Weld Australia

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Weld Australia
Technical Guidance Note

Fume Minimisation Guidelines: Welding, Cutting, Brazing & Soldering

www.weldaustralia.com.au

Foreword

This Technical Guidance Note provides weld fume control guidelines, originally produced as part of a research project of the Cooperative Research Centre for Materials Welding and Joining in 1997. The aim of the research was to establish which processes generated fume at levels which would need to be controlled to comply with the requirements of what is now the national *Code of practice – Managing the risks of hazardous chemicals*, and to provide advice on the control measures which could be introduced to achieve this.

This edition of the *Fume Minimisation Guidelines* also includes comment on the 2017 ruling from IARC (an agency of the World Health Organisation) in relation to welding fume being reclassified from Group 2B Possibly Carcinogenic to Humans to Group 1 Carcinogenic to Humans.

Acknowledgement

Weld Australia would like to thank Mr Andrew Orfanos (AIOH President-Elect) and the members of the Australian Institute of Occupational Hygienists for their assistance in the preparation of this Technical Guidance Note.

Future Revisions

This Technical Guidance Note will be revised from time to time and comments aimed at improving its value to industry will be welcome.

Disclaimer

The use of these Guidelines cannot guarantee full compliance with the Codes of Practice. By following the methodology, a workplace will lessen or mitigate the risk of non-compliance. Further professional assistance, for example by occupational hygienists or ventilation engineers, may be advisable in those circumstances where the Guidelines may not be entirely applicable or unusual conditions prevail.

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About Weld Australia

Who We Are

Weld Australia represents the welding profession in Australia. Our members are made up of individual welding professionals and companies of all sizes. Weld Australia members are involved in almost every facet of Australian industry and make a significant contribution to the nation's economy.

Our primary goal is to ensure that the Australian welding industry remains both locally and globally competitive, both now and into the future.

A not-for-profit, membership-based organisation, Weld Australia is dedicated to providing our members with a competitive advantage through access to industry, research, education, certification, government, and the wider industrial community.

Weld Australia is the Australian representative member of the International Institute of Welding (IIW).

Our Vision & Mission

Our vision is to facilitate the growth of a world class welding industry in Australia.

Our mission is to create opportunities for our members and advocate welding policies and practices which protect the Australian public.

Our Value Proposition

Weld Australia generates revenue through its commercial activities which is then reinvested back into the welding community for the benefit of members.

Weld Australia brings individual and company members together to deliver:

- A forum for the exchange of ideas and the sharing of resources
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- Specialist technical problem solving and a conduit between industry and research organisations
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Further Information

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Welding and the Risk of Cancer

Introduction

Weld Australia is aware that in March 2017, the International Agency for Research on Cancer (IARC) reclassified welding fume from Group 2B *Possibly Carcinogenic to Humans* to Group 1 *Carcinogenic to Humans*. Their assessment was subsequently published in IARC's Monograph 118 in July 2018.

The International Institute of Welding (IIW) through their Commission VIII experts, are evaluating the findings published by IARC and a position statement is being prepared.

Following discussions with Commission VIII, Weld Australia advises that current fume management recommendations remain valid and recommends that the guidelines published within these *Fume minimisation guidelines* and Weld Australia's Technical Note 7 be followed.

Recommendations

In compliance with National and State WHS Regulations, conduct a risk assessment to ensure that the welder and people working nearby, are protected from exposure to fume from welding and welding-related processes (including thermal cutting, gouging etc.). The following actions should be considered in the risk assessment:

1. Where practicable, remove the welder from the source of the fume by mechanising or automating the welding process.
2. In conformance with Weld Australia's *Fume minimisation guidelines*, arrange the work piece so that the welder's head is not in the plume.

   NOTES:

   (i) Unless welding in the horizontal (PC or 2G), overhead (PD, PE, 4F, 4G) or vertical (PF, PG, 3F, 3G) position, the welder's head is likely to be positioned within the plume, and fume management methods or personal protective equipment (PPE), or a combination of both, may be required.

   (ii) All welding processes generate fume. The plume may not be visible to the welder or with some processes, the observer.
3. Relying on a light cross-draught in the vicinity of the welder's face to ensure that the fume is either drawn or blown away from the welder's breathing zone can be unreliable. Whilst mechanically assisted ventilation (e.g. a fan) can be utilised, cross draughts sufficient to disperse fume may cause weld quality issues. Other fume management equipment such as fume extractors (e.g. fixed, downdraft or portable) may be required.
4. Utilise personal protective equipment such as respirator masks and air fed helmets if alternative methods of fume control are not reasonably practicable.

Care should be taken to ensure that other workers are not exposed to the fume by allowing it to accumulate in areas away from the welding or welding related process.

Specialist advice may also be sought from an Occupational Hygienist e.g. www.aioh.org.au, particularly in the preparation and implementation of the risk assessment, and the verification of the application of the controls.

GUIDELINE 1: Hazardous Chemicals and Regulations

1.1 Objective

The objective of the national *Code of practice – Managing the risks of hazardous chemicals* published by Safe Work Australia, is to reduce the risk of adverse health effects for employees exposed to hazardous chemicals (formerly referred to as "hazardous substances") in their day to day workplace activities. This Code of practice, which is referenced in the national code of practice entitled *Welding processes* (also published by Safe Work Australia), was originally based on the Hazardous Substances Regulations introduced by the States and Territories of Australia in 1994.

1.2 History

The National Occupational Health and Safety Commission (NOHSC) first declared National Model Regulations (NMR) to Control Workplace Hazardous Substances in 1990. Following a period of review, a revised version of the NMR and a National Code of Practice for the Control of Workplace Hazardous Substances were declared in December 1993 and published in March 1994. NOHSC documents are advisory and their application in a State or Territory requires legislation to be enacted by that State or Territory. The NOHSC received assurances from the States that, in the interest of uniformity, State regulations would not differ substantially from the NMR.

In 2012, the national model regulations and accompanying codes of practice were published by Safe Work Australia replacing the hazardous substance regulations. The code of practice entitled *Welding Processes* is an approved code of practice under section 274 of the *Work Health and Safety Act* (the WHS Act). Approved codes of practice are 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).

The *Foreword* of the code of practice *Welding Processes* states:

"… 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."

These codes of practice and the model regulations have since been substantially adopted by most States and Territories of Australia.

1.3 What is a Hazardous Chemical?

In general, a hazardous chemical (or hazardous substance) is a substance that has the potential to adversely affect human health. Hazardous chemicals may:

(a) Be included in the *Workplace exposure standards for airborne contaminants* [Safe Work Australia (April 2018)] or on a list produced by a particular State or Territory, or,

(b) Fit the criteria for a hazardous chemical set out in Workplace Australia's *Classifying Hazardous Chemicals* — National Guide.

However, employers need only refer to Safety Data Sheets (SDS – previously referred to as Material Safety Data Sheets or MSDS) for a hazardous chemical identification. The SDS should be updated every five years and be accessible to all personnel.

***NOTE**: The SDS should refer to chemicals using the Global Harmonised System (GHS) of chemical hazard classification.*

1.4 Application to Welding and Allied Processes

Fume is a hazardous substance according to (b) above. Certain fume components may also be on the list of hazardous chemicals in (a). Individuals should not be exposed to levels above those given in the *Workplace standards for airborne contaminants*.

1.5 Responsibilities

Federal and state regulations set out the responsibilities of manufacturers, importers, employers and employees. With respect to welding and allied processes the following requirements apply.

Suppliers must:

- Provide updated / current Safety Data Sheets (SDS) for substances being supplied for the first time to a particular buyer for use in the workplace.
- Label substances that are hazardous chemicals, or can be when used. Refer to WorkSafe Australia's Code of Practice *Workplace labelling of hazardous chemicals*.

Persons conducting business or undertakings (i.e. employers) must:

- Develop and subsequently maintain a register of all hazardous chemicals used or produced in the workplace. This may include consumables, welding fume or any other hazardous chemical in the workplace.
- Maintain a collection of SDS as part of the register. This register must be available for reference by all employees.
- Ensure a suitable and sufficient assessment is made of the risk to health created by welding fume or other hazardous substances. In most circumstances use of these Fume Minimisation Guidelines will assist in the assessment.
- Revise the assessment at least every 5 years or if workplace conditions change significantly.
- Provide training to all employees with the potential for exposure to welding fume.
- Keep records of training and assessment – assessment reports must be available to employees to whom the assessments relate.
- Provide health monitoring for employees assessed as being exposed to a significant health risk in the course of their employment duties.
- Undertake monitoring where the need is indicated in the assessment.
- Ensure that exposure of employees to hazardous chemicals is prevented or adequately controlled to minimise risk to health. Exposure must not exceed the relevant exposure standards.
- Ensure that engineering controls and safe work practices are effectively maintained.

Workers are required to:

- Cooperate with the employer to ensure that activities within the workplace comply with the statutory requirements.
- Report promptly to supervisors/managers any matter that might diminish the employer's ability to achieve compliance.

1.6 Risk Assessments for Fume

The purpose of a workplace risk assessment is to enable decisions to be made about potential health risks, control measures, training requirements, monitoring and health monitoring. An employer has a duty of care to ensure a suitable and sufficient assessment is made where there is potential for exposure to hazardous chemicals. For the purpose of these guidelines the assessment should focus on activity in the workplace and likely exposures (e.g. in operator's breathing zone). Actions to be undertaken during the assessment include:

- Identify all hazardous chemicals used or produced in the work being assessed.
- Review the information on the nature of the hazard and precautions for use and safe handling.
- Assess the risk in terms of degree of exposure and potential health effects.

The possible assessment methods include the following:

(a) Simple and obvious assessments: These are straightforward assessments where, after reviewing the Safety Data Sheets (or equivalent information such as the composition of the metal or alloy to be welded) for hazardous checmicals used at work and identifying their method of use, it can be concluded that there is not a significant risk to health. In respect of fume, this could mean that one of the control measures referred to in Guideline 2 and the applicable process guideline is already in place.

(b) Detailed assessments: If the assessment is not simple and an appropriate generic assessment is not available, a more detailed risk assessment must be undertaken. This involves obtaining information about the hazardous chemicals primarily from SDS sheets and labels, inspecting the workplace, evaluating exposure and evaluating the risk. If the level of exposure cannot be estimated with confidence, atmospheric monitoring by an occupational hygienist or other competent person may be required and the results compared with exposure standards for the substances.

(c) Generic assessments: Where a particular hazardous chemical(s) is used in the same or similar circumstances in different areas of the same workplace or in different workplaces, the nature of the hazard and the degree of risk may be comparable. In such situations, a single assessment of one representative work situation can be applied to other workplaces. This is the basis of these *Welding Fume Minimisation Guidelines*. It is the responsibility of the individual employer to ensure that the generic assessment is valid for their workplace. This type of assessment is generally based on information or outcomes from detailed assessments.

Further information on conducting these types of assessments may be found in the Worksafe publication “Managing risks of hazardous chemicals in the workplace, Code of practice May 2018”.

> ***NOTE:*** *Irrespective of the assessment method, it should be stressed that exposure standards do not represent “no effect” levels for each and every worker. Therefore, the level of exposure should be kept as low as practicable.*

1.7 Actions Following Assessment

Where assessment indicates a significant health risk, decisions must be made on:

(a) Appropriate control measures: Where prevention of exposure to hazardous material is not practicable, the degree of exposure must be controlled to minimise risk to health. If required for welding and allied processes, the controls are listed in these Guidelines;

(b) Instituting periodic airborne contaminant monitoring;

(c) The need for health monitoring: Includes biological monitoring which can assist in assessing the effectiveness workplace controls;

(d) Training: Training shall be provided by the employer to all employees with potential exposure to hazardous chemicals on the health impacts and control measures, and should be commensurate with the identified risk.

1.8 Compliance Actions

The WHS Act and Regulations permit evidence of compliance with codes of practice to be admitted in court proceedings should this be required. Code of practices are usually seen as evidence of what is known about a hazard, risk or control and the court may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

The WHS Act and Regulations also permits the use of alternative compliance methods, such as a technical or industry standards if it provides an equivalent or higher standard of work health and safety than the code. Examples of these documents include Weld Australia’s Technical Note 7 (which is specifically referenced within the Welding Processes code of practice and these fume minimisation guidelines).

> ***NOTE:*** *Regulatory inspectors may refer to approved codes of practice when issuing provisional improvement notices, or prohibition notices.*

GUIDELINE 2: Fume Control Options

2.1 Introduction

Some form of fume control is generally required in welding, cutting, brazing and soldering operations, usually in addition to existing general workshop ventilation. The level of control necessary will be determined by:

- The particular process being used.
- The materials being worked with and subsequent pollutants generated.
- The working environment.

A risk-based approach is recommended (see Guideline 1), and the choice of control must be carefully considered. Expert advice should be sought if an effective control approach is not obvious.

2.2 Workplace Environment

In general, the more enclosed the working area, the more likely pollutant levels will exceed exposure standards. Typically, work done outdoors or in an open work space may require only general ventilation to prevent a build-up of fumes.

Work in a limited work space will usually require local exhaust ventilation, while work in a confined space will require specific respiratory protection and local exhaust. Note however, that in all circumstances the requirement is to prevent all workers being exposed to pollutants in levels above the relevant exposure standards. The welding, brazing or soldering process, the materials being worked with, and other workers must be carefully considered in addition to the work environment.

A definition of various working environments is given in the following.

2.2.1 Outdoor/Natural Ventilation

When working outdoors, natural ventilation is often considered to be a satisfactory form of fume control, particularly where there is only a low rate of fume generation. This type of air movement is highly variable. On some days there will be hardly any air movement at all, particularly in the workers breathing zone if it is sheltered. Consequently, there will be little dilution and dispersion of the pollutants, in which case additional ventilation measures may be required.

2.2.2 Open Work Space

An open work space is defined as an area where all of the following apply:

- The average space per worker exceeds 300m^3 (minimum roof height 3m).
- Free cross-ventilation occurs and fume dispersion is not obstructed by the workpiece, partitions or screens.
- The workplace has adequate general ventilation.
- The operators are able to keep their heads out of the pollutant plume.

2.2.3 Limited Work Space

A limited work space is one which does not comply with all the requirements of an open work space, but is not a confined work space.

2.2.4 Confined Work Space

A confined work space is one which is not a normal work area, and which meets the criteria listed in the code of practice *Confined spaces* (published by Safe Work Australia) or AS 2865 *Confined spaces*. Both documents include specific recommendations on hot work (e.g. welding) in confined spaces.

2.3 Fume Generation

The constituents of the welding fume are generated in one of three ways:

- The filler metal and flux;
- The parent plate, including its coating and/or surface contaminants (e.g. greases, oils etc); or,
- The action of ultraviolet radiation from a welding arc on the surrounding air.

Particulates are produced only in the immediate vicinity of the heat source. They are largely confined to the plume of heated gases which rises from the weld zone. This plume is usually (but not always) visible to an observer, although not to the welder.

