



**HEALTH AND
SAFETY IN
WELDING**



Published by the Department of Labour
Wellington
New Zealand
October 2006
ISBN 0-478-28075-0

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INTRODUCTION

Welding poses a range of both well known and subtle hazards to health and safety. These can act quickly or may show up only in the long term. They can be rapidly fatal (electric shock or exposure to cadmium fumes) or have delayed effects (lung changes over time).

The Department of Labour has adopted the following documents, published by the Welding Technical Institute of Australia (WTIA), as its main sources of advice about health and safety in welding:

- *Health and Safety in Welding 2004 – Technical Note 7 (TN7)*
- *Fume Minimisation Guidelines (FMG)*

Printed copies of TN7 may be obtained from:

Heavy Engineering Research Association
PO Box 76134
Manukau City
Auckland
Tel (09) 262 2885
www.hera.co.nz

The *Fume Minimisation Guidelines* can be downloaded free from:

www.wtia.com.au/fmg.html

This booklet summarises some of the main points in the relevant sections of both the above publications.

The Welding Health and Safety Assessment Tool, along with other related information, can be downloaded from the Department of Labour website:

www.dol.govt.nz

Providing health and safety information and advice for employees who carry out welding and cutting processes can be complex. There are many subtleties and traps for the unwary or inexperienced. If you have any doubt that the information available on the Department of Labour website or in the WTIA publications covers your situation, get help from a specialist.

PART 1: WELDING HAZARDS

FIRES AND EXPLOSIONS

These are an ever-present hazard with many welding processes.

BURNS

Welding causes items to become hot – creating a risk of burns and fires from hot metal and welding spatter.

FUMES

Fumes generated by different welding processes may range from being of nuisance value to highly toxic. Health effects can occur very soon after exposure (e.g. exposure to cadmium fumes can be fatal within hours) or may not result until after many years. Fume control requires appropriate ventilation equipment and may require advice from a specialist.

ELECTRIC SHOCK

Welding processes that use electricity pose both obvious and subtle hazards of electric shock – which can be fatal. Standard precautions, as explained in this book, need to be taken during the use of welding equipment, and expert assistance can be needed in some circumstances to identify subtle hazards. Equipment selection, set-up and maintenance is important and may require specialist advice to ensure safety.

COMPRESSED GASES

Compressed gases in cylinders pose a number of hazards. Methods for their safe use are outlined in *TN7* chapter 5.

HAZARDOUS SUBSTANCES

Hazardous substances used during some welding processes can require highly specialised methods of control (e.g. the extremely toxic hydrofluoric acid.)

TOXIC GASES

Toxic gases may be:

- used in, or generated by, the process (e.g. acetylene, ozone, nitrogen oxides, carbon monoxide)
- generated when coatings on metal surfaces are heated (e.g. epoxy resins, degreasing agents, paint)
- generated when the arc flash and some degreasing chemicals or paints react (e.g. phosgene or phosphine).

Precautions for preventing these hazards from causing harm are outlined in *TN7* chapters 5 and 10.

SUFFOCATION

Inert gases used during welding can flood an area and lower its oxygen content, especially in confined spaces. Suffocation can result.

RADIATION

Arc flash is a well known hazard of welding. Standard precautions (see part 15) should be used to prevent eye and skin exposure – both for the worker and for people in the vicinity. Reflecting surfaces make exposure to radiation more likely.

HEAT STRESS

Working for long periods in hot environments can lead to distress and in an extreme, fatal heat stroke. Specialist advice must be sought if welders work in hot environments. (See *TN7* chapter 23.)

DUST

Associated processes (grinding) may generate hazardous levels of dust.

NOISE AND VIBRATION

Noise and vibration levels during some welding processes can be high and should be controlled and/or appropriate hearing protection should be worn.

MANUAL HANDLING

Some welding processes may involve heavy and or repetitive handling.

SPECIFIC PROCESSES

Several processes, not covered by this booklet, are discussed in *TN7*:

- thermit welding
- laser welding
- electroslag welding
- plasma cutting
- resistance welding
- electron beam welding
- brazing and soldering
- thermal lancing.

PART 2: TRAINING, QUALIFICATIONS AND COMPETENCY

GENERAL

Welding involves a wide range of processes carried out in a variety of working conditions.

Certain work, especially where safety critical items are fabricated, requires a high level of skill and competency (e.g. welding pressure vessels) whereas a high skill level may not be so critical in some general purpose welding.

Only workers with appropriate levels of competence and skill should do welding. They must know:

- the right way to do the work
- the hazards of the work
- how to prevent those hazards causing harm.

Competence in welding may be shown by an appropriate qualification issued by a registered training organisation (such as an industry training organisation (ITO)) or relevant unit standards for welding from the National Qualifications Framework. Welders *should not* use equipment for which they *are not* certified.

Welders should be trained in the use of fire extinguishers and hot work permits, if they are used.

THE VALUE OF EXPERIENCE

Welding is often a complex, safety critical operation and a great deal of knowledge may be required to provide for all aspects of health and safety.

This knowledge will not come entirely by reading or training. Experience, skill and practice should also inform safe working practices.

This means that welding safety should be considered a team effort, with team leaders actively coaching team members and team members referring to knowledgeable team members if they are not sure of correct health and safety practices. This is especially important when doing new tasks.

