Welding fume extraction
Capture, extraction and filtration
Guideline for mobile and stationary systems
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Guideline for mobile and stationary systems
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Preface

People – workplaces – environment
The quality of life that is socially accepted in line with today’s standards can only be achieved where there are clean and humane workplaces. They increase people’s satisfaction with their work, reduce absences due to illness and thus help ensure higher productivity with better results.

Given the wide range of strains put on those working in welding technology, this applies here more than anywhere. However, reducing these strains is not only the result of economic considerations; they must also be reduced due to increased requirements in terms of occupational safety.

The regulations on occupational safety affect many aspects of the welding processes. This guide serves an aid and a point of reference; it includes a summary of the most important provisions on air pollution control at welding workplaces and on the disposal of the hazardous substances captured.

This guide is intended to provide an explanation of the latest relevant provisions for those responsible for occupational safety and environmental protection at welding plants and authorities.

The manufacturers and suppliers who come together in the VDMA’s Welding Smoke Extraction working group provide the necessary reliability in the planning and execution of extraction systems for welding plants.

Their experience and expertise guarantees that the best possible solutions can be created.

Please note that the points, tables and lists provided in each case may merely provide limited examples, and that other methods and representations exist. This guide does not claim to be exact, nor to interpret the existing legal provisions with complete accuracy. It is not a substitute for scrutinizing the relevant directives, laws and regulations. In addition, the particular features of the products in question and the different ways in which they can be used should be taken into account.

Please note that different countries often have very different limits for hazardous substances. This can result in different country-specific requirements for protective measures. This guide is based on the applicable national guideline in Germany. Please give priority to adherence to your country’s national specifications on occupational safety.
1 Preamble

This guide provides an overview of statutory requirements and measures for air pollution control in workplaces in which work such as welding, cutting and related processes (e.g. soldering, thermal spraying) including ancillary work is conducted.

These thermal processes produce fumes (hereinafter referred to as welding fumes) and gases that are classified as hazardous substances in accordance with the current technical regulations. The fume consists mainly of particles measuring less than 10 µm in size. These particles are both inhalable (they impinge on the nose and throat area) and alveolar (they reach the alveoli of the lungs) for humans and can cause respiratory diseases.

Investigations in recent years have shown that welding smoke also contains ultra-fine particles in comparably high number concentrations. Also known as nanoparticles, ultra-fine particles are smaller than 0.1 µm and, due to their size, are able to penetrate cells. Their toxicological properties have not yet been precisely clarified.

Air pollution control measures are therefore necessary, primarily for occupational safety reasons, but sometimes also for environmental protection. Extracting the emissions where they arise is the most efficient way of capturing the majority of welding fume emissions and discharge them with the ambient air before becoming significant.
2 Terms and definitions

Hazardous substance
Dangerous substances or mixtures of substances that are flammable, poisonous (toxic) or carcinogenic, carry a risk of explosion, strain the lungs or respiratory system, or harm the environment. Up-to-date information and data on hazardous substances can be found at http://www.baua.de and in the GESTIS Substance Database at http://www.dguv.de/ifa/de/gestis/stoffdb/index.jsp.

Inhalable dust
Inhalable dust is the portion of solid particles carried in the air with diameters of less than 100 µm, which can be inhaled with breathing air.

Alveolar dust
Alveolar dust is the portion of inhalable dust that penetrates as far as the alveoli (particle size predominantly less than 10 µm).

Ultra-fine dust
Ultra-fine dust is the portion of dusts, smokes and mists with a particle size of less than 0.1 µm (corresponds to 100 nm, also called nanoparticles).

Smokes
Smokes are extremely fine dust particles that are distributed in the air and formed by thermal and/or chemical processes (particle size chiefly less than 10 µm).

Emission rate
The emission rate is a measure of the release of a hazardous substance (here: welding fume or gas) in a specific time. The emission rate is normally given in mg/s for particulate substances and in ml/s for gases.

Outdoor air
Here: Untreated air that flows into a ventilation unit or opening from outside.

Supply air
Airflow that enters a room (or building).

Recirculation air
Airflow that enters a room (or building) and is returned as part of the supply air following treatment in a filter device.

