

# DUST-FREE WORKPLACES WELDING FUMES



**TNO** innovation  
for life

In the Netherlands, between 2000 and 3500 people die of work-related illness every year, including as the result of exposure to carcinogenic materials. These numbers must, and can, be reduced. Prevention is crucial here, as is special attention for workplace behaviour and the instatement of preventative measures. TNO is helping companies to develop dust-free tools and working surroundings.

The government has set legal limits to protect workers' health. These limits set the maximum levels of dangerous substances to which a worker may legally be exposed. The Inspectie SZW (Inspectorate of the Dutch Ministry of Social Affairs and Employment) is responsible for the enforcement of these regulations, in order to drastically reduce the number of work-related cancer cases.

TNO works on prevention using the newest available systems and technologies. We develop tools and production processes for intrinsically safe and healthy workplaces. Many tools are a potential source of carcinogenic substances that are a threat to workers and their working environment. With the right control measures in place, the emission of these substances can be drastically reduced and workers effectively protected.

The design and production of dust-free tools and production processes is, in the first instance, a task for manufacturers. These can consult TNO, which has extensive expertise in this area; for instance, we have developed innovative extraction and filtering systems for dangerous substances. In this way, employers can give their workers effective protection by providing dust-free tools and processes in the workplace.

This TNO publication is specific to welding fumes, that are released when welding unalloyed steel and stainless steel.

**WORK-RELATED CANCERS:  
MORTALITY FIGURES**

Across the EU, every year 100,000 to 150,000 people are diagnosed with a cancer that resulted from workplace exposure to a carcinogenic substance such as breathable quartz, hardwood dust or welding fumes. These cancers kill about 80,000 people per year, and these early deaths represent almost 1.2 million lost years of life.

Besides suffering a lower quality of life, cancer patients undergo medical treatment and often have to work less, or not at all, so their individual difficulties also have a cost to society. The costs of health care and reduced productivity through work-related cancer in the EU have been estimated at between four and seven billion euros per year. When the intangible costs of illness and a possible early death are included, the total cost to society rises to about 350 billion euros per year.

If we convert these estimates for the EU (with a population of more than 500 million) into the number of deaths from work-related cancer in the Netherlands (with a population of 17 million), this means 2000 to 3500 deaths per year. For the sake of comparison: in 2015 there were, tragically, 621 deaths from traffic accidents and 27 deaths on

building sites, while smoking killed almost 20,000 people. Exposure to carcinogenic substances is a huge risk factor, and this justifies tackling it at the source.

TNO has identified three sectors with high exposure levels to carcinogenic substances, in which workers thus run a raised health risk: the construction industry, the wood processing industry and the metalworking industry. The principal carcinogenic substances here are breathable quartz, hardwood dust, welding fumes, and hexavalent chromium.

**EXCEEDING LEGAL LIMITS**

Workers using welding equipment are exposed to carcinogenic fumes. In many cases, the legal limits to this exposure are being exceeded (see Table 1).

**DUST-FREE WORK:  
A CONDITION FOR  
PROTECTING WORKERS  
AGAINST  
WORK-RELATED  
CANCERS**

**TABLE 1. WELDING FUMES: LEGAL LIMIT VALUES AND CANCER RISKS**

Overview of legal limit values and the risks of (lung) cancer through exposure to welding fumes*		
	Limit value (mg/m <sup>3</sup> )	Exposure 'in practice' (mg/m <sup>3</sup> )
GSW TGG-8u Netherlands Unalloyed steel (after 01-04-2015)	1	1 – 15 (TNO 1999)
GSW TGG-8u Netherlands Stainless steel (after 01-04-2015)	1	

\* Welding fumes composition: Al, Mn, Co, Ni, Cr, Mo, Fe, Cu, etc. (known carcinogenics: Cr, Ni and Co)  
Relevant limit values in the Netherlands: Mn (0.1 mg/m<sup>3</sup>) and Cu (0.1 mg/m<sup>3</sup>)