The gaseous decomposition products of contaminants remaining on the workpiece are more widely distributed, and, are generated from the heated portions of the workpiece.

Ozone is generated in a volume of the atmosphere beyond the arc zone. It is not concentrated in the plume to the same extent as particulates. Most welding processes with a visible arc generate levels of ozone which place the welder at some risk of exceeding the exposure standard unless controls are implemented.

Oxides of nitrogen may also be generated by reactions in the air immediately adjacent to the welding zone. The tests conducted by the Working Group on Fume showed that oxides of nitrogen are unlikely to be generated at levels approaching exposure standards in welding processes. Oxides of nitrogen may be a problem with plasma cutting processes using nitrogen additions to the shielding gas.

2.4 General Ventilation

It is essential that the general ventilation of the workplace is adequate to prevent the accumulation of hazardous chemicals or airborne contaminants in the atmosphere. This protects both operators and other workers from exposure to excessive (general fume) levels. It may be preferable to remove fume directly from the source where it is generated, using a ventilated booth or local exhaust ventilation. The latter systems must be designed carefully and used properly to ensure that fume exhaust is adequate.

It may be necessary to consult a ventilation or air conditioning engineer on system design and operation.

2.5 Control Measures

Control measures to minimise worker exposure to hazardous chemicals should recognise the need to protect both the operator of a particular process, and other workers in the workplace.

Where a process would expose workers beyond the limits given in federal and/or state regulations, the control method chosen should follow the hierarchy given in *Managing risks of hazardous chemicals in the workplace, Code of practice May 2018*, viz.

- Change to a process which produces less fume
- Modify the process to produce less fume
- Remove all workers from the location of the hazardous fume
- Apply engineering control methods. These usually need to be considered separately for each worker in a workplace. They include:
  - Preventing the fume entering the breathing zone by use of a cross draft
  - Capturing the fume locally, before it enters the breathing zone
  - Use personal protective equipment (PPE).

Many welding situations will require a combination of these methods.

2.5.1 Processes Producing Less Fume

Guidelines 4 to 16 in this Technical Guidance Note indicate the potential of each process to produce fume. The lower fume process must be further evaluated to determine the need for further controls.

2.5.2 Modification of Processes for Less Fume

The modification of shielding gas by changing the species in the gas mixture, or their balance, or by introducing reactive components, can be used to reduce fume.

Because the bulk of fume in arc processes is generated by the energy of the arc, significant reductions in fume generation rates can be obtained by reducing the energy of the arc.

Unfortunately, the size of these effects cannot be reliably predicted from current knowledge, and these fume control methods must be supported by measurements of workers fume exposure.

2.5.3 Isolate Workers from the Hazardous Fume

Automation of processes allows workers to be remote from the source of all fume components. General ventilation of the workplace must then be adequate to prevent an excessive increase of background levels of fume.

2.5.4 Engineering Control Methods

There are two types of control methods:

- Breathing zone ventilation where hazardous substances are prevented from entering the operators breathing zone by a cross draft of air
- Local exhaust ventilation, where some or most of the hazardous chemicals are captured at source.

2.5.4.1 Breathing Zone Ventilation/Mechanical Dilution

This control is intended to prevent pollutants entering the operators breathing zone by sweeping them away with a cross draft of air. A minimum cross draft away from the operators breathing zone of 0.5m/s will ensure protection against particulate and ozone. A pedestal fan may be adequate for this purpose.

All workers in the workplace must be positioned to avoid fume from other operators, and an adequate level of general ventilation must be provided. Inexpensive instruments for the measurement of air velocity are available from suppliers of fume extractors, air conditioning and laboratory equipment.

2.5.4.2 Local Exhaust Ventilation

Local exhaust ventilation (LEV) captures fume at its source before it enters the operators breathing zone or the workshop atmosphere. LEV should be positioned to capture the plume in which the particulates are concentrated. A minimum capture velocity of 0.5m/s, measured at the fume source is required for protection of the welder from particulate and ozone generated near the arc.

High air velocities at the fume extractor lead to greater efficiency of capture of fumes. Most gas shielded welding processes can tolerate air velocities around the weld zone of about 2m/s. Where adequate welds cannot be made due to disturbance of the gas shield by fume extraction, options available include:

- The shielding gas flow rate may be increased; or,
- The process may be changed; or,
- The welder may be supplied with personal protective equipment (PPE).

Exhaust fume from LEV equipment should be adequately filtered, including for ozone, if it is to be discharged into the workplace. If it is to be discharged outside the workplace, the relevant environmental regulations must be followed, and be isolated from any air intake to the workplace.

Ozone generated between the arc and the operators breathing zone may require additional control measures.

Table 1: Advantages and disadvantages of extraction types.

Extraction Type	Advantages	Disadvantages
Standalone hoods (e.g. articulated arms, or magnetic hose kits)	• Long capture distance so does not interfere with worker • High flow design so will capture/extract high fume concentrations	• Has to be moved around in line with the work, and as a result may not always be used • Generally, has a higher cost per worker
On tool (e.g. fume extraction welding torch, or on-tip soldering extraction)	• Automatically used whenever work is done • High pressure/low flow design uses small diameter hoses, with easier design/installation requirements • Generally has a lower cost per worker	• Adds weight to the tool / handpiece, and reduces flexibility • May not capture all fume (e.g. fume off sparks, residual fume when welding/ soldering finished) • Requires careful set up to capture fume without stripping away shielding gases and regular service to maintain performance
In-bench/fixed (e.g. downdraft or slot benches, solder fume enclosure systems)	• Automatically used whenever work is done • Combines work top/bench with extraction system • Suitable for high velocity fume applications such as oxy-cutting	• Reduced flexibility • Only suitable for work on smaller items • Generally, has a higher cost per worker
Overhead canopy hoods	• Low cost	• Rising fume generally travels straight through the workers breathing zone

2.5.5 PPE Control Methods

Where welding fumes cannot be removed at the source of generation, additional respiratory protection will be required. Respiratory protection selected must filter both particulates and ozone.

A number of factors need to be considered when determining the appropriate type and level of respiratory protection to be used. Such factors not only include the types and amounts of airborne contaminants being generated by the welding process, but also the presence of facial hair and the wearers face shape. Individuals working in and around welding activities may also require some level of respiratory protection.

Care must also be taken regarding hygiene, maintenance and correct facial fit. As such, individuals required to wear respiratory protection must:

a) Have undertaken respirator fit testing;
b) Be trained in the correct wearing and maintenance of such equipment; and,
c) When worn, be clean-shaven at all times.

Compliance with all of these requirements will ensure that the best respirator is selected that to ensures a good fit and maintains an effective seal (see AS 1715).

There are two basic types of respirator: air purifying or air supplied. Refer to AS 1715, *Selection, use and maintenance of respiratory protection devices* for more details.

Table 2: Features and applications of air purifying and air supplied respirators

Type	Style	Features/Applications
Air Purifying	Disposable	Lightweight, maintenance free.
	Maintainable	Suitable for more prolonged use, though with the same protection factor as disposables. Various replaceable filter cartridges available to suit particular pollutants.
	Powered air purifying respirators (PAPR)	Battery powered units which draw air through replaceable filters. Higher protection factor. Can be worn for long periods as they have no breathing resistance, and, deliver a constant flow of air to the wearers face. Incorporated in the actual welding helmet or visor.
Air Supplied	Air line	Breathable air supplied from a compressor through an airline system. Requires a filter/regulator unit to control/clean the air. Incorporated in the actual welding helmet.
	Self-contained breathing apparatus (SCBA)	Air supplied from a backpack tank, for situations where air line systems are not possible.

A risk-based approach should be taken (see Guideline 1) when considering the correct respiratory protection required for the job at hand. The type of respiratory protection required will be determined by both the frequency and duration of the welding activities being undertaken. For example, for a single welding activity of only ten minutes, a disposable P2 respirator with a thin layer of activated charcoal for nuisance levels of ozone, would be required. In contrast, for larger welding jobs, a half face or full-face respirator with both a P2 and organic vapour cartridge, or even a powered air powered respirator (PAPR) may be required.

To determine the appropriate level of respiratory protection required, it is recommended that a workplace risk assessment be undertaken to determine the levels of fume and ozone that welders are being exposed to. Personal exposure monitoring of workers can be undertaken by a occupational hygienist, who, based on the levels of fume and ozone being generated, can identify the correct level of respiratory protection.

As noted previously, for respiratory protection to be effective (excluding PAPR) workers should be clean shaven and have undertaken respirator fit training.

> ***NOTE***: *The P2/N95 mask is a particulate filter personal respiratory protection device, and, is capable of filtering 0.3μm particles. They are used for protection against mechanically and thermally generated particulates or both, especially metal fume produced during welding, thermal cutting and allied processes. It conforms with the requirements of AS/NZS 1716:2012 Respiratory protective devices.*

2.5.6 PPE Alternatives

All alternatives to PPE are readily available in Australia. They are either locally made or imported. They can be purchased direct from the local manufacturer or their distributors and agents e.g. Industrial and welding product suppliers or safety products distributors etc.

Most stand-alone products require no special installation procedures other than the need to ensure sufficient power is available. Some ducted units may require the need of a mechanical services contractor or other skilled tradesman. Design of more elaborate systems can usually be supplied by the manufacturer, mechanical services contractor or a skilled engineer. It is not unusual for the manufacturer or their local agent to perform this task as part of the service. Consideration should be given to ongoing maintenance and efficiency testing requirements.

GUIDELINE 3: Materials

3.1 Introduction

The potential hazards associated with base materials and consumables are detailed in safety data sheets (SDS) which are available from the supplier. This guideline gives a general indication of the effect of the material on fume hazard and may be helpful in situations where SDS are not available, for example in the case of coatings.

3.2 Types of Fume

The materials found in fume consist of:

Particulates

- Metal and metal oxides, lead from paint
- Inorganic fluxes yielding halide salts

Gases and liquids

- Added and photo-oxidant gases
- From coatings, paints and solvents, which can generate gases such as phosgene
- Fluxes from colophony or rosin which can give rise to hydrocarbons, formaldehyde, hydrochloric acid, benzene, styrene, acetone and other chemicals
- Inorganic fluxes yielding halide acids

3.3 Sources of Fume

Materials present in fumes may come from the following sources:

- Consumable – most of the metal fume comes from the consumable
- Surface coatings or surface preparations
- Gases which are added - such as carbon dioxide, argon, helium
- Gases formed by electric arcs - such as ozone and oxides of nitrogen
- Parent metal

It is necessary to consider all these sources to determine the materials in the fume.

3.4 Exposure Standards

The ratio of substances in fume is not equal to the ratio of the input sources. Some elements, which are more volatile than iron, can appear in greater quantity in the fume.

Safe Work Australia not only lists a specific exposure standard for welding fume, it also lists exposure standards for specific metals (e.g. chromium VI in stainless steel) that may also be present within the fume generated. These may have lower exposure limits which should also be observed. In non-ventilated laboratory tests, most welding processes result in a breathing zone concentration greater than the exposure standard. Similarly for ozone and solder flux (pyrolised rosin as formaldehyde), the exposure standard can be exceeded in poorly or non-ventilated workshops.

3.5 Consumables

- Consumables generally contain metals and also various elements, which assist the process and protect the weld from the atmosphere.
- Brazing fluxes contain mixtures of potassium bifluorides and borates. Fluorosilicates, boron, sodium aluminium fluoride and sodium fluoride may be present in specific formulations. Aggressive soldering fluxes contain inorganic salts often with hydrochloric acid as well as fluorides and fluoroborates, orthophosphoric acid and glycerin. Less aggressive solder fluxes contain organic compounds which decompose at soldering temperatures. They may contain hydrazine monohydrobromide, lactic acid, glutamic acid, hydrochloric acid and wetting agents. As these fluxes are highly corrosive, significant risk is present from any skin/eye contact. Non-corrosive fluxes, typically used in electronic applications, are based on rosin in water or solvent and may contain halide or organic acid activator additions. Colophony is rosin.
- Submerged arc welding gives off minimal fume, but care needs to be taken to avoid dust when handling the flux.

Remember to refer to the SDS, which is available from the consumable supplier.

3.6 Coatings

Metals can be coated with plastics, polyurethane, epoxy materials, paint or other metals. Common examples include primers with rust preventatives, galvanised steel and chrome plating. Particular care must be taken for cadmium coatings, which are highly toxic. If it is not possible to identify the coating, fume control must be employed.

For welding, a 20-25mm band should be removed prior to welding. For flame cutting, this band should be 50-100mm.

(a) *Metallic coatings*: galvanising (zinc), sprayed coatings (aluminium, zinc and others), electroplating (chromium with copper and nickel underlays, cadmium, zinc or tin) are common.

(b) *Paints*: give off a complex mixture. Lead, zinc, chromium, cadmium and other metals may arise from pigments and resins.

(c) *Plastics*: give off a complex mixture. Ammonia, hydrochloric acid, carbon dioxide, cyanides can arise. These can be irritant, corrosive, asphyxiating and toxic.

3.7 Surface Preparations

Chlorinated hydrocarbons like trichloroethylene, perchloroethylene, trichloroethane, acetone and freons are used as degreasing agents. Do not breathe vapours of these agents.

Chlorinated hydrocarbons and freons, under certain conditions, can decompose to form phosgene, which is highly toxic. Care must be taken to dry the surface before welding.

3.8 Major Classes of Metals

Mild steel may contain:

- Iron, carbon, manganese, silicon, aluminium
- Occasionally nickel, chromium, molybdenum, niobium, vanadium, boron

Stainless steels may contain:

- Iron, chromium and nickel
- Occasionally molybdenum, manganese, titanium and other elements

Aluminium may contain:

- Aluminium, silicon, iron, copper, manganese, chromium, zinc, titanium
- Occasionally gallium, vanadium and/or boron in wrought alloys
- Occasionally tin and/or lead in cast alloys

Copper, bronze and brass alloys may contain:

- Copper, zinc, nickel, aluminium, tin, lead, silicon, iron
- Occasionally manganese, tellurium, sulphur, chromium, cadmium, beryllium, silver, cobalt

The specific quantities of additions will vary with the grade of material selected. The relevant industry associations listed below should be contacted for further information if required:

- Australian Aluminium Council,
- Australian Stainless Steel Development Association,
- Copper Development Association of Australia,
- Nickel Development Institute.