Exhaust air
Airflow that is extracted from a room (or hall) and guided to the outside. Sometimes called extract air.

Waste
Here: The welding fume separated in the filter unit, including the filter media used.

The terms for air circulation and substance flows for welding fume extraction are explained in Figure 1.
Emissions that are released through welding, cutting and related processes are hazardous substances; the following laws, regulations and technical rules therefore apply.

3.1 German Occupational Safety Act (ArbSchG)

The ArbSchG obligates the operator to determine and assess all hazards associated with the execution of a professional activity before work commences. If necessary, appropriate measures shall be taken to eliminate the hazards or reduce them to an acceptable level (§ 5 ArbSchG).

This also applies to hazards due to hazardous substances. This means that the operator has to determine whether activities with hazardous substances are conducted and whether hazardous substances are produced and/or released during these activities. If this is the case, the activity may only begin once protective measures have been taken. The effectiveness of the protective measure(s) taken must then be checked, improved if necessary and the result documented.

3.2 German Ordinance on Hazardous Substances (GefStoffV)

The GefStoffV (2010 version), in Annex I No. 2 “Particulate hazardous substances”, under 2.3, Para. 5, demands the use of equipment with which hazardous substances are collected where they are released or developing. Specifically, it says: “Dusts shall be collected and disposed of safely as far as possible at the place where they are released or developing. The air extracted shall be conducted in such a way that as little dust as possible passes into the workers’ breathing air. The air extracted shall only be returned to the working area if it has been adequately cleaned.”

Furthermore, in Para. 7: “Equipment to separate, collect and precipitate dusts shall be in accordance with the state of the art. When these devices are first put into operation, it shall be checked that they are adequately effective. At least once a year the devices shall be inspected with respect to their proper functioning, serviced and, where relevant, repaired. The results of the inspections as recorded in accordance with sentences 2 and 3 shall be retained.”

3.3 Technical Rules for Hazardous Substances Welding Work (TRGS 528)

The TRGS 528 specifies the GefStoffV for processes in welding technology and describes protective measures for reducing the exposure to hazardous substances. It supersedes the former trade association rule “Welding Fumes” (BGR 220).

Para. 4.1 demands: “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 minimize the risk thus arising.”

The following order applies for the measures to be taken:
- Selection of procedures and filler metals low in hazardous substances (check of substitution)
- Ventilation measures
- Organizational and hygienic measures
- Personal protective measures (wearing respiratory protection).

Deviations shall be documented with justification.
4 Hazard assessment

Because welding smoke is classified as a hazardous substance, a hazard assessment must be conducted.

4.1 Procedure

The procedure for conducting a hazard assessment for the hazardous substance welding smoke can be conducted in accordance with TRGS 528, for example. The following aspects shall be taken into account:

Step 1:
Gathering information on the composition of the welding fume:
- Base material (workpiece)
- Coatings (e.g. paints, films, galvanic coatings) or contamination (e.g. oils)
- Filler metal (safety data sheet in accordance with ISO 11014, welding smoke data sheet in accordance with DIN EN ISO 15011-4)
- Process gases (e.g. shielding gases) or gases resulting from the process (e.g. ozone)

Step 2:
Determination of the harmful properties of welding smoke components, e.g. in accordance with TRGS 528:
- Substances that place a strain on the respiratory tract and lungs, e.g. iron oxides, aluminium oxide
- Toxic or toxic-irritating substances, e.g. fluorides, manganese oxide, copper oxide, zinc oxide
- Carcinogenic substances, e.g. chromium(VI) compounds, nickel oxide

Further information on substance properties and on the classification of hazardous substances can be found on the website of the Federal Institute for Occupational Safety and Health (http://www.baua.de) and in the GESTIS Substance Database of the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) (see: http://www.dguv.de/ifa/de/gestis/stoffdb/index.jsp).

Step 3:
Determination of the hazard class depending on the process. Examples for this are provided in Table 1 of TRGS 528 (see Table 1, next page).

Step 4:
Determination of the working conditions, including the following:
- Spatial conditions
- Head and body position in forced posture
- Duration of welding

Step 5:
The overall assessment of the hazard is based on the hazard class (step 3) and the working conditions (step 4).