\*\* A carcinogenic process or material is shaded orange

The most important steel welding processes are shielded metal electrode, MIG-MAG, TIG and powder welding. The most common welding process is MIG/MAG welding (used by 70% of the companies questioned (sample size: 1400)). 33% of the companies use oxy-fuel welding (mostly replaced in 2018 by electric welding); 50% use arc welding with shielded electrodes; 46% use TIG welding; and just 2% powder welding. Companies employ, on average, two different welding processes.[1]

The most commonly employed welding techniques are therefore MIG-MAG, shielded electrode and TIG welding. 80% of stainless steel welding is done using TIG. TNO studied these three welding processes more closely in its Worst Case Room in Delft in order to measure the emission of welding fumes during the welding of steel and stainless steel. The results of this TNO research are shown in Tables 2 and 3 below, together with the current limit values for welding fumes given in the Dutch regulations for Workplace Substance Limit Values for an 8-hour workday (GSW TGG-8u (1 mg/m<sup>3</sup>)).

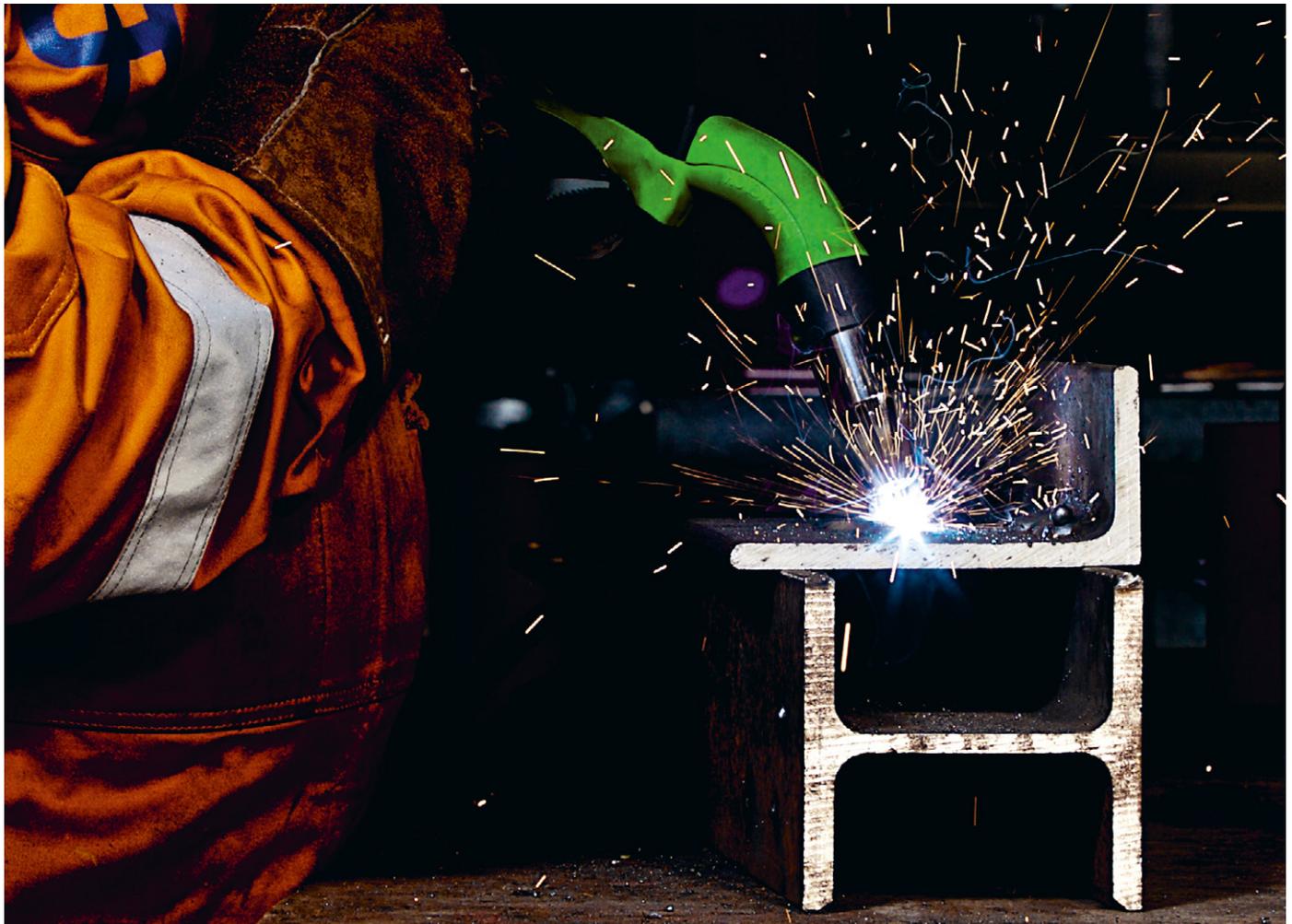
TNO carried out this experimental research in its Worst Case Room, simulating a comparatively unfavourable situation: the welding equipment was in action 25% of the time, with no specific control measures taken, and welding took place in a relatively small workspace.