List of Atmospheric Contaminants, SafeWork Australia's Workplace Exposure Standards, and the Medical Effects

Substance	Type		TWA ppm	TWA mg/m^3	STEL mg/m^3	Carcinogen Category	Medical Effects
Aluminium	Fume	Al		5			Respiratory irritant
Barium	Sol. compounds	Ba		0.5			Respiratory tract and skin irritant, benign pneumoconiosis with heavy exposure
Beryllium	& compounds	Be		0.002		2	Very toxic, damages respiratory tract, quick acting, carcinogenic
Boron oxide				10			Eye and respiratory irritant
Cadmium	& compounds	Cd		0.01		2	Very toxic, lung and kidney damage. Quick acting, may be fatal
Calcium Oxide	Fume	CaO		2			Irritant of eyes, mucous membranes and skin
Chromium	Compounds	Cr (II)&(III) Cr (VI)		0.5 0.05		1	Toxic, damages respiratory tract, corrosive to skin Carcinogenic
Cobalt	Metal dust & fume	Co		0.05			Irritant, fibrosis of the lung, sensitizer
Copper	Fume	Cu		0.2			Metal fume fever
Fluorides		F		2.5			Irritant of eyes, mucous membranes, skin and lungs
Iron Oxide	Fume	Fe2O3		5			Siderosis (no long term effects)
Lead	Fume	Pb		0.05			Affects the nervous system, digestive system, and mental capacity
Magnesium Oxide	Fume	MgO		10			Irritant, metal fume fever
Manganese	Fume	Mn		1	3		Toxic, tiredness, pneumonia, psychotic behaviour
Molybdenum	Sol. Compounds Insol. Compounds	Mo		5 10			Irritant
Nickel	Metal Sol. compounds	Ni		1 0.1		1	Metal fume fever, carcinogenic Respiratory and/or skin irritant
Nitrogen Dioxide		NO_2	3	5.6	9.4		Irritant
Ozone		O_3	0.1 Peak limitation	0.2 Peak limitation			Irritant of the respiratory tract and lungs.
Phosphoric acid		H_3PO_4		1	3		Mild irritant of the eyes, upper respiratory tract and skin.
Potassium Hydroxide		KOH		2 Peak limitation			Severe irritant of eyes, mucous membrane, and skin

Substance	Type		TWA ppm	TWA mg/m³	STEL mg/m³	Carcinogen Category	Medical Effects
Pryrolised rosin (colophony)	Fume			0.1		2	Respiratory and/or skin irritant
Selenium	Compounds	Se		0.1			Irritant of eyes, mucous membranes and skin. Central nervous system effects with chronic exposure.
Silica	Respirable dust	SiO_2		2			Fever, similar to metal fume fever
Sodium Hydroxide		NaOH		2 Peak limitation			Severe irritant of eyes, mucous membrane, and skin
Tin	Oxide & inorganic compounds	Sn		2			Stannosis, a rare benign pneumoconiosis
Titanium Dioxide		TiO_2		10			Mild respiratory irritant
Vanadium Pentoxide	Respirable dust & fume	V_2O_5		0.05			May cause tremor and depression of central nervous system
Zinc Oxide	Fume	ZnO		5	10		Metal fume fever, bronchitis
Weld Fume				5		See notes 3 & 5	See notes 3 & 5

NOTES:

1. *SafeWork Australia's Workplace exposure standards as at 27th April 2018 (currently under review).*
2. *The Australian workplace exposure limits are similar in many instances to those published in the United Kingdom and Europe. In some instances, UK authorities differentiate between Inhalable fractions and Respirable (i.e. penetrate deep into the lungs) fractions with the latter having similar TLV's to those published in Australia. Notable exceptions are outlined in the table opposite.*
3. ***Metal fume fever** - The fumes of several metals and their oxides can give rise to metal fume fever. Fever, nausea, cough, shivering, headache, muscle ache, shortness of breath and general malaise may occur. The condition may start a few hours after the end of the working day, and last a day or so. The fever subsides spontaneously and no chronic effects result.*
4. ***Other health effects** - Certain alloying elements may result in further health complication*
5. ***Risk of Cancer** - See "Welding and the risk of cancer" section published in these Guidance Notes.*

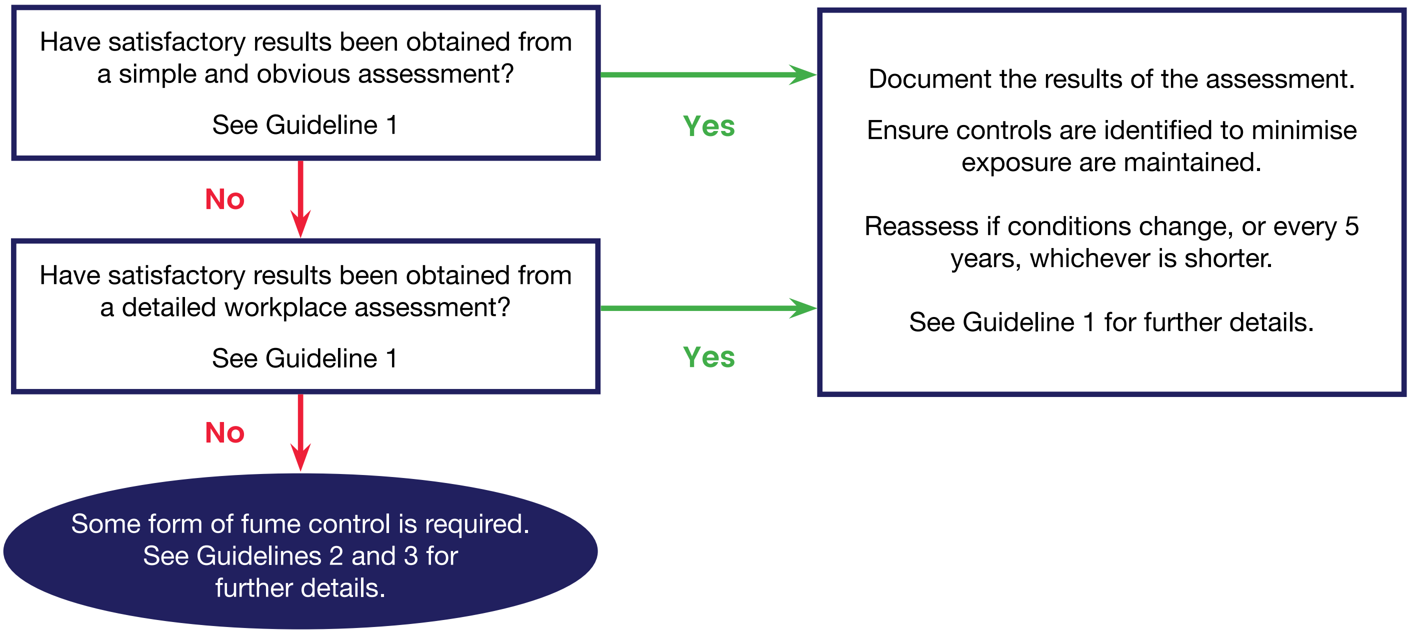
Substance		TWA (mg/m³)
Aluminium	Inhalable Respirable	10 4
Calcium Oxide	Inhalable Respirable	2 1
Magnesium Oxide	Inhalable Respirable	10 4
Manganese	Inhalable Respirable	0.2 0.05
Nitrogen Dioxide		0.96
Pyrolised rosin (colophony)		0.05
Selenium		
Titanium Dioxide	Inhalable Respirable	10

Source: EH40/2005 Workplace exposure limits 2018 published by the Health & Safety Executive of the United Kingdom

GUIDELINE 4: Manual Metal Arc Welding (MMAW)

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from MMAW usually exceeds the recommended levels (see Figure 4.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the welders breathing zone (see Figure 4.2). Accumulation of fumes in the workshop must be prevented by general ventilation.



Steps to Reduce the Effect of Fumes and Gases

1. Process Alternatives

Consider using GMAW, FCAW, SAW or GTAW as these processes may be mechanised and/or on gun fume extraction is available. Higher capital costs are often offset by higher productivity.

2. Process Modifications

Arrange welding to reduce welder's exposure as shown in Figure 4.3. This also reduces fatigue and back problems.

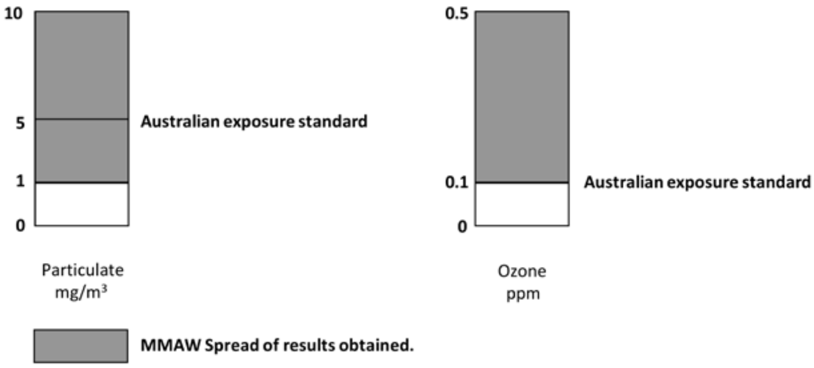


Figure 4.1: MMAW fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

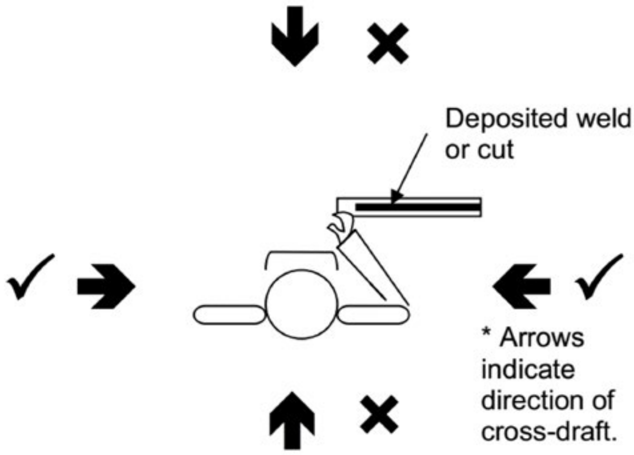


Figure 4.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

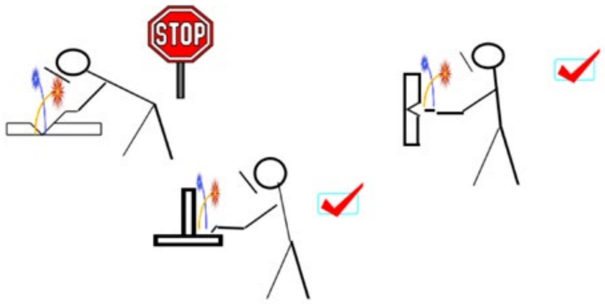
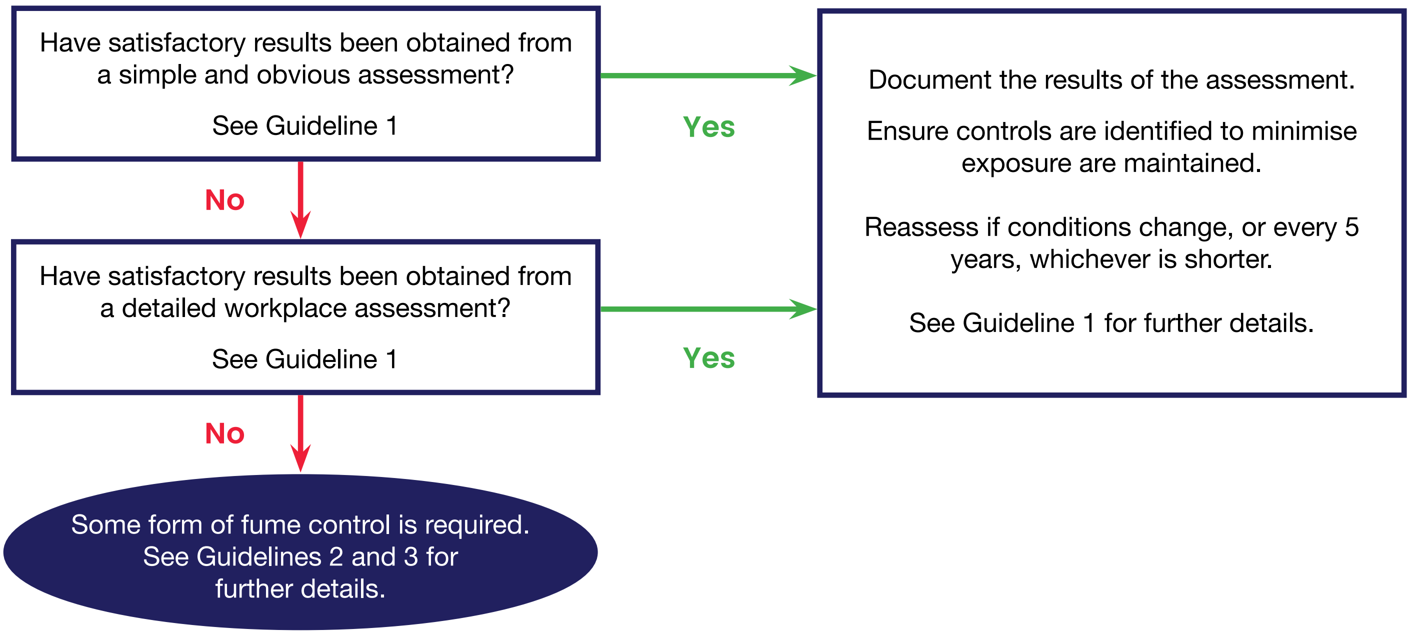


Figure 4.3: The welder's head should not enter the visible fume plume.

GUIDELINE 5: Gas Metal Arc Welding (GMAW)

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from GMAW (or MIG) processes usually exceeds the recommended levels (see Figure 5.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the welders breathing zone (see Figure 5.2). Accumulation of fumes in the workshop must be prevented by general ventilation.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives

Consider using SAW for flat position seams in heavier material. Higher capital costs are often offset by higher productivity.

2. Process Modifications

(a) Arrange welding to reduce welder's exposure as shown in Figure 5.3. This also reduces fatigue and back problems.

(b) Consider using alternative shielding gases (Argon/Helium mixtures reduce ozone, and, for steel, Argon/CO_2 may reduce particulate).

(c) Mechanise the process using simple tractors, turntables or robots.

