Edition: February 2009

Technical Rules for Hazardous Substances	**Welding Work**	**TRGS 528**

The Technical Rules for Hazardous Substances (TRGS) reflect the state of technology, occupational safety and health and occupational hygiene as well as other scientific knowledge for activities involving hazardous substances including their classification and labelling. The

Committee on Hazardous Substances (AGS)

establishes the rules and adapts them to the current state of development accordingly. The Technical Rules for Hazardous Substances are announced by the Federal Ministry of Labour and Social Affairs (BMAS) in the Joint Ministerial Gazette (GMBl).

The present TRGS is based on BGR 220 "Welding Fumes" of the Expert Committee "Metal and Surface Treatment" of the German Social Accident Insurance DGUV. The subject matter of BGR 220 was taken up by the Committee on Hazardous Substances taking due account of the practical instructions of the Committee of the Laender for Occupational Safety and Health (LASI) "Protective measures for Minimising Exposure to Hazardous Substances during Gas-shielded Welding" (LV 42), it was developed further and incorporated in the regulations as TRGS.

Contents

1 Scope

This TRGS applies to activities in welding practice, such as welding, cutting and allied processes conducted on metallic materials, where gaseous and particulate hazardous substances may occur. These substances are also called pollutants in practice.

2 Definitions

Within the meaning of the present TRGS the terms given below are defined as follows:

1. Extraction is the collection of hazardous substances at the places where they arise or escape.
2. Breathing air is the air in the breathing zone of the worker.
3. Confined spaces are spaces without natural air extraction and normally with dimensions (length, width, height or diameter) of less than 2 m, e.g. windowless rooms, mine tunnels, pipe trenches, pipes, shafts, tanks, boilers, vessels, chemical apparatus, cofferdams and cells with false floors in ships.
4. Gaseous hazardous substances are gases arising during welding, cutting and allied processes, e.g. nitrogen oxides, ozone, carbon monoxide and aldehydes.
5. The hazard class[1] gives an indication of the hazards arising with the application of a procedure and the materials used therein. The four hazard classes low, medium, high and very high are deduced from the procedure-specific emission rates (quantity of hazardous substance emitted by a procedure by time) and the possible health-harming effects of the substances released.
6. Ventilation: Technical ventilation (mechanical room ventilation) is the term used to describe the replacement of room air by outside air using flow machines, e.g. fans, blowers. Natural ventilation is the replacement of room air by outside air by means of pressure differentials due to wind or temperature differentials. In this case the exchange of air is normally achieved by open windows and doors.

[1] The hazard class of the procedure may not be mixed up with the protection levels of GefStoffV; see TRGS 400 "Risk Assessment for Activities involving Hazardous Substances".

7. Location-bound procedures: The application of a procedure is deemed to be location-bound (stationary) if it is carried out repeatedly at the same workplace equipped for the purpose, e.g. welding cabin, welding booth, workpiece holding fixture up to approx. ten m².
8. The return of air is the return of the air collected by extraction and cleaned in separators into the working room. Depending on the effectiveness of the separation system a certain portion of hazardous substances is also returned to the working room.
9. Welders according to the present TRGS are all persons who perform welding work.
10. Welding fumes are particulate substances arising during welding, thermal cutting and allied processes.
11. Welding work is work where the processes of welding, thermal cutting and allied processes (such as soldering, thermal spraying, flame heating, flame straightening, flame hardening and resistance heating) are applied. Ancillary jobs directly connected with the welding work, e.g. grinding, count as welding work.
12. Material: High-alloy material (steel) is material which contains in total at least five % by weight alloying elements such as chromium, nickel and manganese. Unalloyed or low-alloy material (steel) is material which contains in total less than five % by weight alloying elements such as chromium, nickel and manganese.

3 Information gathering and risk assessment

3.1 Hazardous substances arising in the individual processes

3.1.1 General instructions concerning processes

(1) Welding work releases hazardous substances which consist of particulate and/or gaseous hazardous substances.

(2) The particulate emissions are called welding fumes. Welding fumes are mixtures of substances whose chemical compositions and concentrations depend on the materials used and the processes applied. The particles released may be part of the alveolar dust fraction (A dust) as well as of the inhalable dust fraction (E dust), see Figure 1 and numbers 3.1.2 to 3.1.5. Furthermore so-called ultrafine particles may arise whose diameter is in the nanometre range.

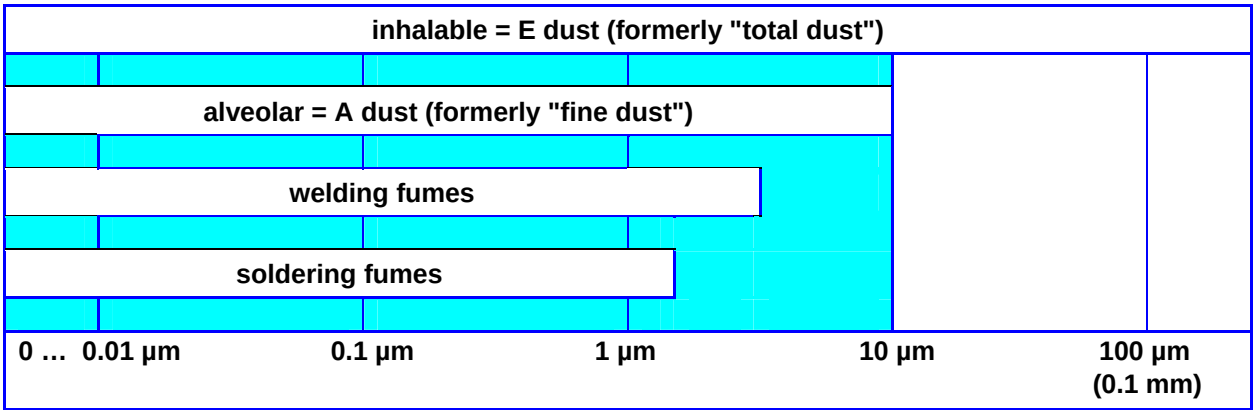


Figure 1: Classification of particulate hazardous substances in welding technology according to particle size (as occurring) on the basis of DIN EN 481.

(3) Activities within the scope of the present TRGS are categorised into four main processes:

1. welding,
2. thermal cutting,
3. thermal spraying,
4. soldering.

3.1.2 Welding

(1) During welding over 95 % of the welding fumes normally arise from the filler metal and only about 5 % from the base metal. The individual particles are mainly smaller than one µm and are therefore alveolar. Agglomerates of larger diameter also form.

(2) The following must be taken into account in particular as gaseous hazardous substances arising:

1. ozone with MIG welding of aluminium materials,
2. carbon monoxide with MAGC welding of unalloyed and low-alloy steel,
3. nitrous gases (NO, NO_2, NO_X) with autogenous procedures

(for designation of procedures see annex 1).

3.1.3 Thermal cutting

With thermal cutting the fumes arise from the base metal. The composition of the fumes depends on the chemical composition of the base metal and any coatings or impurities that may be present. The particles in the fumes have diameters of between 0.03 and – in agglomerated form – approximately ten µm. They are mainly alveolar. In addition there arise nitrous gases in particular in flame cutting and plasma cutting with compressed air. In the case of the plasma and laser cutting of aluminium mate-

rials, it can be expected that, in addition to the release of particles, ozone will arise in particular.