This yielded values well in excess of the legal limits for welding fumes for shielded-electrode welding; for MIG-MAG and TIG (with shielded electrodes) these legal limits were exceeded by a factor of 30 or more. When innovative technological solutions are applied, however, this exposure is greatly reduced (see Table 4).

The right choice of welding equipment and technological solution, used in the right way, can reduce exposure to harmful fumes by a factor of 100 compared to the most unfavourable situation. This represents an excellent opportunity for companies to instigate healthier welding conditions. TNO's measurements for a 25% in-action time, measured in the worker's breathing zone, are given in Table 3 on the next page.

The use of welding equipment together with the right control measures reduces exposure to acceptable levels. Under these conditions, when measured in TNO's Worst Case Room, the legal limits for welding fumes were not exceeded.

**DRASTICALLY  
LOWERING THE  
NUMBER OF  
VICTIMS OF  
WORK-RELATED  
CANCER?  
USE A WELDING  
TORCH WITH AN  
INTEGRATED  
FUME  
EXTRACTOR**





Excess exposure factor:  
50 – 100 times the limit  
for welding fumes  
(TNO Worst Case Room)



Excess exposure factor:  
25 – 50 times the limit  
for welding fumes  
(TNO Worst Case Room)



Excess exposure factor:  
5 – 25 times the limit  
for welding fumes  
(TNO Worst Case Room)



Excess exposure factor:  
1 – 5 times the limit  
for welding fumes  
(TNO Worst Case Room)

## CHOOSE A WELDING TORCH WITH INTEGRAL EXTRACTION

Note:

The results of the measurements in the TNO Worst Case Room are not identical compared to practice conditions, but do illustrate the quantity of welding fume released during the various welding processes and above all, also the effect of control measures.

The measurement results as measured in the TNO Worst Case Room are about a factor 2 higher than in practice.

TABLE 2: FUME CONCENTRATIONS FOR VARIOUS STEEL WELDING PROCESSES

	Type of welding tool	Material being welded	Production rate (in-action time percentage)	Welding fumes concentration (mg/m <sup>3</sup> )*
	Shielded electrodes, 250 A	steel	25%	> 50
	Shielded electrodes, 120 A	steel	25%	30
	MIG-MAG, cored wire, 250 A	steel	25%	30
	MIG-MAG, cored wire, 100 A	steel	25%	5
	MIG-MAG, solid wire, 250 A	steel	25%	20
	MIG-MAG, solid wire, 100 A	steel	25%	2.4
	Under powder	steel	25%	< 0.3
	Shielded electrode 1999 practice (TNO)	steel	5-25%	2-20 5-30
	MIG-MAG 1999 practice (TNO)	steel	5-25%	1-10 0.9-13
	TIG (TNO)	steel	5-25%	0.8-4.2

\* Concentration measured in TNO Worst Case Room, in the worker's breathing zone, 25% tool in-action time, room volume 15m<sup>3</sup>, fresh air supply 150m<sup>3</sup>/hr.

\*\* Excess exposure factor compared to Dutch legal limits for welding fumes (1 mg/m<sup>3</sup>).