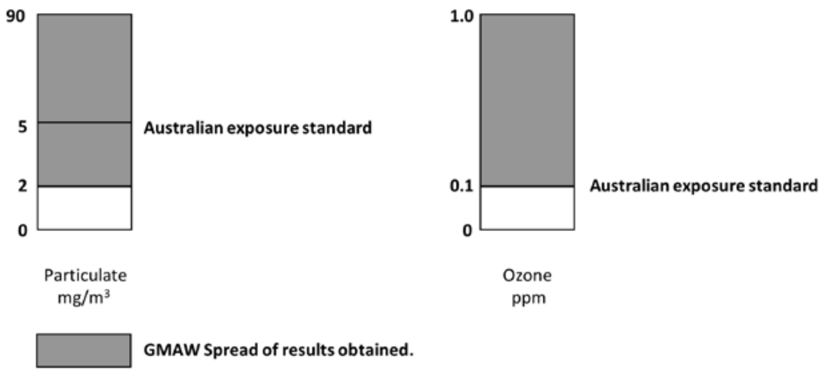


Figure 5.1: GMAW fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

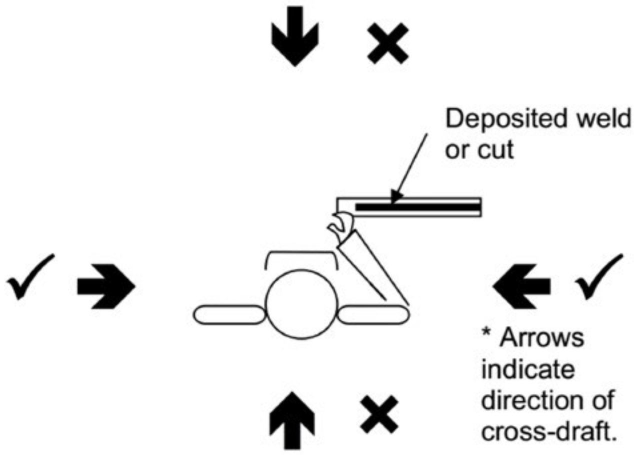


Figure 5.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

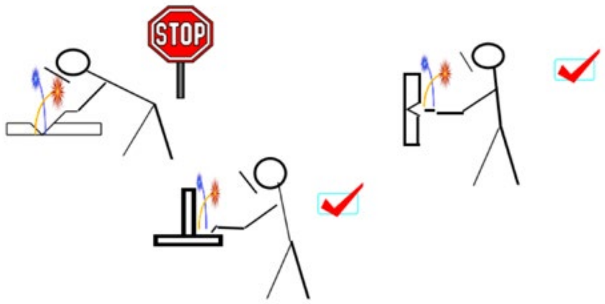
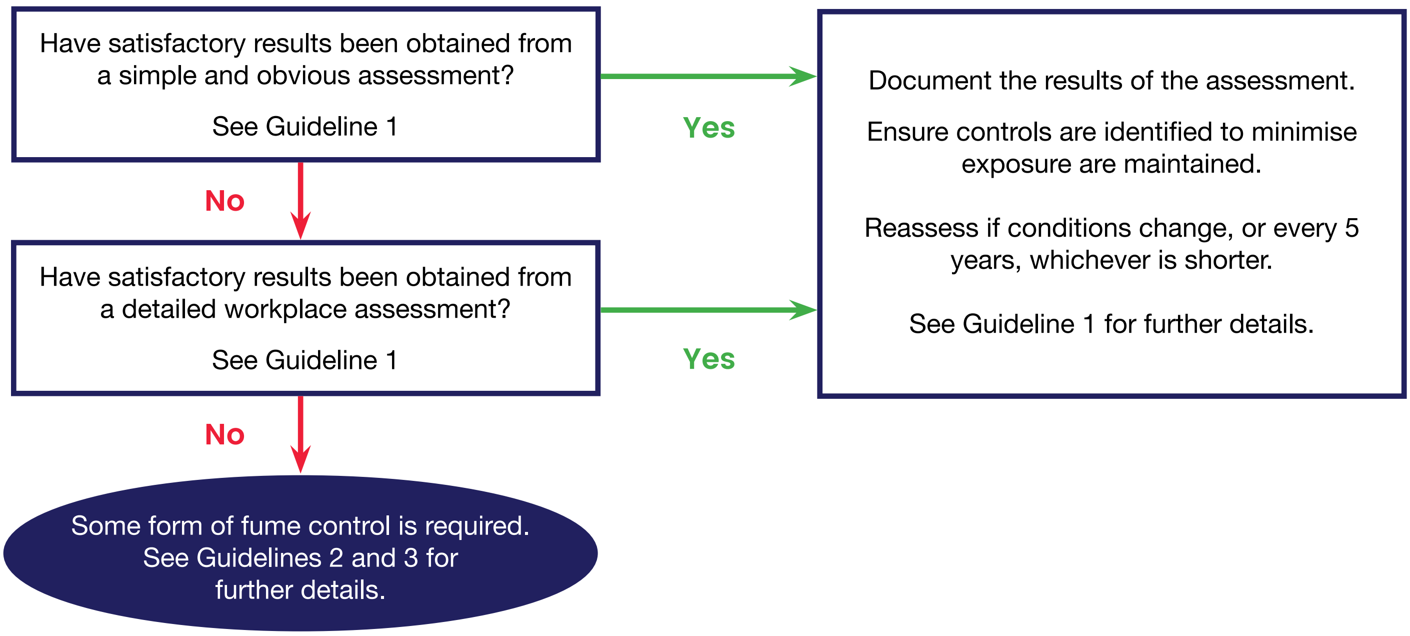


Figure 5.2: The welder's head should not enter the visible fume plume.

GUIDELINE 6: Gas Tungsten Arc Welding (GTAW)

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from GTAW (or TIG) usually exceeds the recommended levels (see Figure 6.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the welders breathing zone (see Figure 6.2). Accumulation of fumes in the workshop must be prevented by general ventilation.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives

Laser and electron beam welding may be viable but higher capital costs must be offset by higher productivity.

2. Process Modifications

(a) Arrange welding to reduce welder's exposure as shown in Figure 6.3. This also reduces fatigue and back problems.

(b) Consider using alternative shielding gases (Argon/Helium mixtures reduce ozone in aluminium welding and Argon/Hydrogen may be used to reduce ozone levels with austenitic stainless steel).

(c) Mechanise or automate the process.

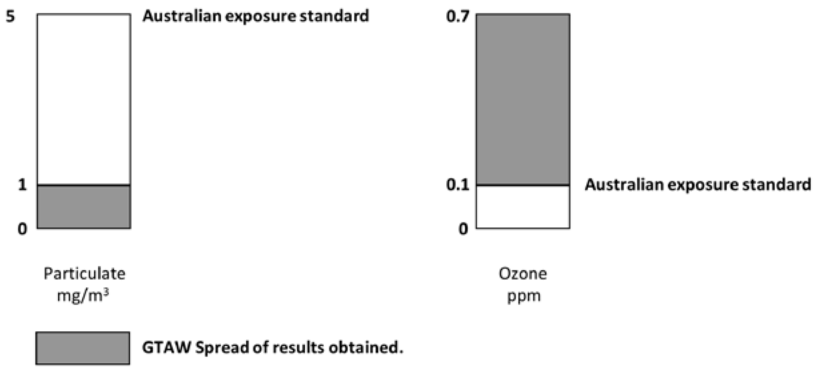


Figure 6.1: GTAW fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

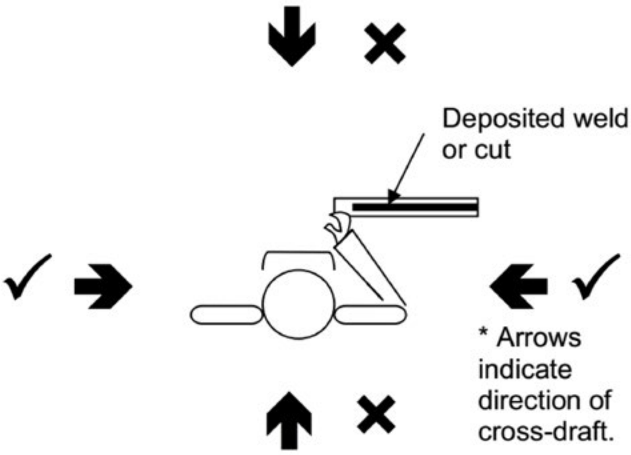


Figure 6.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

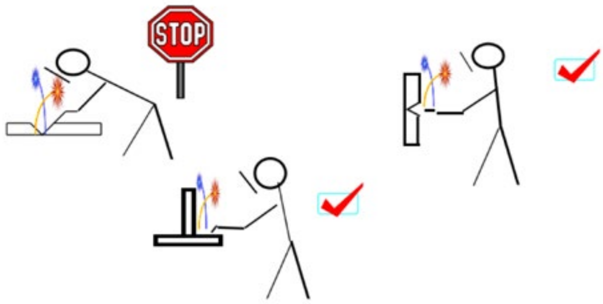


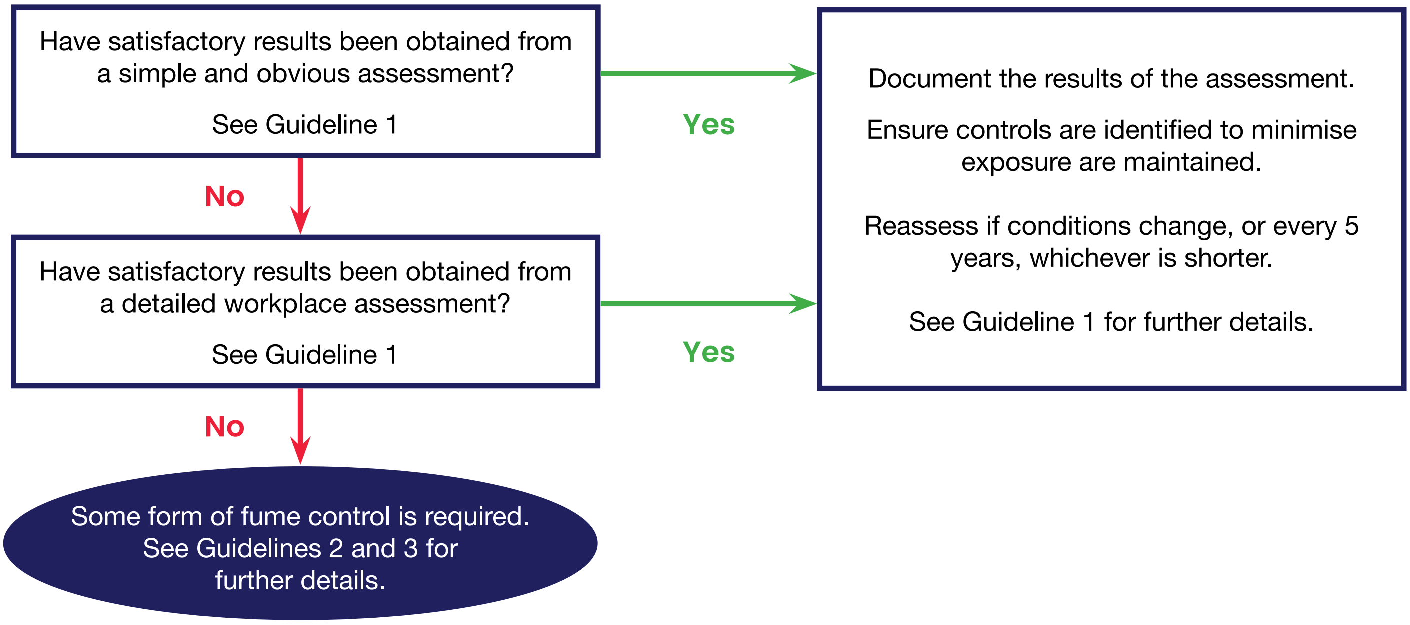
Figure 6.3: The welder's head should not enter the visible fume plume.

GUIDELINE 7: Flux Cored Arc Welding (FCAW)

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from FCAW usually exceeds the recommended levels (see Figure 7.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the welders breathing zone (see Figure 7.2). Due to the high levels of fume generated, there is a greater likelihood of co-workers exposure exceeding the relevant exposure standards unless good general ventilation is implemented.

Particular care should be taken with self-shielded hardfacing wires which are normally expected to be used outdoors.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives

Consider using SAW or GMAW for flat position seams in heavier material and for hardfacing. Higher capital costs are often offset by higher productivity.

2. Process Modifications

(a) Arrange welding to reduce welder's exposure as shown in Figure 3. This also reduces fatigue and back problems.

(b) Consider using alternative shielding gases (Argon/Helium mixtures reduce ozone and Argon/CO_2 may reduce particulate fume).

(c) Mechanise the process using simple tractors, turntables or robots.

