BG Information
for Safety and Health
at work

BGI 790-012

BG Information Sheet

BG/BGIA Recommendations
for Risk Assessment
in compliance with the Hazardous
Substances Ordinance

Tungsten inert gas welding (TIG welding)

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Contents

BG Information Sheets contain advice and recommendations with the intention to facilitate the practical use of regulations for special areas or circumstances.

BG Information Sheets are primarily addressed to employers and are aimed at assisting him/her in the implementation of his/her duties arising from national occupational safety and health regulations, accident prevention regulations and possibly rules and showing ways to prevent occupational accidents, diseases and health hazards.

When observing the recommendations contained in the BG Information Sheet, especially the exemplary possible solutions, the employer can assume to have taken suitable measures for the prevention of occupational accidents, diseases and health hazards. Other solutions are possible, if safety and health are equally protected. If technical rules have been specified by the relevant committees substantiating national occupational safety and health regulations, they shall be given priority.

Preliminary note

BG/BGIA recommendations for risk assessment in compliance with the Hazardous Substances Ordinance are published by

- **the industrial Berufsgenossenschaften (BG) and**
- **the BG Institute for Occupational Safety and Health (BGIA)**

in agreement with the federal states and the Federal Institute for Occupational Safety and Health (BAuA). They are intended to help employers with the part of the risk assessment related to activities with hazardous substances and are integrated into the collected edition of the Hauptverband der gewerblichen Berufsgenossenschaften as BG Information Sheets under the order numbers **BGI 790-001ff.**

The present BG/BGIA recommendations were prepared through cooperation of

- **Expert committee “Metal and Surface Treatment” (FA MO),**
  Section “Hazardous Substances in Welding in Allied Processes”, Hannover
- **Berufsgenossenschaft for fine mechanics and electrical engineering (BGFE), Köln**
- **Association of metal BGs (VMBG), Düsseldorf,**
- **Regional administrative authority Kassel, department 35.3 “Expert centre for product security and hazardous substances”, Kassel**

1 Scope

1.1 The present BG/BGIA recommendations are related to the use of tungsten inert gas welding (TIG welding).

If other welding processes are used in the same work area or emissions from neighbouring work areas occur, it shall be checked, if other determinations for risk assessment, e.g. measurements, are required.

1.2 The present BG/BGIA recommendations are **not** valid for

- TIG welding activities in containers and confined spaces,

- TIG welding activities with thoriated electrodes.

See BG Rule “Arbeiten in Behältern, Silos und engen Räumen” (Work in Containers, Silos and Confined Spaces) (BGR 117-1) and BG Information Sheet “Handling of thoriated tungsten electrodes during tungsten inert gas welding (TIG)” (BGI 746).

Protective measures for TIG welding activities are recommended as assistance in the execution of the risk assessment. When using the protective measures, the workplace limit values will be observed.

2 Terms and definitions

For the purpose of the present BG Information Sheet, the following terms are defined:

1. **TIG welding** is a gas shielded welding process, where the arc between the workpiece and a tungsten electrode burns in an atmosphere of inert gas. Due to the high melting point of tungsten, the electrode does not melt as in other welding processes.

2. **Technical capture** of the hazardous substances **at the point of generation** means a technical ventilation, extracting the hazardous substances directly at their point of generation.

3. **Positively tested “mobile welding fume extraction devices”** are extraction devices complying with the increased requirements for the extraction of carcinogenic hazardous substances.

See BGIA handbook: Sicherheitstechnisches Informations- und Arbeitsblatt 510 215 (Technical Safety Information and Work Sheet) “Mobile Schweißrauchabsauggeräte – Positivliste” (Mobile welding fume extraction devices – positive list).

3 Work procedures/activity

For TIG welding, usually argon, helium or mixtures of these two are used as shielding gas. The TIG welding process can be done without filler metal (fusion welding) or with filler metal. The filler metal is usually fed by hand. With this type of procedure, many weld seam types can be produced in all positions. Direct or alternating current is used. The weldable workpiece thicknesses for steel are up to 4 mm and for aluminium up to 5 mm.