**TABLE 3. FUME CONCENTRATIONS FOR VARIOUS STAINLESS STEEL WELDING PROCESSES**

	Type of welding tool	Material being welded	Production rate (in-action time percentage)	Welding fumes concentration (mg/m <sup>3</sup> )*
	Shielded electrodes, 75 A	stainless steel	25%	15
	MIG-MAG, cored wire, 250 A	stainless steel	25%	30
	MIG-MAG, solid wire, 250 A	stainless steel	25%	22
	MIG-MAG, cored wire, 100 A	stainless steel	25%	5.6
	MIG-MAG, solid wire, 100 A	stainless steel	25%	2.5
	TIG, solid wire, 85 A	stainless steel	5-25%	< 0.2

\* Concentration measured in TNO Worst Case Room, in the worker's breathing zone, 25% tool in-action time, room volume 15m<sup>3</sup>, fresh air supply 150m<sup>3</sup>/hr.

\*\* Excess exposure factor compared to Dutch legal limits for welding fumes (1 mg/m<sup>3</sup>).

**TABLE 4. WELDING PROCESSES WITH FUME CONTROL MEASURES AND PREVENTION FACTORS**

Type of welding tool	Material being welded	Welding fumes concentration (mg/m <sup>3</sup> ) *	Control measure	Prevention factor**
Shielded electrodes, 250 A	steel	> 50	none	none
Shielded electrodes, 120 A	steel	30	none	none
MIG-MAG, cored wire, 250 A	steel	30	7XE EXTRACTOR, welding visor with dust filter	25-50
MIG-MAG, cored wire, 250 A	steel	30	7XE EXTRACTOR	10-25
MIG-MAG, cored wire, 100 A	steel	5	7XE EXTRACTOR	10-25
MIG-MAG, solid wire, 250 A	steel	20-25	7XE EXTRACTOR, welding visor with dust filter	25-50
MIG-MAG, solid wire, 250 A	steel	20-25	7XE EXTRACTOR	10-25
MIG-MAG, solid wire, 100 A	steel	2-3	7XE EXTRACTOR	10-25
MIG-MAG, solid wire, 250 A	steel	20-25	BINZEL, welding visor with dust filter	4-20
MIG-MAG, solid wire, 250 A	steel	20-25	BINZEL	2-10
MIG-MAG, solid wire, 250 A	steel	20-25	welding table, downward extraction	100
MIG-MAG, solid wire, 250 A	steel	20-25	welding cabin, rearward extraction	100
MIG-MAG, solid wire, 250 A	steel	20-25	welding visor with dust filter (100% use)	100
MIG-MAG, solid wire, 250 A	steel	20-25	welding visor with dust filter (in practice)	2
TIG, 85 A	steel	< 0.1	TIG welding torch with extraction	10

\* Concentration measured in TNO Worst Case Room, in the worker's breathing zone, 25% tool in-action time, room volume 15m<sup>3</sup>, fresh air supply 150m<sup>3</sup>/hr.

\*\* Excess exposure factor compared to Dutch legal limits for welding fumes (1 mg/m<sup>3</sup>).

**USE THE RIGHT WELDING EQUIPMENT**

To control the amount of welding fumes being emitted, TNO recommends taking the following steps. Each step offers an improved level of effectiveness:

**Step 1:** Choose the least pollutant welding process

**Step 2:** Weld at the lowest possible current

**Step 3:** Use a welding torch that has integrated fume extraction

**Step 4:** Use a welding visor that has its own filters or fresh air supply

The use of welding equipment together with the right control measures reduces exposure to acceptable levels. Under these conditions, when measured in TNO's Worst Case Room, the legal limits for welding fumes were not exceeded.

**ENFORCEMENT**

The Inspectie SZW is responsible for enforcing regulations and checking workplaces for the presence of visible dust in the breathing zone of workers performing such actions as drilling, chopping, grinding or sawing. If dust is released towards the breathing zone during these activities, it means that the correct steps have not been taken to prevent it, or that equipment is not functioning correctly.

In both situations the company is required to take appropriate action. The Inspectie SZW is authorized to impose fines or even halt work in order to enforce compliance.

More information (in Dutch) on the Inspectie SZW and its enforcement policy can be found at [www.inspectieszw.nl](http://www.inspectieszw.nl).

**DUSTFREEWORKING.TNO.NL**

**A HEALTHY LIFE**

Our ambition is to create a vigorous, healthy and productive society. For tomorrow's healthy living, TNO develops innovations for safe and healthy workplaces. Prevention is the key.

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