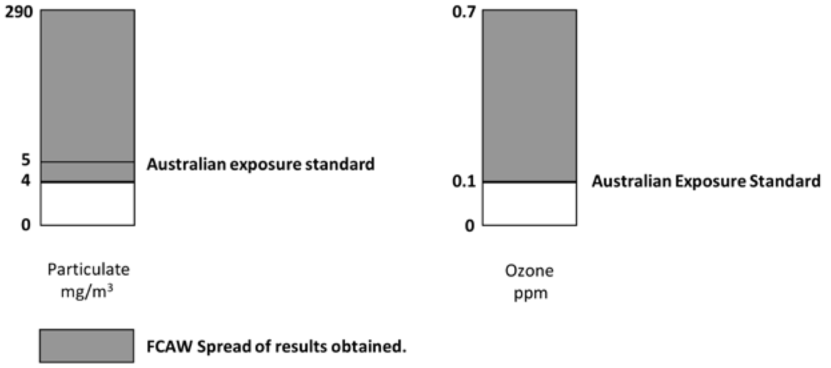


Figure 7.1: FCAW fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

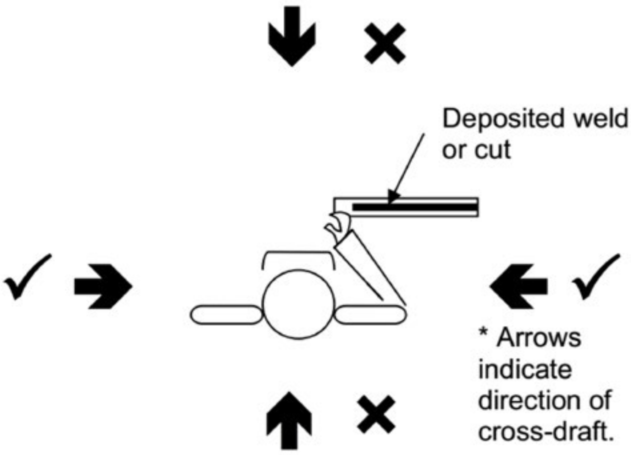


Figure 7.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

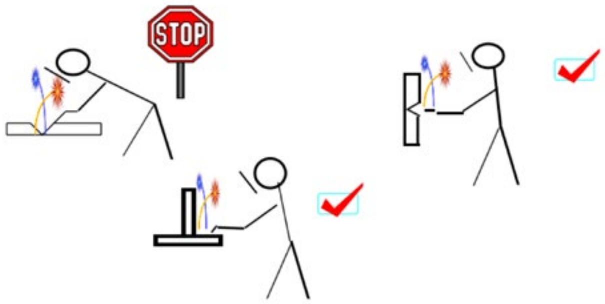


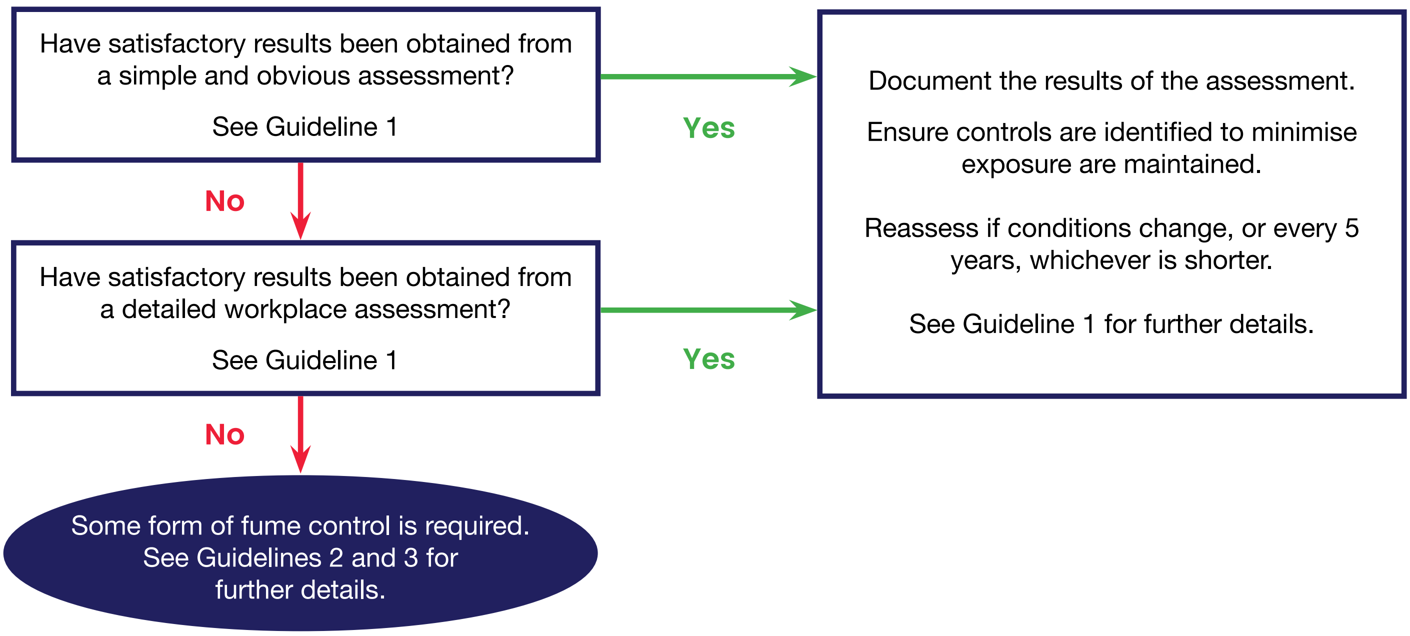
Figure 7.3: The welder's head should not enter the visible fume plume.

GUIDELINE 8: Hardfacing

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, fume from FCAW hardfacing operations usually exceeds the recommended levels (see Figure 8.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the welders breathing zone (see Figure 8.2). Due to the high levels of fume generated, there is a greater likelihood of co-workers exposure exceeding the relevant exposure standards unless good general ventilation is implemented.

Hardfacing consumables are often highly alloyed and fumes may contain significant levels of manganese and chromium. See Guideline 3 for relevant exposure standards.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives

Consider using wearplate or alternate processes such as submerged arc surfacing.

Gas Metal Arc and Gas Tungsten Arc surfacing both produce less fume than other "open arc" processes.

2. Process Modifications

(a) Arrange welding to reduce welder's exposure as shown in Figure 3. This also reduces fatigue and back problems.

(b) Mechanise the process using simple tractors, turntables or robots.

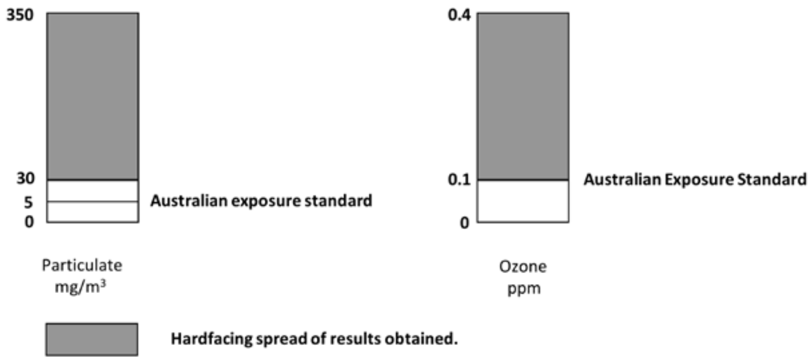


Figure 8.1: Hardfacing fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

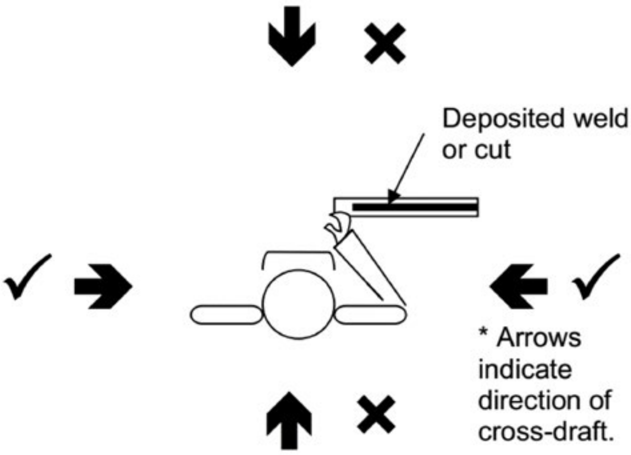


Figure 8.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

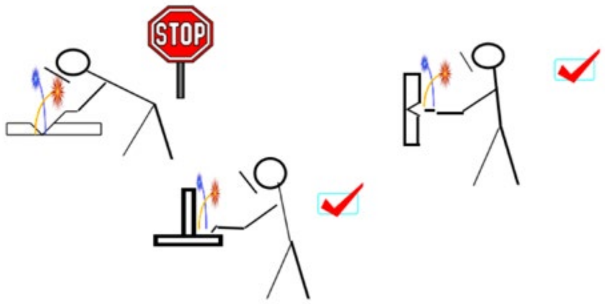
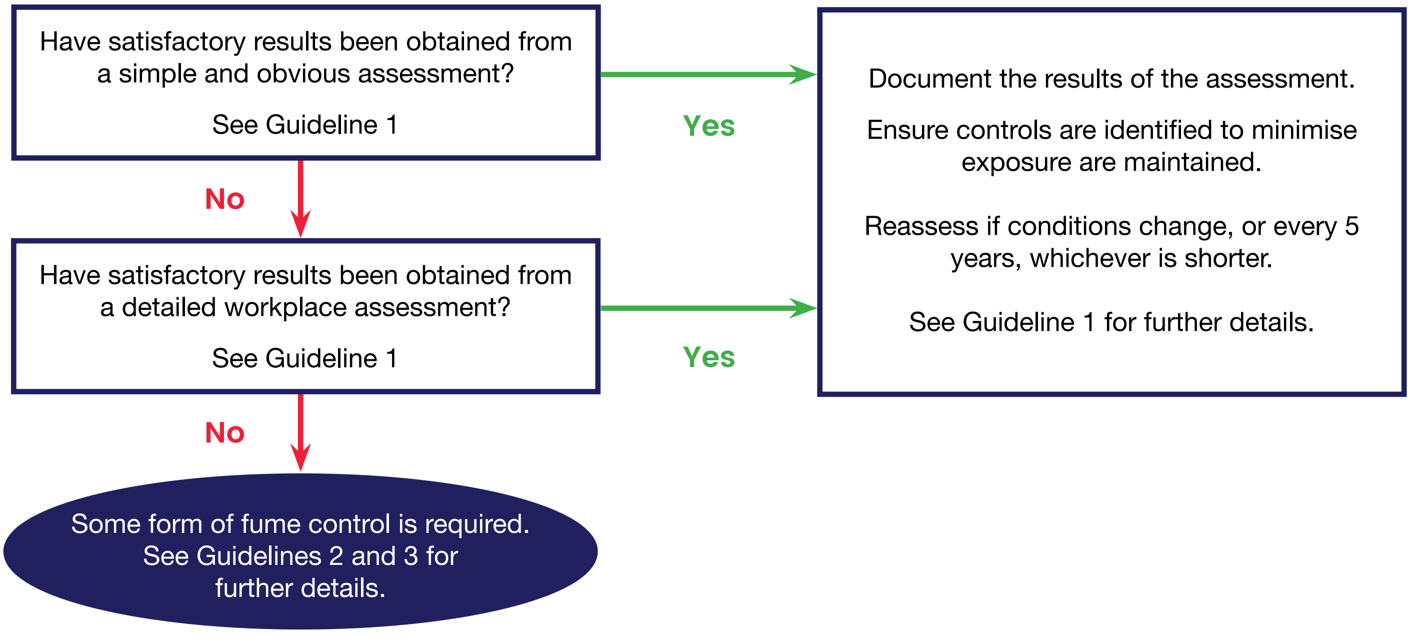


Figure 8.3: The welder's head should not enter the visible fume plume.

GUIDELINE 9: Plasma Cutting

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from plasma cutting usually exceeds the recommended levels (see Figure 9.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the operators breathing zone (see Figure 9.2). Accumulation of fumes in the workshop must be prevented by general ventilation. Oxides of nitrogen may be a problem with plasma cutting processes using nitrogen additions to the shielding gas.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives

Consider guillotining, laser cutting, mechanical cutting or water jet cutting.

2. Process Modifications

(a) Arrange cutting to reduce operator exposure as shown in Figure 3. This also reduces fatigue and back problems.

(b) Plasma cutting is easily mechanised and readily automated.

NOTE: *Automatic cutting processes (water table or travelling head) are beyond the scope of this guideline. Please consult the manufacturer for safe use of automated plasma cutting equipment.*

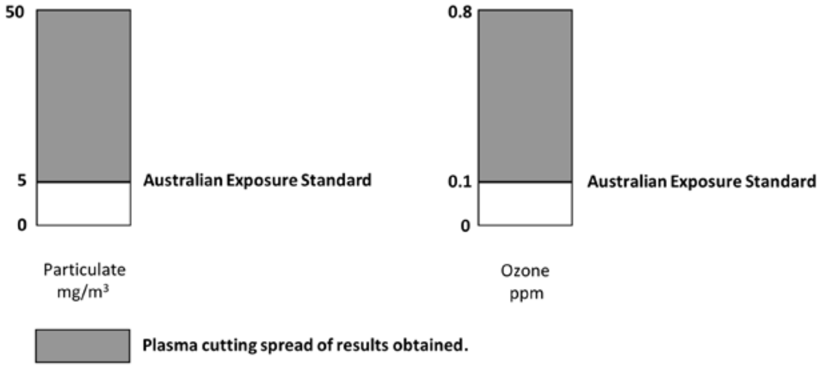


Figure 9.1: Plasma cutting fume production at the breathing zone under still air conditions compared to the regulations (not to scale).

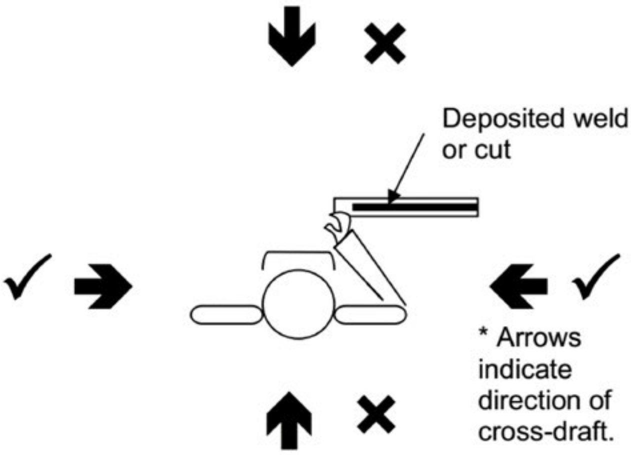


Figure 9.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

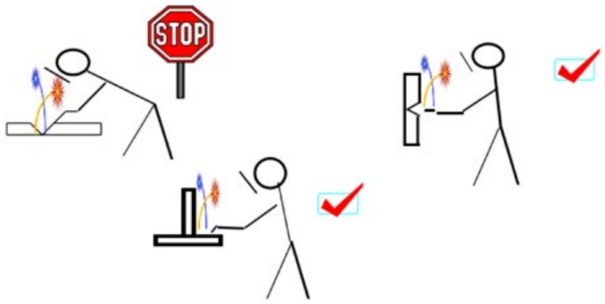
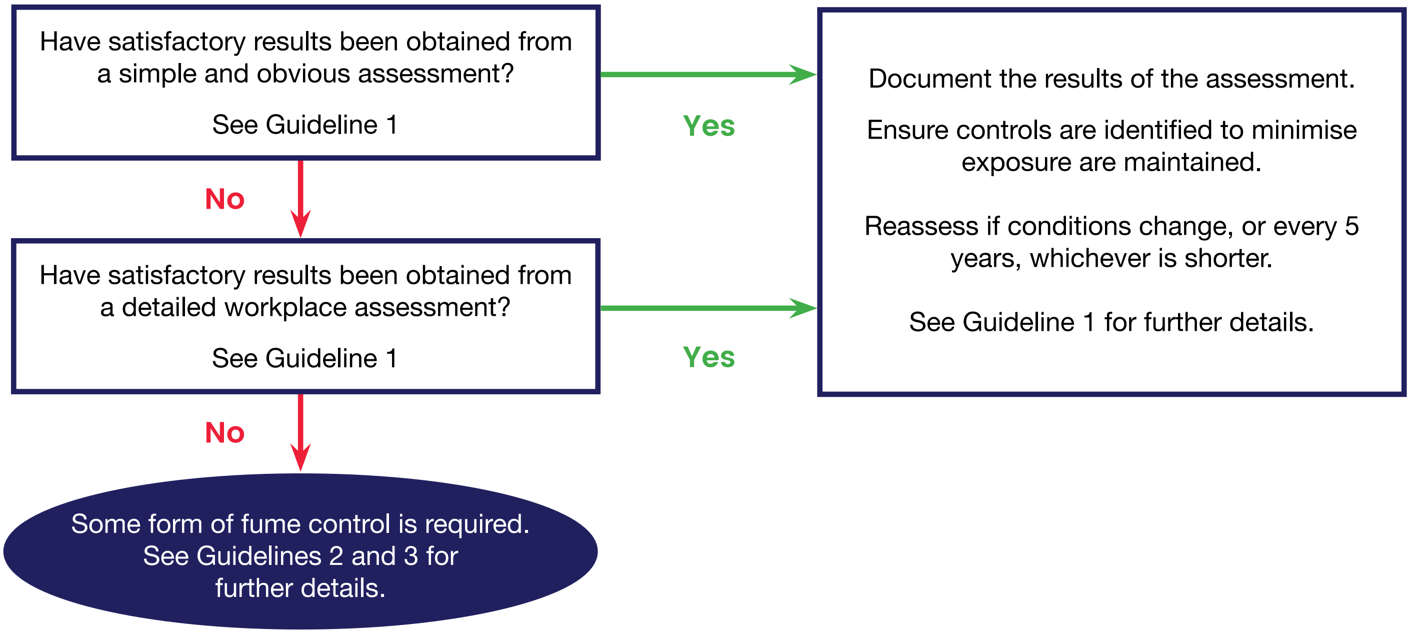


Figure 9.3: The welder's head should not enter the visible fume plume.