The hazard can be increased in case of a long welding duration and/or forced posture, for example. On the other hand, low welding durations or welding outdoors can reduce the hazard. TRGS 528, Chapter 3.2.4 contains more information.
### Assessment of the procedures with reference to emission rates, taking into account specific factors or effects specific to individual materials, assignment to hazard classes (taken from TRGS 528)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Emission rate(^1) in mg/s</th>
<th>Hazard class of procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Substances that place strain on the respiratory tract</td>
<td>Toxic or toxic-irritating substances</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Submerged arc(^2)</td>
<td>&lt; 1</td>
<td>Low</td>
</tr>
<tr>
<td>Gas welding (autogenous procedure)</td>
<td>&lt; 1</td>
<td>Low</td>
</tr>
<tr>
<td>TIG(^3)</td>
<td>&lt; 1</td>
<td>Low</td>
</tr>
<tr>
<td>Laser welding without filler metal</td>
<td>1 to 2</td>
<td>Medium</td>
</tr>
<tr>
<td>MIG/MAG (low-energy gas-shielded welding)</td>
<td>1 to 4</td>
<td>Low</td>
</tr>
<tr>
<td>Electric arc, MIG (general)</td>
<td>2 to 8</td>
<td>High</td>
</tr>
<tr>
<td>MAG (solid wire), flux-cored wire welding with shield gas, laser welding with filler metal</td>
<td>6 to 25</td>
<td>High</td>
</tr>
<tr>
<td>MAG (flux-cored wire); flux-cored wire welding without shield gas</td>
<td>&gt; 25</td>
<td>Very high</td>
</tr>
<tr>
<td>Soldering</td>
<td>&lt; 1 to 4</td>
<td>Low</td>
</tr>
<tr>
<td>Autogenous flame cutting</td>
<td>&gt; 25</td>
<td>Very high</td>
</tr>
<tr>
<td>Electric arc spraying</td>
<td>&gt; 25</td>
<td>Very high</td>
</tr>
</tbody>
</table>

TRGS 528
\(^1\) Empirical values that can be further reduced in individual cases by optimizing process parameters.
\(^2\) Automated procedure
\(^3\) According to exposure description in BGI 790-12
In accordance with Chapter 5 of this guide, the protective measures shall then be determined depending on the hazard class.

Where the hazard class is medium, high or very high, ventilation measures shall be taken. In addition, further measures may be necessary to protect the welder, such as wearing personal respiratory protection. Where the hazard class is low, the necessity of ventilation measures must be examined. The same applies to work with low exposure (less than half an hour per shift and less than two hours per week).

**Note:**

### 4.2 Working in accordance with VSK, EGU and TRGS

If work processes and protective measures that are described in process- and substance-specific criteria (VSK) in line with TRGS 420 or in a “Recommendation for Hazard Determination of the Accident Insurers (EGU) in accordance with GefStoffV” (formerly called BG/BIA or BG/BGIA recommendations) are applied, it is safe to assume that the requirements of the GefStoffV with regard to protective measures to be taken are met.

The following EGU, among others, are currently available for processes in welding technology:
- BGI 790-014 for soft soldering
- BGI 790-012 for TIG welding
(see: http://www.dguv.de/ifa/de/pra/bg_bgia_empfehlungen/liste/index.jsp)

A hazard assessment in line with steps 1 to 5 listed above is not required when a process described in a VSK or an EGU is used or when a protective measure named in a substance-specific TRGS (e.g. TRGS 505 “Lead”) is implemented.
5 Measures

This guide only covers air handling measures that collect and discharge welding smoke. Aspects such as the welding process, the type of workplace (mobile/portable or stationary/fixed) and the size of the workpieces to be processed must be taken into account when choosing the measures to take.

Air handling measures for collecting welding smoke are shown in Figure 2.

5.1 On torch extraction

Both welding torches with integrated extraction nozzles and welding torches with a small extraction pipe located on the torch are available for collecting the welding smokes directly where they arise (see Figure 3).

