Deutsche Gesetzliche Unfallversicherung
Fachausschuss
Metall- und Oberflächenbehandlung

Exposure to ozone during welding and allied processes*

During machining and processing of metal materials by means of welding and allied processes, gaseous and particulate hazardous substances are formed. Ozone is one of the important gaseous hazardous substances.

Ozone (O_3) is formed by ultraviolet radiation from the oxygen in air. During arc processes, the arc generates UV radiation, the intensity of which depends on the current intensity. Ozone is formed wherever the intensity of the UV radiation is sufficient.

At high temperatures, ozone is instable towards other substances. The presence of other gases, fumes or dusts in the air accelerates the decomposition of ozone to oxygen.

Due to the instability of ozone, the difference between emission and immission (concentration at the workplace) shall be especially considered.

1 Emission (ozone formation)

The formation of ozone (emission) during welding depends on the following parameters:

- processes
- materials
  (e.g. aluminium/aluminium magnesium/ aluminium silicon/chromium nickel steel)
- shielding gases (e.g. argon, helium)

In order to determine the level of ozone emissions for the different welding processes, different measuring methods were used:

- the "fume box method" where the quantity per unit of time is measured;
- the "radiation chamber method" where the ozone concentration (mg/m³) for different distances to the arc is measured.

It was found that

- the highest emissions occur during metal inert gas welding (MIG);
- during tungsten inert gas welding (TIG), the measured emission values are one order of magnitude below those measured for MIG welding;
- significantly higher emissions occur during machining of AlSi materials than during machining of ALMg4 materials.

Contents:

2 Immission (concentration) at the workplace

Occupational limit value: 0,2 mg/m³; 0,1 ml/m³

The concentration of ozone at the workplace depends on the following factors:

- emission;
- distance from the arc;
- other substances present (gases, particles);
- protective devices present.

As the UV radiation extends beyond the direct welding zone, ozone is also produced outside the area of the arc and the shielding gases.

Concentration measurements are intended to identify the actual exposure of the welder and his/her surroundings and - together with emission rates - are important for the evaluation of the hazard to the welder and for the specification of protective measures.

Process/material	Ozone concentration (ml/m³)	
	In the plume	In the welder's breathing zone
MAG welding non-alloyed and low-alloyed steel	0,4-0,85	0,025-0,1
MIG welding AlMg 4,5 Mn AlSi 5	- 3 - 10	- 0,2 - 0,4
TIG welding chromium nickel steel Al4,5 Mn	0,25-0,4 - 0,4	- 0,04 - 0,02

Table 1: Examples for ozone concentrations measured at the person and in the plume during gas shielded processes

* **This expert committee information sheet has been prepared by members of the working group "Hazardous substances in welding and allied processes".**

3 Ozone concentrations during MAG, MIG and TIG welding

3.1 Metal active gas welding (MAG)

During metal active gas welding, a lower ozone concentration can generally be expected due to heavy fume formation. In general, there is no special hazard to the welder relating to ozone.

3.2 Metal inert gas welding (MIG)

During metal inert gas welding of aluminium materials, the formation of ozone (caused by UV radiation and the strongly reflecting materials) shall be considered in addition to the total dust.

Comparable to the emission measurements, the highest ozone concentrations were measured during MIG welding of AlSi materials (e.g. AlMgSi1 as parent metal with AlSi5 as filler metal). The ozone concentration increases with the current intensity and the length of the arc.

The use of an Ar/He shielding gas mixture during MIG welding of aluminium materials results in lower ozone concentrations than the use of pure argon as shielding gas, measured under equal conditions. It becomes obvious that the ozone concentration significantly decreases with increasing distance to the arc at constant parameters as e.g. material, shielding gas, current intensity.

3.3 Tungsten inert gas welding (TIG)

Due to lower current intensities, the generated ozone concentrations are lower during tungsten inert gas welding than during metal inert gas welding. Similar to MIG welding, the ozone values increase from aluminium magnesium alloys over pure aluminium to aluminium silicon alloys.

For TIG welding as well, the ozone concentration is primarily dependent on the material used; secondly the type of shielding gas used and the distance to the arc have a perceptible influence on the ozone concentration measured.

Material/shielding gas	Ozone concentration (ml/m³)		
	Distance to the arc		
	150 mm	250 mm	400 mm
<u>Pure aluminium</u> Shielding gas: argon 7 l/min Current intensity: 150 A	0,15	0,08	0,02
<u>AlMg 4,5 Mn with S-AlMg 5</u> Shielding gas: He 20 l/min	0,6		
<u>AlMn with S-Al 99,5</u> Shielding gas: He 20 l/min	3,5		
<u>AlMgSi 1 with S-AlSi 5</u> Shielding gas: He 20 l/min	2,2		

Table 2: Ozone immission (concentration) during tungsten inert gas welding (examples)

During TIG welding of CrNi steel, the ozone concentrations are lower than during TIG welding of aluminium materials.

Results from measurements in front of the welder's face shield from the MEGA data base of the BGIA (institute for occupational safety and health of the DGUV (German Social Accident Insurance)) show that the 95% value of 0,19 mg/m³ is below the occupational limit value for ozone. Other values, which were measured in the framework of an EU project behind the welder's face shield with a chemiluminescence monitor are in the range of 0,01 mg/m³ to 0,1 mg/m³.

4 Summary

For most process/material combinations in welding and allied processes the (measured) ozone concentrations in the welder's breathing zone are below 0,1 ml/m³, the currently valid occupational limit value.

During MIG welding of aluminium materials, and here especially AlSi, there are, however, concentrations exceeding the limit value.

Especially for the latter process/material combinations, the use of effective ventilation systems is required. The ventilation system shall be so designed that not only the area near the arc is covered, but the breathing zone of the welder is also completely included.

For fully automated processes, a radiation screen is recommended, preventing ozone formation in the breathing zone of the operator.

<u>Bibliography:</u>

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