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A PRACTICAL GUIDE TO

WELDING FUME CONTROL

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There is a critical need to give workplaces clear and practical advice that can help to keep welding fume exposure to an acceptable level.

This guide is based on a simple premise - the health risk posed by welding fume is serious, however, keeping yourself safe can be straightforward.

Consequently, in this guide, we outline the dangers of welding fume and then give you actionable and practical guidance based specifically on the welding industry.

CONTENTS

Welding Fume Is Serious. Action Is Required.

The important point to understand is that while the risk posed by welding fume is serious, keeping yourself safe can be straightforward.

The 2017 IARC reclassification of welding fume as 'carcinogenic to humans' simply confirmed what was already known – welding fume is extremely bad for health and workplaces must protect their workers. Excessive exposure to welding fume can cause multiple types of cancer, including lung, larynx, and urinary tract.

'Welders present, on average, a 43% increased risk of lung cancer when compared with those who have never welded or been exposed to welding fume'[1]. 'This increased risk of lung cancer is regardless of the type of steel welded, the welding process and independent of exposure to smoking'[1]. Precedent for workers' compensation based on a link between welding fume and cancer was established in the Australian courts back in 2014, opening the door for future compensation claims.

Aside from cancer, welding fume can also cause serious long-term health effects like lung function abnormalities, including bronchial asthma, chronic obstructive pulmonary disease (COPD), pneumoconiosis and other pulmonary fibrosis, as well as stomach ulcers, kidney damage and nervous system damage.

Recognising welding fume as carcinogenic and the other associated health risks should encourage all employers of welders to review their risk assessments and revise their control measures.

There is no known level of safe exposure to welding fume: action is required.

Simple Takeaway

There is no known level of safe exposure to welding fume: action is required.

A Practical Guide to Fume Control.

Applying a practical approach to the ‘Hierarchy of Control’.

The hierarchy of control is a step-by-step system for controlling risks in a workplace. This framework is used across a range of industries and while it applies to welding, it was not built specifically for the welding industry.

So, while it is important to understand the overall framework, a control framework built specifically for welding fume may be valuable to those seeking to understand how to protect their welders or themselves.

To give you a more simplified and practical approach to controlling welding fume, we offer the ‘Practical Guide to Fume Control’ comprising of three steps: 1. Mitigation of Risk, 2. Product Controls and 3. Administrative Controls.

Figure 1.1 - A Practical Guide to Fume Control

1 Mitigation of Risk

When it comes to welding fume, all efforts should be made to mitigate the risks where possible.

Examples include:

- Removing surface coatings on materials.
- Changing to less hazardous materials (both consumables and base materials).
- Using a welding technique that produces less fume (different application or working with lower amps)
- Where possible, workers should position themselves to ensure they keep their heads away from the plume and also ensure any ventilation airflow moves the welding fume away from the breathing zone, not through it.

While the highest levels of controls (elimination and substitution) within the 'hierarchy of control' give the highest level of protection and reliability in many industries, they are often not practicable or possible when it comes to the welding industry. Substituting materials can result in quality issues and using lower amps is often not an option.

Even when you can mitigate risk, if there is welding to be done, there will be welding fume. Welding fume is inherent in the process of welding. As a result, we see that in the welding industry, the higher levels of control can often only mitigate the risks associated with welding fume, making the lower levels of control essential.

Simple Takeaway

Higher levels of control can often only mitigate the risks associated with welding fume. Product and administrative controls are essential.

2 Product Controls

Welding Personal Protective Equipment (PPE)

In relation to the hierarchy of controls, PPE is often referred to as the last resort. When it comes to welding, suitable PPE must always be worn. PPE for respiratory protection from welding fume is commonly available in two main forms: 1) Welding Helmets with integrated respiratory protection and 2) Half mask respirators.

Welding Helmets with Integrated Respiratory Protection

'Welding helmets with integrated powered air purifying respirators (PAPR) are the most widely used form of respiratory protection amongst welders in Australia and New Zealand'[2] and are mandatory within many businesses.

They have a Required Minimum Protection Factor (RMPF) of 50, meaning that they supply breathing air a minimum 50 times cleaner than the welder would otherwise be breathing unprotected and can also protect the welders' eyes and face from radiation and high velocity particles. Integrated hard hats (safety helmets) and earmuffs are also available with these systems to give welders five levels of protection (eye, face, respiratory, head, hearing).