On torch extractions require the lowest air volume flows of any collecting system, due to their direct proximity to the welding location. However, the small cross-section of the suction hose and nozzle means that very high under-pressure (10 000 Pa or more) is required in the extraction system.

The disadvantages of the system lie in the handling of the welding torch and impairments in some welding positions.
5.2 High-vacuum 'at source' extraction

The use of funnel or slit-shaped suction nozzles (see Figure 4) enables hazardous substances to be collected from a distance of up to 150 mm. The extraction nozzles are usually held in position by magnets.

Connection to the extraction system is usually via hoses with a nominal width of around 45 mm. An air volume flow of approx. 100 to 150 m³/h is required at a relative underpressure of min. 6 000 Pa in the extraction system. Due to the low suction range of the nozzles, they only collect smoke within a limited range. They therefore need to be frequently repositioned.

5.3 Low-vacuum 'at source' extraction

Low-vacuum 'at source' extraction is undoubtedly used most frequently in practice. The hazardous substances are collected by means of extraction hoods (see Figure 5) and flexible extraction arms with nominal widths of approx. 150 mm and lengths of up to around 10 m.

Thanks to their construction, the extraction hoods can be positioned freely and retain the position set unsupported.

Depending on the shape and size of the extraction hood, air volume flows of around 700 to 1,000 m³/h at an underpressure of around 800 to 1,200 Pa are required for collecting hazardous substances. The systems are able to collect welding smokes well even from a distance of around 300 to 400 mm.
It is important to ensure that the extraction arms run smoothly. Smooth-running extraction arms make use easier and improve acceptance among welders significantly.

It is also useful to equip the extraction hood with lighting. This not only improves the light conditions in the working area, but also causes the welder to constantly take the extraction arm with him.

5.4 Extraction hood

This type of hazardous substance collection is typically used for extraction at robot welding stations and other automated welding processes. The welding smokes reach the collection area of the extraction hood through thermal buoyancy (see Figure 6). Additionally, vertical blinds can be installed at the sides of the hoods; these reduce the influence of disruptive cross flows (e.g. uncontrolled air flows in the room) and thus improve smoke collection.

The size and shape of the extraction hood depends on the working area of the welding robot in question. The air volume flow should be dimensioned in such a way that the entire thermal flow resulting from the welding position is collected. Air volume flows in the range of 2,000 to 4,000 m³/h are usual. The underpressure required in the extraction system is just a few 100 Pa.

These systems are hardly suitable for manual welding processes, as they would not reduce the strain from hazardous substances in the breathing area of the welder.

Figure 6: Extraction hood over a welding robot  Source: TEKA Absaug- und Entsorgungstechnologie GmbH
5.5 General ventilation

These systems are used in support of the aforementioned processes or when they cannot be used. A general distinction is made between layered and mixed ventilation. The welding smoke is usually extracted at a height of 4 to 6 m.

In both processes, the welding smokes are collected rather randomly. To save energy, the air handling equipment is chiefly operated in recirculation air mode. The air volume to be recirculated per hour is usually as many times the rooms volume. Please also note Chapter 7.2 of this guide. Calculation bases for the design of general hall ventilation systems can be found in VDI/DVS 6005, among other sources.

In layered ventilation (see Figure 7), the supply air is fed into the room at low velocity through source outlets close to the ground around the welding locations. This supports the buoyancy of the welding smokes and noticeably improves the air quality around the source outlets.

In mixed ventilation (see Figure 8), the supply air is fed into the room via ventilation grates or jet nozzles in the upper area of the hall. This ensures mixing of the air in the hall. Spreading of hazardous substances into adjacent working areas that are not contaminated is not permissible.
6 Review of effectiveness

6.1 Procedure

The effectiveness of the protective measure(s) taken must be checked, improved if necessary and the result documented.

The strain of the employees (exposure) from welding smoke and gases is determined by measuring the concentration of hazardous substances in the air at the workplace (see TRGS 402).

For welding processes in which non-alloy/low-alloy materials (i.e. basic and filler metals containing less than 5 wt% of chromium, nickel, cobalt, manganese, copper, barium, and fluorides) are/could be processed, and for processes in which the welding smoke contains no mutagenic, carcinogenic, fibrogenic, toxic or allergic substances, determining the welding smoke concentration non-specifically in the alveolar dust fraction is sufficient.