3.1.4 Thermal spraying

The fumes and gaseous hazardous substances arising with thermal spraying are formed from the spray material and the fuel and carrier gases used. The chemical composition of these fumes depends on the composition of the spray additives used. With thermal spraying particles with an individual size of up to 100 µm form. They are inhalable and partly alveolar. With flame spraying in particular nitrous gases also arise.

3.1.5 Soldering

The chemical composition of the fumes with soft soldering and brazing depends on the fluxes and solders used. The particles arising mainly have diameters of between 0.01 and 0.15 µm. They are alveolar. The gaseous hazardous substances that have to be special taken account of are aldehydes with soft soldering and hydrogen chloride with brazing.

3.2 Risk assessment

3.2.1 General instructions on risk assessment

(1) Under Section 7 GefStoffV and Section 5 Occupational Safety and Health Act the employer must conduct a risk assessment prior to commencement of the work in which the risks for workers connected with their work are identified and measures are specified to protect their health. The possible risk for workers in adjacent workplaces must also be considered.

(2) The risk for welders due to hazardous substances is identified with reference to the hazard class specific to the particular process, taking account of other influencing factors which determine exposure of the workers at the workplace.

(3) The following sections give instructions regarding information gathering in the context of the risk assessment. They deal with the factors specific to individual materials, processes and workplaces by which the exposure at the workplace is determined in the main. They must be taken into account in the risk assessment.

(4) Details concerning the conduct of the risk assessment are given in TRGS 400.

(5) In the case of welding work where carcinogenic substances may be released, and especially during the welding of high-alloy materials, it is possible that a residual cancer risk cannot be completely discounted even when the measures of the present TRGS have been taken. Further measures to reduce exposure must therefore be aimed at.

3.2.2 Material-specific factors

The welding fumes and gases arising during welding work consist of hazardous substances with partially different health-harming effects. According to their effects they are classified as:

– substances that place a strain on the respiratory tract and lungs[2]	e.g. iron oxides, aluminium oxide
– toxic or toxic-irritating substances	e.g. fluorides, manganese oxide, copper oxide, aldehydes (during soldering with colophonium-bearing fluxes)
– carcinogenic substances	e.g. chromium(VI) compounds, nickel oxides

3.2.3 Process-specific factors

(1) The evaluation of procedures with respect to particulate emissions is conducted by assigning them to the hazard classes of low, medium, high and very high. The evaluation depends on factors specific to the individual processes and materials, i.e. on the emission rate and the effect (see number 3.2.2). Information concerning the evaluation of welding procedures can also be found in, for example, the relevant welding data sheet according to DIN EN ISO 15011-4 (see also annex 5, for example). Examples of the assessment of welding procedures are given in Table 1; the table is not conclusive.

2 Strain on the respiratory tract and lungs means here that effects in the sense of a chronic inflammation (chronic bronchitis) may occur by an overload of particles.

Table 1: Assessment of the procedures with reference to emission rates, taking account of factors or effects specific to individual materials, assignment to hazard classes.

Procedure	Emission rate[3] (mg/s)	Hazard class of procedures[4]		
		Substances that place strain on respiratory tract and lungs	Toxic or toxic-irritating substances	Carcinogenic substances
Submerged arc[5]	< 1	low	low	low
Gas welding (autogenous procedure)	< 1	low	low	--
TIG[6]	< 1	low	medium	medium
Laser welding without filler metal	1 to 2	medium	high	high
MIG/MAG (low-energy gas-shielded welding)	1 to 4	low	medium	medium to high
Electric arc, MIG (general)	2 to 8	high	high	high
MAG (solid wire), flux-cored wire welding with shield gas, laser welding with filler metal	6 to 25	high	high	high
MAG (flux-cored wire); flux-cored wire welding without shield gas	> 25	very high	very high	very high
Soldering	< 1 to 4	low	medium	medium
Autogenous flame cutting	> 25	very high	very high	very high
Electric arc spraying	> 25	very high	very high	very high

(2) With welding work where not only welding fumes (particles) but also toxic and/or carcinogenic gases arise, such as

1. ozone with MIG welding of aluminium materials; ozone arises from the atmospheric oxygen due to the action of ultraviolet radiation from the electric arc,[7]
2. carbon monoxide with MAGC welding of unalloyed and low-alloy steel,
3. nitrous gases (NO,NO_2 ,NO_X) with autogenous procedures for joining, cutting and coating,
4. aldehydes with soft soldering,
5. hydrogen chloride with brazing and
6. hazardous substances, specifically isocyanates, aldehydes and epoxides from coatings or impurities already present,

3 Empirical values which can be reduced in individual cases by optimising the process parameters.
4 The hazard class of the procedure may not be mistaken for the protection levels of the GefStoffV; see TRGS 400.
5 Automated procedure
6 According to exposure description in BGI 790-12
7 Mention should also be made to damage to the skin caused by UV radiation (welder's burn); it can be avoided by wearing complete welder's protective clothing.

both the risks arising from the welding fumes and those arising from gaseous hazardous substances must be included in the risk assessment. The risks for flame cutting due to decomposition products of coating must be considered separately in the risk assessment. For dioxins during flame cutting, see TRGS 557 "Dioxins". (For information on emissions from gaseous hazardous substances with various procedures see also number 3.1.)

(3) Gases escaping unintentionally from compressed gas cylinders or defective feed lines can displace atmospheric oxygen in working areas, thus giving rise to the risk of suffocation. This applies to a particular degree with respect to jobs being performed in confined spaces and below ground level. If combustion gases or shielding gases with a high percentage of hydrogen escape in an uncontrolled way, they can form explosive gas mixtures. If oxygen escapes unintentionally, there is the risk of fire. Even materials that are normally not highly inflammable may ignite under oxygen.

3.2.4 Factors specific to individual workplaces

(1) Factors specific to individual workplaces, such as spatial conditions, the ventilation situation, head and body position and duration of welding influence in addition the circumstances at the workplace, and hence the level of exposure.

(2) In the case of welding work in confined spaces or in areas with a low air exchange a high exposure must be expected.

(3) Where welding jobs have to be carried out in a constrained posture and the welding fumes pass directly into the welder's respiration zone, a high exposure must be expected.

(4) Low exposure may be the case if the welding jobs are only carried out for a short time (less than half an hour per shift and less than two hours per week). This does not apply with respect to jobs in confined spaces. Examples of such jobs may be:

1. repair welding jobs in automobile manufacture, on builder's yards and in mechanical workshops,
2. tacking jobs on pipe fixtures,
3. brazing jobs in heating construction.

(5) If, at welding workplaces, ancillary jobs such as machining operations are also carried out on stationary installations or with hand-held devices (grinding, cutting, cleaning, polishing etc.), additional particulate emissions will arise from the workpieces being worked on owing to mechanical erosion.

(6) As a function of the nature and extent of the machining steps (e.g. grinding), it must be checked whether additional protective measures have become necessary or whether the protective measures already taken at the welding workplaces are suitable with respect to these emissions (Note: Welding fume extraction installations are normally not suitable for extracting combustible dusts, e.g. aluminium dust). If additional measures are necessary, they must be specified in the context of the risk assessment.