RELEVANT STANDARDS

Standards applying to welding processes include:

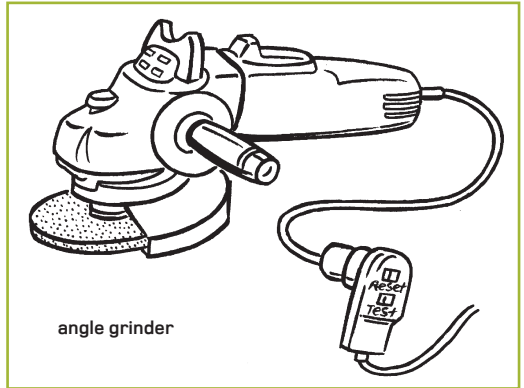
- NZS 4711: 1984. *Qualification tests for metal-arc welders.*
- AS/NZS 1338.1:1992 *Filters for eye protectors—Filters for protection against radiation generated in welding and allied operations*
- The AS/NZS 1554 series. Covers: *Welding of steel structures; Welding of high strength quenched and tempered steels; Welding of steel structures to high levels of fatigue loading; Welding stainless steel for structural purposes*
- AS 1796—*Certification of welders and welding supervisors*
- AS 2214—*Certification of welding supervisors – structural steel welding.*
- AS/NZS 3100:2002 *Approval and test specification – General requirements for electrical equipment*
- AS/NZS 3195:2002 *Approval and test specification – Portable machines for electric arc welding and allied processes*
- AS/NZS 1995:2003 *Welding cables*
- AS/NZS 3957:2006 *Light-transmitting screens and curtains for welding operations.*

The New Zealand Qualifications Authority (NZQA) publish a list of over 30 unit standards for welding processes. This includes US 21907 *Demonstrate and apply knowledge of safe welding procedures under supervision*, and there are also health and safety components in each of the unit standards listed. See the Department of Labour website.

PART 3: EQUIPMENT SELECTION, MAINTENANCE AND SAFETY

Consult *TN7* for details of selecting the right equipment for the particular welding process being carried out.

Generally, the manufacturer or supplier of the equipment will give detailed directions for setting up the equipment, safe usage and maintenance. These directions should be followed.



PART 4: GENERAL HEALTH AND SAFETY IN WELDING

GOOD HOUSEKEEPING

Good housekeeping, especially the removal of combustible materials, is essential.

GAS

If you can smell gas – don't light any gas torches or use electric welding equipment, but don't rely wholly on your sense of smell to warn you.

EYE PROTECTION

Wear eye protection and cover bare skin. Be aware that:

- arc flash can occur through the side of the eye
- arc flash can cause 'sunburn' on exposed skin.

HOT SURFACES

Mark hot surfaces as such. Better still, assume everything is hot.

FIRST AID

In addition to standard training, first-aiders in welding situations should know about the symptoms of electric shock, arc flash and the consequences of exposure to heated coatings on metals (e.g. when galvanised metal is welded).

PART 5: FIRE AND EXPLOSION PREVENTION AND HOT WORK

GENERAL

Prevent the ignition of combustible materials that may be near the welding process. If welding a metal wall or partition (or if welding near one), you should check what is behind it.

Know how to use gas equipment safely.

- Oxygen under pressure can cause the spontaneous combustion of oil or grease. Keep all regulators and air hoses free of oil and grease, and avoid getting grease/oil on hands, gloves and overalls.
- Use the right gases for the situation. **Never** substitute oxygen for compressed air.
- In confined spaces, the risk of fuel gases and air combining to ignite or explode is increased. Don't allow welding gas supply lines to lie in a confined space where they may leak.

Keep appropriate fire extinguishers available and visible at all times. Make sure staff are trained in their use.

Consult the relevant sections of TN7 (chapters 5 and 16), NZS 4781:1973 *Code of practice for safety in welding and cutting* and AS 2865 *Hot work*.

WORK ON DRUMS AND TANKS

Severe explosions and fires, many resulting in fatalities, have been caused by welding, cutting, brazing, soldering on pipes, tanks, drums, and similar vessels which previously contained flammable materials.

Containers which have held petrol, white spirit or other flammable substances are highly dangerous to work on and a pin-point of heat can be enough to set off an explosion or fire. Equally dangerous are pipes or containers which have held substances like linseed oil, soap, diesel oil, acids that react with metals to produce hydrogen, or combustible solids which may have left a residue of dust. It is essential to remove all residues. The preferred method is to steam clean and then either fill with an inert gas such as carbon dioxide or nitrogen, or fill

with water, leaving a very small vented space at the point where the repair is to be made. (Allow for the expansion of liquid in small-bore pipes.) Washing containers with cold or hot water, or blowing with air are both ineffective.

Cleaning with trichloroethylene must be carried out with care, since it is toxic and decomposes on heating and may form phosgene gas.

Welders should study the booklet *Hot Work on Tanks and Drums* (obtainable at any Department of Labour office) before carrying out such repairs. Also, see *TN7* chapter 21. A sample hot work permit follows:

HOT WORK PERMIT

TO BE DISPLAYED ON THE WELDING OR CUTTING APPARATUS AND RETURNED TO THE RESPONSIBLE OFFICER ON COMPLETION OF THE WORK.

Permission granted to: (Name)

To use (Type of equipment)

In (location)

On (date)

From (time)

To (time

completed)

- 1. All combustible materials removed or made safe
- 2. No flammable liquids, vapours, gases or dusts present
- 3. Extinguishers/hoses provided on site
- 4. Operator knows how to use fire equipment
- 5. Operator knows location of telephone/fire alarm
- 6. Site inspected after completion of work.

Permit issued by (responsible officer)

On the left is an example of a hot work permit which can be printed on a card and attached to a welding trolley.

Below is an example of the hot work permit advocated in NZS 4781.

HOT WORK PERMIT

.....
(Name)

is hereby authorised to carry out cutting*, burning*, welding*
(*cross out **where not** applicable)
Other work on

.....
(Plant or equipment)

as from

.....
(Date, time)

Signed

.....
Factory manager

I have inspected the work. The permit has been withdrawn as from as from

.....
(Date, time)

Signed

.....
Factory manager (or nominee)

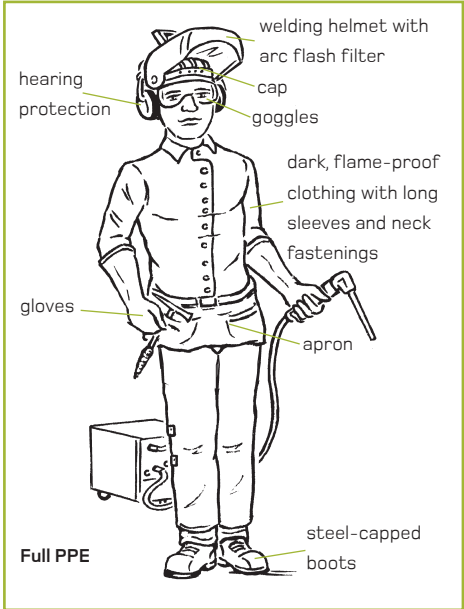
PART 6: PERSONAL PROTECTIVE EQUIPMENT (PPE)

Standard personal protective equipment (PPE) for the variety of welding processes includes:

- welding helmet with a suitable arc flash filter, not less than shade 10. (**Note:** A welding helmet does not protect against fumes.)
- eye protection – and use dark clothing to avoid ultraviolet (UV) rays
- flameproof overalls with long sleeves and neck fastenings
- gloves (AS/NZS 2161 – *Occupational protective gloves*)
- apron
- respiratory protection



- hearing protection



Welding without this protection may allow bare skin to be exposed to the welding arc.



