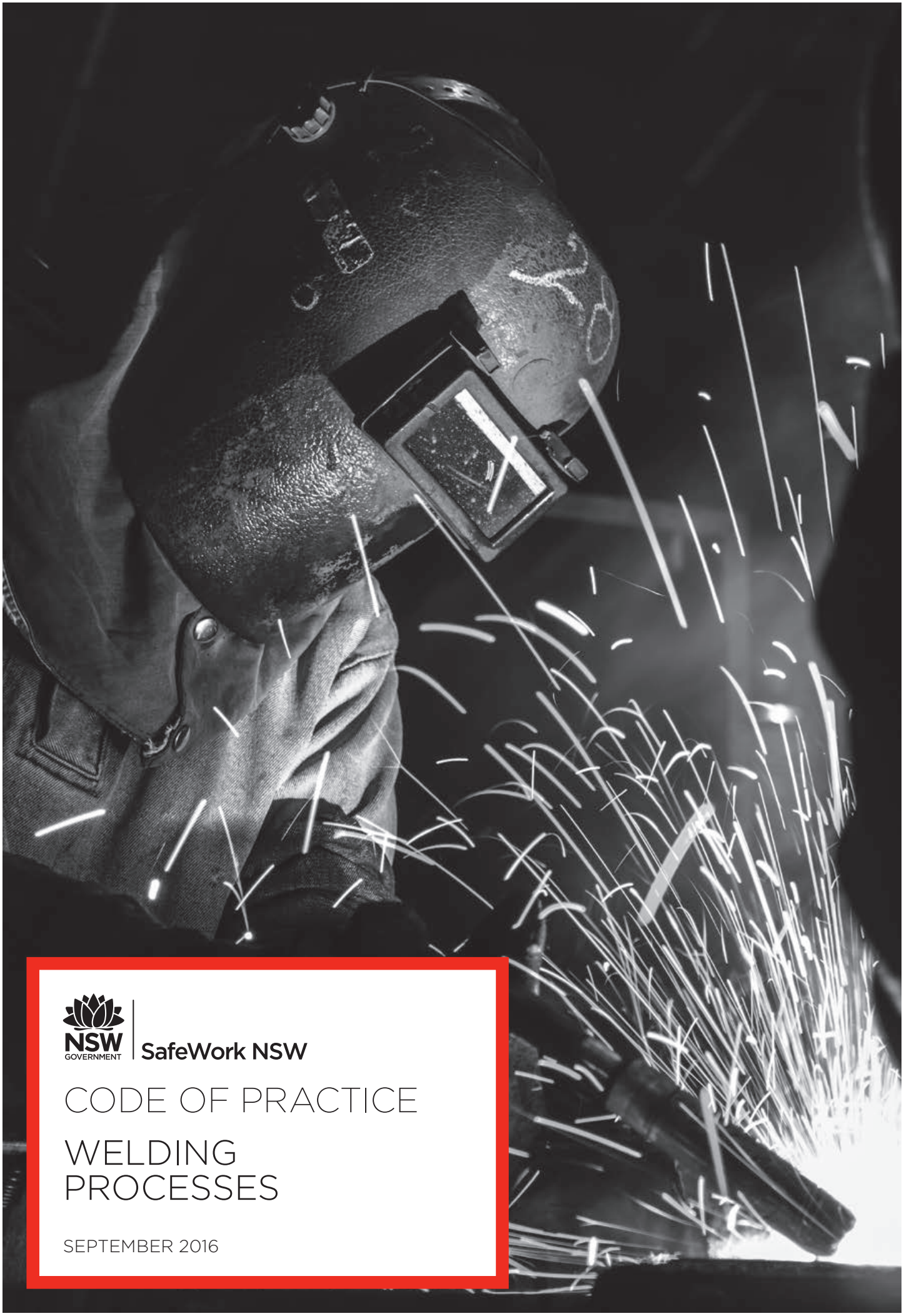

NSW GOVERNMENT | SafeWork NSW

CODE OF PRACTICE

WELDING PROCESSES

SEPTEMBER 2016

NSW note: This code is based on a national model code of practice developed by Safe Work Australia under the harmonisation of national work health and safety legislation and has been approved under section 274 of the NSW *Work Health and Safety Act 2011*. Notice of that approval was published in the NSW Government Gazette referring to this code of practice as *Welding processes code of practice* on 18 July 2014. This code of practice commenced on 18 July 2014. Subsequent amendments under section 274 (2) of the NSW *Work Health and Safety Act 2011* have been published and commenced as detailed in the list of amendments contained in this code.

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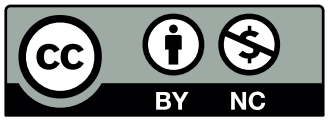

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Foreword

This Code of Practice on welding 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 that 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.

Scope and application

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

Although this Code focuses on welding processes, it may also be relevant to manage the risks associated with allied processes. Welding and allied processes involve similar hazards and in some cases the same risk control measures can be implemented. There are many different types of allied processes including metal preparation, metal cutting, gouging, brazing and soldering that need specific control measures. For more guidance on allied process control measures refer to *Health and Safety in Welding WTIA Technical Note No. 7*.

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 is welding?

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, for example can be welded together using a suitable heat source to form permanent joins.