GUIDELINE 10: Oxy-Fuel Cutting

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

It should be noted that in tests conducted under still air conditions, breathing zone fume from oxy-fuel cutting usually exceeds the recommended levels (see Figure 10.1). No special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the operators breathing zone (see Figure 10.2). Accumulation of fumes in the workshop must be prevented by general ventilation.



Steps to Reduce the Effect of Fume and Gases

1. Process Alternatives
Consider guillotining, plasma cutting, mechanical cutting or water jet cutting.

2. Process Modifications
- (a) Arrange cutting to reduce operator exposure as shown in Figure 3. This also reduces fatigue and back problems.
- (b) Oxy-fuel cutting is easily mechanised and readily automated. Guide wheels are available for manual cutting torches.

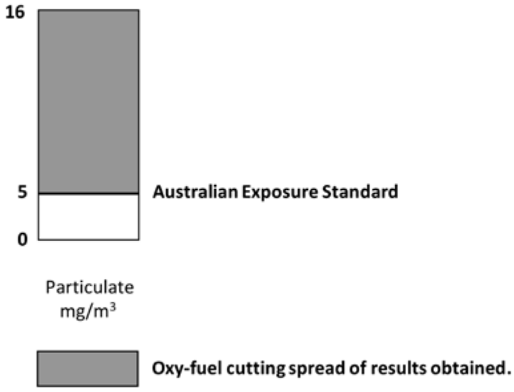


Figure 10.1: Oxy-fuel cutting fume production at the breathing zone under still air conditions com pared to the regulations (not to scale).

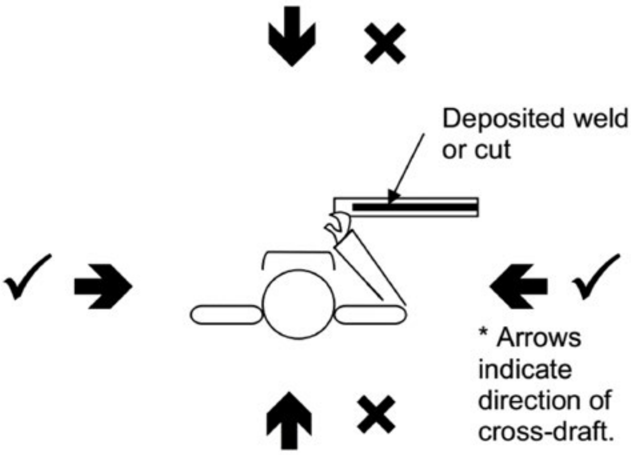


Figure 10.2: Preferred and non-preferred direction of cross draft for breathing zone ventilation.

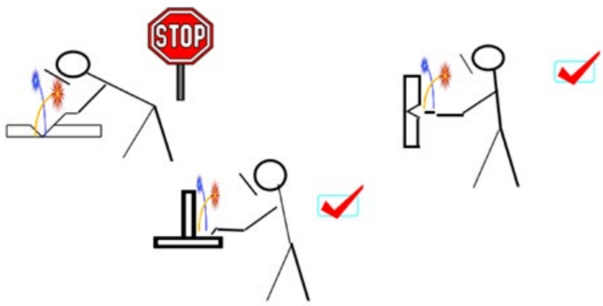


Figure 10.3: The welder's head should not enter the visible fume plume.

GUIDELINE 11: Low Fume Level Processes

Low Fume Processes

(a) Submerged arc welding (SAW)
(b) Electroslag welding
(c) Water jet cutting
(d) Resistance welding e.g. spot, seam and projection welding
(e) High frequency induction welding
(f) Friction welding
(g) Ultrasonic welding
(h) Semi automatic stud welding

Materials

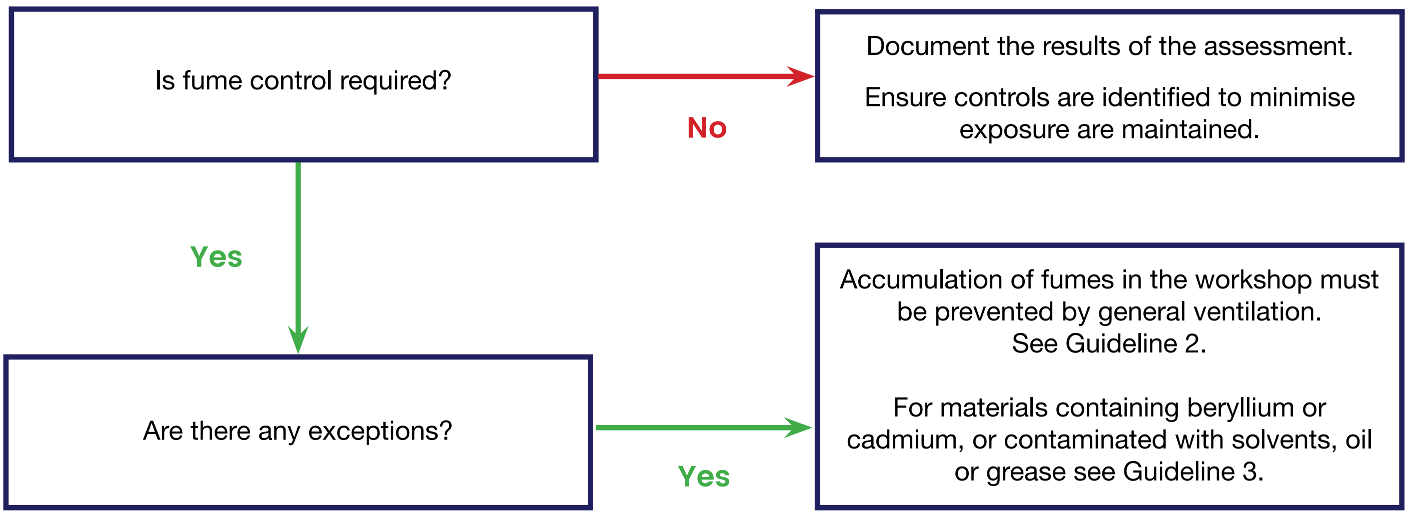
All materials known not to contain beryllium or cadmium as an alloying element or as a coating, and not contaminated with solvents, oil or grease. (see Guideline 3).

Explanation

Atmospheric contaminants are generated only in small quantities by these processes, because either:

(a) The arc region is protected by a heavy slag blanket, which filters out metallic fume and prevents the formation of significant gaseous fume (ozone and oxides of nitrogen) by ultraviolet radiation from the arc (SAW welding), or
(b) The process does not use an arc (all the other processes in the list).

In addition, all of these processes are automatic or semiautomatic, and do not require the operator to be close to the work.



GUIDELINE 12: Brazing and Soldering: Plumbing Industry

Scope

Covers the brazing and soldering of copper and brass tube for plumbing, drainage, gas fitting, air conditioning, refrigeration, fire and mechanical services.

Materials

Brass and copper tube made from phosphorus deoxidised copper, high residual phosphorus alloy C12200 and 70/30DR arsenical brass alloy C26130 (alloy 259).

Covers solder and silver brazing alloys which comply with the Australian and New Zealand standard AS/NZS 3500.1 *Plumbing and drainage—Water services*. Soft solder must be “lead free” (i.e. containing not more than 0.1% lead) and silver brazing alloys must be “cadmium free” (i.e. containing not more than 0.05% cadmium and a minimum of 1.8% silver).

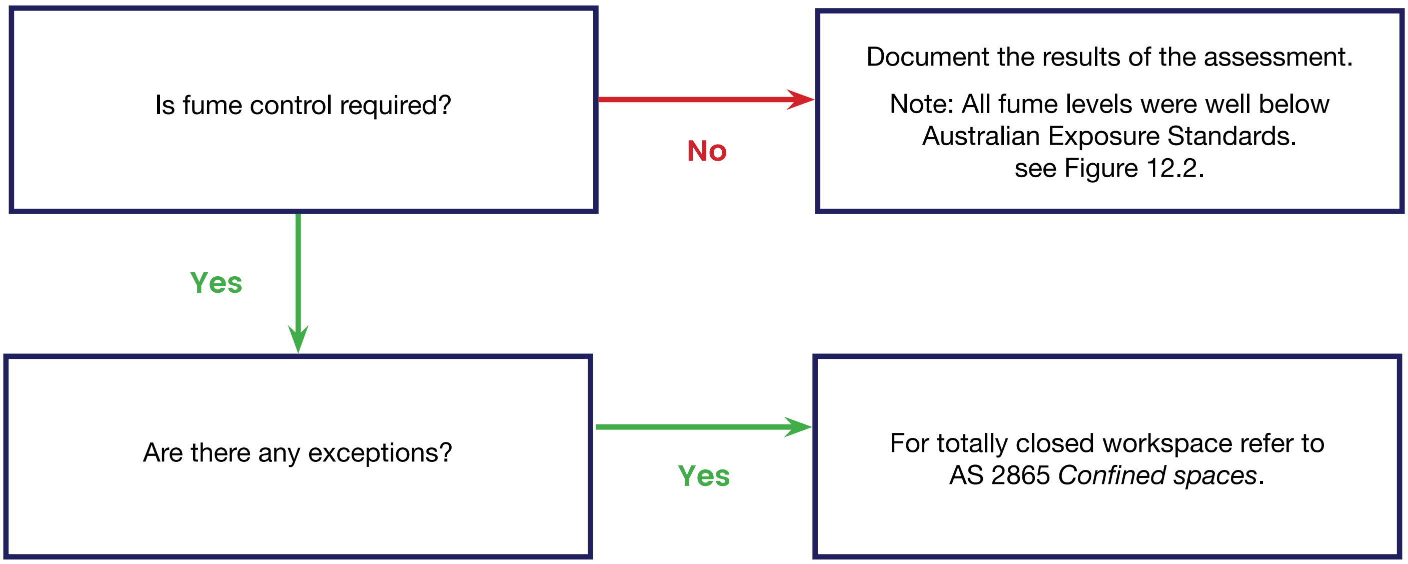
Overview

This guideline is based on a two-stage research program.

Initial testing was performed by Bakkham Pty Ltd in conjunction with the CDAA. It involved copper/copper, copper/brass, brass/brass, copper/gunmetal in a range of common pipe and fitting sizes e.g. DN15 to DN100. 2% silver solder, 15% silver solder and *Aquasafe* soft solder (99% tin) were used and where fluxes were required *Eziweld, Laco, Yorkshire and Tenacity* brands were employed. Further tests were performed by CSIRO in conjunction with CRC, WTIA and CDAA using heavy wall large diameter pipe to represent the worst-case scenario. Tube sizes were: AS 1432 Copper: DN150 Type B (152.40x2.03mm); AS 3795 Brass DN100 type D (101.60 x 1.22mm). All work was conducted at waist level in an enclosed booth 2m x 2m with open top and minimum air movements. Operators kept their head out of the visible plume and samples were taken from the breathing zone for periods over 30 minutes (see Figure 12.1).

NOTE: *AS 3795 has been withdrawn.*

Results



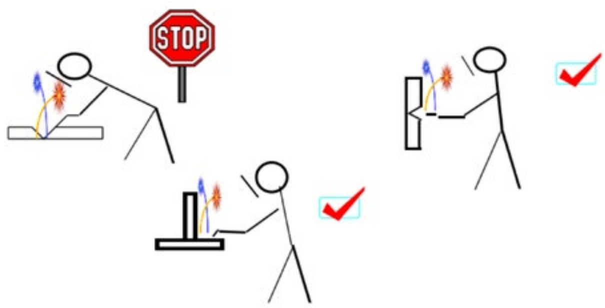


Figure 12.1: The welder's head should not enter the visible fume plume.

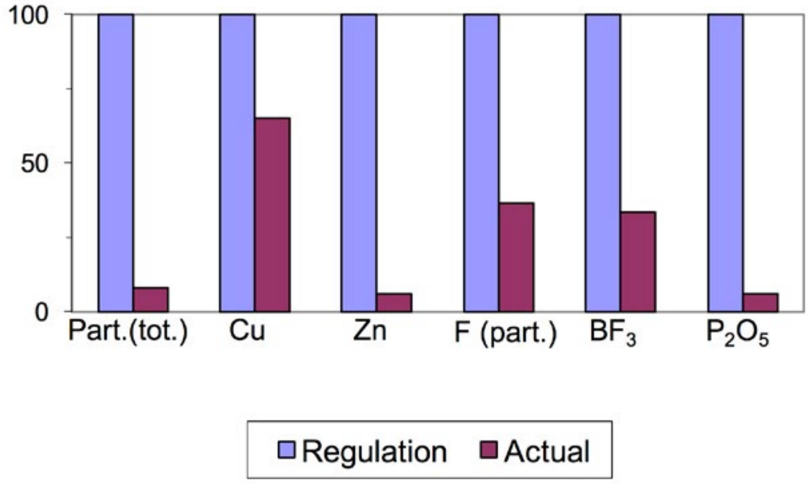


Figure 12.2: Plumbing fume production and analysis at the breathing zone as a percentage of Australian Exposure Standard limits.