With a flip-up welding helmet with powered air respiratory protection, welders can have completely clear and uninhibited views of their workpiece and surroundings while maintaining their desired level of respiratory protection with no breathing resistance. The powered air respirator goes where the welder goes, allowing unrestricted movement around the workplace with clear vision, comfort, and uninterrupted eye, face and respiratory protection.

A recent study conducted within a large manufacturing company with over 1,500 employees, including 600 certified welders, found that 'foreign body eye injuries decreased over 70% year-on-year in areas that implemented the PAPRs with integrated flip-up auto darkening welding helmets. Worker compensation claims decreased markedly while employee morale increased substantially'[3].

PAPRs can provide protection to welders using the most common materials (aluminium, stainless steel, galvanised steel etc.) and applications (MMA, TIG, GMAW, FCAW, SAW) where there is an environment with general shop ventilation.

In restricted spaces*, a welding helmet with integrated supplied air respiratory protection will be effective.

The next page features a practical guide to welders' personal protective equipment based on the material to be welded, the welding process and the ventilation conditions of your working environment.

Image: An example of a flip-up auto-darkening welding helmet with an integrated powered air purifying respirator.

Figure 2.1 - A practical guide to respiratory protection based on material, process, and environment.

P = Powered air purifying respirator.
P+A = Powered air purifying respirator with a A1 gas filter installed.
P+ODOUR = Powered air purifying respirator with an odour filter installed.
S = Supplied air via regulator and filtration unit.

Material to be welded	Welding method	Ventilation conditions of your working environment		
		Environment with good ventilation /extraction.	Environment with limited ventilation /extraction ------> increasing exposure.	Restricted space* Note: this respiratory protection solution may not be suitable for Confined Spaces as defined in AS2865.
Aluminium	GMAW	P	P or P+A	S
	TIG	P	P or P+A	S
	PLASMA (cutting and gouging)	P	P or P+A	S
Stainless steel	GMAW/FCAW/SAW	P	P or P+A	S
	TIG	P	P or P+A	S
	MMA (stick)	P	P or P+A	S
	PLASMA (cutting and gouging)	P	P+A or S	S
Steel not coated or painted	GMAW/FCAW/SAW	P	P	S
	MMA (stick)	P	P	S
	PLASMA (cutting and gouging)	P	P or S	S
Steel (lead based paints / oil and grease present)	GMAW/FCAW/SAW	P	P or P+ODOUR	S
	MMA (stick)	P	P or P+ODOUR	S
	PLASMA (cutting and gouging)	P	P or S	S
Steel galvanised	GMAW/FCAW/SAW	P	P or P+ODOUR	S
	MMA (stick)	P	P or P+ODOUR	S
	PLASMA (cutting and gouging)	P	P or S	S
Steel coated with 2-component paints or insulated with 2-part polyurethanes (risk of isocyanates)	GMAW/FCAW/SAW	P	P+A or S	S
	MMA (stick)	P	P+A or S	S
	PLASMA (cutting and gouging)	P	P+A or S	S

This chart has only been provided as an example and is provided as a basic guideline. It should not be used as the only means of selecting a respirator. Powered and supplied air respirators must never be used in atmospheres Immediately Dangerous to Life or Health (IDLH) without emergency breathing device capability (AS/NZS1715). Always consult your Safety Engineer or Occupational Hygienist.

**A 'restricted space' for the purposes of this document refers to a situation where 1) local exhaust ventilation (LEV) fume extraction is not possible due to a limitation of space, 2) general plant air (dilution) can not effectively reach the welder and 3) the space is not a confined space as defined by AS2865.*

Half mask respirators

Disposable or reusable half mask respirators can be worn underneath a welding helmet to provide a RMPF of 10. The welder must be fit tested (annually is recommended) and clean shaven to ensure an effective negative pressure seal.

When compared to disposable and reusable half-face mask respiratory protection, PAPRs provide superior respiratory protection and comfort and do not require fit testing or a complete clean shaven condition.

Image: An example of a disposable half mask respirator (left) and a reusable half mask respirator with replaceable filters (right).