Many different energy sources can be used for welding including gas flames, electric arcs, electric resistance, lasers, electron beams, friction, molten metal baths and ultrasound. Welding includes joining methods as diverse as fusion welding, forge welding, friction welding, braze welding, brazing, soldering and explosion welding. Welding is a potentially hazardous activity and precautions are required to avoid electrocution, fire and explosion, burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

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

A **person conducting a business or undertaking** has the primary duty 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.

A person conducting a business or undertaking that carries out welding activities must eliminate risks arising from welding, or if that is not reasonably practicable, minimise the risks so far as is reasonably practicable.

The WHS Regulations include more specific requirements to manage the risks of hazardous chemicals, airborne contaminants and plant, as well as other hazards associated with welding such as noise and manual tasks.

Designers, manufacturers, importers and suppliers of plant or substances used in welding must ensure, so far as is reasonably practicable, that the plant or substance they design, manufacture, import or supply is without risks to health and safety. This duty includes carrying out testing and analysis as well as 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.

Workers 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 co-operate with any reasonable policy or procedure relating to health and safety at the workplace. If personal protective equipment is provided by the person conducting the business or undertaking, the worker must use it in accordance with the information, instruction and training provided.

1.3 What is required to manage risks associated with welding processes?

The WHS Regulations require a person conducting a business or undertaking to 'manage risks' associated with specific hazards, including noise, hazardous chemicals, confined spaces, plant and electricity.

Regulation 32–38

In order to manage risk under the WHS Regulations, a duty holder must:

- *identify reasonably foreseeable hazards that could give rise to the risk*
- *eliminate the risk so far as is reasonably practicable*
- *if it is not reasonably practicable to eliminate the risk – minimise the risk so far as is reasonably practicable by implementing control measures in accordance with the hierarchy of risk control*
- *maintain the implemented control measure so that it remains effective*
- *review, and if necessary revise all risk control measures so as to maintain, so far as is reasonably practicable, a work environment that is without risks to health and safety.*

This Code provides guidance on managing the risks of welding processes by following a systematic process that involves:

- identifying the hazards
- if necessary, assessing the risks associated with these hazards
- implementing control measures, and
- reviewing 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.

Section 47

A person conducting a business or undertaking must consult, so far as is reasonably practicable, with workers who carry out work for them and who are (or are likely to be) directly affected by a work health and safety matter.

Section 48

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 necessary 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 control measures.

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 they use and the potential hazards they face.

Consultation with workers can 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

Section 46

A person conducting a business or undertaking must 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 share responsibility for a health and safety matter with other business operators who are involved in the same activities or who share the same workplace. In these situations, you should exchange information 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 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 processes, 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*.

Information, training, instruction and supervision

Section 19

A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of any information, training, instruction, and supervision necessary to protect all persons from risks to their health and safety arising from work carried out.

Regulation 39

A person conducting a business or undertaking must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to:

- *the nature of the work carried out by the worker*
- *the nature of the risks associated with the work at the time of the information, training and instruction, and*
- *the control measures implemented.*

The person must also ensure, so far as is reasonably practicable, that the information, training and instruction is provided in a way that is readily understandable to whom it is provided.

The information, training and instruction that is provided to workers who carry out welding should include:

- the proper use, wearing, storage and maintenance of personal protective equipment (PPE)
- how to work safely in hazardous environments, such as a confined space
- first aid and emergency procedures
- how to access safety data sheet (SDS) for hazardous chemicals
- the nature of, and reasons for, any health monitoring if required.

2. The risk management process

2.1 Identifying the hazards

The first step in managing risks associated with welding processes is to identify all the hazards that have the potential to cause harm.

Welding and allied processes can have similar hazards and you can follow the same process to identify hazards. For example both welding and allied processes produces ultra violet and infra-red radiation which can cause burns, cancer and blindness.

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

- conducting a walk through assessment of the workplace observing the work and talking to workers about how work is carried out
- inspecting the materials and equipment that will be used during the welding process
- reading product labels, SDS and manufacturer's instruction manuals
- talking to manufacturers, suppliers, industry associations and health and safety specialists
- reviewing incident reports.

2.2 Assessing the risks

A risk assessment involves considering what could happen if someone is exposed to a hazard combined with the likelihood of it happening.

Under the WHS Regulations a risk assessment is not mandatory for welding however, it is required for specific situations, for example when working in a confined space.

In some circumstances, a risk assessment will assist to:

- identify which workers are at risk of exposure
- determine what sources and processes are causing that risk
- identify if and what kind of control measures should be implemented
- check the effectiveness of existing control measures.

Risks will depend on various factors, including the:

- properties of the materials being welded
- surface coating of the items being welded (for example whether they contain lead or other toxic materials)
- condition of the welding equipment
- conditions under which welding is carried out (for example, confined spaces)
- skills, competence and experience of the welder.

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

The following questions may help to assess the risk:

- In the event of exposure to the hazard, will the outcome be severe, moderate or mild?
- How often, and for how long, will exposure to the hazard occur?

2.3 Controlling the risks

The hierarchy of control measures

Some control measures are more effective than others. Control measures can be ranked from the highest level of protection and reliability to the lowest. This ranking is known as the *hierarchy of control*.

You must always aim to **eliminate a hazard** and associated risk first. For example, fabrications may be designed to include many pre-cast components or extruded shapes to eliminate the need to weld.