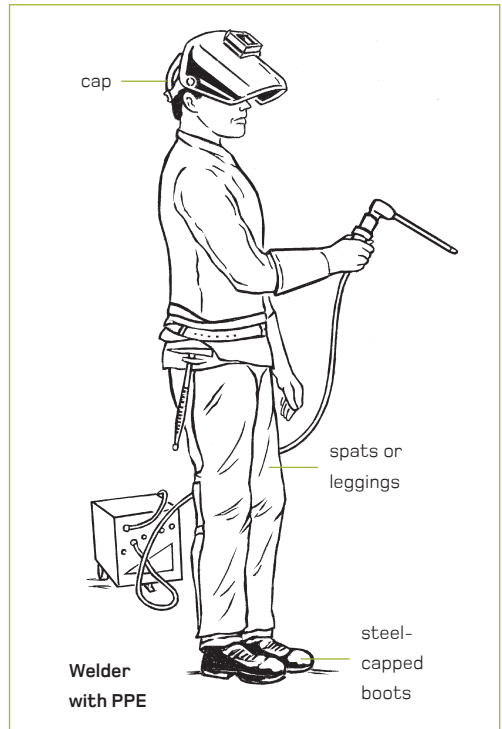
Eye protection may be worn under a welding helmet for additional protection. Eye protection must be worn when using a tool such as a chipping hammer or powered grinder to prepare or deslag metal.

Additional items of protective clothing may include:

- a cap
- neck covering (for protection from arc flash in confined spaces)
- spats or leggings
- steel-capped boots (AS/NZS 2210 *Guide to occupational protective footwear*).

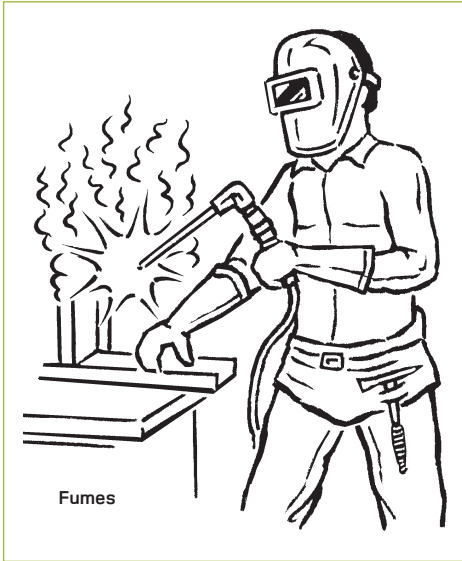
Additional respiratory protection may be required (e.g. when welding galvanised metal or when cadmium is present in welding rods). This may range from simple filter masks that fit under the welding helmet to powered air purifying respirators. Specialist help may be needed to select, fit and maintain these items. Please refer to the Department of Labour publication *A Guide to Respiratory Protection*; AS/NZS 1715:1994 *Selection, use and maintenance of respiratory protective devices*; and TN7, chapter 19.

Personal protective equipment must be paid for by the employer – see section 10(2) of the Health and Safety in Employment Act 1992. Some protective equipment is designed to protect people in the vicinity from arc flash – such as portable welding screens. These should be dark in colour as shiny surfaces can reflect a significant amount of the arc flash.



PART 7: FUME AND GAS CONTROL

Exposure to welding gases and fumes can be fatal. Unsafe atmospheres and toxic welding gases and fumes may create a risk of discomfort, suffocation, fire and poisoning.



Nuisance dusts include iron and aluminium oxides generated in large quantities, which should be controlled at source.

Examples of toxins are ozone, carbon monoxide, nitrogen oxides and fumes from highly toxic metals including cadmium, zinc, beryllium, lead, chromium, nickel, manganese and copper. Fumes from some of these metals can cause cancer.

Inert shielding gases may pose risks of oxygen depletion and therefore suffocation, especially in confined spaces.

Some welding gases present risks of fire and explosion.

Welding in confined spaces may increase the risks of each of these types of hazard (see Part 13: Welding in confined spaces).

Preparation of metal surfaces may cause toxic fumes or vapours to be released. Examples include:

- when paints or plastic coatings are heated
- if degreasing agents, oil or grease are not removed from metal surfaces
- welding car parts painted with isocyanate paints.

The interaction of the welding arc and certain degreasing agents can generate the highly toxic gas phosgene.

Fumes generated by fluxing agents in welding rods, welding pastes and silver brazing fluxes can cause allergic reactions.

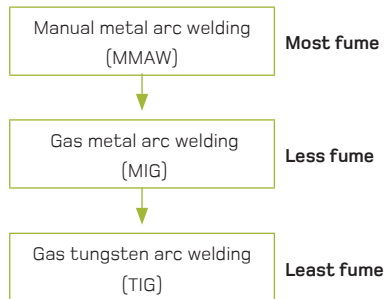
You cannot rely on the sense of smell to detect any of these hazards. Some cannot be smelt at all and the sense of smell can become insensitive to those odours it can detect.

Special efforts to ensure adequate ventilation (especially in confined spaces) and to control fumes are necessary.