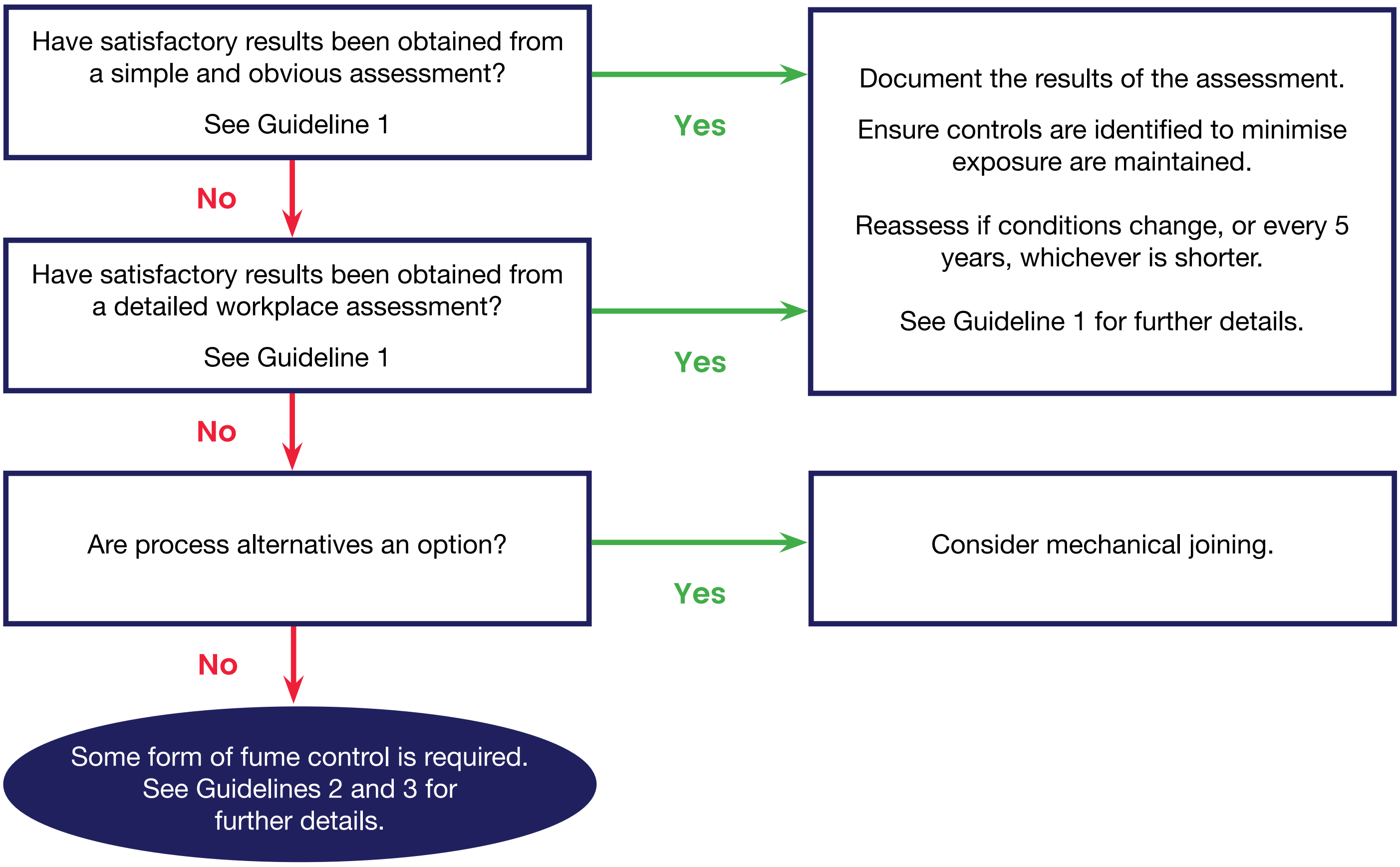
***Note**: All exposures must be controlled so far as is reasonably practicable.*

GUIDELINE 13: Soft Soldering: Electrical/Electronic Industry

Melting range (typical 60Sn 40Pb) 183°-190°C

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

For non routine repair activities, no special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the operators breathing zone. In normal soldering operations a risk assessment is likely to find that there is no significant risk of lead absorption, but control measures must be in place to limit exposure to all flux fumes.



NOTES:

1. *For bench work local exhaust extraction to remove fume before reaching the breathing zone is recommended using tip extraction on soldering irons or articulated arm/suction tube extraction from the work place. Mobile extraction units or respirators can be used for maintenance (e.g. wave solder bath) and field work.*
2. *Mechanical ventilation should be backed up with complete filtration of fume particulate and gases to avoid recirculation of pollutants into the work environment. Typically, a three-stage system is used comprising of coarse filter to remove down to 95% of 1 um, then a high efficiency particle air filter to remove 99.997% of 0.3 um followed by a gas filter e.g. activated carbon. A preventative maintenance regime is required for such a system.*

Scope

Process	Typical Application	Typical Solders	Typical Fluxes
Hand soldering iron	General assembly	• 63/37, 60/40 Sn Pb • 50Sn/48.5 Pb/1.5 Cu (limits tip erosion) • 62 Sn/36Pb/2 Ag (low melting point) • Plain or flux cored wire	Rosin (colophony) with or without halide activator.
Wave soldering	PCB plug in devices	• 63/37,60/40 Sn Pb • 62/36/2Ag (board separately fluxed)	Rosin in solvent or "no clean" modified rosin with halide free/carboxylic acid activator
Reflow soldering	PCB surface mount devices	60Sn/40 Pb solder cream incorporating flux. Screen printed. Reflowed under inert atmosphere.	"No clean" modified rosin. Halide free activator.

Fume Species

Solder

Metal oxide fumes are usually less than the relevant Australian Exposure Standards at soldering temperature. Lead is poorly absorbed by intact skin but is absorbed if swallowed from dirty hands giving various chronic health effects.

Rosin Flux

(a) Formaldehyde, abietic acid, isopropyl alcohol, benzene, toluene, hydrochloric or hydrobromic acid from amine/halide activator.

(b) Water soluble resin free fluxes containing phosphorus hexate give hexanoic acid fumes.

Health Effects

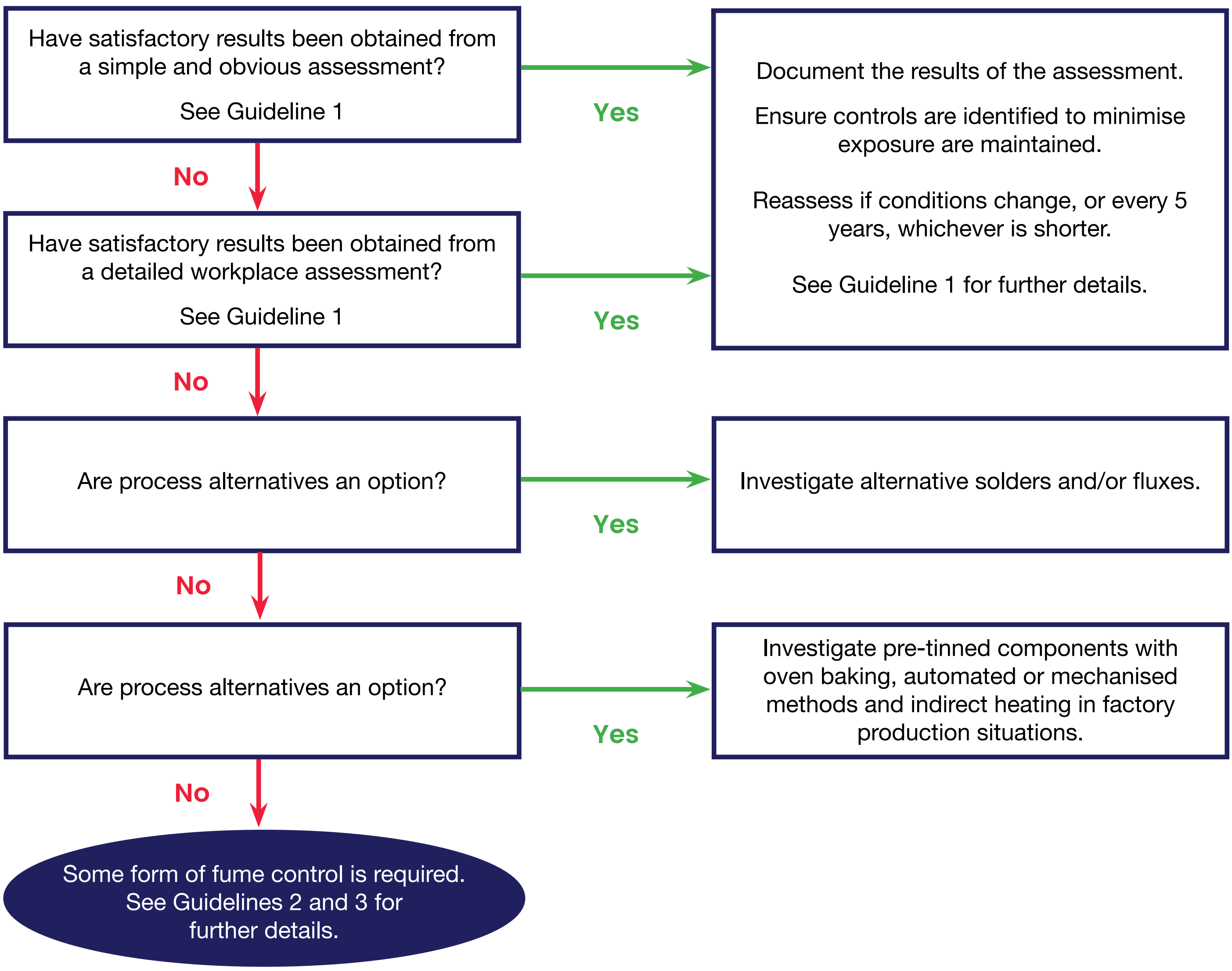
Solder Fume

Headache, nausea, strong respiratory irritation, occupational asthma, adverse lung function.

GUIDELINE 14: General Soft Soldering

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

For intermittent maintenance work, no special measures may be necessary to protect the operator. For continuous production work, clean air movement exceeding 0.5 m/s across the operators breathing zone may be required. Accumulation of fumes in the workshop must be prevented by general ventilation. Solders containing zinc, cadmium or indium are not covered by this guideline - See Guideline 15. If using flux cored wire containing rosin (colophony) - see Guideline 13.



NOTES:

1. *For some production operations one of the types of local exhaust may be required.*
2. *Under normal circumstances it should be possible to satisfy the regulatory requirements by process and work practice modifications. Known exceptions are still air, confined spaces (see AS 2865 Safe Working in a Confined Space) or where particular hazards are identified in Material Safety Data Sheets.*

Scope

Covers soft soldering in such industrial activities as electro-mechanical assembly, radiator manufacture and repair, battery manufacture, tool and die repair, also arts and crafts.

Materials

Solders

Most commonly, lead/tin solders from 95/5 to 50/50 (melting range 300°–315°C to 183°–212°C) also lead/silver, lead/silver/tin solders for high temperature strength and corrosion resistance (e.g. in electric motors) melting range 296°–370°C. Also 96/4 tin/silver for stainless steel and jewellery with good wetting (melting range 220°-240°C).

Fluxes

Inorganic, corrosive, general purpose fluxes most commonly contain zinc chloride and ammonium chloride with hydrochloric acid activator but other halide salts and acids, including fluorides, are found in some fluxes. Organic fluxes cover a variety of organic acids also hydrazine hydro bromide, aniline hydrochloride and phosphate which decompose at soldering temperatures. Vehicles range from water to various organic carriers and wetting agents. It is clearly important to consult the manufacturers SDS for the flux used.

Processes

Heating methods include soldering iron, torch flame, hot dip, induction, resistance, furnace (of assemblies) and infrared.

Health Effects

Metal Fume

Solder alloys containing lead give off negligible lead fume unless overheated (>450°C). Lead is very harmful if absorbed into the body but is not readily absorbed through intact skin. Avoid eating, drinking or smoking in the work area and attend to personal hygiene to avoid lead entering by mouth.

> ***NOTE***: *In radiator repair shops, high blood lead levels are not uncommon due to the absence of local exhaust ventilation and poor hygiene practices.*

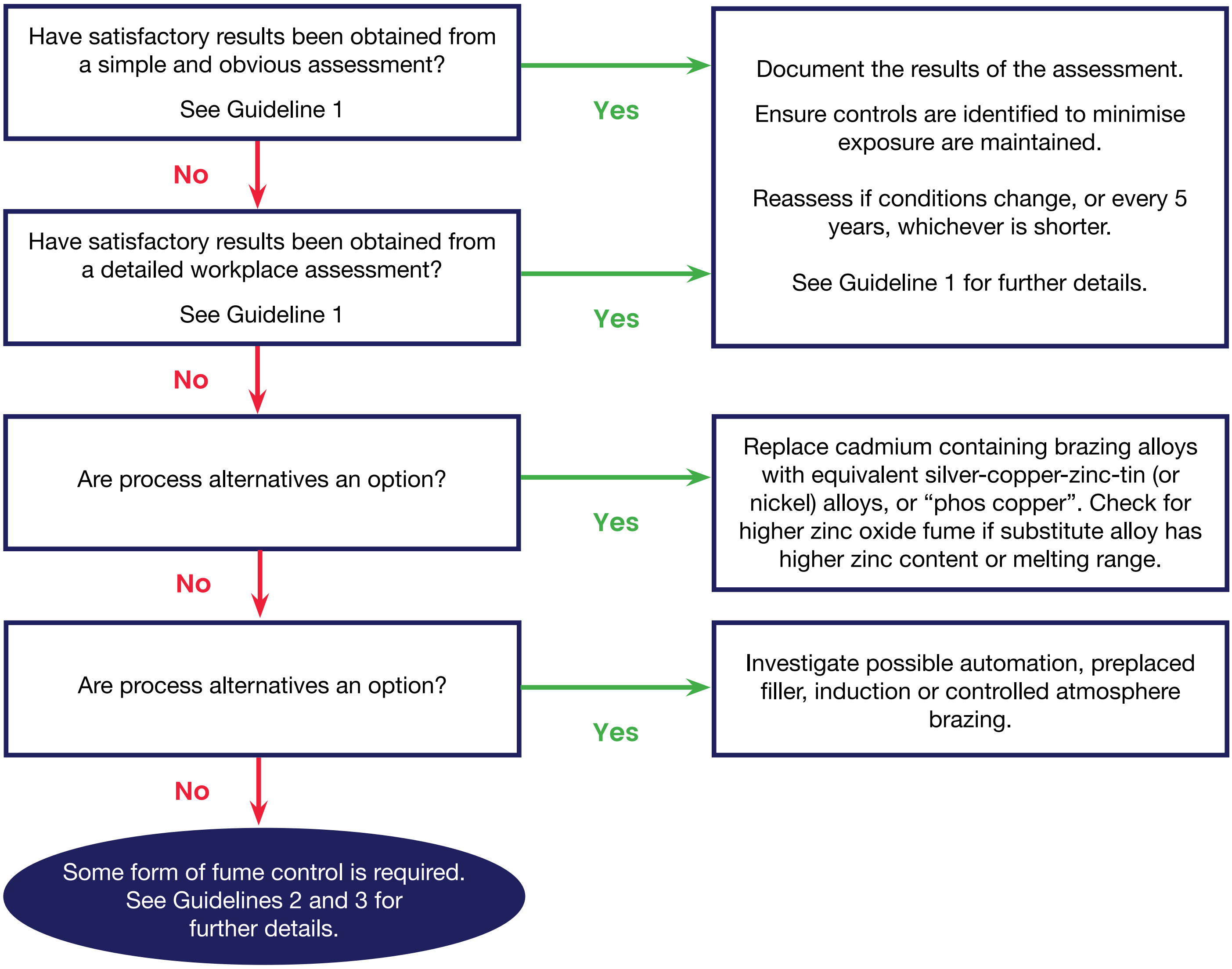
Flux Fume

Consult relevant SDS. Exposure to halides is highly irritating to eyes, skin and respiratory tract while chronic exposure to zinc halides can cause lung damage. Ammonium chloride is usually a mild irritant, but repeated exposure can lead to occupational asthma. By comparison hydrogen fluoride, bromide and chloride have peak limitation exposure standards. These must not be exceeded even instantaneously.

GUIDELINE 15: General Industrial Brazing

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

For intermittent work, not involving cadmium, indium or lithium, no special measures may be necessary to protect the operator provided clean air movement is greater than 0.5 m/s across the operators breathing zone. Accumulation of fumes in the workshop must be prevented by general ventilation.