Figure 2.2 - Quick Reference Welding Respiratory PPE Comparison Chart

	Welding Helmets with Integrated Respiratory Protection	Half Mask Respirators
Protection Factor (RMPF)	50 (or 100+*)	10
Fit Testing Required	No	Yes, recommended annually
Requirement to be clean shaven	No	Yes
Breathing resistance	No	Yes
Comfort Considerations	Steady flow of fresh air helps to cool and reduces sweat and heat buildup. Approximately 1kg worn on the welders waist**.	The negative pressure seal can result in an uncomfortable fit in welding conditions (sweat, heat). Can interfere with the welding helmet.
Cost Considerations	A PAPR draws air into the system from behind the welder away from the greatest concentration of welding fume. For this reason, the filters on a PAPR will typically need to be changed far less frequently than a disposable respirator or reusable respiratory filters. Long term, a PAPR can be the more economical solution.	While half mask respirators have a lower upfront cost, they can be the more expensive long-term option. Worn on the welder's face in closer proximity to the plume, filters can become loaded extremely quickly in certain welding environments.

** Welding helmets with integrated powered air respiratory protection have a RMPF of 50. Welding helmets with integrated supplied air respiratory protection have a RMPF of 100+.*

*** Weight based on 3M™ Adflo™ PAPR. Weights of PAPR's available in the market can vary significantly.*

Practical Engineering Controls - Extraction

Ventilation can assist in reducing exposure to welding fume and other airborne contaminants. There are two key practical ventilation controls you can introduce:

Local Exhaust Ventilation (LEV)

Properly located LEV can capture welding fume at the source, which is the most effective way to collect and remove fumes. Popular options consist of fixed installations, portable systems and on-gun extraction. It is recommended that respiratory PPE is always worn in combination with LEV.

Image: An example of a two arm portable LEV extraction system (left) and a lightweight portable version suitable for on-gun extraction (right).

Dilution Ventilation (General Shop Ventilation)

'General shop ventilation', as it is known in the industry, occurs when contaminants released into the workshop mix with air flowing through the room. Dilution is not as effective as LEV in controlling welding fume exposure as large volumes of dilution air may be required and it is extremely difficult to control individual exposure near the contaminant source where dilution has not yet taken place.

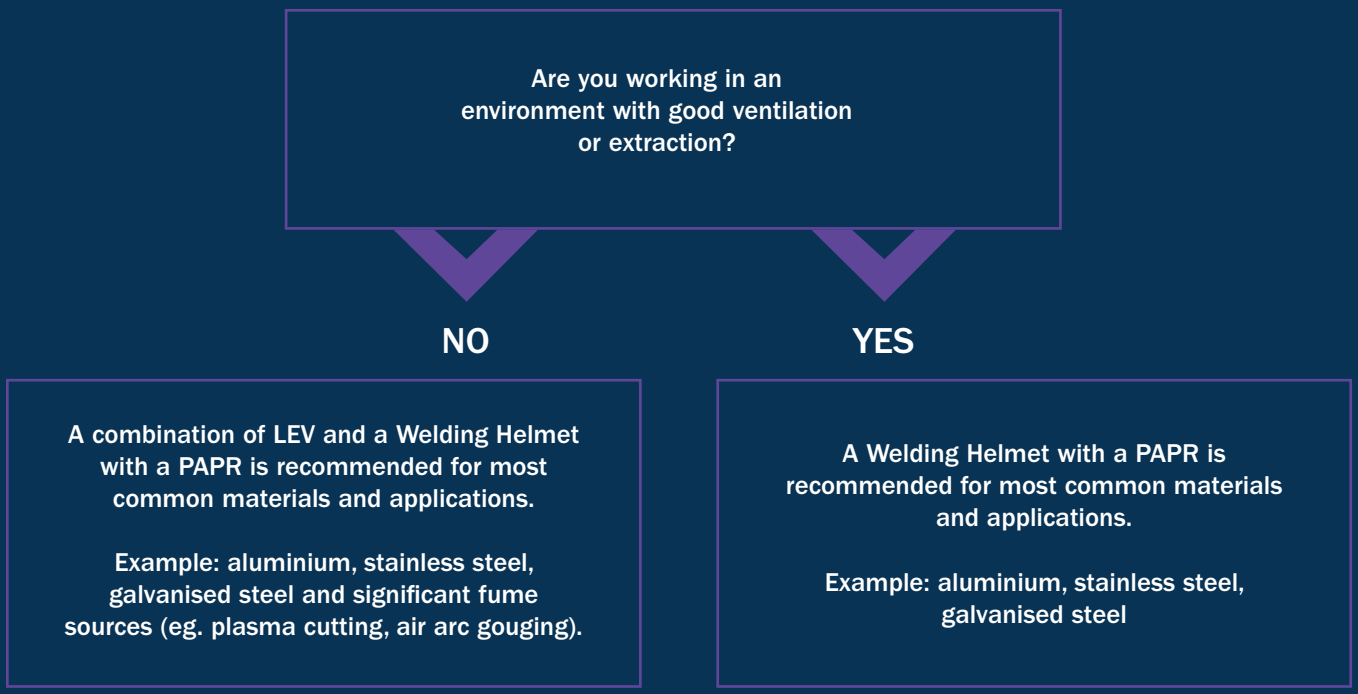
This option should only be used to control low levels of welding fume. It is recommended that respiratory PPE is always worn in combination with General Shop Ventilation.

