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# Welding fume: a known carcinogen

A closer look at the recent reclassification of welding  
fume as Group 1: Carcinogenic to Humans

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## Forward

There is no doubt that the recent reclassification of welding fume as carcinogenic to humans by the International Agency for the Research on Cancer (IARC) has encouraged many welders and workplaces to rethink their stance on welders' respiratory protection. This white paper aims to investigate the recent reclassification from an Australian perspective pulling relevant information from multiple sources into one easy to read

document, so that employers of welders and welders themselves can make better decisions regarding welding fume and suitable respiratory protective measures. This paper also attempts to raise awareness of workplace cancer risks associated with welding so that welders question and challenge whether they are suitably protected even when operating under the current Australian workplace exposure standards for welding fume.

## So firstly, what actually changed?

As you may already be aware, in March 2017, scientists from around the world met at the International Agency for Research on Cancer (IARC; Lyon, France) to evaluate the carcinogenicity of welding fume. Based on substantial new evidence through observational and experimental studies, welding fume has now been reclassified from

“possibly carcinogenic to humans” as it was originally classified in 1989 to its new Group 1 classification as “Carcinogenic to Humans”. The working group concluded that there is “sufficient evidence in humans” that welding fumes cause lung cancer and limited evidence for kidney cancer<sup>4</sup>.

## What does this new categorisation mean?

“Group 1” or “Category 1A” in Australian terms has the following description as outlined in “the guidance on the interpretation of workplace

exposure standards for airborne contaminants” by Safe Work Australia:

### **CATEGORY 1A – KNOWN TO HAVE CARCINOGENIC POTENTIAL FOR HUMANS**

Substances known to have carcinogenic potential for humans are substances for which there is sufficient evidence to establish a relationship between human exposure to these substances and the development of cancer<sup>3</sup>.

## What are the current Australian Workplace Exposure Standards for welding fume and what do they mean?

“In addition to complying with the exposure standards for specific contaminants, the fume concentration in the breathing zone (which is inside a welder’s helmet when a helmet is worn) must not exceed 5 mg/m<sup>3</sup> using a TWA”<sup>3</sup> (Time Weighted Average). This means that the maximum average airborne concentration of total welding fume when calculated over an 8 hour working day, over a five day working week, must not

exceed 5 milligrams of substance per cubic metre of air. In addition to this general exposure standard there are then specific exposure standards for particular types of chemicals. Below we list the most common fumes and chemicals workers may be exposed to when welding and the respective health effect as well as the TWA exposure limit released by Safe Work

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## Australian Workplace Exposure Standards<sup>1,2</sup>

Fume Type / Chemical	Source	Health Effect	TWA (mg/m <sup>3</sup> )
Aluminium	Aluminium component of some alloys, e.g., nickel-chromium, copper, zinc, steel, magnesium, brass and filler materials.	Respiratory irritant.	5
Beryllium	Hardening agent found in copper, magnesium, aluminium alloys and electrical contacts.	“Metal Fume Fever.” A carcinogen. Other chronic effects include damage to the respiratory tract.	0.002
Cadmium	Stainless steel containing cadmium or plated materials, zinc alloy.	Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.	0.01
Chromium	Most stainless-steel and high-alloy materials, welding rods. Also used as plating material.	Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium).	0.5 or 0.05 (Depending on chemical form)
Copper	Alloys such as nickel-copper, brass, bronze. Also some welding rods.	Acute effects include irritation of the eyes, nose and throat, nausea and “Metal Fume Fever.”	0.2
Iron Oxides	The major contaminant in all iron or steel welding processes.	Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.	5
Lead	Solder, brass and bronze alloys, primer/ coating on steels.	Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning. Ototoxic and therefore risk of hearing loss.	0.05
Manganese	Most welding processes, especially high-tensile steels.	“Metal Fume Fever.” Chronic effects may include central nervous system problems. Ototoxic and therefore risk of hearing loss.	1
Zinc Oxides	Galvanized and painted metal	Metal Fume fever	5

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## Have the Australian workplace exposure standards been revised in light of the recent reclassification of welding fume?