In thermal spraying and at mixed workplaces (welding and grinding), the inhalable fraction (inhalable dust) may be significant in addition to the alveolar fraction. The dust concentration in the inhalable fraction must also be determined here.

If a welding process releases chromium or nickel compounds (e.g. welding of chromium nickel steel) or other substances with particularly toxic properties (e.g. zinc, copper or manganese oxide), their concentrations in the air at the workplace must be determined separately.

Alongside the metrological determination methods, TRGS 402 also permits the use of other determination methods such as calculations, the transfer of measurement results determined at workplaces with comparable working conditions, and the consideration of results from occupational medicine check-ups.

The exposure data determined in this way are to be compared with occupational exposure limits (OEL) (see Chapter 6.2 of this guide) whenever possible. If an occupational exposure limit is exceeded, the employer must immediately take further and suitable protective measures and conduct a new hazard assessment. The results of the review of effectiveness shall be documented.
6.2 Occupational exposure limit

The occupational exposure limit that applies for welding, cutting and related processes depends on the materials to be processed.

The general dust limit in accordance with TRGS 900 applies to the assessment of exposure to iron oxides, aluminium oxide (apart from smoke), magnesium oxide (apart from smoke) and titanium dioxide. The following values applied at the time of printing of this guide:

- Alveolar dust fraction
  (Alveolar dust) = 3 mg/m³

- Inhalable dust fraction
  (Inhalable dust) = 10 mg/m³

The substance-specific occupational exposure limits apply to substances with particularly toxic properties (e.g. manganese = 0.5 mg/m³ in accordance with TRGS 900).

No occupational exposure limits have been defined for carcinogenic hazardous substances such as chromium (VI) compounds and nickel oxide (released when welding chromium nickel steels, for example). In accordance with § 7 (4) GefStoffV, the employer must rule out hazards to the health and safety of employees performing activities which involve hazardous substances. If this is not possible, he shall reduce them to a minimum.

The latest values are stated in Table 2 of the TRGS 528. The values stated here for chromium(VI) compounds and nickel oxide can be used as replacement values to assess chromium and nickel exposures during welding work until tolerance and acceptance values are available (see: http://www.baua.de; notification 910).
### Example – State of the art from exposure data relating to welding work1,2 (taken from TRGS 528)

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

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Weld filler metal or material</th>
<th>Welding fumes in mg/m³</th>
<th>Chromium(VI) compound in mg/m³</th>
<th>Nickel and its compounds in mg/m³</th>
<th>Ozone in mg/m³</th>
<th>Nitrogen oxide in mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas welding (autogenous welding)</td>
<td>non-alloy, low-alloy steels</td>
<td>particulate emissions not relevant</td>
<td>cannot be given ³</td>
<td>cannot be given ³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMA = Manual Metal Arc</td>
<td>non-alloy, low-alloy steels</td>
<td>≤ 3 (A)⁵ ≤ 10 (E)⁶</td>
<td>not relevant</td>
<td>cannot be given ³</td>
<td>cannot be given ³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high-alloy steels</td>
<td>≤ 3 (A)⁵ ≤ 10 (E)⁶</td>
<td>≤ 0.03 (E)⁶</td>
<td>≤ 0.05 (E)⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAG / MIG</td>
<td>non-alloy, low-alloy steels</td>
<td>≤ 3 (A)⁵ ≤ 10 (E)⁶</td>
<td>not relevant</td>
<td>≤ 0.2</td>
<td>cannot be given ³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high-alloy steels</td>
<td>≤ 3 (A)⁵ ≤ 10 (E)⁶</td>
<td>≤ 0.02 (E)⁶</td>
<td>≤ 0.1 (E)⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submerged arc welding</td>
<td></td>
<td>≤ 1 (A)⁵</td>
<td>not relevant</td>
<td>not relevant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIG welding⁴</td>
<td></td>
<td>≤ 1 (A)⁵ ≤ 2 (E)⁶</td>
<td>≤ 0.01 (E)⁶</td>
<td>≤ 0.01 (E)⁶</td>
<td>≤ 0.1</td>
<td>cannot be given ³</td>
</tr>
<tr>
<td>Resistance welding</td>
<td></td>
<td>≤ 2 (A)⁵ ≤ 4 (E)⁶</td>
<td>not relevant</td>
<td>not relevant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal spraying</td>
<td>Flame cutting</td>
<td>≤ 2 (A)⁵ ≤ 10 (E)⁶</td>
<td>≤ 0.01 (E)⁶</td>
<td>≤ 0.05 (E)⁶</td>
<td>cannot be given ³</td>
<td>cannot be given ³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 3 (A)⁵ ≤ 10 (E)⁶</td>
<td>not relevant</td>
<td>cannot be given ³</td>
<td>NO: ≤ 2.5</td>
<td>NO₂: ≤ 2</td>
</tr>
</tbody>
</table>