It should be noted that natural ventilation (eg. wind) is not a reliable way of diluting or dispersing welding fume.

A Practical Approach to Product Controls

A combination of ventilation and respiratory PPE is the most practical and effective 'product control' method to protect workers from welding fume. Respiratory PPE should always be worn to complement the use of ventilation. The figure below gives you practical advice on how to select respiratory controls for full-time welders based on the options outlined previously and what is most effective for the welding industry.

Figure 2.3 - A practical approach to product controls



If LEV is not possible due to a restriction of space and dilution can not effectively reach the welder then supplied air respiratory protection may be required.

Where airborne contaminants exist that cannot be reliably filtered by a PAPR, supplied air is recommended.

This chart assumes that all efforts to mitigate risk associated with welding fume through elimination and substitution have been carried out. Procedural controls (eg. minimise work conducted in restricted spaces, training on PPE, ventilation maintenance) should be introduced to support PPE and ventilation controls. This chart does not address confined spaces as defined by AS2865 or atmospheres Immediately Dangerous to Life or Health (IDLH). If you require advice on these environments please contact AWS (www.awsi.com.au). Consultation with a PPE and extraction expert such as AWS (www.awsi.com.au) and an occupational hygienist is recommended to ensure your specific application, environment, materials, and limitations (space, need for mobility) are considered.

3 Administrative Controls

Procedural controls must be introduced to support product-based controls.

Training and product maintenance

As an employer, once you have selected the appropriate PPE, 'you must provide the worker with information, training and instruction in the proper use and wearing of that PPE'[4]. Proper guidance should be given on the storage of equipment and care and maintenance guidelines should be clear and followed.

For LEV systems, you must implement a maintenance and test regime to ensure proper operation.