Due to the low fume emission, TIG welding may be called a “low-emission” welding process as far as welding fume is concerned. On the other hand, the formation of ozone is favoured by low welding fume emission, especially during welding of aluminium.

4 Exposure to hazardous substances

4.1 Hazardous substances

The exposure to hazardous substances during TIG welding is mainly influenced by the type of filler metal (chromium nickel steel, aluminium alloys) and the type of current.

See BG Information Sheet “Hazardous Substances during Welding and allied processes” (BGI 593).

During welding, gaseous and particulate substances are always generated. The particles generated during welding having an aerodynamic diameter < 1 µm are called welding fumes. For the measurement of the exposure to welding fumes, the respirable dust fraction (A dust) behind the welder’s shield has to be collected.

See EN 481 “Workplace atmospheres; size fraction definitions for measurement of airborne particles” and EN ISO 10882 “Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operator's breathing zone”

The measuring system for A dust available in the Federal Republic of Germany at present cannot be used for sampling behind the welder’s hand shield due to its dimensions. For this reason, the personal sampling equipment for the inhalable dust fraction (E dust) is used. As the dust/fume formed during welding consists of A dust by 75 to 100 %, the results obtained for E dust are always higher than those for the pure A dust fraction.

See BG Information Sheet “Hazardous Substances in Welding and Allied Processes” (BGI 593).

In **table 1,** the hazardous substances occurring as a function of the composition of the material (base and filler metal) are listed together with their occupational exposure limit values (AGW).

Hazardous substance	Occupational exposure limit value [g/m³]	[l/m³]	Peak limitation (excess factor)	Remarks
Welding fume (measured as E dust)	3 A		4	
Ozone	0,2	0,1	= 1 =	DFG
Nickel oxide[1)]	(0,5 E)	former TRK		
Chromium(VI) compounds	(0,05 E)	former TRK		
[1)] Analytically analysed as nickel and its compounds				

Table 1: Hazardous substances, occupational exposure limit values and peak limitation
(A: Respirable dust fraction, E: inhalable dust fraction)

See as well Technical Rules for Hazardous Substances “Arbeitsplatzgrenzwerte” (Occupational Exposure Limit Values) (TRGS 900)

Nickel oxide is classified as carcinogenic, class 1 and chromium(VI) compounds are classified as carcinogenic, class 2. The technical guidance concentrations were valid until December 31, 2004. At present there are no specified occupational exposure limit values for these two substances.

Investigations have shown that for TIG welding regardless of base and filler metals welding fume and ozone may be used as key components for the determination.

See BG Information Sheet “Hazardous Substances in Welding and Allied Processes” (BGI 593) and “Untersuchungen zur Schadstoffentstehung beim MIG-Schweißen von Nickel- und Nickelbasislegierungen” (Holzinger, K.)

4.2 Evaluation of the exposure to hazardous substances

The measuring results of all Berufsgenossenschaften determined during TIG welding in the period 1999 to 2003 were taken from the measuring data documentation of the Berufsgenossenschaften (MEGA) (see **Annex)**. The measuring results are representative for the length of shift. They confirm laboratory investigations and show that TIG welding is a low-fume welding process.

4.2.1 Welding fume (measured as E dust)

All measuring results for welding fume are below the limit value for A dust of 3 mg/m³. The 95% value of the MEGA evaluation without restrictions is 2,51 mg/m³.

The 95% value for the sub-collective “Sampling behind the welder’s hand shield” is 2,15 mg/m³.

The 95% value in the focal action of the regional administrative authority of Kassel is even lower with 1,62 mg/m³ measured behind the welder’s head shield with consistent follow-up capture.

In individual cases, the A dust measuring system was used in spite of the difficult positioning.

All measuring results are below the limit value for A dust of 3 mg/m³. The 95% value is 0,88 mg/m³. Due to the low number of data, these data were not used for the evaluation.

4.2.2 Ozone

Only few measuring data for ozone are available in the MEGA data base. Only the data measured with a directly indicating measuring instrument were used. The majority of the measuring results were determined in front of the welder’s shield. The 95% value is 0,19 mg/m³, which is below the occupational exposure limit value for ozone.