(7) When electrodes are being ground, it must be expected that dusts which are a health hazard will be released and so extraction is essential. This applies in particular with respect to the grinding of thorium-bearing electrodes, see also number 4.2 (6).

(8) When galvanised materials are being ground, the release of zinc oxide fumes must be considered in the risk assessment, taking due account of the factors specific to the workplace.

3.2.5 Overall assessment of the risk

(1) The employer must establish with the reference to Table 1 the hazard class obtained for the procedures and materials used. The major criterion for the relevant procedure is the highest hazard class obtained for the three substance groups listed. Furthermore he must take account of the gaseous hazardous substances according to number 3.1 and number 3.2.3(2) released by the procedures used.

(2) In addition, the employer must determine the conditions specific to the individual workplace, such as duration of welding and spatial conditions. Then he must assess the resulting risk of the activity taking account of all influencing factors. The protective measures according to the Hazardous Substances Ordinance and number 4 of the present TRGS are then laid down. The protective measures given are normally also suitable for minimising the exposure to ultrafine particles.

(3) Furthermore the employer must take into account in the risk assessment the knowledge obtained from the preventive medical examinations, and in particular from the biomonitoring. This knowledge must be transmitted by the occupational physician in such a way that the legitimate interests of the workers are protected. The employer may not use these specifications to justify the right to examine individual examination results.

(4) In the case of procedures which lead to a high risk, especially in the handling of carcinogenic materials or materials the release of which can be expected, skilled occupational medical expertise must be consulted in the risk assessment. This also applies with respect to the assessment of measures intended to ward off risks if typical work accidents or occupational diseases have arisen for the welding workplace.

(5) For procedures with medium, high and very high hazard classes, ventilation measures must be taken in accordance with the state of the art because of the particular emissions, see numbers 4.3 to 4.5. Furthermore additional measures may be necessary to protect the welder, e.g. the wearing of a personal respirator.

(6) For procedures with low hazard class it must be checked in the risk assessment whether technical ventilation measures are needed. The same applies accordingly to jobs with low exposure.

4 Protective measures

4.1 Principle

(1) If it is not possible during welding work to avoid the exposure of workers to hazardous substances, it is necessary to take suitable protective measures to eliminate or minimise the risk thus arising. Under the Hazardous Substances Ordinance the following measures must be considered in the order of priority shown here in relation to the specific circumstances prevailing in the company:

1. selection of procedures and filler metals low in hazardous substances (check of substitution, number 4.2),
2. ventilation measures (numbers 4.3 to 4.5),
3. organisational and hygienic measures (number 4.6),
4. personal protective measures (number 4.7).

(2) Basically the measures indicated in TRGS 500 "Protective measures" must be organised. Furthermore the measures given below in the present TRGS must be taken. The measures laid down must be documented in the risk assessment.

(3) If activities involving hazardous substances are carried out by one worker alone, the employer must stipulate additional protective measures or ensure appropriate supervision, see also TRGS 500.

4.2 Selection of procedures and filler metals low in hazardous substances

(1) Taking due account of the state of the art the employer must apply welding, cutting and allied processes and use filler metals where the release of hazardous substances is as low as possible. If product-specific requirements contradict the use of a relevant process, other procedures may be applied. For the implementation and documentation of the substitution check see TRGS 600 "Substitution".

(2) Procedures where the release of hazardous substance is low include, for example:

1. submerged arc welding,
2. tungsten inert gas welding (TIG welding) with thorium oxide-free tungsten electrodes,
3. low-energy gas-shielded welding,
4. pulse arc welding,
5. plasma cutting in water bath.

(3) As far as technically possible, priority should be given to the use of the pulse arc technique when performing MIG/MAG welding. With the use of this technique the welding fume emission rates are considerably lower than with conventional MIG/MAG welding.

(4) For gas-shielded welding with high-allow welding wire the release of carcinogenic chromium(VI) compounds in the fumes is substantially lower than with manual electric arc welding using coated high-alloy stick electrodes or with high-alloy flux-cored wires.

(5) If on the other hand nickel-base materials or pure nickel are used as weld filler metal, the release of carcinogenic nickel oxide in the welding fumes in manual electric arc welding is less than in MIG/MAG welding.

(6) The technological need to use thorium oxide-bearing tungsten electrodes in TIG welding must be justified and documented in the risk assessment, see also Radiation Protection Ordinance. Mention should be made of the measures required under radiation protection law.

(7) The lists in paragraphs 1 – 6 are not conclusive. In individual cases further procedures low in hazardous substances may be applied.

4.3 Ventilation measures

(1) Ventilation measures are suitable if they minimise the risk for the workers from hazardous substances. This must be achieved primarily by extracting the hazardous substances in the area where they arise.

(2) As a further or additional ventilation measure, technical room ventilation such as is required under the Workplaces Ordinance can minimise exposure. In rooms or parts of rooms where welding work is being carried out the feed air and waste air of room ventilation systems should be such that they support thermal current arising during welding. Laminar flow or displacement flow has proven especially suitable for this purpose. For instructions on the design of room ventilation systems see VDI/DVS 6005, VDI 2262 and VDI 3802.

(3) In individual cases it may be that, as a result of the risk assessment, natural ventilation is adequate. Examples of this include submerged arc welding and TIG welding of unalloyed and low-alloy steels.

4.4 Extraction in source area

(1) Depending on the welding procedure, the nature of the workplace (mobile/changing or stationary/fixed) and the size of the workpieces to be worked on, the ventilation measures listed below are suitable for collecting hazardous substances in the area where they arise:

1. extraction integrated in the burner or mounted directly on the burner,
2. welder protection guards and shields with integrated extraction,
3. stationary or mobile extraction systems with fixed or tracking collection elements (suitable for stationary and mobile workplaces), and
4. examples can be found in BGI 593, LV 42, VDI/DVS 6005 and VDI 2262, Sheet 4.

(2) The closer to the source area the extraction is implemented, the more effective the collection of hazardous substances. It must be noted here that the required weld seam quality is achieved.

4.5 Air return

(1) Air extracted may only be returned to the working area if it has been adequately purified. Ventilation systems with air return may be used if they are type-approved or if individual measurements are conducted to check the required effectiveness. Instructions on the fresh air fraction in room ventilation systems are given in BGR 121 "Workplace ventilation – ventilation measures".

(2) At workplaces where welding work of allied processes involving the emission of carcinogenic or mutagenic substances or substances toxic to reproduction of category 1 or 2 are performed (especially with the use of chromium- and nickel-bearing materials) air extracted there may not be returned. This does not apply if type-approved welding fume extraction devices of the welding fume separation classes W2 or W3 are used. For instructions concerning the welding fume separation classes see DIN EN ISO15012-1 "Health and safety in welding and allied processes – Requirements testing and marking of equipment for air filtration – Part 1: Testing of the separation efficiency for welding fume" (issued March 2005).

4.6 Organisational measures

(1) The composition and quantity of the hazardous substances emitted are influenced among other things by the welding parameters selected (e.g. welding current, welding voltage, type and composition of inert gas). To minimise the hazardous substance emissions the welding parameters recommended by the manufacturers of electrodes or gases must be adhered to. Prior to the commencement of welding work care must be taken to ensure that residues on surfaces are removed, e.g. residues from cold cleaners.