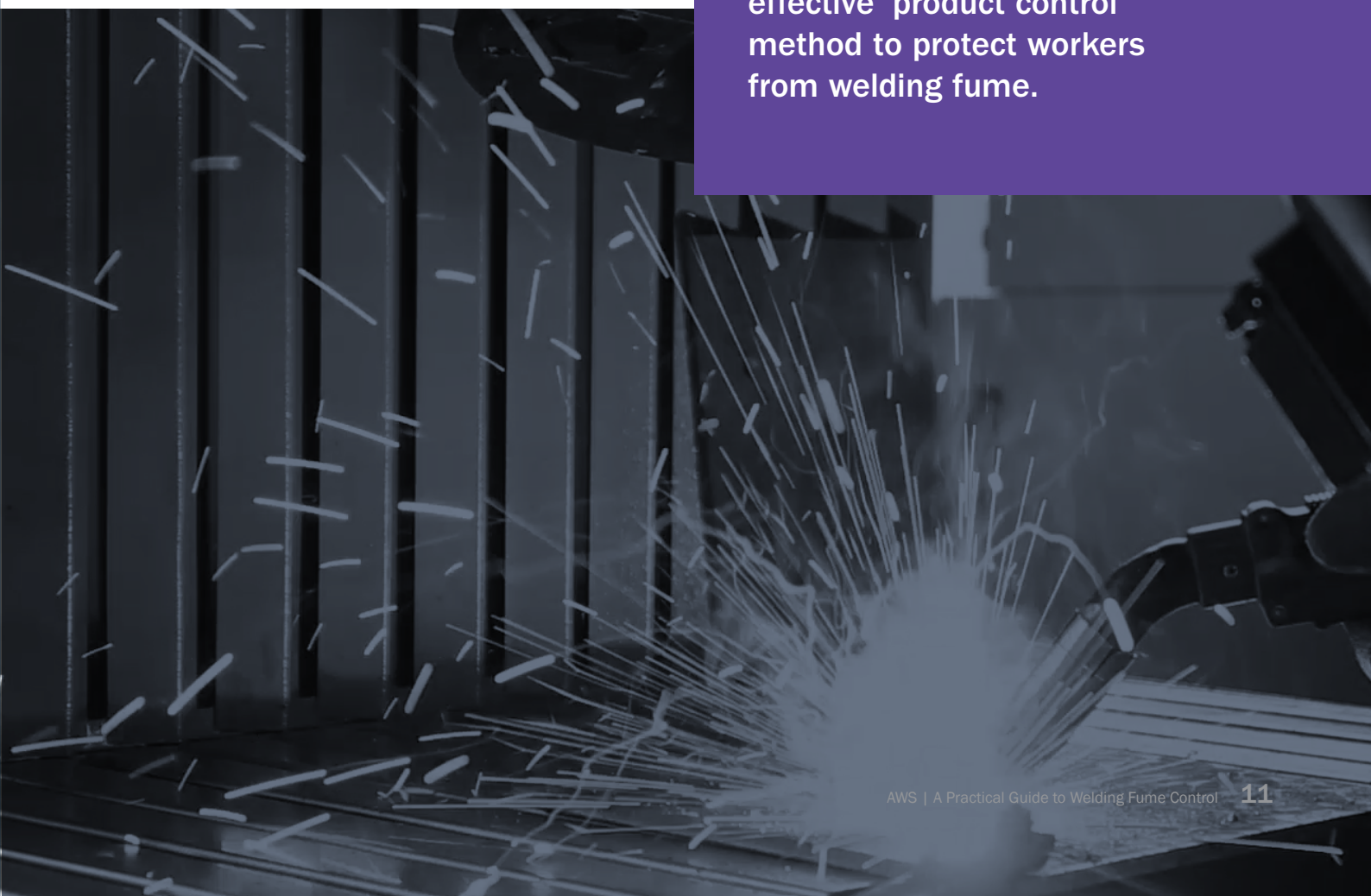
Ensure you select suppliers who can not only provide equipment, but also administer the required training and support. Also, ensure all required spare parts are readily available and stocked.

Working area considerations

- Minimise work conducted in confined spaces. The product controls outlined in this guide are not rated to protect the welders in confined spaces or atmospheres Immediately Dangerous to Life or Health (IDLH). For guidance on these environments please contact AWS (www.awsi.com.au).
- Introduce a dedicated area for welding.
- Control access to the working area.

Simple Takeaway

A combination of extraction ventilation and respiratory PPE is the most practical and effective 'product control' method to protect workers from welding fume.