The ozone concentrations measured with a chemiluminescence monitor behind the welder's shield in the framework of a EU project [Examination of the Measurement and Control of Ozone Emissions during Welding and Allied Processes] are in the range of 0,01 mg/m³ up to 0,1 mg/m³.

The short-term values are observed under the specified conditions (15 minute average value below 0,2 mg/m³ and duration of increased exposure below 1 hour).

In addition, the ozone concentration significantly decreases with growing distance to the arc at constant parameters, e.g. material, shielding gas and current intensity.

See BIA Report 10/96 "Ozon".

4.2.3 Nickel oxide and chromium(VI) compounds

The 95 percent value of the nickel oxide measurements is 0,047 mg/m³ for the evaluation "without restrictions". The evaluation of the sub-collective "inside welder's face shield" resulted in a significantly lower 95 percent value of 0,023 mg/m³. This value is 4,6 % of the former TRK of 0,5 mg/m³. Five measuring results of the eight nickel oxide measurements of the focal action of the regional administrative authority of Kassel were below the detection limit of 0,01 mg/m³ and three of the measuring results were 0,02 mg/m³.

The 95 percent value of the chromium(VI) measurements is 0,008 mg/m³ in the MEGA evaluation "without restrictions" and 0,004 mg/m³ in the evaluation of the sub-collective "inside the welder's face shield", which is 8 % of the former TRK of 0,05 mg/m³. The six measuring results for chromium(VI) of the focal action of the regional administrative authority of Kassel were between < 0,0005 mg/m³ and 0,0045 mg/m³.

4.2.4 Summary

For welding fume, all 95 percent values are below the limit value for A dust. For ozone, also all values are below the occupational exposure limit value.

For chromium(VI) compounds and nickel oxide, the values of all collectives are far below the former TRK values.

5 Protective measures

In comparison to other welding processes, TIG welding is the process with the lowest hazardous substances exposure. On the basis of the exposure measurements in work areas, the exposure evaluation yields the following result: During TIG welding, the A dust limit value for welding fume and the limit value for ozone are observed.

Due to the results presented in the Annex, no exposure measurements of welding fumes and ozone are necessary during TIG welding, if the conditions and recommendations described in the following are observed.

5.1 TIG welding of chromium nickel steel

When TIG welding chromium nickel steel, nickel oxide and chromium(VI) compounds are formed. These are carcinogenic hazardous substances. The former TRK values were invalidated. The valid Hazardous Substances Ordinance requires that for carcinogenic substances of classes 1 and 2 supplementing protective measures according to § 11 (protection class 4) shall be taken in addition to protective measures according to §§ 8 to 10. That means that general hygiene measures and basic measures are supplemented by protective measures requiring primarily a substitution. If this is not possible for technical reasons the hazard to the workers shall be reduced as far as possible to the state of the art.

Nickel oxide and chromium(VI) compounds can be detected by measurements (up to 5 % of the former TRK for nickel oxide and up to 8 % for chromium(VI) compounds). The substitution by other welding processes or other materials is usually not possible. Therefore, the hazard to the workers shall be reduced as far as possible by measures to the state of the art.

A minimization of the hazard can only be reached by means of a technical protective measure for capturing the hazardous substances at the point of origin.

Suitable technical exhaust capture systems are welding tables or welding booths or, at mobile (non-stationary) workplaces, exhaust systems with mobile capture elements. Exhaust systems with mobile capture elements can be used as an alternative to welding tables or welding booths, if they are positively positioned in direct vicinity of the emission source and are moved forward in analogy to the work progress.

Positively tested “mobile welding fume extraction devices” may e.g. be taken from the BGIA manual or the BG-PRÜFZERT data base under www.hvbg.de/d/bgp/index.html.

See BGIA manual: Information and Work Sheet on Technical Safety 510 215 “Mobile Schweißrauchabsauggeräte – Positivliste” (Mobile welding fume extraction devices –positive list).

The ventilation systems and the systems for the separation of the hazardous substances is subject to regular maintenance (warranty of operability) and shall be regularly tested, at least once a year. The test results shall be documented.