If this is not reasonably practicable, the risk must be minimised by using one or more of the following approaches:

- **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 and nearby workers 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 controls** – use engineering control measures to minimise the risk, for example, ventilation systems to remove welding fumes.

If risk then remains, it must be minimised by implementing **administrative controls**, so far as is reasonably practicable. For example, if a welding process takes place in a very hot environment, 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.

Any remaining risk must be minimised with suitable **personal protective equipment** (PPE). For example, if the welder has to stand on metallic surfaces that form part of the electric circuit it may become live. The use of rubber-soled boots will reduce the risk of electric shock.

Administrative control measures and PPE rely on human behaviour and supervision. If used on their own, they tend to be least effective in minimising risks.

A combination of these control measures may be required in order to adequately manage the risks with welding. You should check that your chosen control measure does not introduce new hazards.

Chapter 3 of this Code provides information on control measures for welding processes. Guidance on allied processes control measures can be found in *Health and Safety in Welding WTIA Technical Note No. 7*.

2.4 Reviewing control measures

The control measures that are put in place to protect health and safety should be regularly reviewed to make sure they are effective. 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 measure is not working effectively it must be revised.

Common review methods include workplace inspection, consultation, testing and analysing records and data.

If problems are found, go back through the risk management steps, review your information and make further decisions about controlling the risk.

3. Specific hazards and control measures

3.1 Airborne contaminants

Regulation 351

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.

Welding 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.

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

To determine the risk of exposure to fumes during welding 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 rust proofed steel in the material that will be welded.

For exposure to welding fumes, total fume concentrations as well as individual fume components should be considered.

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 the risk, measures to minimise it must be used. For example:
  - substituting a hazardous chemical with a less hazardous one
  - reducing the quantity of a hazardous chemical that is used, handled or stored at the workplace
  - isolating the source of exposure to the hazardous chemical, for example, welding in isolation booths away from others
  - using engineering control measures, for example, installing ventilation systems to capture or remove airborne contaminants. Refer to 4.1 of this code for more information on ventilation.
- Implement administrative control measures, for example procedures to handle hazardous chemicals safely.
- Provide appropriate respiratory protection.

Check the SDS 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.

Exposure standards

Regulation 49

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 that exceeds the exposure standard for the substance or mixture.

Exposure standards represent airborne concentrations of a particular substance or mixture that must not be exceeded. There are three types of exposure standard:

- 8-hour time-weighted average
- peak limitation
- short term exposure limit.

Exposure standards are based on the airborne concentrations of individual substances that, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers.

Chemicals with workplace exposure standards are listed in the *Workplace Exposure Standards for Airborne Contaminants*. These exposure standards are also available from the Hazardous Substances Information System (HSIS) on the Safe Work Australia website. The HSIS database contains additional information and guidance for many substances. Although exposure standards may also be listed in Section 8 of the SDS, you should always check the *Workplace Exposure Standards for Airborne Contaminants* or HSIS to be certain.

Guidance on interpreting exposure standards is available in the *Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants*.

To comply with the WHS Regulations, monitoring of workplace contaminant levels for chemicals with exposure standards may need to be carried out.

Monitoring airborne contaminant levels

Regulation 50

A person conducting a business or undertaking must ensure that air monitoring is carried out to determine the airborne concentration of a substance or mixture at the workplace to which an exposure standard applies if:

- *the person is not certain on reasonable grounds whether or not the airborne concentration of the substance or mixture at the workplace exceeds the relevant 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:

- when there is uncertainty about the level of exposure
- to indicate whether exposure standards are being exceeded or approached
- to test the effectiveness of the control measures.

Air monitoring should be carried out by a person such as an occupational hygienist with skills to carry out the monitoring according to standards and to interpret the results. Where monitoring of airborne contaminants is used to determine a person's exposure, the monitoring must be undertaken in the breathing zone of the person.

Monitoring should also be conducted in the breathing zones of other workers in the vicinity to ensure that they are not exposed to hazardous levels of fumes.

Results from air monitoring indicate how effective your control measures are, for example whether ventilation systems are operating as intended. If monitoring identifies that the exposure standard is being exceeded, the control measures must be reviewed and any necessary changes made.

Records of air monitoring for airborne contaminants with exposure standards must be kept for a minimum of 30 years and must be available to workers who are exposed.

Air monitoring cannot be used to determine a risk to health via skin contact of airborne chemicals.

3.2 Radiation

Radiation is energy travelling as waves of electromagnetic radiation or subatomic particles. Electric arc and laser welding emit ultraviolet, visible light and infra-red radiation. Gas welding emits visible light and infra-red radiation.

The potential effect of radiation on the body depends on the type, intensity, the distance you are from it and the duration of exposure. Eye disorders and skin burns may be caused by exposure to intense ultraviolet and infra-red radiation in welding. 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.

The effects of ultraviolet and infra-red radiation are not normally felt until sometime after exposure. Radiation from laser welding is less obvious than from electric welding arcs but both are serious hazards.

Workers directly involved in the welding process 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.
- If welding is being carried out, entry into the work area is not permitted unless safeguards are used such as PPE.
- Provide PPE 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.

3.3 Electrical risks

Regulation 147

A person conducting a business or undertaking must manage risks to health and safety associated with electrical risks at the workplace.

Regulation 149

This includes ensuring that any unsafe electrical equipment is disconnected from its electricity supply.