BASIC METHODS OF GAS AND FUME CONTROL

CREATE LESS FUMES

- Use a welding technology that creates less fumes (and is also more cost effective). For example, substitute manual welding with gas metal arc (MIG) welding, or substitute MIG with submerged arc welding.
- Use electrodes that create less fumes.
- Reduce the current to the minimum possible.
- An approximate decreasing order of fume generation is:



SUBSTITUTE DANGEROUS WORK METHODS

- Substitute a dangerous substance with a less dangerous one.
- Arrange the work so that hot gases and fumes do not rise into the worker's face.
- Automate where appropriate.

USE DILUTION VENTILATION

This method disperses fumes and gases from near the worker to the wider workplace. Placing extraction fans in walls and ceilings, keeping doors open or having a large volume of room space for each worker are common approaches.

This method is suitable only for low toxicity fumes and **is not** suitable where toxic substances or metals are generated or welded.

See *TN7* Section 17.4 and Table 17.1.

USE LOCAL EXHAUST VENTILATION

This is the preferred option.

Local exhaust ventilation systems capture fumes and gases near the point where they are generated. This method is essential for many welding processes.

See *TN7* Chapter 17 and the *WTIA Fume Minimisation Guidelines* and part 8 of this guide for more detail.

LIMIT THE EXPOSURE PERIOD

This administrative control may not prevent toxic effects from short-term exposure and is unsuitable for toxic contaminants.

It may be essential when working in confined spaces. See part 13: Welding in confined spaces.

USE PERSONAL PROTECTIVE EQUIPMENT (PPE)

Certain PPE is standard in welding processes, but should be regarded as a method of last resort for fume control, where other methods prove unsatisfactory. See details above and in part 8: Local exhaust ventilation for welding processes.

PART 8: LOCAL EXHAUST VENTILATION FOR WELDING PROCESSES

Chapter 17 of *TN7* and the *Fume Minimisation Guidelines* cover this topic fully. These notes aim to give a brief overview of welding ventilation best practice.

The amount of fume generated depends on:

- the process being used
- the type of welding consumables (rods) used
- what is being welded
- any coatings on it
- the temperature
- the amperage and voltage of the welding current
- gas and arc temperatures
- heat input and
- the duration and frequency of the work.



After these aspects of the task have been chosen to minimise fume generation, some fumes may remain. The best way to prevent exposure is to provide appropriate ventilation.

MECHANICAL DILUTION VENTILATION

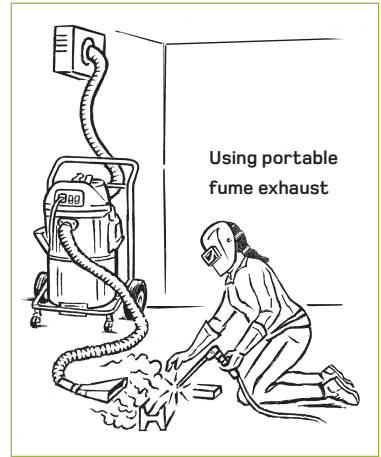
This will be adequate only in the circumstances described in *TN7* Section 17.4 and Table 17.1.

Portable fans blowing fume away from the welder's breathing zone are one way of providing exhaust fume control. A capture velocity of 0.5 m/s is required. Velocities up to 2.0 m/s should not interfere with shielding gases. This may not be suitable in some circumstances.

LOCAL EXHAUST VENTILATION

Local exhaust ventilation has the following components:

- A hood, a duct system, an air-cleaning device, an exhaust fan and a stack.
- A ventilation slot at the rear of the welding bench. Precise specifications for the air-flow rates for different types and sizes of capture hoods can be found in *TN7*.
- Specific purpose ventilation. Fixed hoods can be located at points where welding occurs for example, where components to be welded are held in jigs.
- Ventilation equipment mounted on the welding gun. Care needs to be taken over the design (for worker acceptance) and the disturbance of shielding gases, if they are used. Regular maintenance is essential if this equipment is to work properly.
- Relocatable exhaust hoods connected to fans and air-cleaners by flexible tubing. These may connect to a fixed fan or vacuum cleaner-type unit. They allow the welder to reposition the suction inlet as welding proceeds.



Capturing fumes when the point of welding moves may be more difficult, but is important when exposure is significant.

Local exhaust ventilation may be required whenever:

- welding takes place in confined spaces
- the metals listed in *TN7* Table 17.2 are being welded.

Whenever workers may be exposed to beryllium or cadmium, **local exhaust ventilation and personal respiratory equipment must be provided**, such is their toxicity, no matter where welding is carried out.

Coatings on metals often give rise to hazardous exposures. The correct identification of metal coatings and their removal is the preferred control measure. Local exhaust ventilation (and possibly personal protective

equipment) will be essential to control toxic dusts/fumes if these coatings cannot be removed.

Special measures to control toxic products (phosgene and phosphine) that can be generated when metals contaminated with degreasing agents and phosphate paints (respectively) are welded, are described in *TN7* part 17.11.

Equipment may be needed to measure the levels of gases such as carbon monoxide, ozone and nitrogen oxides.

The fume control worksheet shown in part 21 can indicate the level of protection required in other circumstances.

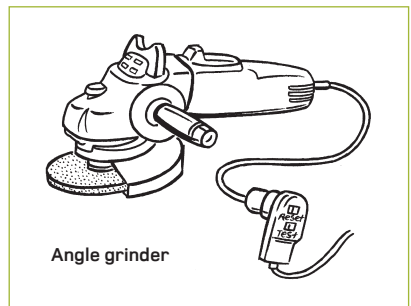
PART 9: ELECTRICAL SAFETY

See *TN7* chapters 4 and 14 for details about general electrical safety and the specific electrical safety measures required for each different welding process. Ensure equipment is constructed to the relevant standards (AS 1966 and AS/NZS 3195).

Ask the advice of the welding equipment supplier or an appropriately qualified specialist when purchasing and/or installing welding equipment. Some basic precautions follow.