5.2 TIG welding of unalloyed or low alloy steel or aluminium materials

If the risk assessment proves that no chromium nickel steel (stainless steel) is welded, extraction with capture at the point of origin is not necessary. Local technical ventilation shall, however, be provided. It has to be made sure that the ventilation system is effective in the whole room, at least in the welding area. The requirements for design and operation of the ventilation system are specified in the BG Rule “Arbeitsplatzlüftung – Lufttechnische Maßnahmen” (Workplace ventilation – Ventilation Measures) (BGR 121).

6 Information for use

The user of the present BG/BGIA recommendations shall verify the validity of the conditions in case of modifications of the process and otherwise regularly, at least once a year, and shall document the result. Part of this, among others, is to verify the unmodified validity of the present BGI/BGIA recommendations. The verification is carried out in the framework of the risk assessment in compliance with § 7 of the Hazardous Substances Ordinance.

BG/BGIA recommendations give information with practical relevance to the employer on how to make sure that the occupational exposure limit values (AGW) are observed or that the state of the art is reached, if no AGWs are available. Other requirements of the Hazardous Substances Ordinance, especially the information collection (§ 7), the duty to observe the hierarchy of the protective measures (§ 9) the duty to prepare instructions for use and to regularly instruct workers (§ 14) and the duty to carry out preventive occupational medical examinations (§§ 15 and 16) remain valid for the use of the present BG/BGIA recommendations.

7 Verification

The present BG/BGIA recommendations were first adopted in May 2005. They are checked at least every three years for up-to-dateness. Should modification become necessary, they will be published.

8 Further reading

Mobile Schweißabsauggeräte –Positivliste. Sicherheitstechnisches Informations- und Arbeitsblatt 510 215. 46 LFG.I/2005. In BGIA-Handbuch Sicherheits- und Gesundheitsschutz am Arbeitsplatz.

Berufsgenossenschaftliche Informationen: Schadstoffe beim Schweißen und bei verwandten Verfahren (BGI 593). Edition 2003. Editor.: Verwaltungsgemeinschaft der Metall-Berufsgenossenschaften. Carl Heymanns Verlag, Köln

EN 481 Workplace atmospheres; size fraction definitions for measurement of airborne particles. Edition 07/1993

EN ISO 10882: Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operator's breathing zone. Edition 01/2001

Technische Regeln für Gefahrstoffe: Arbeitsplatzgrenzwerte (TRGS 900) in the current version. Bundesarbeitsblatt January 2006, P. 41ff

Holzinger, K.: Untersuchungen zur Schadstoffentstehung beim MIG-Schweißen von Nickel- und Nickelbasislegierungen“ Final Report. Editor: Institut für Schweißtechnische Fertigungsverfahren – ISF, Aachen 1996

Examination of the Measurement and Control of Ozone Emissions during Welding and Allied Processes. Final Technical Report WELD-OZONE, Project funded by the European Community, Force Technology, Denmark, Norddeutsche Metall-Berufsgenossenschaft, Germany, Finnish Institute of Occupational Health, Finnland, TWI Ltd., UK, Instituto de Saldadura e Qualidade, Portugal

Smola, T; Blome, H.: Ozon. BIA-Report 10/96. Editor: Hauptverband der gewerblichen Berufsgenossenschaften, Sankt Ausgustin 1996

Berufsgenossenschaftliche Regeln für Sicherheit und Gesundheit bei der Arbeit. Arbeitsplatzlüftung – Lufttechnische Maßnahmen (BGR 121), Edition 1.04. Carl Heymanns Verlag, Köln

Annex

Hazardous substances exposure during tungsten inert gas welding (TIG welding)

1 Hazardous substances exposure

The present BG/BGIA recommendations are based on evaluations of workplace measurements during TIG welding.

Subject to the hazardous substance up to 239 measurements were carried out with the sampling system recognized in the Berufsgenossenschaftliches Messsystem Gefahrstoffe (BGMG; measuring system for hazardous substances of the BG). Personal sampling was carried out in the welder's breathing zone, stationary sampling was generally carried out in relation to a person.