Regulation 150

A person conducting a business or undertaking must ensure that electrical equipment that is used in an environment in which the normal use of the electrical equipment exposes the equipment to operating conditions that are likely to result in damage or reduce the life of the equipment (through moisture, heat, vibration, mechanical damage, corrosive chemicals or dust) is inspected and tested regularly by a competent person.

Regulation 164

In such conditions the person conducting a business or undertaking must also ensure, so far as is reasonably practicable, that any electrical risk associated with the supply of electricity to the electrical equipment through a socket outlet is minimised by the use of an appropriate residual current device (RCD).

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 may result in serious burns or death by electrocution. Electric shock or electrocution can occur through direct contact with the electrode, live parts, the work piece, or through contact with a device such as an unearthed cable or tool. The risk of electric shock can be exacerbated through moisture and high humidity.

Control measures

- Use fully insulated electrode holders. The holder should never be dipped into water to cool, or be placed on conductive surfaces.
- Prevent contacting electrodes or welding wire with bare hands when in the holder or welding gun (wear dry welding gloves), and make sure that holders or welding guns are never held under the armpits.
- Prevent holders or electrodes coming into contact with any other person.
- Check the working area does not have any potentially live structures, components or wet areas.
- Install a RCD.
- Inspect all equipment to check that it is in good condition prior to use, including power switches, terminals, connections, cables and insulation.

The working environment should be designed to minimise the risk of electric shock. For example, areas where welding is undertaken, can be insulated and air-ventilated to prevent workers from perspiring as perspiration is a conductor of electricity.

Table 1 below lists several ways to minimise the risk of electric shock when carrying out welding.

Table 1: Procedures to minimise the risk of electric shock

Work phase	Procedure
Before welding	Become familiar with the procedures and emergency plans for your workplace and make sure you understand how to perform welding activities safely and what you need to do if a person suffers an electric shock.
	Do not work in an environment that is damp, humid or wet, or where a worker may be exposed to rain.
	Check the condition of the equipment is well maintained. For example, conductors should be well insulated to prevent contact with live conductors.
	Install shut down mechanisms such as fuses, low voltage safety switches or residual current devices on equipment.
During welding	In hazardous working environments avoid working alone.
	Use an appropriate hazard reducing device.
	Avoid leaning against the material or structure during welding.
	Wear personal protective equipment including welding gloves and rubber insulated shoes while working.
	Where practicable stand, lay or sit on non-conducting material while carrying out welding.
	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.
	Minimise perspiration by allowing time to dry equipment during breaks, changing clothing, gloves, using ventilators and using an air fed welding mask.
	Do not change electrodes by hand whilst simultaneously touching the bench or the work piece.
	Do not connect or change welding cables before switching off the power at the mains.
	Where devices have an earth (ground) connection, it is essential it is connected at all times.
After welding	Check the condition of all equipment after use and report any defects.

Further guidance about electrical safety is available in:

- Code of Practice: *Managing Electrical Risks at the Workplace.*
- *Welding Electrical Safety, WTIA Technical Note No. 22, published by the Welding Technology Institute of Australia.*
- AS 1674.2: *Safety in welding and allied processes – Electrical.*
- AS 60974.1: *Arc welding equipment - Welding power sources (Section 11 and 13 for hazard reducing devices).*

Electromagnetic fields

Electric arc welding produces 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 make sure work will not affect the supply of power or if there are any special precautions welders need to take when working in those areas.

Control measures

- Use barriers to isolate people who are not directly involved in the welding process.
- Use 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 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.

3.4 Fire and explosion

Regulation 52

A person conducting a business or undertaking must manage risks to health and safety associated with ignition sources in a hazardous atmosphere at the workplace that are not part of a deliberate workplace process or activity.

Regulation 53

A person conducting a business or undertaking must ensure that flammable or combustible substances kept at the workplace are kept at the lowest practicable quantity.

Welding generates 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 manage risks to health and safety associated with an ignition source in a hazardous atmosphere. This includes identifying 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, acetylene, 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 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.

Under the WHS Regulations an atmosphere is a hazardous atmosphere if the concentration of a flammable gas, vapour, mist or fume exceeds 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 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'. For further guidance about 'hot work' or 'hot work permit' refer to AS 1674.1: *Safety in welding and allied processes – Fire precautions*. You should also take into consideration the areas and businesses surrounding the workplace.

Control measures

- Isolate fuel sources from ignition sources.
- Purge all traces of flammable or combustible materials from drums, vessels and tanks which are to be welded prior to welding, and preferably 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.
- Check work areas are well ventilated to prevent accumulation of flammable vapours in the work area.
- Check work area is free from rubbish, paper or dust that could be potential fuel sources or produce dust explosions.
- Use flash back arrestors on gas hoses to prevent the flames travelling back and igniting the gas in cylinder.
- Drain and purge equipment, such as gas hoses, and lock the gas off at the valve immediately after use.
- Do not store flammable and combustible materials near welding area.
- Keep and maintain fire fighting equipment near welding area.

3.5 Burns and exposure to heat

Regulation 40

A person conducting a business or undertaking must ensure, so far as is reasonably practicable, workers carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety.

Regulation 209

Persons with management or control of plant must ensure, so far as is reasonably practicable, that any pipe or other part of the plant associated with heat or cold is guarded or insulated so that the plant is without risks to the health and safety of any person.