Confined Spaces

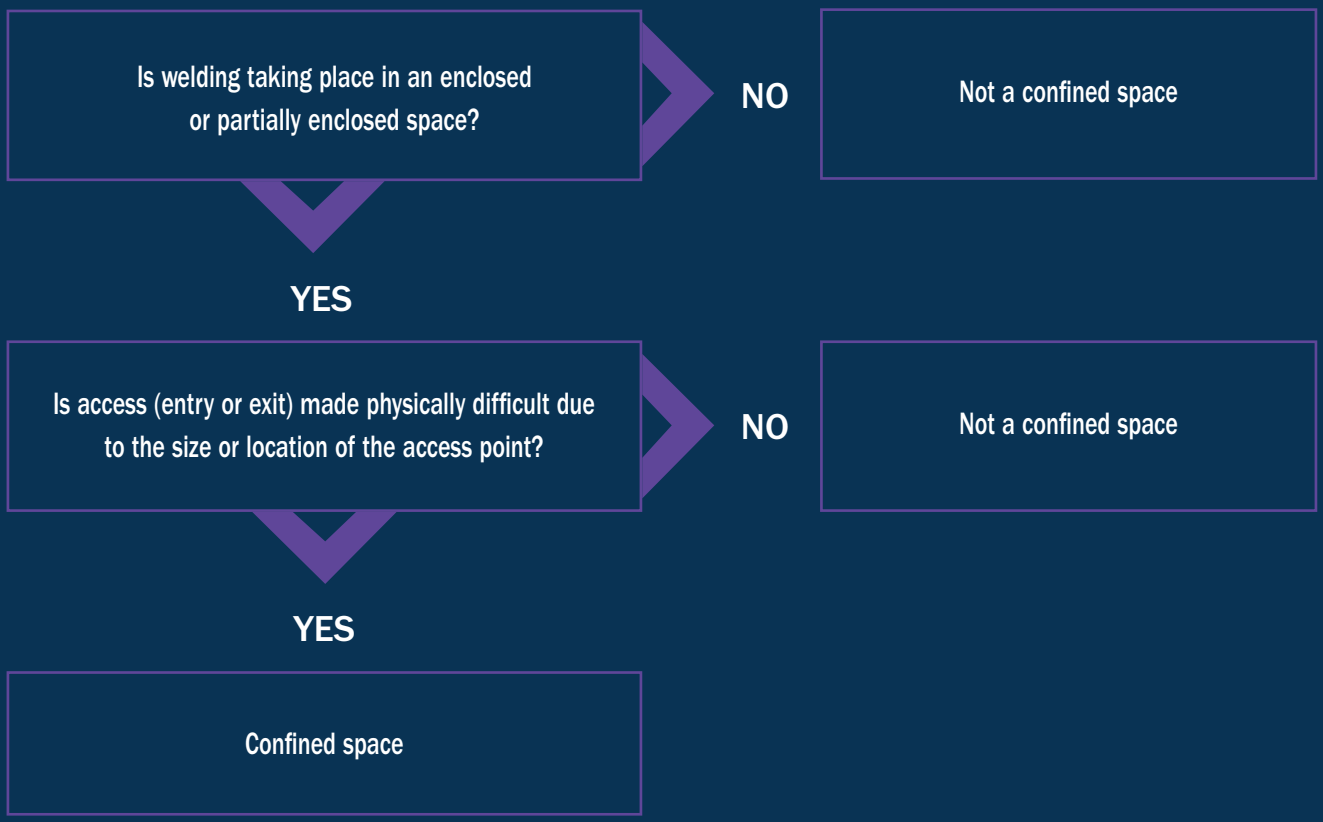
All practical advice in this guide to this point has excluded confined spaces.

Confined spaces are complicated when it comes to welding. A safe atmosphere in a confined space is one that has a safe oxygen level, is free of airborne contaminants (or in concentrations known to be below their allowable exposure standard), and any flammable gas, vapour or mist is at concentrations below 5 percent of its lower explosive level.

However, when welding, especially in an enclosed or partially enclosed space, it is normal for any welding task to at least potentially create an atmosphere that has airborne concentrations above the relevant exposure standards or >5% of relevant explosive limits.

So, how do you identify a confined space and what practical steps can be taken should welding be required within a confined space?

Figure 3.1 - How to identify a confined space relevant to welding.



Spaces that are not at normal atmospheric pressure (such as a boiler) must be brought to atmospheric pressure while any person is in the space.

If the space is a mine shaft or the workings of a mine, you must seek guidance from state/territory legislation and regulatory bodies.

‘Confined spaces pose dangers because they are usually not designed to be areas where people work. Confined spaces often have poor or no ventilation which allows hazardous atmospheres to quickly develop, especially if the space is small’[5].

‘A confined space is determined by the hazards associated with a set of specific circumstances and not just because work is performed in a small space’[5]. ‘Entry into a confined space means a person’s head or upper body is in the confined space or within the boundary of the confined space’[5].

Within the welding industry, confined spaces are commonly found in tanks, pipes, containers, pressure vessels, shafts, tunnels or other similar enclosed or partially enclosed structures.