The “Australian Workplace Exposure Standards for Airborne Contaminants” by Safe Work Australia was last published on the 18 April 2013. Four years before the recent reclassification of welding fume as carcinogenic. “The guidance on the interpretation of workplace exposure standards for airborne contaminants” released by Safe Work Australia very clearly states that “exposure standards are updated occasionally and may not always reflect the latest research or state of knowledge on the hazardous effects of chemicals. Classifications may become out-dated and incorrect where new information about a substance’s hazards become

available. Exposure standards do not identify a dividing line between a healthy or unhealthy working environment and are only provided for information purposes to help minimise exposure. Therefore, exposure standards should not be considered as representing an acceptable level of exposure to workers. They establish a statutory maximum upper limit”<sup>3</sup>.

As a result, it’s important to note that the current Australian exposure standards should only be taken as a starting point and they have not been revised since the reclassification of welding fume by the IARC.

## If Australian welders are operating under the exposure standard are they safe?

Based on the typical respiratory rate of 20 litres of air per minute or 2,300 m<sup>3</sup> of air per year, a welder operating within the workplace exposure standards for general welding fume (5 mg/m<sup>3</sup>), wearing no respiratory protection could inhale up to 11 grams

of welding fume per year. So year on year, an unprotected welder operating within the workplace exposure limits can inhale 11 grams of a now known, identified and classified carcinogen.

## How do Australia’s workplace exposure standards stack up with the rest of the world?

In Germany, there is a regulation translated as “Technical Rules for Welding Applications” (TRGS 528) which are based on the TRGS 900 Exposure Limits. Currently the exposure limit and regulation for general dust or non-specified welding fume (where no other specific exposure limit exists for that substance) is 1.25 mg/m<sup>3</sup>. All German exposure limits are monitored and revised (if necessary) every two years to give the best possible picture of the hazards and associated risks.

Therefore an Australian welder operating under the legal workplace exposure limits (5 mg/m<sup>3</sup>) 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<sup>3</sup>) regulation in Germany.



Achtung – ab 2014 gilt die neue Absenkung des Allgemeinen Staubgrenzwertes gemäß TRGS 900!

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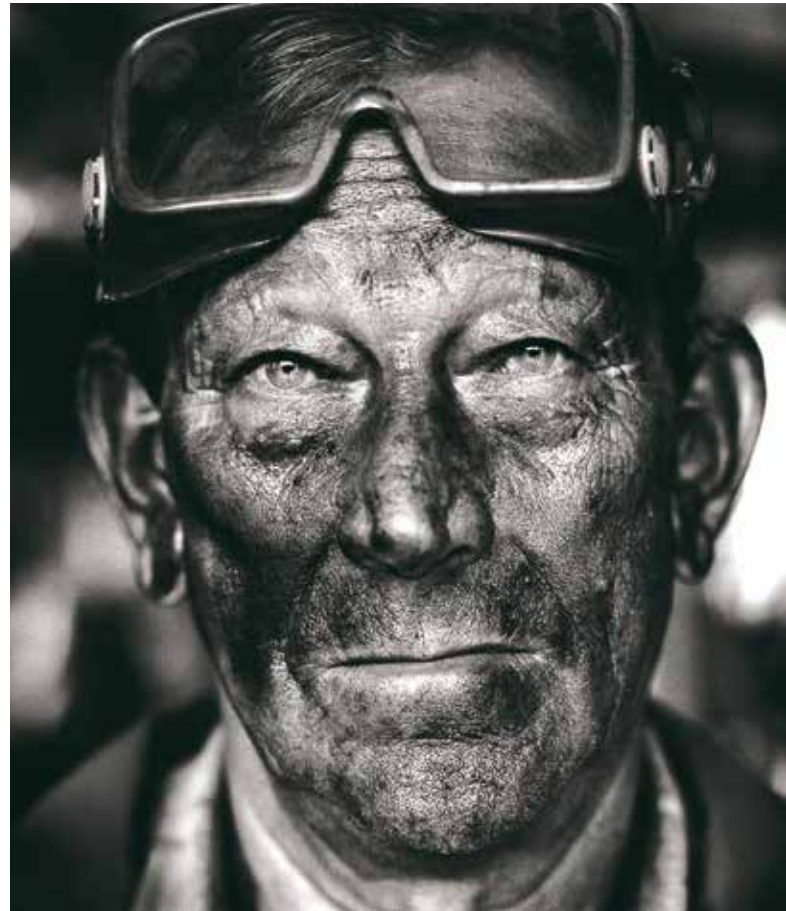
## Have there been any recorded cases in Australia where a solid link between welding and cancer was established?