EQUIPMENT ELECTRICAL SAFETY

- ensure the equipment has the correct current capacity
- provide an isolating switch
- where a flammable gas or solvent is present, an electrical spark might cause an explosion, so welding should not occur
- take care to preserve electrical polarity when using two welding machines on electrically connected metals
- use a welding machine with an automatic cut-out to ensure the duty cycle cannot be exceeded
- inspect equipment regularly (AS/NZS 3100:2002 *Approval and test specification – General requirements for electrical equipment* and AS/NZS 3195:2002 *Approval and test specification – Portable machines for electric arc welding and allied processes*). Do not use equipment with frayed or cracked leads, connectors or fittings or broken switches and cover plates. Do not allow them to be used while waiting for repairs (see AS/NZS 1995:2003 *Welding cables*). Leads need to be tested and tagged
- select an appropriate rod holder (AS 2826-1985: *Manual metal-arc welding electrode holders*)
- check the electrical safety of the rod holder or welding hand-piece regularly – maintain or replace as required



- use the shortest possible leads and ensure they are capable of carrying the required current safely
- use a residual current device (RCD) when using hand-held power tools
- use appropriately-rated powerboards rather than double adaptors or piggyback plugs.

SAFE USE OF EQUIPMENT

- be aware of welding where water may be present (showers, kitchens, boats, spas, swimming pools etc.)
- never twist or knot a lead, bend it sharply, tack it to a wall or drape it over your body
- dry your hands before welding. If you get sweaty, dry off, take a break and use a wooden duckboard to insulate yourself
- disconnect electrical equipment immediately after use
- pull on the plug, not the lead, to unplug equipment
- use welding gloves – keep them and any protective clothing dry. Don't work in the rain. Don't hold electrodes under the armpits.

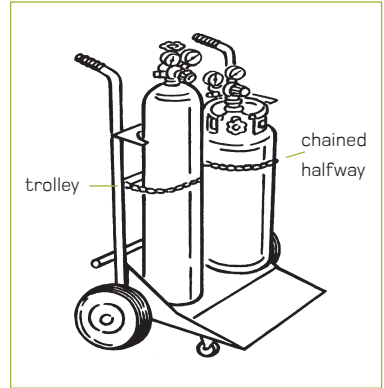
If you use a petrol motor generator to power a welding set, be aware that carbon monoxide can kill quickly. Don't use in confined spaces, including ones that appear to be ventilated, such as a parking garage.

TN 22, *Welding Electrical Safety*, is also available from the Welding Technical Institute of Australia.

PART 10: SAFE USE OF WELDING GASES

MAINTENANCE OF GAS BOTTLE INTEGRITY

- cylinders should be correctly labelled
- cylinders should be stored in a ventilated area
- cylinders should be properly secured against falls
- fuel gas cylinders and oxygen cylinders should be stored separately
- gas cylinders should be kept away from electrical apparatus and sources of heat
- acetylene cylinders should be stored upright
- gas cylinders should be regularly examined for signs of defects, rusting or leakage
- empty cylinders should be appropriately marked and stored with their valves closed.



INTEGRITY OF EQUIPMENT CONNECTED TO GAS CYLINDERS

- flashback arrestors must be fitted to fuel and oxygen bottles
- the integrity of the equipment fitted to gas cylinders should be inspected routinely
- cylinders, cylinder valves, couplings, regulators, hoses and apparatus should be kept free of oily or greasy substances
- red should be used to identify acetylene (and other fuel gas) hoses, blue for oxygen hoses, and black for inert gas and air hoses
- copper piping should not be used with acetylene.

CORRECT USAGE OF GAS EQUIPMENT

Operators should know:

- the correct assembly procedures for attaching equipment to gas cylinders
- the correct procedures and materials (detergent, not soap) for leak testing
- the correct procedures for lighting gas torches and shutting them off
- the signs of a flashback, what to do in response, how to check if damage has occurred to equipment and the actions necessary if it has occurred
- never to crack a fuel gas cylinder valve near a source of ignition
- before a regulator is removed, to close the valve and release gas from it
- NOT to use the oxygen cylinder to dust off clothing
- NOT to use the oxygen to 'sweeten' the atmosphere.

The use of LPG should be avoided in holes and trenches, where it can pool at a low level.

PART 11: HAZARDOUS SUBSTANCES

HAZARDS FROM METALS USED IN WELDING

Metal fumes generated during welding range in toxicity. Because fumes from different metals are combined in the welding plume, it is clear that avoidance of the plume is the best protection against inhalation.

Aluminium: Fume group A (least toxic). Exposure to aluminium fumes may produce some lung effects. There is no clear picture of the dose required (concentration x time) for these to occur.

Barium: Fume group C (highly toxic). Water or acid soluble barium compounds are extremely poisonous. Fumes containing barium may result in a lung condition called baritosis which is one of the benign pneumoconioses in which inhaled particulate matter lies in the lungs for years without producing symptoms. Baritosis produces abnormal physical signs including incapacity for work, interference with lung function, or liability to develop pulmonary or bronchial infections or other thoracic disease.

Beryllium: Fume group D (extremely toxic). Used mainly as an alloy with other metals, beryllium is deadly and extreme precautions must be taken. This metal must be welded in inert atmospheres, inside airtight enclosures, with the welder outside.

Cadmium: Fume group D (extremely toxic). Used in electroplating and as an alloy with metals, cadmium is also an ingredient in some paints. A single exposure to cadmium oxide fumes can cause fatal lung irritation.

Chromium: Fume group C (highly toxic). The oxidation of chromium alloys can produce chromium trioxide fumes, often referred to as chromic acid. These fumes may produce skin irritation as well as bronchitis and other problems.

Cobalt: Fume group C (highly toxic). Milling tungsten carbide tips (during saw sharpening) can cause airborne dust concentrations great enough to lead to 'hard metal' respiratory disease. Cobalt (a binder ingredient) is considered a crucial factor in producing this disease, though this may involve an interaction with the tungsten carbide itself.

Copper: Fume group B (toxic). Like zinc, Inhalation of copper fume may cause 'metal fume fever'.

Iron: Fume group A (least toxic). Prolonged, heavy exposure to fumes from welding iron articles can result in a condition called siderosis, with visible changes on an x-ray but no changes in lung function.