(2) The employer must keep ready devices, machines and ventilation equipment in a technically impeccable and serviced condition. The workers must use these in the appropriate fashion.

(3) Where there are breaks in work and before the end of work the valves on compressed gas cylinders and gas tapping points must be closed (not only the valves on the pressure reducer must be closed!).

(4) The employer must take care to ensure that only equipment which is state of the art may be used to collect and separate hazardous substances. When such equipment is used for the first time, evidence must be provided of its adequate effectiveness. The equipment must be serviced and, where necessary, repaired.

(5) The equipment must be tested at least annually by a qualified person to check that it is in good working order. The tests must be documented. See TRBS 1203 "Qualified persons – General requirements" and BGR 121 "Workplace ventilation – ventilation measures".

(6) The number of workers exposed to hazardous substances must be minimised.

(7) The working positions of the workers must be selected so as to ensure as far as possible that the impact of hazardous substances is minimised.

(8) If an unfavourable working position is unavoidable, care must at least be taken to ensure that the protective shield is placed as close as possible to the worker's face. In some cases the workpieces may be placed in more favourable positions using rotating and tilting devices.

(9) Workers who are exposed to hazardous substances in their working area may not take any food or beverages there (no eating, drinking or smoking at the workplace). For this purpose appropriate recreation rooms must be provided which the workers can then use. Smoking can substantially increase the health-harming consequences of hazardous substances at the workplace. Mention should be made here of other hygiene requirements according to Section 9 Subs. 3 GefStoffV and TRGS 500.

(10) When cleaning the working area, methods must be applied which avoid any swirling up of dust. This should be achieved, for example, using wet sweeping machines or with suitable and tested industrial vacuum cleaners. Dry sweeping or blowing of dust deposits using compressed air is fundamentally not permissible. The prohibition with respect to compressed air also relates to the cleaning of work clothing.

4.7 Personal protective measures (respiratory protective equipment)

(1) Where the protective measures listed in the numbers 4.1 to 4.6 are not adequate or their implementation is not technically possible, the employer must provide suitable respiratory protective equipment to protect workers. These must be used by the workers.

(2) Protective measures are not adequate if occupational exposure limits (OEL) are not complied with or the concentration of A dust in the air at the workplace is greater than three mg/m^3.

(3) If carcinogenic hazardous substances are released by welding work, especially when welding high-alloy steels, respiratory protective equipment according to number 4.7 (4) must be provided. This does not apply to low-emission procedures such as submerged arc or TIG welding.

(4) The following are examples of respirators that may be used as personal protective measures:

1. ventilated helmets / hoods with blower and particle filter TH2P or TH3P,
2. masks with blower and particle filter TM1P, TM2P, TM3P,
3. full-face masks or mouthpiece fittings with P2 or P3 filters,
4. half-face / quarter-face masks with P2 or P3 filters, particle-filtering half-face masks FFP2 or FFP3 or
5. insulation devices.

(5) The wearing of respiratory protective equipment is governed by the provisions of BGR 190 "Use of respiratory protective equipment".

(6) When respiratory protective equipment which does not involve any strain (e.g. ventilated helmets or hoods) ise used, the activity limitations laid down in BGR 190 do not apply. Only if there are additional strains for the equipment wearer due to the heavy nature of the work and the ambient climate must the calculation of the wearing time of 220 minutes as a base value be assumed.

(7) If gaseous hazardous substances arise during welding, combination filters must be used when wearing filtering respiratory protective equipment.

(8) If filter devices with blowers are used for working with a naked flame or for activities where welding splashes or sparks may be produced, there is the risk that the respirator filters will catch fire – normally not noticeable in the initial stages. Lethal fumes may develop in the filter (in particular CO and CO_2). For such work use must therefore be made of filter devices where structural measures (such as close-meshed metal screens upstream of the suction openings or "spark traps") prevent the penetration of welding splashes and sparks into the filter; as an alternative, insulation devices may be used.

(9) For welding jobs carried out in confined spaces, e.g. in shipbuilding, in box girders or false floors, a procedure is described for the selection of respiratory protective equipment:

1. If possible a feed air and exhaust air system as described in number 4.3 (2) must be installed in the working area.
2. If this is not possible or not adequate for spatial reasons, preference must be given to the wearing of ventilated hoods or helmets.
3. If it is not possible to use ventilated hoods and helmets for spatial reasons, FFP2 masks with exhalation valve at least must be worn when welding low-alloy steels, and FFP3 masks with exhalation valve when welding high-alloy steels.
4. If it is to be expected that nitrous gases will be emitted, e.g. with flame straightening, suitable respiratory protective equipment must be used, see BGR 190.
5. If there is the risk of oxygen deficiency, respiratory protective equipment which is not dependent on the ambient air (insulation devices) must be used.

5 Effectiveness check

5.1 General remarks concerning effectiveness check

(1) The effectiveness of the protective measures taken must be checked. Annex 2 contains a practical aid to number 5 "Effectiveness check" (based on TRGS 402 "Identification and assessment of the risks from activities involving hazardous substances: inhalation exposure").

(2) Under 4.6 (4) and (5) technical protective measures, e.g. ventilation and extraction installations, must be checked regularly, at least once a year, to establish their adequate functioning and effectiveness.

(3) In the case of hazardous substances for which an occupational exposure limit (OEL) is laid down in TRGS 900 "Occupational exposure limits", the effectiveness of the protective measures taken must be verified by means of workplace measurements or by other, equivalent assessment procedures (Section 9 GefStoffV) or equivalent verification/detection methods (Section 10 GefStoffV) where no procedure- and substance-specific criteria (PSC) or substance-specific technical rules are available, or where a sector-specific practical aid can be applied.

(4) The following can be given as PSC according to TRGS 420 "Process- and substance-specific criteria (PSC) for the risk assessment: BGI 790-014 BG/BGIA recommendation for the risk assessment according to the Hazardous Substances Ordinance – Soft soldering with soldering iron on electric and electronic assemblies or their individual components (iron soldering).

(5) The following can be given as a substance-specific TRGS: for activities involving lead (soft soldering with lead-bearing solder, removal of lead-bearing coatings, welding or flame cutting of lead-bearing metal parts, machining of lead and lead alloys), the substance-specific Technical Rule TRGS 505 "Lead" can be used.

(6) When PSCs are applied, a check must be conducted once a year to establish whether the operational prerequisites for applying the criteria remain unchanged in the working areas.

(7) If TRGS 900 does not specific any occupational exposure limits for the substances released at the workplace, for the effectiveness check sector-specific practical aids in particular or the exposures must be adhered to according to the state of the art.

(8) The following can be given as a sector-specific aid: BGI 790–012 BG/BGIA recommendation for the risk assessment according to the Hazardous Substances Ordinance – tungsten inert gas welding (TIG welding).

(9) The state of the art for hazardous substances exposures during welding can be found in Table 2. If relevant substances are not mentioned in Table 2, the employer must, for example, lay down provisional target values in the context of the risk assessment. It must be identified whether the provisional target values are adhered to. See TRGS 400 and 402.

(10) The substances or A and E dust given in Table 2 are deemed the same time to be representative measuring variables according to TRGS 402, see also number 5.2.