“Around 5,000 cases nationally every year are linked to workplace carcinogens, with an estimated 3.6 million Australians exposed to cancer-causing agents at work”<sup>7</sup>.

In 2014, theage.com.au reported on an Australian first linking a Melbourne man’s deadly lung tumour to toxic welding fumes. “Anh Tran, a 54-year-old ex-smoker whose right lung was surgically removed, won WorkCover compensation after a court ruled that working as a welder had raised his risk of contracting lung cancer”<sup>6</sup>.

“The Victorian County Court ruled in favour of Mr Tran in light of testimony from medical experts that former welders were 44 per cent more likely to contract lung cancer compared to people who have never worked in the field”<sup>6</sup>.

“It was the first time in Australia that compensation had been awarded due to a link between lung cancer and welding fumes”<sup>6</sup>, opening the door for future compensation claims.



## Who is responsible for welder safety in the workplace in Australia?

The employer has the primary responsibility to ensure that welders, as far as reasonably practicable, are not exposed to health and safety risks whilst performing their job. If it is impossible to eliminate the risk entirely the employer must minimise the risk as far as reasonably practicable by introducing engineering or administrative controls such as ventilation and the use of personal protective equipment such as welding powered air respirators or supplied air respirators.

Welders must be informed of the risks and be a part of the decision making process to draw on their knowledge and expertise to help select the most appropriate control measures including any personal protective equipment they may require.

“Welders also have a responsibility to take

reasonable care for their own health and safety.

Welders must comply with any reasonable instruction and co-operate with any reasonable policy or procedure relating to health and safety at the workplace. If personal protective equipment is provided by the person conducting the business or undertaking, the worker must use it in accordance with the information, instruction and training provided”<sup>1</sup>.

“If there is any doubt that the controls implemented have been effective or to determine whether an exposure standard is being exceeded, air monitoring will be necessary. The Australian Institute of Occupational Hygienists can be contacted to help find a qualified occupational hygienist who may be able to help”<sup>3</sup>.



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## So what can be done to protect welders in Australia based on this reclassification?

“Unlike most chronic toxic effects, which usually manifest during the period of exposure, a carcinogenic effect may take many years from the initiating event to a clinical diagnosis of cancer. A diagnosis of cancer may not be made until long after cessation of exposure”<sup>3</sup>.

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

- Identify reasonably foreseeable hazards that could give rise to the risk
- eliminate the risk so far as is reasonably practicable
- if it is not reasonably practicable to eliminate the risk – minimise the risk so far as is reasonably practicable by implementing control measures in accordance with the hierarchy of risk control

- maintain the implemented control measure so that it remains effective
- Review, and if necessary revise all risk control measures so as to maintain, so far as is reasonably practicable, a work environment that is without risks to health and safety”<sup>1</sup>.

“Therefore, in the case where elimination and the substitution of less hazardous materials is technically not possible, the use of the carcinogenic substances should be controlled to the highest practicable standard by the application of effective engineering controls such as ventilation systems and, where necessary, complemented by the use of appropriate personal protective equipment”<sup>3</sup>.

## What Personal Protective Equipment (PPE) should be worn by welders?

“In most cases PPE must be worn by workers when welding to supplement higher levels of controls such as ventilation systems or administrative controls”<sup>1</sup>. In the 2017 Occupational Cancer Risk Series on Welding released by the Cancer Council they advise that welders should “wear either air supplied or air purifying respiratory protection<sup>5</sup>” and use “a full face welding helmet, with a UV filtered lens<sup>5</sup>” as well as suitable clothing, welding gloves and welding boots.

Welding helmets have come a long way since the humble “hiderok”. Auto-darkening welding helmet configurations are now available with integrated powered or supplied air respiratory protection options. These configurations can give welders combined eye, face and respiratory protection compliant with Australian standards with the added benefit of keeping welders cooler and more comfortable. Some options can also give welders five levels of protection with integrated hearing and safety helmet options.



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# How does Powered Air Purifying Respiratory Protection and Supplied Air Respiratory Protection protect the welder and is there any official measure of protection given?