Lead: Fume group C (highly toxic). Poisoning generally results from inhalation of fumes, although the swallowing of dust is also a cause. Lead-based paints are a source of lead fumes, especially when old steel structures are cut or welded. Signs and symptoms of lead poisoning may include abdominal pains, constipation, headaches, weakness, muscular aches or cramps, loss of appetite, nausea, vomiting, weight loss, and anaemia. In severe cases, it can be fatal.

Magnesium: Fume group B (toxic). The oxide fumes from magnesium can produce metal fume fever, which is characterised by influenza-like symptoms.

Manganese: Fume group B (toxic). Manganism is a serious occupational disease but its link to welding is controversial.

Mercury: Mercury vapour can be produced by welding or cutting metals coated with protective materials containing mercury compounds, such as the antifouling paints used on ships' hulls. Nowadays, less toxic substitutes are used in place of mercury, but there will still be some vessels in service which are protected with mercury-containing antifouling compounds. Exposure to mercury vapour may result in abdominal pain, vomiting, diarrhoea, and other serious problems which, collectively, can result in death.

Nickel: Fume group C (highly toxic). Often used as an undercoating on chrome-plated parts, nickel and its compounds are generally considered to have low toxicity.

Silver: Fume group C (highly toxic).

Tin: Fume group A (least toxic).

Titanium: Fume group A (least toxic). Dust may irritate the respiratory tract in high concentrations.

Tungsten: Fume group B (toxic). Milling tungsten carbide tips (during saw sharpening) can cause airborne dust concentrations great enough to lead to 'hard metal' respiratory disease. Cobalt (a binder ingredient) is considered a crucial factor in producing this disease, though this may involve an interaction with the tungsten carbide itself.

Vanadium: Fume group C (highly toxic). Dust and vanadium pentoxide fumes may cause severe eye, throat and respiratory tract irritation and pain.

Zinc: Fume group B (toxic). Welding, brazing, or flame cutting of galvanised steel causes zinc oxide fumes. Inhalation of these may result in metal fume fever.

FLUORIDES

These and other toxic compounds of fluorine may be found in some welding and brazing fluxes, electrode coverings and submerged arc fluxes. Containers are labelled to warn of the presence of fluorides. The fumes will cause chills, fever, painful breathing, and coughs if inhaled. Over a long period, fluoride can build up in the bones, causing them to lose calcium and become brittle.

HAZARDS FROM GASES GENERATED BY WELDING PROCESSES

The following gases are generated from welding processes and are particularly serious hazards that must be protected against.

- **Nitrogen dioxide:** Formed in the welding arc directly from the air, nitrogen dioxide is very irritating to the eyes and mucous membranes of the lungs and throat. Exposure to concentrations between 200 ppm and 700 ppm (parts per million) can be fatal. Lower concentrations may produce only mild bronchial irritation, but will be followed several hours later by acute pulmonary oedema (fluid in the lungs).
- **Phosgene:** This gas is produced when residues of chlorinated hydrocarbon degreasers, such as trichloroethylene and perchloroethylene, are left on metal being welded or flame-cut. The heat and the ultraviolet radiation cause the degreaser to decay into phosgene gas, which was used as a poisonous gas in the First World War. Freon gas, which is used in many refrigeration plants and as a propellant in aerosol cans, will also decompose to form phosgene when exposed to ultraviolet rays. Phosgene will produce skin inflammation. Inhalation of high concentrations will cause pulmonary oedema. Death may result through respiratory or heart failure.
- **Phosphine:** When steel which has been coated with a phosphate rust-proofing is welded, phosphine gas is generated. High concentrations will irritate the eyes, nose and skin. Very high concentrations can result in severe damage to kidneys and other organs, and perhaps death.

- **Ozone:** A gas produced by the ultraviolet radiation in the air in the vicinity of arc welding and cutting operations, ozone is very irritating to all mucous membranes. Excessive exposure produces pulmonary oedema. Other effects of exposure include headache, chest pain, and dryness of the respiratory tract.

AGENTS FOR CLEANING AND PASSIVATING STAINLESS STEEL

These substances are both very dangerous and will require specialised methods of storage, use and disposal:

- nitric acid
- hydrofluoric acid.

PART 12: METAL PREPARATION

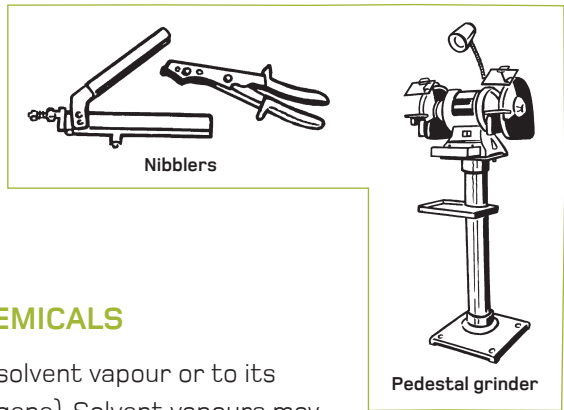
The methods used to prepare metals for welding pose a series of specific hazards, each of which requires control. See *TN7* chapter 10 for further details.

ABRASIVE BLASTING

This poses hazards to the eyes, lungs and hearing through noise, vibration and dust creation. Abrasive blasting needs to be carried out in a blasting cabinet with ventilation.

MECHANICAL PREPARATION

Power tools (grinders and nibblers) can pose hazards of eye injury, vibration injury and electric shock.



USE OF DEGREASING CHEMICALS

There may be exposure to the solvent vapour or to its decomposition products (phosgene). Solvent vapours may be flammable and explosive. Skin contact can result in occupational dermatitis. See the AS 1627 series.

CLEANING WITH CAUSTIC OR ACID SOLUTIONS

These can pose hazards of contact with the solution or its corrosive and/or irritant fumes. Hydrogen gas can be generated. Hydrofluoric acid poses extreme dangers and should be used only with specific precautions.