5.2 Additional provisions and instructions concerning the effectiveness check by means of workplace measurements

(1) For nearly all welding jobs the measurement and assessment of the hazardous substances exposure can be simplified thanks to extensive measuring data and knowledge gained form research projects.

(2) For welding jobs with low-alloy steels basically the alveolar dust fraction (A dust) is to be regarded as a representative measuring variable for assessing the exposure of the welder or for the effectiveness check of protective measures.

(3) According to the procedure and material combinations it may be necessary to assess other measuring variables such as the E dust fraction, chromium(VI) and nickel compounds, ozone, nitrogen oxide, manganese oxide and carbon monoxide.

(4) For MAG, MIG and TIG procedures with high-alloy steels, the measuring result for A and E dust is normally sufficient to assess the chromium (VI-) nickel fractions. In individual cases the corresponding substances must be assessed in addition, e.g. for MIG welding with a nickel fraction in the material of greater than 30%.

(5) When welding high-alloy steels using manual electric arc and MAG procedures (flux-cored wire) further measuring procedures must be determined, e.g. chromium(VI) compounds.

(6) With the MIG welding of aluminium A and E dust as well as ozone must be considered as hazardous substances.

(7) For substances with stipulated OEL the results must be compared with this, and for substances without OEL with the concentrations given in Table 2. As a substitute equivalent verification methods can be applied (see TRGS 402).

(8) Workplace measurements can be dispensed with if the risk assessment shows that there is only a low exposure, see number 3.2.4 (4). For further instructions concerning the identification and assessment of exposures, see annex 2.

(9) Knowledge gained from biomonitoring, especially with the use of validated procedures, within the framework of the preventive medical examinations, can be referred to for the effectiveness check.

Table 2: State of the art from exposure data relating to welding work[8,9]

The information given here relates to workplaces with welding fume extraction.

Procedure	**Weld filler metal or material**	**Welding fumes** in mg/m³	**Chromium(VI) compound** in mg/m³	**Nickel and its compounds** in mg/m³	**Ozone** in mg/m³	**Nitrous oxdes** in mg/m³
Gas welding (autogenous welding)	unalloyed, low-alloy steels	particulate emissions not relevant			cannot be given[10]	cannot be given[10]
Manual electric arc	unalloyed, low-alloy steels	≤ 3 (A) ≤ 10 (E)	not relevant		cannot be given[10]	cannot be given[10]
	high-alloy steels	≤ 3 (A) ≤ 10 (E)	≤ 0.03 (E)	≤ 0.05 (E)		
MAG / MIG	unalloyed, low-alloy steels	≤ 3 (A) ≤ 10 (E)	not relevant		≤ 0.2	cannot be given[10]
	high-alloy steels	≤ 3 (A) ≤ 10 (E)	≤ 0.02 (E)	≤ 0.1 (E)		
Submerged arc welding		≤ 1 (A)	not relevant		not relevant	
TIG welding[11]		≤ 1 (A) ≤ 2 (E)	≤ 0.01 (E)	≤ 0.01 (E)	≤ 0.1	cannot be given[10]
Resistance welding		≤ 2 (A) ≤ 4 (E)	not relevant		not relevant	
Thermal spraying (flame, electric arc, plasma spraying)		≤ 2 (A) ≤ 10 (E)	≤ 0.01 (E)	≤ 0.05 (E)	cannot be given[10]	cannot be given[10]
Flame cutting		≤ 3 (A) ≤ 10 (E)	not relevant		cannot be given[10]	NO: ≤ 2.5 NO_2: ≤ 2

8 Sector- and workplace specific deviations are possible.

9 The information given in Table 2 is subject to the following condition: Less than 5% exposure-relevant ancillary jobs are carried out, such as grinding, cutting, cleaning and polishing.

10 State of the art cannot be given because the data required to fix a value is not available in sufficient quantities. Number 5.1 (9) applies.

11 See also BGI 790-012

5.3 Documentation

The results of the effectiveness check must be documented in the risk assessment. The results of the workplace measurements must be retained and made accessible to the workers. The documentation must describe what measures are being taken to eliminate or minimise according to the state of the art the risks due to hazardous substances.

5.4 Consequences of the effectiveness check

If the effectiveness check reveals that occupational exposure limits and/or exposure values are not complied with in accordance with the state of the art, other exposure-reducing measures must be organised without delay and then the risk assessment must be repeated (see also TRGS 402).

5.5 Establishment of findings

Under number 6 of TRGS 402 a check must be made at regular intervals or following major changes in the procedural conditions to establish whether the findings arrived at continue to apply without modification.

6 Preventive medical examinations

(1) If a welding fume concentration of three mg/m^3 A dust is not adhered to, preventive occupational medical examinations must be organised by the employer. If the risk assessment reveals that this figure is reliably adhered to, the employer has the duty to offer such preventive medical examinations.

(2) In the case of exposure to substances of the annex part 1 of the Ordinance on occupational health care, relevant precautionary occupational medical examinations (e.g. specific examinations for fluorine/fluorides, cadmium, lead and, where relevant, E dust) must be organised or offered during and also on completion of these activities. Subsequently with exposure to carcinogenic or mutagenic substances of category 1 or 2 (e.g. cadmium or chromium(VI) compounds) preventive medical examinations (subsequent examinations) must be offered or it must be organised that they are regularly available. For this purpose there are relevant services provided by the statutory accident insurance institutions.

(3) Some hazardous substances or their metabolic products or metabolic compounds which pass into the organism through the inhalation of welding fumes can be determined in biological material (especially urine, full blood or blood serum or in the red corpuscles). Important indications for the risk assessment and the effectiveness check of the protective measures can be obtained from the examination results together with the other knowledge gained during the examination. It must be taken into account here that the individual results constitute personal data which is subject to the medical practitioner's mandatory secrecy (see also number 3.2.5).

(4) Biomonitoring is a part of the precautionary occupational medical examinations where recognised procedures for it are available.

7 Instruction and information

(1) The employer must draw up working instructions for welding work under the Hazardous Substances Ordinance. The working instructions must be made known to the workers in a comprehensible form and language.

(2) When drawing up working instructions account must be taken under Section 14 of the Hazardous Substances Ordinance of risks relating to working areas and substances.

(3) For instructions regarding the drawing up of such documents see Technical Rules for Hazardous Substances TRGS 555 "Working instructions and Information for workers".

(4) Examples of a set of working instructions for "Manual electric arc welding with coated, chromium/nickel-bearing stick electrodes in vessels" and for "Flame heating and straightening in a ship's tank" are given in annex 4.

(5) The employer must give the workers courses of instruction on a safe mode of working when welding. This information must encompass the following aspects:

1. the hazardous substances released with the welding procedure used and the risks arising therefrom,
2. the effects of welding parameters,
3. the welding position,
4. the working position (posture),
5. the correct application of the ventilation equipment,
6. the personal protective equipment to be used,
7. general occupational medical/toxicological advice including explanation of the voluntary examinations offered (Section 14 Subs. 3 GefStoffV),
8. hygiene measures,
9. conduct in the case of operational disturbances,
10. first aid.

It must be taken into account that the welder normally cannot see his workplace and the burdens arising because of the dazzle effect.