Respirators are rated based on a Required Minimum Protection Factor (RMPF) in Australian Standard AS/NZS1715. This indicates, if properly worn, the level to which the respirator protects the wearer from the surrounding pollutants. Powered Air Purifying Respirators if correctly worn have a RMPF of 50 meaning that they supply air a minimum 50 times cleaner than the welder would otherwise be breathing unprotected. Supplied air respirators provide the welder with a RMPF of 100+. Or in other terms, these systems deliver air to the welder that is at least 100 times cleaner than the air in the

surrounding environment. To put this into perspective, disposable and reusable respirators have a RMPF of 10 if properly fitted and worn. Therefore disposable and reusable half face respirators provide 1/5th of the protection of a powered air respirator and 1/10th of the protection of a supplied air respirator.

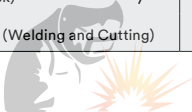
The below figure gives a basic guideline of what type of respiratory protection could be worn based on material, process and ventilation. This chart has only been provided as an example and is only provided as a basic guideline. It should not be used as the only means of selecting a respirator.

**P** = Powered air respirator with particle filter (P).

**P + A** = Particle and gas filtration via powered air respirator with both a high efficiency particulate filter (P) and an A1 gas filter installed.

**S** = Supplied air via regulator and filtration unit.

Material to be welded	Welding method	Ventilation conditions of your working environment			
		Good environment, with forced ventilation	Limited ventilation	Restricted space - <small>Note: Not suitable for Confined Spaces as defined by AS2865.</small>	Classified as IDLH
<b>Aluminium</b>	MIG	<b>P</b>	<b>P / P + A</b>	<b>S</b>	Powered and supplied air respirators must never be used in atmospheres Immediately Dangerous to Life or Health (IDLH). Always consult your Safety Engineer or Occupational Hygienist.
	TIG	<b>P</b>	<b>P / P + A</b>	<b>S</b>	
	MMA (stick)	<b>P</b>	<b>P / P + A</b>	<b>S</b>	
<b>Stainless steel</b>	MIG	<b>P</b>	<b>P / P + A</b>	<b>S</b>	
	TIG	<b>P</b>	<b>P / P + A</b>	<b>S</b>	
	MMA (stick)	<b>P</b>	<b>P / P + A</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>P</b>	<b>P + A / S</b>	<b>S</b>	
<b>Steel not coated or painted</b>	MIG/MAG	<b>P</b>	<b>P</b>	<b>S</b>	
	STICK WELDING	<b>P</b>	<b>P</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>P</b>	<b>P / S</b>	<b>S</b>	
<b>Steel painted (lead based paints)</b>	MIG/MAG	<b>P</b>	<b>P</b>	<b>S</b>	
	MMA (stick)	<b>P</b>	<b>P</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>P</b>	<b>P / S</b>	<b>S</b>	
<b>Steel galvanised</b>	MIG/MAG	<b>P</b>	<b>P</b>	<b>S</b>	
	MMA (stick)	<b>P</b>	<b>P</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>P</b>	<b>P / S</b>	<b>S</b>	
<b>Steel coated with 2-component paints or insulated with 2-part polyurethanes (risk of isocyanates)</b>	MIG/MAG	<b>P</b>	<b>S</b>	<b>S</b>	
	MMA (stick)	<b>P</b>	<b>S</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>P</b>	<b>S</b>	<b>S</b>	
<b>Material cleaned with trichloroethylene</b>	MIG	<b>S</b>	<b>S</b>	<b>S</b>	
	TIG	<b>S</b>	<b>S</b>	<b>S</b>	
	MMA (stick)	<b>S</b>	<b>S</b>	<b>S</b>	
	PLASMA (Welding and Cutting)	<b>S</b>	<b>S</b>	<b>S</b>	


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## How can the RMPF of a respirator be used to calculate and minimise the risk?