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 other exposed skin, 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.
- Mark or label as 'hot' equipment, metals, plates or items likely to be hot in the welding area to minimise accidental burns. Contact with heated surfaces can be avoided by using thermal insulating materials and wearing personal protective equipment.

Heat

Welding 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. Working in a hot environment can cause heat rash, heat stress, heat stroke and result in permanent injury or death. Heat stress is a serious medical condition and 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.

Wearing PPE can also restrict air movement and sweat evaporation which can make a worker's immediate environment hot.

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.

Control measures

- Ventilate work areas to reduce the build up of heat in the workplace.
- Workers should drink cool drinking water and take regular scheduled rest breaks.

Further information is available in the *Code of Practice: Managing the Work Environment and Facilities*.

3.6 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 a particular hazards. Leaking fuel gas is usually recognised by odour, however, oxygen leaks are harder to detect and therefore potentially more hazardous.

Control measures

- Store and handle cylinders appropriately. For further guidance refer to AS 4332: *The storage and handling of gases in cylinders*.
- Keep cylinders maintained free from leaks or dents.
- Store cylinders in an upright position to ensure the safety device functions correctly.
- Secure cylinders to prevent dislodgement.
- Flash back arrestors should be fitted at the blow pipe and regulator end of both the oxygen and fuel gas lines.
- Keep the cylinder valve closed when the cylinder is not being used.
- 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.

To ensure the controlled release of gas in an emergency situation, 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. Acetylene cylinders must be fitted with a fusible plug in the neck of the cylinder and must always be stored and used in an upright position.

Control measures

- Avoid work being carried out in oxygen-enriched (over 23 per cent) or oxygen-depleted (under 19.5 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 to check it is free of harmful contaminants and contains an adequate oxygen level. See 3.10 of this Code for more information about confined spaces.
- Check cylinder fittings, hoses and connections are not damaged or in poor condition.

3.7 Noise

Regulation 57

A person conducting a business or undertaking must manage the risk to health and safety relating to hearing loss associated with noise. The person conducting a business or undertaking must ensure that the noise a worker is exposed to at the workplace does not exceed the exposure standard for noise.

Regulation 58

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 exceeds the exposure standard for noise.

Exposure to high noise levels can cause permanent hearing loss. Equipment for performing welding can generate varying levels and frequencies of noise that may cause workers to be exposed to noise that exceeds the exposure standard. Specifically plasma arc welding generally exceeds the noise levels generated by other welding activity and ranges between 98 to 112 dB(A).

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. 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 control measures). If these measures are not reasonably practicable, implement administrative control measures 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 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 anemia. Other symptoms include abdominal pain, convulsions, hallucinations, coma, weakness, tremors and the possible increased risk of cancer. Lead exposure can also affect both male and female reproductive systems. A developing foetus is particularly at risk, especially in the early weeks before a pregnancy becomes known.

Under the WHS Regulations 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 per cent by dry weight of lead metal is defined as a **lead process**.

This means certain requirements in the WHS Regulations apply including identifying lead risk work and removing a worker from lead risk work in certain circumstances.

Regulation 395

A person conducting a business or undertaking that carries out lead processes must provide information about the lead process to:

- *a person who is likely to carrying out the lead process, before they are engaged, and*
- *a worker, before they commence carrying out the lead process.*

If work is identified as lead risk work after a worker commences the work, the person conducting a business or undertaking must give information about the lead process to the worker as soon as practicable after it is identified as lead risk work and before health monitoring of the worker is provided.

The information that must be given is about the health risks and toxic effects associated with exposure to lead. If the lead process involves lead risk work, information must also be given on the need for and details of health monitoring.

Control measures

The WHS Regulations require you to:

- ensure so far as is reasonably practicable that lead is confined to a lead process area at the workplace and that, the lead process area is kept clean
- ensure that methods used to clean a lead process area do not create a risk to health of persons in the immediate vicinity or have the potential to spread the contamination of lead
- take all reasonable steps to ensure that a person does not eat, drink, chew gum, smoke or carry materials used for smoking in a lead process area
- provide and maintain clean changing rooms, washing, showering and toilet facilities
- provide workers with eating and drinking facilities that, so far as is reasonably practicable, cannot be contaminated with lead from a lead process
- ensure that workers remove clothing and equipment that is or likely to be contaminated with lead and wash their hands and faces before entering an eating or drinking area.

The WHS Regulations also specify control measures for the laundering, disposal and removal of personal protective equipment that is likely to be contaminated with lead dust.

There are also specific notification requirements under the WHS Regulations for notifying the regulator within 7 days that lead risk work is being undertaken.

3.9 Other hazards

Confined spaces

Regulation 64

A person conducting a business or undertaking must manage the risks to health and safety associated with a confined space at a workplace including risks associated with entering, working in, on or in the vicinity of a confined space (including a risk of a person inadvertently entering the confined space).

Hazards that may be encountered in a confined space include:

- heat and fumes generated by welding
- 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
- 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* and section 4.1 of this Code.

Falls

Regulation 78

A person conducting a business or undertaking must manage the risks to health and safety associated with a fall by a person from one level to another that is reasonably likely to cause injury to the person or any another person.