(6) The occupational medical/toxicological advice must instruct the workers on the health hazards of the main components of the welding fumes, such as metal oxides, fluorides and gases which have an irritant-toxic effect (ozone, nitrous gases) as well as the other components which may arise, especially from the coating and the non-metallic accompanying components. At the same time the relationship between particle size and respirability should be explained. In particular it must be pointed out that the welding fumes consist mainly of small and very small particles (A fraction or ultrafine dusts). It must be explained that inhalation of welding fumes can lead to diseases of the respiratory tracts, such as chronic bronchitis and asthma, and that there is a synergetic effect with smoking, i.e. with smoking there is an increased risk of diseases of the respiratory tracts. If there is pre-existing bronchial over-sensitivity or diseases of the respiratory tracts there is an increased risk of accelerated loss of pulmonary function. It must also be explained that for certain welding procedures and materials there is a risk of contracting cancer (e.g. chromium(VI) compounds, nickel).

Where relevant it must also be pointed out that certain hazardous substances may cause poisoning in terms of systemic effects (e.g. lead, manganese) and also sensitisation (chromium, nickel).

(7) The sense and scope of the precautionary occupational medical examinations must be explained to the workers and it must be made clear that such preventive examinations can help detect disorders such as chronic bronchitis at an early stage, but normally damage that has already occurred cannot be reversed. It is therefore important to make particularly clear that only technical and personal protective measures will be able to prevent possible illness due to the influences of welding work, but this is not possible by means of preventive medical check-ups.

Annex 1 to TRGS 528

Glossary

Description of procedure	Explanation
Submerged arc welding	In submerged arc welding one or a number of metal wires are melted under a flux cover as an electrode in the electric arc which forms between the end of the wire and the workpiece. The procedure can only be carried out mechanically and only in a horizontal welding position. Thanks to the flux cover of the arc there are only slight emissions of hazardous substances. After the welding has been performed, the flux is extracted.
Gas welding (autogenous process)	In gas fusion welding the energy carrier used is normally acetylene as the combustion gas with oxygen. The weld filler metal – bare wire – is fed separately and is melted in the welding flame at a temperature of approx. 3100 °C.
TIG welding	Tungsten inert gas welding (TIG) is an inert gas welding procedure where the electric arc burns between the workpiece and a tungsten electrode in an inert gas. Given the high melting point of tungsten, the electrode does not melt off. The inert gases used are argon, helium or mixtures thereof. The TIG welding process can be used with or without weld filler metal. The filler metal is normally fed manually. With this welding procedure it is possible to make many kinds of seam in all positions. Use is made of direct or alternating current. The weldable workpiece thicknesses range with steel up to approx. four mm and with aluminium up to approx. five mm.
MAG welding (solid wire) with shielding gas	Metal active gas welding (MAG) is an shielding gas welding procedure where the electric arc burns between a melting wire electrode and the workpiece in an inert gas atmosphere. The wire electrode is fed continuously as filler metal using a wire advancing device in adequate relation to the melting rate. The inert gases used are usually argon-carbon dioxide mixtures. The MAG procedure is suitable in particular for welding unalloyed and low-alloy steels as well as high-alloy steels.
MAG welding (flux-cored wire) with/without shielding gas	With MAG welding flux-cored wires are also used. Flux-cored wires are "tubular" welding wires filled with flux which either exhibit the properties of the coating on the stick electrodes or improve other features of the weld. The procedure can be used both with and without the addition of welding shielding gases (self-protecting flux-cored wires). With the latter the flux melts and forms a gaseous protective dome over the molten pool. The slag produced must be removed.
MIG/MAG welding (low-energy gas-shielded weld)	For thin sheets or heat-sensitive alloys pulse-controlled MIG/MAG brief electric arc processes are being used increasingly. These minimise the quantity of input heat with a secure fusion welding joint by control of the current pulse.
MIG welding	Metal inert gas welding (MIG) is closely related to MAG welding; but the shielding gases used are inert gases such as argon, helium or mixtures thereof. The process is used in particular to weld non-ferrous metals.
Manual electric arc welding	With manual electric arc welding rutile, basic-coated or acid-coated stick electrodes are melted in the electric arc. The coating has both metallurgical functions (addition of alloying elements) and process-related functions (formation of a shielding atmosphere above the molten material, stabilisation and alignment of the electric arc). The melting of the coating produces slag, which must be removed from the seam after welding.
Resistance welding	Resistance welding is a mechanised electric welding procedure used in particular to join thin-walled workpieces such as fine sheets. The workpieces are first pressed together with welding tongs or rollers. By application of a current pulse at the electrodes of the welding tongs, the workpieces are heated up at points in the areas of the electrodes and fuse together under the pressure exerted by the welding tongs.
Laser welding with and without filler metal	Laser welding is a procedure where the required heat is generated by a laser beam. The laser beam penetrates the material surface and the laser's energy is absorbed into the material, converted into heat and used for the welding or

	cutting process. Mainly CO_2 lasers and Nd:YAG lasers are used.
Soldering	Joining processes to join various metallic materials with the help of a melted filler metal (solder), whose melting temperature is below that of the base metals; the base metals are wetted without being melted. The work is partly performed with the addition of pasty or powder fluxes, which are intended to clean the workpiece surface, improve wettability and prevent the formation of surface films. With soft soldering the solder melts at working temperatures below 450°C, and with hard soldering above 450°C. Depending on the nature of the solder location a distinction is drawn between solder joining and solder coating.
Autogenous flame cutting	Using combustible gases (mostly acetylene, but also propane, butane or mixtures thereof) and oxygen or air the material is heated up along a burning groove to a temperature which is higher than the ignition temperature of the material (for low-alloy steels: approx. 1050 °C). Then the cutting oxygen, which is under high pressure, is connected. The material is thus burnt in the burning groove and expelled. Using flame cutting only unalloyed or low-alloy steels can be cut (construction steels such as S235JRG3, S355J2G3).
Metal spraying procedure	Flame, electric arc or plasma spraying are procedures used to coat the surfaces of metallic workpieces by spraying on a metal coating. The spraying filler metal is fed in the form of powders or sticks to a nozzle. In the nozzle it is melted in a fuel gas / air or fuel gas / oxygen mixture, in an electric arc or in a plasma and is then sprayed in a carrier gas stream at high speed on the surface of the workpiece to be coated. Normally high nickel- or chromium-bearing spray filler metals are used to give the workpiece surface special technical properties, such as high wear resistance, and resistance to corrosion or high temperatures.