As discussed above, the general workplace exposure limit in Australia for general welding fume is 5 mg/m<sup>3</sup> TWA when no specific chemical is identified with a workplace exposure limit lower than the general guideline. Also alluded to above, this means that an unprotected welder could inhale up to 11 grams of carcinogenic welding fume per year working within the current workplace exposure standards. The tube pictured below contains 11 grams of welding fume particles. If a powered air purifying respirator is worn with a RMPF of 50 the wearer's exposure can be reduced to at least 1/50th. In this example, this

would reduce the welder's potential inhalation from 11 grams (complete tube below) to approximately 0.22 milligrams over a full year (the level above the purple line in the image below). "The incidence of cancer is usually dose related"<sup>3</sup> meaning that "the greater the exposure to the carcinogen, the higher the risk of developing the cancer associated with that substance or mixture. Conversely, the smaller the exposure, the lower the probability of developing cancer"<sup>3</sup>. Therefore, Australian welders run a lower risk of developing cancer when wearing suitable PPE when welding.

### 11 grams of welding particles

To illustrate a general example: Working within the Australian workplace exposure standards for general welding fume (5 mg/m<sup>3</sup>), a full-time welder may inhale up to 11 grams of welding fume every year.



### Powered Air

A Powered Air Purifying Respirator (PAPR) has a Required Minimum Protection Factor of 50, meaning that the wearer's exposure should be reduced to 1/50th. In this example, when a welder is wearing a PAPR they may inhale approximately 0.22mg (the area above the purple line) when welding over a year at the Exposure Standard concentration of 5 mg/m<sup>3</sup>.

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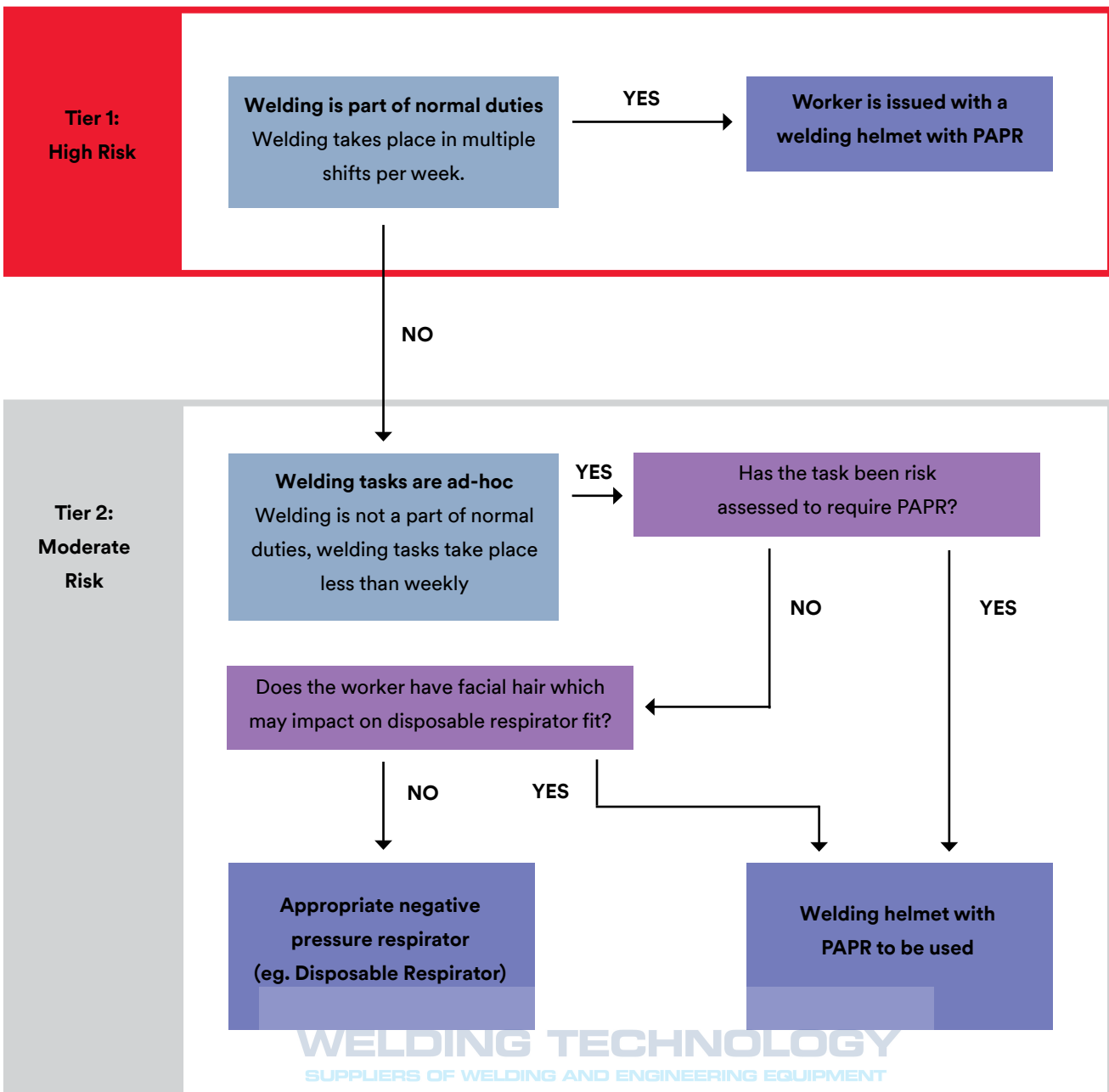