The WHS Regulations require the following specific control measures to be implemented where it is reasonably practicable to do so:

- carry out the work on solid construction, that includes a safe means of access and egress
- if a fall risk cannot be eliminated, minimise the risk by providing and maintaining a safe system of work including:
  - using fall prevention devices (for example, temporary work platforms and guard railing)
  - work positioning systems (for example, fire resistant/flame proof 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 should not be carried out on ladders. There is a risk of injury from falls due to the limited visibility of the worker, instability when working on a ladder and risk of electrocution if an aluminium ladder is used in conjunction with electric welding. Ladders may also be damaged by welding.

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

Manual tasks

Regulation 60

A person conducting a business or undertaking must manage the risks to health and safety relating to a musculoskeletal disorder associated with hazardous manual tasks.

Welding may result in back strain from lifting or pushing and muscle strain from working in awkward positions. Additional hazards may arise from the use of personal protective equipment that restricts movement, grip and mobility.

Ways of minimising 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 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
- 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
- the proximity of the welder's breathing zone to the fume source.

Local exhaust ventilation

A local exhaust system may comprise the elements listed:

- 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
- 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)
- 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.

Figure 1

Local Exhaust ventilation in confined space welding

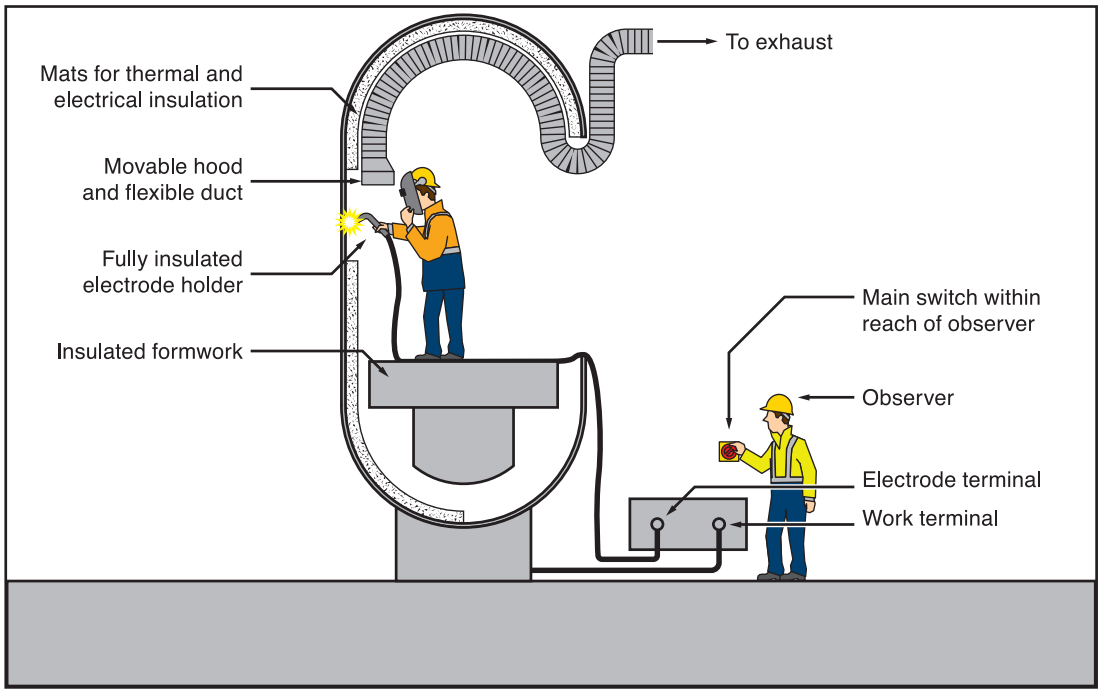
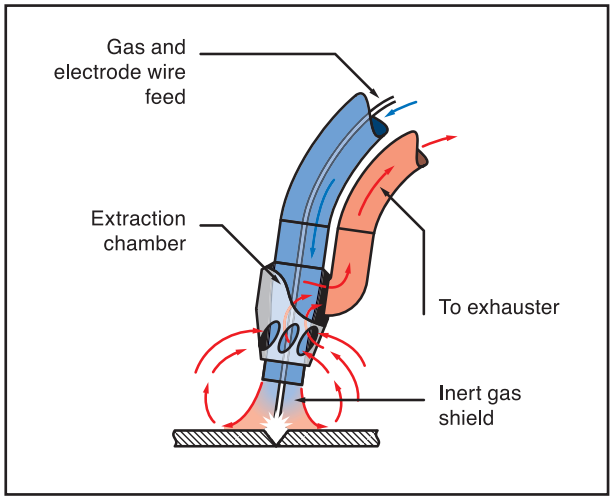


Figure 2

Fume extraction attached to the welding gun



Natural ventilation

Natural ventilation should only be used for general comfort not as an engineered control measure for atmospheric contaminants and fumes. Natural ventilation can assist with the transfer of contaminants from the work area however it is not a reliable way of diluting or dispersing contaminants. For example, if a worker is working in a fixed position and the natural wind velocity is mild or wind is in a direction towards the worker, the worker may remain exposed to contaminants that have not been removed from the worker's breathing zone.