Literature:

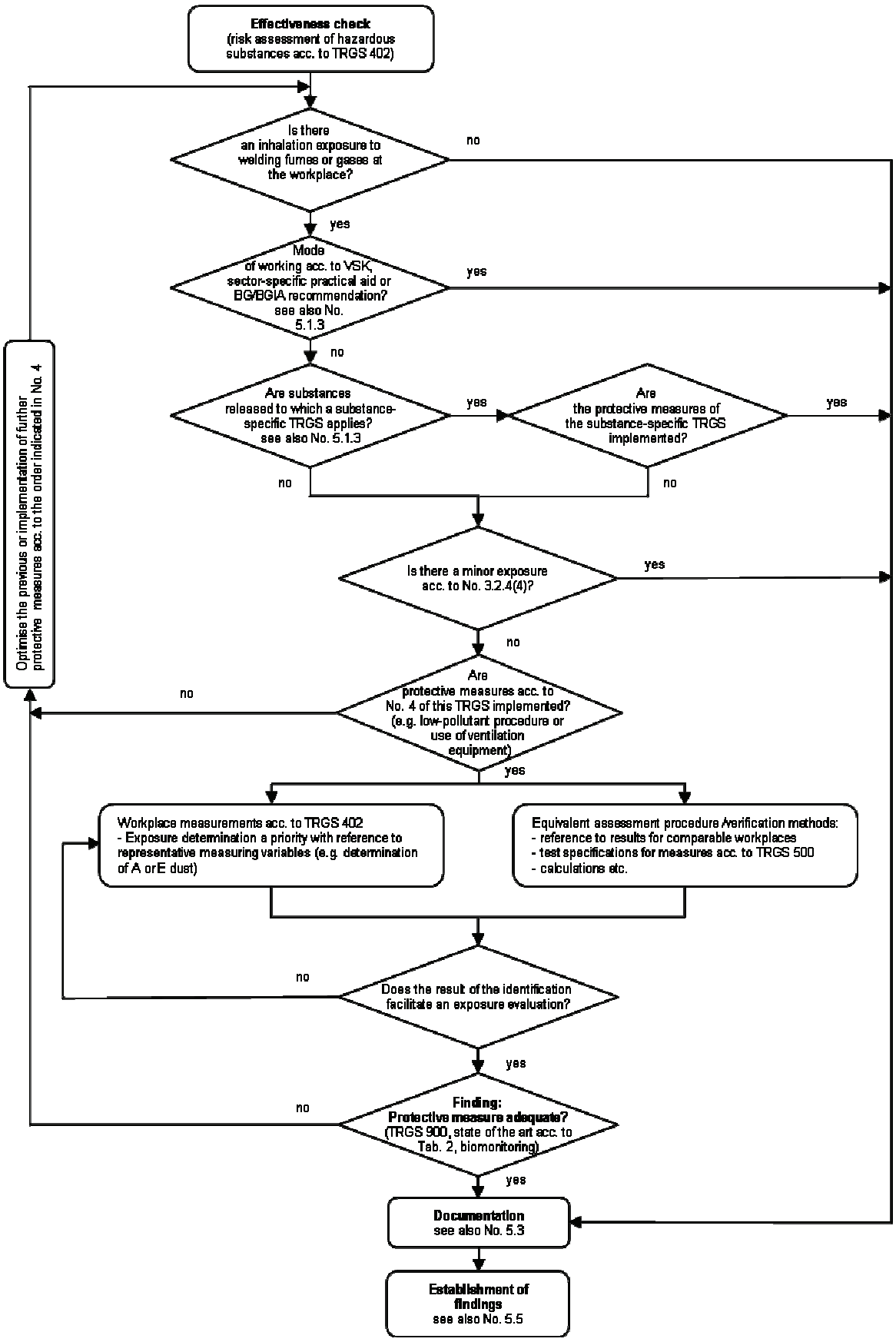
[1] Handbuch der Schweißverfahren Teil I: Lichtbogenschweißverfahren Fachbuchreihe Schweißtechnik Volume 76/I R. Killing ISBN: 978-3-87155-184-0

[2] DIN EN 14610 Welding and allied processes. Definitions of metal welding processes; trilingual version EN 14610:2004; edition: 2005-02

[3] DIN 1910-100 Welding and allied processes - Vocabulary - Part 100: Metal welding processes with additions to DIN EN 14610:2005, edition: 2008-02

Annex 2 to TRGS 528

Practical aid for number 5 Effectiveness check (based on TRGS 402)



Annex 3 to TRGS 528
Instructions for identifying exposure by means of measurements

(1) The measurements must be conducted in the welder's breathing zone. If welder guards or shields are used to protect against optical radiation, the sampling will be carried out behind the protective guard or shield.

(2) The measuring systems currently available for A dust can only be used to a limited extent during welding work on account of their dimensions. For sampling purposes on the individual concerned, the BGIA sampling unit PGP-EA can be recommended. With this equipment system the alveolar (A) and respirable (E) dust fractions can be determined simultaneously from a single air stream. Metal compounds relevant in the working area cannot be determined using this sample carrier.

(3) If E dust and metal compounds in the E dust are taken into account in the working process, the individual E dust sampling system (including PGP-GSP) can be used and the metal compounds can be determined upstream of the impacted filter (membrane filter).

(4) In addition there may be situations which have to be covered by a stationary or, where relevant, individual-related sampling process outside the protective guard or shield, for example when assessing the risk to adjacent workplaces (bystanders) or when assessing welding procedures and/or welding positions.

(5) If it must be expected that ozone will arise, a stationary ozone measurement must be conducted in addition in the working area.

(6) Grinding dusts influences the result with respect to welding fumes (A dust). If grinding work is performed in the working area and if its proportion in terms of time is more than five %, the inhalable fraction (E dust) must be determined in addition.

Annex 4 to TRGS 528

Examples of working instructions

(COMPANY NAME)	WORKING INSTRUCTIONS[12]	No.: …..

WORKING AREA: shipbuilding, vessel and apparatus construction	WORKPLACE: confined spaces, e.g. false floor ACTIVITY: flame heating, straightening

HAZARDS TO HUMAN HEALTH AND THE ENVIRONMENT

- poisoning by nitrous gases (the effects can even emerge 72 hours after exposure!)
- asphyxiation due to oxygen deficiency
- burning due to oxygen enrichment
- explosion hazard due to accumulation of combustible gases
- fire hazard due to combustible substances in the rooms
- burns due to heated parts, slag and burner flame
- noise

PROTECTIVE MEASURES AND RULES OF CONDUCT

- Always use room ventilation; only begin heating up when room ventilation is effective (check).
- Do not work with face over the flame.
- Do not burn flame unnecessarily.
- Never allow oxygen to flow out to "improve the air".
- Check burner tackle for porous hoses and establish that screw connections are tight.
- Do not pull hoses over sharp edges.
- Remove burner tackle from room during breaks and at end of work or detach hoses at feed point.
- Remove combustible substances such as greases, oils, paint, wood, paper etc. from the working area. If this is not possible, cover substances and keep fire extinguishers ready.
- Do not lay fuel gas hoses around the body.
- Use non-inflammable welder suit. Pull trouser legs over shoes.
- Use protective gloves, goggles and hearing protectors.

RESPONSE IN THE CASE OF DISTURBANCES

- If the ventilation fails, stop work immediately and leave the room
- If there is a hose fire, leave the room immediately and close gas valves at the feed point.
- Fight incipient fire with fire extinguishers and raise fire alarm (Telephone: 112).

