

FUME MINIMISATION GUIDELINES

Welding, Cutting, Brazing and Soldering

GUIDELINE 2:

FUME CONTROL OPTIONS

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.

The choice of control must be carefully considered and expert advice should be sought if an effective control approach is not obvious.

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 will 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 below:

2.1 Outdoor/natural ventilation

When working outdoors, natural ventilation is often considered to be a satisfactory form of fume control. 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.

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 300m³ (minimum roof height 3 m).
- 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.

2.3 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.

2.4 Confined work space

A confined work space is one which is not a normal work area and which meets the criteria listed in AS 2865, Safe Work in a Confined Space.

Note that AS 2865 includes specific recommendations on hot work (e.g. welding) in confined spaces.

3. FUME GENERATION

The constituents of the welding fume are generated in one of three ways: from the filler metal and flux, from the parent plate or its contaminants, or from 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 often 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.

4. GENERAL VENTILATION

It is essential that the general ventilation of the workplace is adequate to prevent the accumulation of hazardous substances 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.

5. CONTROL MEASURES

Control measures to minimise worker exposure to hazardous substances 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 state regulations, the control method chosen should follow the hierarchy given in Guidance Note For the Assessment Of Health Risks Arising From The Use Of Hazardous Substances In The Workplace [NOHSC 3017: 1994], 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.

Many welding situations will require a combination of these methods.

5.1 Processes producing less fume

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

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.

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.

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 substances are captured at source.

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 is generally 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.

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 2 m/s. Where adequate welds cannot be made due to disturbance of the gas shield by fume extraction, 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 should be followed, and it should be isolated from any air intake to the workplace.

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

EXTRACTION TYPE	ADVANTAGES	DISADVANTAGES
Stand alone hoods (e.g. articulated arms, or magnetic hose kits)	<ul style="list-style-type: none"> • long capture distance so does not interfere with worker • high flow design so will capture/extract high fume concentrations 	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • automatically used whenever work is done • combines work top/bench with extraction system • suitable for high velocity fume applications such as oxy-cutting 	<ul style="list-style-type: none"> • reduced flexibility • only suitable for work on smaller items • generally has a higher cost per worker
Overhead canopy hoods	<ul style="list-style-type: none"> • low cost 	<ul style="list-style-type: none"> • rising fume generally travels straight through the workers breathing zone

5.5 PPE control methods

Various styles of respirators are available. When deciding on respirators as a control method, consideration must be given to fellow workers who may also be exposed to fume, and any effect on equipment maintenance or performance caused by the fume. Care must also be taken regarding hygiene, maintenance and correct facial fit. Respirators must filter both particulates and ozone.

There are two basic types of respirator: air purifying or air supplied. Refer to AS1715, Selection, Use and Maintenance of Respiratory Protection Devices, for more details.

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 back pack tank, for situations where air line systems are not possible.

5.6 Relative cost and availability

An indication of the relative cost and availability of the various control measures is provided below.

RELATIVE COSTS OF WELDER PROTECTION OPTIONS

\$ PER WELDER / WORK STATION

		Low end		High end		Comments
Air movement	Unfiltered	800	Blower only			Spreads the fumes to other areas of the workplace. May be acceptable for external work or one-man operations.
Stand alone hoods Fume arm extraction	Unfiltered	2,700	Extractor and arm (1.0m)	10,000	Wall-mounted extractor, beam (6.0m), arm (4.0m), ducted exhaust	Unfiltered units may be acceptable for external work or one-man operations otherwise filtering is preferred.
	Filtered	2,900	Extractor and arm (1.0m)	8,000	Wall-mounted extractor, beam (6.0m), arm (4.0m) (ducted exhaust not required)	Long beams and arms allow work to be carried out over a large radius. Large extraction units are available which can be connected to several arms by a ducted system.
On tool On-gun extraction	Filtered	2,400	Extractor and attachment	3,500	Extractor and attachment	Best option for all wire welding (especially where welding is not continuous or in localised area of the job) but may be limited by wire thickness.
In-bench fixed Downdraft benches	Filtered	5,000	Un-ducted	10,000	Various configurations available	Usually quite effective but enclosure design often restricts size of job that can be worked on
Overhead canopy hood Extraction hood	Unfiltered	3,100	Ducted	6,000	Larger duct system	Can suck the fumes through the welder's breathing zone and unfiltered units will spread the fumes around the workplace.
	Filtered	5,600	Un-ducted	8,000		If unfiltered units are installed the fumes could be ducted outside depending on local regulations.

Disposable P2 Respirator		3.20				Simple to use, does not require a respirator maintenance program. Requires staff training.
Half face Respirator		40 Mask		90 Mask	P2 Filters 13 Cartridge 17	Requires a maintenance program. Requires staff training.
Powered Air Purifying Respirator (PAPR)		900 Respirator		1,800 Respirator	Filters 45 each	Requires battery charging and replacement. Welding mask incorporated in the unit. Requires a maintenance program. Requires staff training. Portable, lightweight and comfortable units that are battery powered designed to last a full eight hour shift.
Air line respirator		600		1,200		Ideal for confined space welding or working environments with limited ventilation with high levels of particle fumes and gases. Suitable for fixed bay welding. Requires a supply of breathable compressed air. Requires staff training.

Availability: All alternatives 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. eg 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