4.2 Personal protective equipment (PPE)

Regulation 44

If personal protective equipment is to be used at the workplace, the person conducting the business or undertaking must ensure the equipment is selected to minimise risk to health and safety including by ensuring that the equipment is:

- *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, and*
- *used or worn by the worker, so far as is reasonably practicable.*

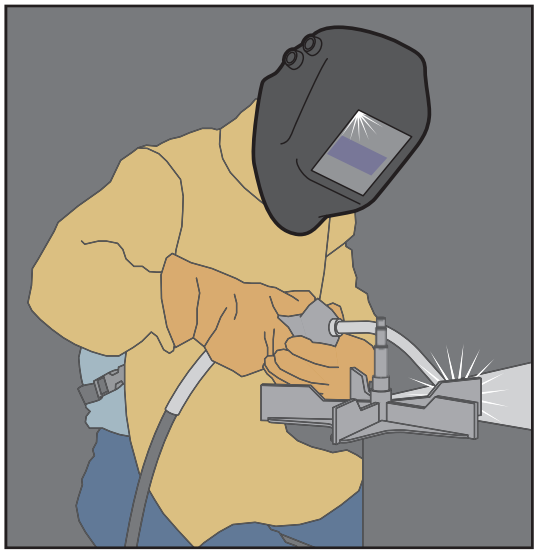
A person conducting a business or undertaking who directs the carrying out of work must provide the worker with information, training and instruction in the proper use and wearing of personal protective equipment; and the storage and maintenance of personal protective equipment.

A worker must, so far as reasonably able, wear the PPE in accordance with any information, training or reasonable instruction and must not intentionally misuse or damage the equipment.

In most cases PPE must be worn by workers when welding to supplement higher levels of controls such as ventilation systems or administrative controls (see Figure 3).

Figure 3

Welder wearing welding helmet, dry leather welding gloves and leather apron



When PPE is worn by workers, it should not introduce other hazards to the worker, such as musculoskeletal injuries, thermal discomfort, or reduced visual and hearing capacity.

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

PPE type	Hazards	Recommendation
Eyes, face and head protection (eg 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. • For further information refer to: AS/NZS 1338: *(series) Filters for eye protectors,* AS/NZS 1338.1: *Filters for eye protectors – Filters for protection against radiation generated in welding and allied operations* and AS/NZS 1336: *Recommended practices for occupational eye protection* and AS/NZS 1337: *Eye protectors for industrial applications*.
Hearing protection (eg ear muffs and ear plugs)	Hearing loss	• Ear plugs or ear muffs may be required to minimise the risks of noise. • For further information refer to: AS/NZS 1270: *Acoustics – Hearing protectors* and AS/NZS 1269.3: *Occupational noise management – Hearing protector program.*
Gloves/ gauntlets	Heat, ultraviolet light and burns from hot debris and sparks	• Gloves should be fire resistant and protect exposed skin on the hands and wrists. • For further information refer to: AS/NZS 2161: *(series) Occupational protective gloves.*
Clothing (eg 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. • For further information refer to: AS/NZS 4502: *(series) Methods for evaluating clothing for protection against heat and fire.*
Foot protection (eg 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. • For further information refer to: AS/NZS 2210: *(series) Occupational protective footwear* and AS/NZS 2210.1: *Safety, protective and occupational footwear – Guide to selection, care and use.*
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. • For further information refer to: AS/NZS 3957: *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 should 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, eg confined spaces. • For further information refer to: AS/NZS 1716: *Respiratory protective devices* and be selected in accordance with AS/NZS 1715: *Selection, use and maintenance of respiratory protective equipment.*

4.3 Maintenance of equipment

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

Electrical equipment such as power sources, generators and welding machines and 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 uses. PPE should be stored in a clean environment to avoid contamination or damage or according to instructions provided by the manufacturer.

5. Health monitoring

Health monitoring of a person means monitoring the person to identify changes in their health status because of exposure to certain substances. It involves the collection of data in order to evaluate the effects of exposure and to determine whether or not the absorbed dose is within safe levels. This allows decisions to be made about implementing ways to eliminate or minimise the worker's risk of exposure, for example reassigning a worker to other duties that involve less exposure or improving control measures.

Regulation 368

A person conducting a business or undertaking must ensure health monitoring is provided to a worker carrying out work for the business or undertaking if:

- *the worker is carrying out ongoing work at a workplace using, handling, generating or storing hazardous chemicals and there is a significant risk to the worker's health because of exposure to a hazardous chemical referred to in Schedule 14, table 14.1, of the WHS Regulations, or*
- *the person identifies that because of ongoing work carried out by a worker using, handling, generating or storing hazardous chemicals there is a significant risk that the worker will be exposed to a hazardous chemical (other than a hazardous chemical referred to in Schedule 14, table 14.1) and either:*
  - *valid techniques are available to detect the effect on the worker's health, or*
  - *a valid way of determining biological exposure to the hazardous chemical is available and it is uncertain, on reasonable grounds, whether the exposure to the hazardous chemical has resulted in the biological exposure standard being exceeded.*

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, chemicals or noise has occurred
- determining levels of toxic substances in the body so that informed decisions can be made about the effectiveness of control measures and whether any further action needs to be taken (eg eliminating or minimising exposure).

Biological monitoring is a way of assessing exposure to hazardous chemicals that may have been absorbed through the skin, ingested or inhaled, therefore, biological monitoring techniques should also be used. For example, workers exposed to 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.

If health monitoring is required a person conducting a business or undertaking must ensure the type of health monitoring referred to in the WHS Regulations is provided, unless:

- an equal or better type of health monitoring is available, and
- the use of that other type of monitoring is recommended by a registered medical practitioner with experience in health monitoring.