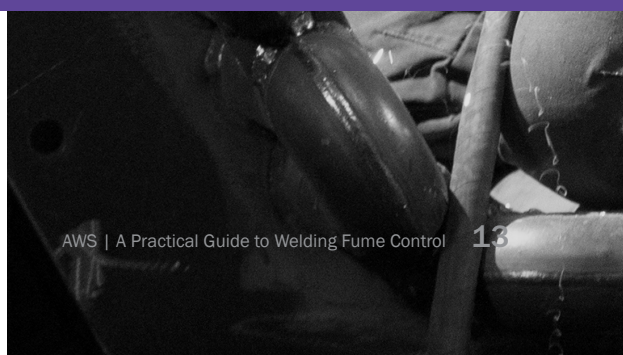
How to control welding fume when welding in a confined space is unavoidable:

- Confined spaces can be deadly and decisions on how to handle a specific confined space must be assessed on the spot and always comes down to the specifics of the individual situation.
- Confined spaces are a multifactorial issue, and protection against welding fume is only one of the issues that needs to be considered.
- There should be a suitably trained and knowledgeable person doing the assessment and design of a safe system for any confined space entry.

If welding in a confined space, ensure that the employee doing the confined space assessment is suitably trained having completed a confined space course by a qualified training company or engage a trained consultant. If unsure, please contact AWS (www.awsi.com.au) for more information.

Simple Takeaway

If welding is taking place in an enclosed or partially enclosed space where access is made physically difficult - it’s likely a confined space.



Who is responsible?

The employer has the primary responsibility to ensure that welding fume exposure is controlled, and welders are protected. The two key points regarding employer responsibility are as follows:

- If employers are unsure whether the welding fume exposures at their workplace exceeds the relevant exposure standard, OH&S regulations require that they must ensure air monitoring is carried out.

- Under both the Australian Work, Health and Safety Laws and the New Zealand Health and Safety at Work Regulations, the employer is financially responsible for providing PPE to workers and must not charge anyone for using PPE.

When selecting suitable PPE, the employer, where reasonable, should consult with the welders. A welder's knowledge, experience and personal preferences improve the overall decision-making process. As someone who is directly affected by welding hazards, a welder is entitled to take part in the consultation process and selection of suitable PPE.

Personal preferences are the key to user acceptance – so look for gear that welders feel comfortable wearing. As a welder, you should aim to educate yourself on the risks, understand the appropriate PPE available and look to involve yourself in the consultation process and ultimate selection of suitable PPE.

For guidance on air monitoring in Australia and New Zealand, please contact AWS (www.awsi.com.au).

Simple Takeaway

The employer must ensure air monitoring is conducted when needed and is financially responsible for providing PPE.

Exposure limits are just the beginning

The exposure standards in Australia and New Zealand 'do not identify a dividing line between a healthy or unhealthy working environment'[6]. They simply establish a legal maximum upper limit. 'Therefore, exposure standards should not be considered as representing an acceptable level of exposure to workers'[6].

Take for example, a welder operating within the workplace exposure standards for general welding fume (5 mg/m^3). If the welder is wearing no respiratory Personal Protective Equipment (PPE), they could inhale up to 11 grams of a carcinogenic substance (welding fume) every year*.

Moreover, an Australian or New Zealand welder operating under the legal workplace exposure limits for welding fume in Australia is exposed to 4 times the level of a known carcinogen than that of a German welder working under the TGRS 528 (1.25 mg/m^3) exposure limits in Germany.

The world has shifted to more of a health and safety focus—the result of court cases and research. Australian and New Zealand companies are now completely changing their stance on welding fume and welders' PPE.