RESPONSE IN THE CASE OF ACCIDENTS, FIRST AID

– Stop work – If there are burns, immediately cool body parts affected under running water and call first aid personnel. – Give first aid	– In the case of coughing and if feeling unwell, visit doctor and mention nitrous gases. – Fetch help by calling112 – Notify superiors

MAINTENANCE, WASTE DISPOSAL

Servicing and maintenance only by delegated personnel

CONSEQUENCES OF NON-COMPLIANCE

– Health damage – Material damage	– Action under labour law

Date: _____	Signature: Release: _____

12 These Working Instructions are intended as an example and must be adjusted to suit the specific circumstances.

(company name)	WORKING INSTRUCTIONS[12] according to Section 14 of the Hazardous Substances Ordinance	No. …

1. Area of Application

Working area/Workplace/Activity: shipbuilding, chemical apparatus manufacture

Activity: manual electric arc and MAG welding of chromium-nickel steels

2. Description of Hazardous Substance

Welding fumes
with carcinogenic fractions of
chromium(VI) compounds and nickel oxides

3. Hazards to Human Health and the Environment

- inhalation of these welding fumes can cause cancer
- irritation of the respiratory tracts and the mucous membrane of the stomach
- allergic reaction of the skin to nickel oxide

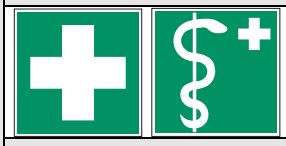
4. Protective Measures and Rules of Conduct

- always extract welding fumes at the place of origin
- position collecting element above the welding location and always track welding work
- work only in ventilated rooms
- use externally ventilated welding helmet
- do not eat, drink or smoke at the workplace
- clean face and hands before breaks and after end of shift, and change soiled working clothes
  only clean the workplace by vacuum cleaning (do not sweep!)

5. Response in the Case of Danger — Emergency phone number: …

– If the extraction system or ventilation system or the welder's helmet fails, stop work immediately and leave the working area.
– Notify superiors

6. First Aid — Emergency phone number: …



If respiratory tracts show signs of allergic reaction or irritation, stop work and visit doctor.

7. Proper Waste Disposal

- not applicable

Date:	Signature/Release:

Annex 5 to TRGS 528

Information which has to be included in the welding fumes data sheet
(based on DIN EN ISO 15011-4)

Welding Fumes Data Sheet

Manufacturer/Supplier:	Address:
Date drawn up or validated:	

Commercial name of filler metal:	Type of filler metal:
Standards according to which the filler metal was manufactured:	

Testing laboratory:	Date of test report:
	Observations of testing laboratory:

Test Conditions

Parameters	Test Conditions
Diameter of filler metal (mm)	
Current intensity (A)	
Voltage (V)	
Polarity (dc^+/ac/dc-)	
Type of gas	
Gas flow rate (l/min)	
Welding rate (mm/min)	
Material of test piece	
Power source: type, manufacturer and model	
Burner: manufacturer, model and diameter of gas envelope (mm)	
Distance between contact nozzle and workpiece (mm)	
Wire feed rate (mm/s)	

Fume Emission Rate and Data on Chemical Composition

Fume emission rate (mg/s and g/h)	

Main components of fumes	Chemical composition (% by weight)

Annex 6 to TRGS 528

Literature

(1) Technical Rules for Hazardous Substances (TRGS)

1. TRGS 400 "Risk Assessment for Activities involving Hazardous Substances",
2. TRGS 402 "Identification and assessment of the risks from activities involving dangerous substances: inhalation exposure",
3. TRGS 500 "Protective measures",
4. TRGS 557 "Dioxins",
5. TRGS 900 "Occupational exposure limits".

(2) BG Rules

1. Working in tanks, silos and confined space (BGR 117-1),
2. Workplace ventilation –ventilation measures (BGR 121),
3. Use of respiratory protective equipment (BGR 190),
4. Operation of work equipment (BGR 500), especially chapter 2.26 “welding, cutting and allied processes”; for online version see http://www.dguv.de (Webcode: 572676).

(3) BG Information, LASI Guidelines

1. Selection criteria for special occupational healthcare according to the BG principle for the special preventive occupational medical examinations; welding fumes (BGI 504-39),
2. Pollutants in welding engineering (BGI 593),
3. Certified respiratory protective equipment (BGI 693),
4. Nitrous gases in welding, cutting and allied processes (BGI 743),
5. Handling thorium oxide-bearing tungsten eloectrodes in tungsten inert gas welding [TIG] (BGI 746),
6. BG principle for preventive occupational medical examinations G 39 "Welding fumes",
7. BG/BGIA recommendations for the risk assessment according to the Hazardous Substances Ordinance – Tungsten inert gas welding (TIG welding)" (BGI 790-012),
8. BG/BGIA recommendation “Soft soldering with soldering iron on electric and electronic subassemblies or their individual components (iron soldering)” (BGI 790-014)
9. Study report "Solder fume emissions in soft soldering" BGIA-Projekt 3060, www.hvbg.de/d/bia/pro/pro1/pr3060.html.
10. LASI publication: Practical instructions "Protective measures to minimise exposure to hazardous substances during gas-shielded welding" (LV 42)

(4) Standards

1. DIN EN 481 Workplaces Atmospheres; Size Fraction Definitions for Measurement of Airborne Particles (edition 1993-09-00),
2. DIN EN ISO 15011-4 Health and safety in welding and allied processes -- Laboratory method for sampling fume and gases -- Part 4: Fume data sheets (edition 2006-06-00) with amendment A1, edition 2007-03-00 (draft),
3. DIN EN ISO15012-1 Health and safety in welding and allied processes -- Requirements testing and marking of equipment for air filtration -- Part 1: Testing of the separation efficiency for welding fume (edition 2005-03-00)
4. DIN EN ISO 10882-1 Health and safety in welding and allied processes -- Sam-

pling of airborne particles and gases in the operator's breathing zone -- Part 1: Sampling of airborne particles (edition 2001-04-00),
5. DIN EN ISO 10882-2 Health and safety in welding and allied processes -- Sampling of airborne particles and gases in the operator's breathing zone -- Part 2: Sampling of gases (edition 2001-04-00),
6. DIN EN 29454-1 Soft soldering fluxes. Classification and requirements. Classification, labelling and packaging (ISO 9454-1:1990) (edition 1994-02-00),
7. VDI/DVS 6005 Ventilation systems for welding workplaces (edition 2005-10-00),
8. VDI 2262 Part 1 VDI 2262 Workplace air; reduction of exposure to air pollutants; general requirements (edition 1993-04-00),
9. VDI 2262 Part 2 Workplace air - Reduction of exposure to air pollutants - Processing and organisation measures (edition 1998-12-00),
10. VDI 2262 Part 3 Workplace air; reduction of exposure to air pollutants; ventilation technical measures (edition 1994-05-00),
11. VDI 2262 Part 4 Workplace air - Reduction of exposure to air pollutants - Capture of air pollutants (edition 2006-03-00).

(5) Sampling and measuring procedures

BGIA Work Folder, No. 8586; see also http://www.bgia-arbeitsmappedigital.de

(6) Type-approved welding fume extraction devices

Machines to remove dusts which are a health hazard – General information and positive list, BGIA Manual, Identity No. 510 210

(7) Personal protective equipment, beyond respiratory protection, for welding work involving other risks

1. Welders' protective clothing in accordance with DIN EN 470-1 "Protective clothing for use in welding and allied processes. General requirements" (see also BGR/GUV R 189 "Use of protective clothing"),
2. Eye and face protection with welder protection filters acc. to annex 2 BGR / GUV R 192 "Use of eye and face protection ",
3. Protective gloves according to BGR/GUV R 195 "Use of protective gloves",
4. Hearing protectors according to BGI/GUV-I 5024 "Hearing protector information".