Health monitoring is not an alternative to implementing control measures. If the results indicate that a worker is experiencing adverse health effects or signs of exposure to a hazardous chemical, the control measure must be reviewed and if necessary revised.

A person conducting a business or undertaking must:

- inform workers and prospective workers about health monitoring requirements
- ensure health monitoring is carried out by or under the supervision of a registered medical practitioner with experience in health monitoring
- consult workers in relation to the selection of the registered medical practitioner
- pay all expenses relating to health monitoring
- provide certain information about a worker to the registered medical practitioner
- take all reasonable steps to obtain a report from the registered medical practitioner as soon as practicable after the monitoring has been carried out
- provide a copy of the report to the worker and the regulator if the report contains adverse test results or recommendations that remedial measures should be taken. Also provide the report to all other persons conducting a business or undertaking who have a duty to provide health monitoring for the worker
- keep reports as confidential records for at least 30 years after the record is made (40 years for reports relating to asbestos exposure), and
- not disclose the report to anyone without the worker's written consent unless required to under the WHS Regulations.

The WHS Regulations contain specific requirements relating to health monitoring for lead. If a worker is carrying out lead risk work, health monitoring must be provided to a worker before the worker first commences lead risk work and 1 month after the worker first commences lead risk work.

Further information on health monitoring can be found in the *Health Monitoring for Exposure to Hazardous Chemicals – Guide for Persons Conducting a Business or Undertaking*.

Appendix A – By-products of welding

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 *Workplace Exposure Standards for Airborne Contaminants* published on the Safe Work Australia website to determine if an exposure standard has been set.

Source and Health Effect of Welding Fumes		
Fume Type	Source	Health Effect
Aluminium	Aluminium component of some alloys, eg nickel-chromium, copper, zinc, steel, magnesium, brass and filler materials.	Respiratory irritant.
Beryllium	Hardening agent found in copper, magnesium, aluminium alloys and electrical contacts.	'Metal Fume Fever'. A carcinogen. Other chronic effects include damage to the respiratory tract.
Cadmium Oxides	Stainless steel containing cadmium or plated materials, zinc alloy.	Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.
Chromium	Most stainless-steel and high-alloy materials, welding rods. Also used as plating material.	Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium).
Copper	Alloys such as nickel-copper, brass, bronze. Also some welding rods.	Acute effects include irritation of the eyes, nose and throat, nausea and 'Metal Fume Fever'.
Fluorides	Common electrode coating and flux material for both low-and high-alloy steels.	Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs.
Iron Oxides	The major contaminant in all iron or steel welding processes.	Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.
Lead	Solder, brass and bronze alloys, primer/coating on steels.	Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning. Ototoxic and therefore risk of hearing loss.
Manganese	Most welding processes, especially high-tensile steels.	'Metal Fume Fever'. Chronic effects may include central nervous system problems. Ototoxic and therefore risk of hearing loss.
Molybdenum	Steel alloys, iron, stainless steel, nickel alloys.	Acute effects are eye, nose and throat irritation, and shortness of breath.
Nickel	Stainless steel, nickel-chromium, nickel-copper and other high-alloy materials, welding rods and plated steel.	Acute effect is irritation of the eyes, nose and throat. Increased cancer risk has been noted in occupations other than welding. Also associated with dermatitis and lung problems.
Vanadium	Some steel alloys, iron, stainless steel, nickel alloys.	Acute effect is irritation of the eyes, skin and respiratory tract. Chronic effects include bronchitis, retinitis, fluid in the lungs and pneumonia.
Zinc Oxides	Galvanized and painted metal.	Metal Fume Fever.

Source and Health Effect of Welding Gases		
Gas Type	Source	Health Effect
Carbon Monoxide	Formed in the arc.	Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death. Ototoxic and therefore risk of hearing loss.
Hydrogen Fluoride	Decomposition of rod coatings.	Irritating to the eyes and respiratory tract. Overexposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.
Nitrogen Oxides	Formed in the arc.	Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems such as emphysema.
Oxygen Deficiency	Welding in confined spaces, and air displacement by shielding gas.	Dizziness, mental confusion, asphyxiation and death.
Ozone	Formed in the welding arc during open arc welding processes including Manual Metal Arc Welding (MMAW), Flux Cored Arc Welding (FCAW), especially during plasma-arc, Metal Inert Gas (MIG) and Tungsten Inert Gas (TIG) processes.	Acute effects include fluid in the lungs. Very low concentrations (eg one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function.
Phosphine	Metal coated with rust inhibitors. Phosphine is formed by reaction of the rust inhibitor with welding radiation.	Irritant to eyes and respiratory system, can damage kidneys and other organs.

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

List of amendments

Date	Location	Amendments
September 2016	Front cover	Insert republication date of September 2016.
September 2016	Inside cover	The inside cover is replaced with an amended 'NSW Note' which includes a reference to the new amendments as contained in the list of amendments.
September 2016	Table of contents	The table of contents references this list of amendments.
September 2016	Section 3.6	5th dot point is amended to add the words (as bolded) 'Flash back arrestors should be fitted at the blow pipe and **regulator end of both** the oxygen and fuel gas lines.'
September 2016	Last page	Includes a List of Amendments to the code.

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This Code of practice provides practical guidance on how to manage health and safety risks associated with welding.

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