CONTAMINATED SURFACES

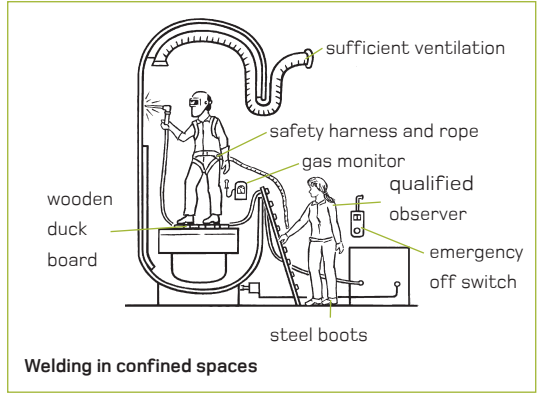
When coatings on metals are heated it should be assumed that the decomposition products are toxic.

PART 13: WELDING IN CONFINED SPACES

TN7 chapter 20 deals with this topic and refers to AS 2865. A confined space is:

any space that is not intended as a regular workplace AND has restricted means of entry/exit AND has inadequate ventilation.

Key elements of safe welding in confined spaces include the following.



ACCESS AND EMERGENCY RESCUE

A trained, alert observer must be stationed outside the space.

Safe access is required and pre-planned emergency rescue (including a safety belt or lifeline) must be assured through the use of suitable emergency equipment.

ELECTRIC SHOCK

Risks of electric shock are increased when working in confined spaces. A range of measures are described in TN7, including having an observer outside the space with access to a cut-off switch and rescue equipment. Always site the welding equipment outside a confined space.

VENTILATION

Ventilation for welders in confined spaces is of clear importance. Local exhaust ventilation will be needed. Don't enter a confined space unless you are sure the atmosphere is safe.

ATMOSPHERE TESTING

The atmosphere in a confined space may become rapidly depleted in oxygen content. Check with a monitoring device before entry. As welding proceeds, inert gases may rapidly displace oxygen – check the atmosphere with a continuous monitor located near the welder’s breathing zone. Check for toxic or explosive atmospheres, if appropriate.

ARC FLASH

Reflected arc flash in a confined space may affect bare skin (e.g. the back of the neck).

FIRE PROTECTION

A fire in a confined space will be more serious than a normal fire.

HEAT STRESS

Confined spaces may be hot because of solar load (if outside), or may become hot during the pre-heating of metals. Take precautions to prevent heat affecting the worker. Cool air is one option but may not provide sufficient protection against radiant heat from hot surfaces. Working in a confined space (especially if hot) can affect a welder, given the level of protective equipment required and it may be necessary to limit the welder’s working time.

PERMIT TO WORK

Welding in a confined space may be subject to a permit to work. An example is shown opposite.

PERMIT TO WORK

Permit number _____

PART A: WORK REQUEST

Location of work (building/room) _____ Contact name and phone number _____

Summary of work to be done _____

PART B: SAFETY PROCEDURES: To be implemented prior to commencement of work.

1. The following processes are to be suspended during the course of the work

2. The following equipment is to be withdrawn from service during the course of the work

3. All users have been made aware of this supervision/withdrawal Yes No
4. Safety warning notices have been posted where required Yes No
5. The following steps have been taken to eliminate, control or contain hazards in the area

6. The following safety measures are recommended

APPROVAL

I confirm that I have inspected the work area detailed above and declare that to the best of my knowledge and belief the work can be carried out safely and without serious risk of injury to health.

Signed _____ Date _____ Time _____

PART C: CONTROL OF RISKS ARISING FROM THE WORK

1. Isolation of services: (please tick as appropriate)

water power fuel lines compressed gases others (specify)

2. Are there safety implications resulting from the isolation? Yes No
3. Lock-off required? Yes No Location _____
4. Safety signs posted? Yes No * If yes, what safety precautions are required to control the risks?

5. Air monitoring required? Yes No _____
6. Are there hazards associated with the work? Yes No _____

DECLARATION I understand the precautions to be taken under this permit.

Name (print): _____ Company/Department _____

Signed _____ Date _____ Time _____

Permit validity period **From:** Date: ___/___/___ Time: ___:___ **To:** Date ___/___/___ Time: ___:___

If the work is not completed within this timescale a new permit-to-work must be completed.

PART D: COMPLETION OF WORK

I confirm that the work has been completed in accordance with this permit. Services have been restored and the work area is ready for re-occupation.

Signed _____ Date _____ Time _____

PART E: REINSTATEMENT OF WORK AREA

I confirm that all equipment has been returned to service, safety signs have been removed and the users informed that work may resume in this area.

Signed _____ Date _____ Time _____

PART 14: HOT METALS SPARKS

Hot metal sparks are a constant hazard in many welding processes.

Essential safety measures are to ensure:

- good housekeeping
- training in the selection and use of fire-fighting equipment
- prevention of sparks entering clothing/boots through the use of flame-resistant personal protective equipment.

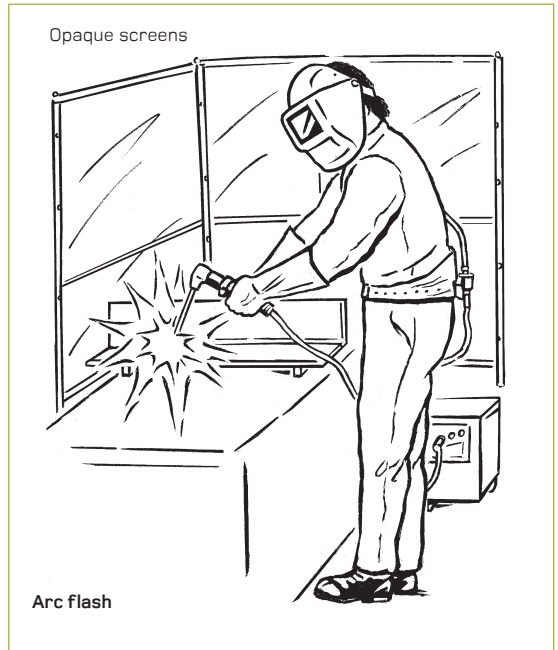
PART 15: RADIATION (ULTRAVIOLET, INFRARED AND LASERS)

Hazards of ultraviolet radiation from arc flash can affect both the eyes and skin and are covered elsewhere in this booklet.