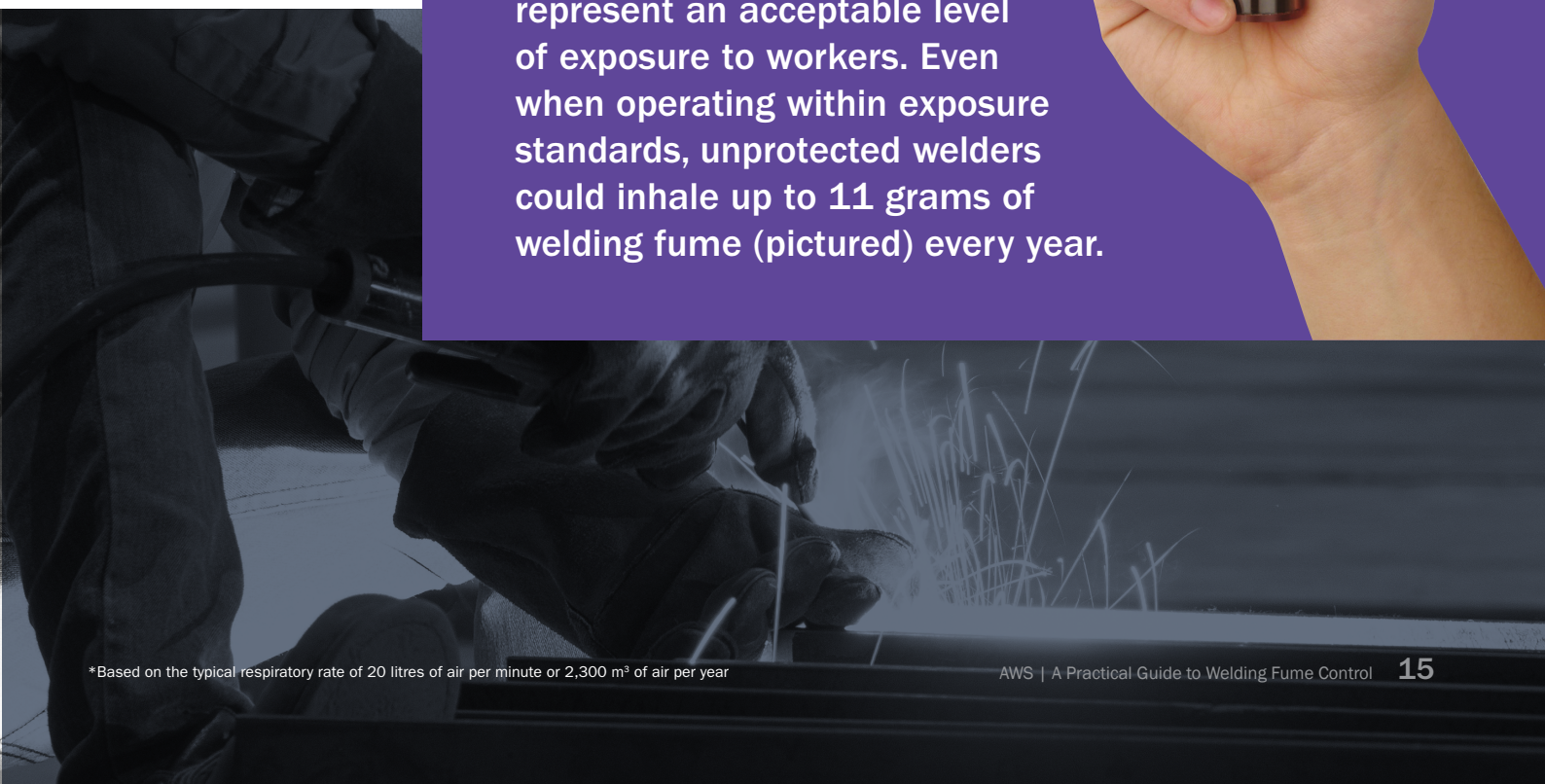
The 2017 reclassification of welding fume as carcinogenic prompted many to rethink and challenge what was historically considered 'normal'. The 2019 statistical analysis concluding that welders have a '43% increased risk of lung cancer'[1] regardless of the type of steel welded, the welding process or time-period is of serious public health relevance.

Being aware of information like this should act as the trigger at your workplace to introduce PPE with higher protection factors to give exposed workers the protection they deserve.

For a step-by-step summary on how to get started, please find the enclosed 'blue-print to welding fume control' or get in touch with AWS (www.awsi.com.au).

Simple Takeaway

Exposure standards do not represent an acceptable level of exposure to workers. Even when operating within exposure standards, unprotected welders could inhale up to 11 grams of welding fume (pictured) every year.



*Based on the typical respiratory rate of 20 litres of air per minute or 2,300 m^3 of air per year

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