NOTES:

1. *Ventilation by local exhaust will usually be required. In cases where cadmium, indium or lithium fume occurs, personal respiratory protection will also be necessary.*
2. *Under normal circumstances it should be possible to satisfy the regulatory requirements by process and work practice modifications. Known exceptions are still air, confined spaces (see AS 2865 Confined spaces) or where particular hazards are identified in Safety Data Sheets.*

Scope

Covers capillary brazing of iron, copper, nickel and precious metal alloys, indeed all alloys of appropriate melting point that can be successfully fluxed or prevented from oxidation by controlled atmosphere or vacuum furnace heating including dissimilar metals, cemented carbides etc.

Materials

Filler Metals

Filler metals most commonly used fall into one of two broad classes:

(a) **Low Temperature Brazing Alloys (melting range 600°-850°C) which include silver solders.** These are silver/copper alloys commonly with significant amounts of zinc and cadmium (or tin and nickel) and sometimes manganese for use with certain nickel alloys, stainless steel and cemented carbides. Also included are copper alloys with high phosphorus and usually some silver for self-fluxing brazing of copper ("phos copper").

(b) **High temperature brazing alloys (melting range 890°-1085°C).** These include most commercial grades of copper, some brass and bronzes alloyed with silver and copper alloys with small additions of boron, nickel, manganese and silicon usually for protective atmosphere furnace brazing of steel and carbides. Also a few specialist alloys such as 82/18 gold/nickel for high temperature oxidation resistance are used.

Fluxes

The common silver brazing fluxes are complex mixtures of potassium fluorborates, bi-fluorides and borates, sometimes with small amounts of potassium hydroxide and chloride. For prolonged heating of steels, particularly stainless and for materials rich in chromium carbide, fluorosilicates and boron are included whilst for aluminium bronzes, sodium aluminium fluoride/sodium fluoride handle the aluminium oxide.

Processes

Torch (with hand fed rod or preplaced filler), automated with gas/air burners, induction and furnace (controlled atmosphere or vacuum) all with preplaced filler and resistance (spot brazing).

Health Effects

Metal Fume

When present, zinc, cadmium and sometimes lithium or indium oxides are the main metal fume constituents. Cadmium is a very toxic metal whose fume in high concentrations causes a range of chest and lung problems which can be fatal. Long term low concentration exposure can affect sense of smell, weight loss and induce emphysema, pulmonary fibrosis, kidney damage and possibly cancer. Using proper heating techniques, fluxing and avoiding overheating, manual torch brazing can give metal and oxide fume from brazing alloy constituents (other than cadmium and zinc) that are low enough to be discounted as health hazards. Excessive exposure to zinc oxide can cause metal fume fever.

Flux Fume

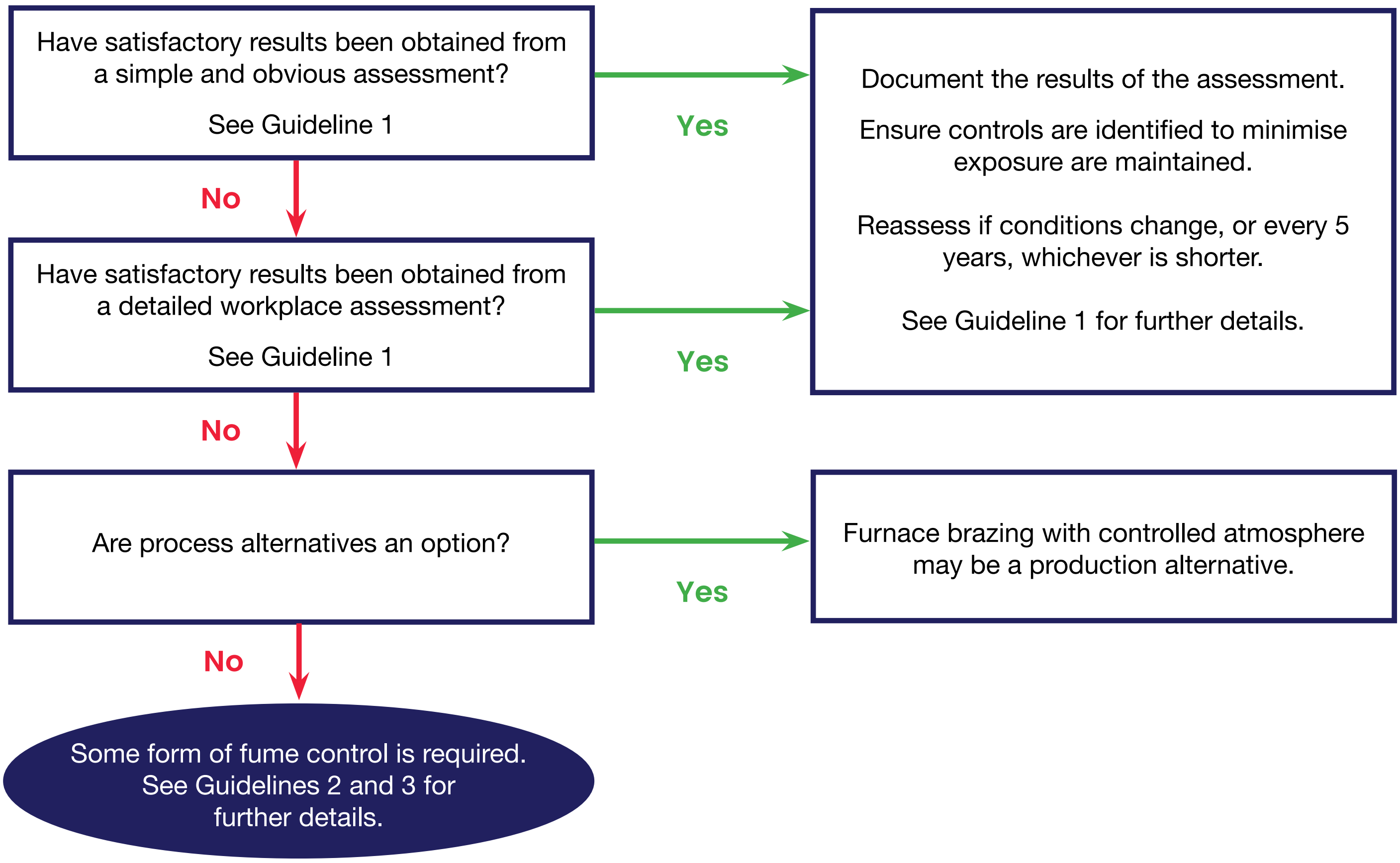
Commonly contain hydrogen fluoride and boron trifluoride also sodium aluminium fluoride and sodium fluoride in some formulations. Dusts of boric acid, potassium hydroxide, potassium chloride and potassium tetraborate can arise dependent on flux type. Toxic and corrosive if swallowed, these fumes (particularly halides) irritate eyes, skin and respiratory tract. Long term exposure to fluoride dusts and vapours can give fluoride poisoning (fluorosis).

GUIDELINE 16: High Temperature Braze Welding

Appropriate melting points 890°-900°C

An employer has a duty to ensure that a suitable and sufficient assessment is made where there is potential for exposure to hazardous substances.

For intermittent maintenance work, no special measures may be necessary. For continuous work, clean air movement greater than 0.5 m/s across the operators breathing zone may be required. Accumulation of fumes in the workshop must be prevented by general ventilation.



***NOTES**:*

1. *Ventilation by local exhaust will usually be required. For work performed in a limited or crowded space, supplementary respiratory protection may be needed.*
2. *Under normal circumstances it should be possible to satisfy the regulatory requirements by process and work practice modifications. Known exceptions are still air, confined spaces (see AS 2865 Confined Spaces) or where particular hazards are identified in Safety Data Sheets.*

Scope

Process	Typical Application	Typical Filler Metal (rod)
Gas Braze Welding	Maintenance brazing of cast iron and steel	Manganese bronze (AS 1167, RCuZn-C)
Gas (Braze and Fusion) Welding	Braze welding of mild steel for low stress applications and welding of high melting point brass and bronze alloys	Tobin bronze (AS 1167, RCuZn-A)

Fluxes either as rod coating or separately applied, are typically boric acid/sodium meta-borate mixtures but some (e.g. those used for tinning dirty cast iron) also contain alkali fluorides.

Fume Species

Filler Metal (rod)

Copper, copper oxide, zinc oxide, tin oxide (negligible).

Flux

Boric acid dust, sodium metaborate.

Health Effects

Metal Fume

Prolonged exposure can cause irritation to eyes and nose, and/or metal fume fever. Tin oxide has low toxicity.

Flux Fume

High temperature boric acid fluxes are not significantly absorbed through intact skin or mucosa. With fluorides present, fumes are highly irritating to respiratory tract. Over exposure can cause nose bleeds and fluorosis (fluorine poisoning).

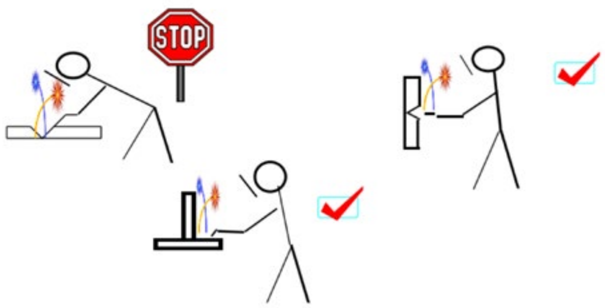


Figure 16.1: The welder's head should not enter the visible fume plume.

Weld Australia Technical Notes

TN 1 - The Weldability of Steels

Gives guidance on the preheat and heat input conditions (run size, current, voltage) required for acceptable welds and to avoid cold cracking in a wide variety of steels. The Note is applicable to a wide range of welding processes.

TN 2 - Successful Welding of Aluminium

This note covers the major welding processes as they are used for the welding and repair of aluminium and its alloys. Information is given on the processes, equipment, consumables and techniques. It also provides information on the range of alloys available and briefly covers safety, quality assurance, inspection and testing, costing and alternative joining processes.

TN 3 - Care and Conditioning of Arc Welding Consumables

Gives the basis and details for the correct care, storage and conditioning of welding consumables to control hydrogen and to ensure high quality welding.

TN 4 - The Industry Guide to Hardfacing for the Control of Wear

Describes wear mechanisms and gives guidance on the selection of hardfacing consumables and processes for a wide range of applications. Includes Australian Hardfacing Suppliers Compendium 1998.

TN 5 - Flame Cutting of Steels

Gives a wealth of practical guidance on flame cutting including detailed procedures for efficient cutting, selection of equipment and gases, practices for identifying and curing defective cutting, methods of maximising economy and other important guidance on the use of steels with flame cut surfaces.

TN 6 - Control of Lamellar Tearing

Describes the features and mechanisms of this important mode of failure and the means of controlling tearing through suitable design, material selection, fabrication and inspection. Acceptance standards, repair methods, specification requirements and methods of investigation are proposed. Four appendices give details on the mechanism, material factors, tests for susceptibility and the important question of restraint.

TN 7 - Health and Safety in Welding

Provides information on all aspects of health and safety in welding and cutting. Designed to provide this information in such a way that it is readily useable for instruction in the shop and to provide guidance to management. Recommendations are given for safe procedures to be adopted in a wide variety of situations in welding fabrication.

TN 8 - Economic Design of Weldments

Principles and guidance are given on methods and procedures for optimising design of weldments and welded joints and connections to maximise economy in welding fabrication. Factors influencing the overall cost of weldments which need to be considered at the design stage are discussed.

TN 9 - Welding Rate in Arc Welding Processes: Part 1 MMAW

Gives practical guidance and information on the selection of welding conditions to improve productivity during manual metal arc welding (MMAW). Graphs are provided showing rates as a function of weld size. The graphs enable a direct comparison of different types of welding electrodes when used for butt and fillet welds in various welding positions.

TN 10 - Fracture Mechanics

Provides theory and gives practical guidance for the design and fabrication of structures, planning of maintenance and assessment of the likelihood of brittle or ductile initiation from flaws in ferrous and non-ferrous alloys. Engineering critical assessment case histories are discussed.

TN 11 - Commentary on the Structural Steel Welding Standard AS/NZS 1554

The Note complements AS/NZS 1554 parts 1 to 7, by presenting background information which could not be included in the Standard. It discusses the requirements of the Standard with particular emphasis on new or revised clauses. In explaining the application of the Standard to welding in steel construction, the commentary emphasises the need to rely on the provisions of the Standard to achieve satisfactory weld quality.

TN 12 - Minimising Corrosion in Welded Steel Structures

Designed to provide practical guidance and information on corrosion problems associated with the welding of steel structures, together with possible solutions for minimising corrosion.

TN 13 - Stainless Steels for Corrosive Environments (A Joint publication with ACA)

Provides guidance on the selection of stainless steels for different environments. Austenitic, ferritic and martensitic stainless steels are described together with the various types of corrosive attack. Aspects of welding procedure, design, cleaning and maintenance to minimise corrosion are covered.

TN 15 - Welding and Fabrication of Quenched and Tempered Steel

Provides information on quenched and tempered steels generally available in Australia and gives guidance on welding processes, consumables and procedures and on the properties and performance of welded joints. Information is also provided on other fabrication operations such as flame cutting, plasma cutting, shearing and forming.

TN 16 - Welding Stainless Steel

This Technical Note complements Technical Note Number 13 by detailing valuable information on the welding of most types of stainless steels commonly used in industry.

TN 18 - Welding of Castings

Provides basic information on welding procedures for the welding processes used to weld and repair ferrous and non-ferrous castings. It also provides information on the range of alloys available and briefly covers non-destructive inspection, on-site heating methods and safety.

TN 19 - Cost Effective Quality Management for Welding

Provides guidelines on the application of the AS/NZS ISO 9000 series of Quality Standards within the welding and fabrication industries. Guidance on the writing, development and control of Welding Procedures is also given.

TN 20 - Repair of Steel Pipelines

Provides an outline of methods of assessment and repair to a pipeline whilst allowing continuity of supply.

TN 21 - Submerged Arc Welding

Provides an introduction to submerged arc welding equipment, process variables, consumables, procedures and techniques, characteristic weld defects, applications and limitations. Describes exercises to explore the range of procedures and techniques with the use of solid wire (single and multiple arcs) and provides welding practice sheets, which may be used as instruction sheets to supplement demonstrations and class work, or as self-instruction units.

TN 22 - Welding Electrical Safety

Provides information and guidance on welding electrical safety issues: welding equipment, the body and the workplace.

TN 23 - Environmental Improvement Guidelines

Provides information and guidance on how to reduce consumption in the Welding and Fabrication industry, while reducing the impact on the environment at the same time.

TN 25 – Welding Specification for the Water Industry

Published with the Water Services Association of Australia. Applies to all metal fabrication and repair work involving welding, carried out by a Water Agency (WA) and its Contractors/Subcontractors. Prescribes weld preparation, qualification of welding procedures and personnel, workmanship and inspection requirements for welds related to the arc welding by manual metal arc and other processes approved by the WA responsible Welding Coordinator.

Notes

Weld Australia

Weld Australia

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