During the measuring periods of at least two hours duration, the usual welding activities were carried out.

Table 2 contains the statistically evaluated workplace concentrations for the period from 1999 to 2003. They give the shift-related exposure in case the TIG welding activities are carried out during the whole shift.

Hazardous substance	Number of enterprises	Number of measuring results	50 percent value [mg/m³]	95 percent value [mg/m³]
Welding fume (measured as E dust)	110	184	0,36	2,53
Nickel oxide	166	239	0,0039	0,047
Chromium(VI) compounds	149	218	0,0025	0,008
Ozone	19	23	0,032	0,19

Table 2: Evaluation of measuring results of all Berufsgenossenschaften
(undifferenciated: personal/stationary, with/without capture, in front of/behind welder's hand shield)

All measuring results for ozone were obtained with a directly indicating monitor and were evaluated without restrictions due to the small number. The measurements were mainly carried out in front of the welder's hand shield.

The data collectives with or without capture, personal or stationary and in front of or behind the welder's hand shield did not reveal any differences; therefore, they were combined for the evaluation. A direct comparison of different conditions at the same workplace cannot be effected due to lacking data.

The number of measuring results for chromium(VI) compounds and nickel oxide is greater than the number of welding fume measurements as in individual cases at some workplaces only these substances were determined by the sample carrier.

2 Sampling position “inside the welder’s face shield (hinged shield)”

From the total measuring data collective comprising measuring data during TIG welding for the period from 199 to 2003 (**Table 2**) a sub-collective was evaluated (**Table 3**) taking into account only those measuring results where the sampling was carried out inside the welder’s face shield.

Hazardous substance	Number of enterprises	Number of measuring results	50 percent value [mg/m³]	95 percent value [mg/m³]
Welding fume (measured as E dust)	36	47	0,37	2,15
Nickel oxide	33	43	0,0038	0,023
Chromium(VI) compounds	26	35	0,004	0,004

Table 3: Evaluation of measuring results of all Berufsgenossenschaften
(Restriction to sampling position “at the person, inside the welder’s face shield (hinged shield)”)

3 Measuring results of the focal action of the regional administrative authority of Kassel

The expert centre Hazardous Substances of the Hessian administrative authority in Kassel executed measurements at several TIG welding workplaces in the framework of a measuring action focussing on “Dust exposure during welding and grinding”. The measurements were carried out at the person behind the welder’s hand shield in the period from August 2002 to September 2003 (**Table 4**).

Hazardous substance	Number of enterprises	Number of measuring results	50 percent value [mg/m³]	95 percent value [mg/m³]
Welding fume (measured as E dust)	5	12	0,78	1,62 (maximum value)

Table 4: Measuring results of the focal action of the regional administrative authority of Kassel

This focal action also yielded another six measuring results (mg/m³ for chromium(VI) compounds (0,0015; 0,0045; < 0,0005; < 0,004) and eight measuring results (mg/m³ for nickel oxide (0,02; 0,02; 0,02; < 0,01; < 0,01; < 0,01; < 0,01). A statistical evaluation with indication of the 50 percent and the 95 percent value was not carried out due to the low number of measuring data.

4 Measuring data from the EU project “Examination of the Measurement and Control of Ozone Emissions during Welding and Allied Processes”

The measurements were effected with a chemiluminescence monitor exclusively behind welder’s face shields. The 19 measuring results from the Federal Republic of Germany were determined by the Norddeutsche Metall Berufsgenossenschaft (NMBG).

Hazardous substance ozone	Number of measuring results	90 percent value [mg/m³]	Maximum value [mg/m³]
UK	15	0,054	0,107
D(NMBG)	19	0,025	0,027
FIN	4	-	0,012

Table 5: Measuring results of the EU project

5 Assessment of the hazardous substances exposure

The results of the exposure measurements (MEGA evaluation) and the focal action of the regional administrative authority of Kassel show that for welding fume all 95 percent values are below the occupational exposure limit value for A dust. For ozone, all values are below the occupational exposure limit value as well.

For chromium(VI) compounds and nickel oxide, the values of all collectives are far below the former TRK values.