The skin has its own warning mechanism for thermal radiation but the eyes do not. When exposed to heat, the eyes should be protected. See AS/NZS 1338.1:1992 *Filters for eye protectors – Filters for protection against radiation generated in welding and allied operations*.

The safety of laser cutting/welding processes will require specialist advice both in terms of the safe use of the equipment and personal protection.

See AS/NZS ISO 11553:2004 *Safety of machinery – Laser processing machines – Safety requirements* and the AS/NZS 2211 series on laser safety.



PART 16: WORKING TECHNIQUE

Keeping the head out of the welding plume is an essential element of welding safety, as is good housekeeping.

PART 17: NOISE AND VIBRATION

NOISE

Noise levels can be hazardous during some welding and metal cleaning processes.

The Department of Labour *Approved Code of Practice for the Management of Noise in the Workplace* should be followed to identify noise sources, assess their significance and apply control measures.

TN7 refers to Australian noise control practices, and **should not** be referred to for methods of noise assessment, as the New Zealand methods are different.

Audiometry will be required where employees are exposed to hazardous levels of noise to ensure that hearing is not damaged by exposure to it.

VIBRATION

The prolonged use of powered hand tools may expose welders to harmful levels of vibration, resulting in decreased blood circulation in the fingers. The effect of vibration is exacerbated when working in the cold. Vibration exposure can be reduced by:

- selecting the appropriate tool
- selecting a tool designed with ergonomic principles in mind
- regular maintenance
- wearing gloves.

PART 18: MANUAL HANDLING

Some welding tasks can involve heavy and/or repetitive manual handling or work with sustained awkward postures for long periods without a break.

The joint Department of Labour/ACC *Code of Practice for Manual Handling* should be used to identify hazards in manual handling tasks, assess their significance and devise controls.



PART 19: HAND TOOL FITNESS AND SAFETY

Hand tools used during metal preparation and weld treatment can pose several types of hazard:

- hand tools can create sparks and ignite some welding gases
- electrically-powered tools (grinders) pose the risk of electric shock – check electrical safety regularly and use RCDs
- tools used for deslagging, grinding and chipping may pose hazards to the eyes – wear eye protection
- prolonged use of poorly maintained power hand tools can result in injuries from vibration
- the physical design of hand tools (if not based on ergonomic principles) can pose the risk of a musculoskeletal disorder. Relevant factors are tool weight, trigger design, grip/handle diameter and tool shape
- air-powered tools can discharge cold air over the hands
- using tools with wet/sweaty hands may compromise electrical safety and/or cause the hands to slip
- ensure any electrical or heat insulation on the tool handle remains intact
- grinding wheel hazards – safety principles must be adhered to.

See www.osh.dol.govt.nz/order/catalogue/78.shtml

PART 20: SPECIFIC REQUIREMENTS OF THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992

The Health and Safety in Employment (HSE) Act 1992 requires employers to take all the practicable steps open to them in the circumstances to prevent harm occurring to employees. This requirement is covered in the sections above and in *TN7* and the *Fume Minimisation Guidelines*.

The HSE Act places some additional obligations on employers, including the requirements to:

- provide information, training and supervision to employees
- pay for protective equipment – in a range of circumstances
- when employees are exposed to significant hazards, to carry out (with each employee's informed consent) health monitoring
- involve employees in health and safety matters.

INFORMATION, TRAINING AND SUPERVISION

Basics are covered previously in this booklet. *TN7*, equipment suppliers and experienced welders may be consulted for more information.

Information should be given in a manner the employee can understand and cover the items in this booklet plus what to do in emergency situations, (fire, explosion, electrocution, confined space collapse, burns, eye injuries and exposure to fumes).

Training should cover the right way to do the task, the hazards in it, how to prevent hazards causing harm, incident/damage reporting procedures and how to use PPE.

Supervision should continue until a welder is competent, and will always be required in some situations, such as confined space entry.

MONITORING

ENVIRONMENTAL MONITORING

This may be required to assess the level of exposure to welding fumes, to monitor exposure to gases such as ozone or nitrogen oxides produced during certain welding processes or to monitor oxygen content or the build up of explosive gases in confined spaces.

PERSONAL HEALTH MONITORING

This must be carried out, with the person's informed consent, if they are faced with a significant hazard. The decision as to whether a significant hazard is faced rests with the employer.

Hearing, vision and lung function testing are typically monitored in welders. Biological monitoring to establish the absorption of substances such as lead or manganese will be appropriate if welders are exposed to these substances.

Exposure to welding fumes has been shown to cause a number of respiratory conditions, including fume fever, chemical pneumonitis, reversible bronchospasm and occupational asthma.

Biological monitoring may be necessary to follow the health of people exposed to welding fumes. See www.cdhb.govt.nz/chlabs/testsframe.htm.

Respiratory conditions arising as a consequence of welding fume exposure are best monitored by the following:

- a respiratory questionnaire given to the exposed employees and either self-administered or administered by an occupational health nurse. (See the Department of Labour website at www.dol.govt.nz.)
- the use of serial peak flows. Peak flows measure the amount of air forcibly expelled from the lungs in one second. Various values or patterns are evident when the lungs are not functioning properly
- a peak flow meter is required (available from the occupational health nurse) and the recordings are usually done for a period of time at work and away from work (to give normal values)
- the Department of Labour recommends recording the best of three blows, repeated four times a day (before work, in the middle of work, at the end of work and as the person goes to bed at night) for two weeks, with some

period of this two weeks being away from work. (Peak flow charts are available on the Department's website.)

- if the respiratory questionnaire or the peak flow recordings suggest a problem then more specific lung function testing and x-rays may be appropriate. This would be undertaken at the discretion of the investigating doctor or occupational health nurse (under the advice of the treating doctor).

EMPLOYEE PARTICIPATION

Employees must be involved in the development of health and safety procedures.

PART 21: WELDING FUME CONTROL SUMMARY WORKSHEET

This worksheet can be used to obtain an idea of the level of protection required for different welding processes.

The Welding Fume Control Tool is currently being reviewed.

NOTES