## Are there any examples from local large Aussie companies changing their stance on welding fume and welder's PPE?

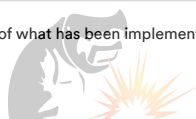
A number of large Australian companies are now changing their stance on PPE for welders after the reclassification of welding fume by the IARC. The below figure is an example of the changes implemented by a large Australian company to

strengthen their controls by enforcing the use of powered air purifying respirators (PAPR) to reduce welding fume exposure to "As Low As Reasonably Practicable". This change was made as a direct result of the IARC's reclassification.

### Respirator Selection



This flow chart has only been noted as an example of what has been implemented by an Australian company and may not be suitable for your workplace conditions.

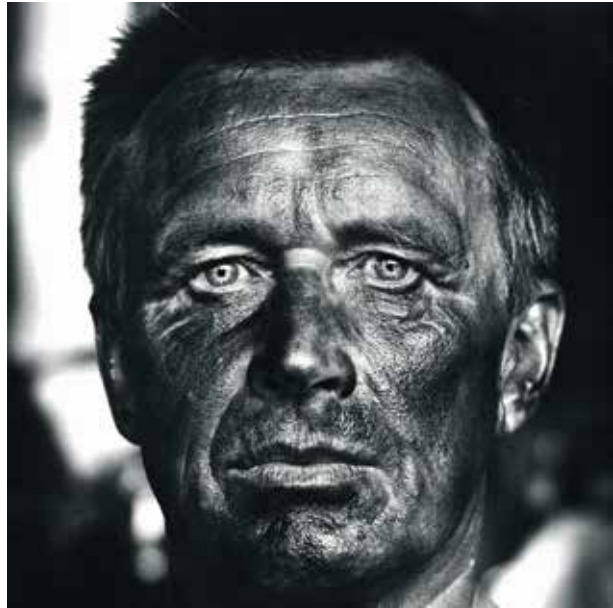


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## So what needs to be done in Australia to promote change in the workplace exposure standards for welding fume?

There is a current project by Safe Work Australia to review and update “all” of the current standards. Safe Work Australia has confirmed that welding fumes (not otherwise classified) will be included in the review.

With what is now known surrounding the carcinogenicity of welding fume it is hoped that the current review will look to update the current welding fume exposure standards.



## Where do I go for further information?

For further information on the dangers of welding fume and a strategic approach that can help to reduce exposure please read our White Paper on Welding Fume which can be downloaded from the

literature section of our website - [www.awsi.com.au](http://www.awsi.com.au). For further reading on any of the subjects discussed in this paper, start where we started, by reading the documents listed in the references below.

## References

- 1) Welding processes code of practice, Safe Work Australia, April 2016
- 2) Workplace exposure standards for airborne contaminants, Safe Work Australia, April 2013
- 3) Guidance on the interpretation of workplace exposure standards for airborne contaminants, Safe Work Australia, April 2013
- 4) TheLancet.com/oncology volume 18 May 2017
- 5) Occupational Cancer Risk Series, Cancer Council, 2016
- 6) Door Opens For Welders' Cancer Compensation, theage.com.au, 2014
- 7) Welders reminded to protect themselves at work to reduce cancer risk, Cancer Council Queensland, 2017

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# More Information

If you'd like more information on the hazards of welding fume or selecting suitable respiratory protection for your specific welding application please get in touch with AWS at [www.awsi.com.au](http://www.awsi.com.au)

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