1 Sector and workplace-specific deviations are possible.
2 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.
3 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.
4 See also BGI 790-012
5 (A) Alveolar dust
6 (E) Inhalable dust
7 Air handling and filter technology

7.1 Filter technology

Suitable filter systems must be used to separate hazardous substances. The hazard potential and the quantity of hazardous substances shall be taken into account when selecting the filter systems.

Mobile and stationary filter systems have effective separation equipment, allowing the requirements regarding occupational safety and environmental protection (recirculating air and exhaust air) to be met. Various mechanical and electrostatic filter systems are available.

Cleanable surface filters can be used to filter welding smoke (see Figure 9).

Separation of gases is not possible with the named filter systems. Adsorption separators can be used for this.

7.2 Recirculation air

(air recirculation in accordance with TRGS 528 Section 4.5)

In recirculating air mode (air recirculation), the health hazard from hazardous substances that are not separated in filter systems must be taken into account.

Extracted air may only be returned to the working area if it has been adequately cleaned.

Ventilation systems with air recirculation may be used if they are type-approved or if individual measurements are conducted to check the required effectiveness.

Every air recirculation also requires a feed of supply air that is free from harmful substances (usually outdoor air). This air supply is used to dilute and displace hazardous substances, especially gases, in the room air. BGR 121 and guideline VDI 2262 Part 3 contain provisions on the ratio of outdoor air to recirculation air.

This guide states an outdoor/recirculation air ratio of ≥ 0.43 for hazardous substances with occupational exposure limits; this means that at least 430 m³/h of outdoor air must be supplied per 1,000 m³/h of circulating air in a room.

At workplaces where welding or related processes that emit carcinogenic, mutagenic or reproductive substances in category 1 or 2 (especially where materials containing chromium or nickel are used), air extracted there may not be returned. This does not apply when type-ap-
proved welding smoke extraction devices of welding smoke separation class W2 or W3 are used. For information on welding smoke separation classes, see DIN EN ISO 15012-1.

In accordance with the guideline named above, the outdoor/recirculation air ratio must be ≥ 1 for hazardous substances with such classifications; this means that at least 1,000 m³/h of outdoor air must be supplied per 1,000 m³/h of recirculation air in a room.

7.3 Exhaust air

Devices and systems for extracting welding smoke in which the exhaust air is conveyed to the outside do not usually require approval under the Federal Immission Control Act.

TA Luft (Technical Instructions on Air Quality Control) and other provisions must be taken into account in order to protect the general public and the neighborhood against harmful environmental impacts from air contamination.

In accordance with the scope of TA Luft, harmful environmental impacts shall be avoided or, if unavoidable, limited to a minimum using state-of-the-art technology.

The most important requirements of the TA Luft from July 24, 2002 with regard to welding smoke are as follows:

**Total dust, including particulate matter (Chapter 5.2.1 TA Luft)**

The dust emissions contained in the exhaust air may not exceed a mass flow of 0.20 kg/h or a mass concentration of 20 mg/m³. Even with a mass flow smaller than or equal 0.20 kg/h, a mass concentration of 0.15 g/m³ in the exhaust air may not be exceeded.

**Inorganic particulate matter (Chapter 5.2.2 TA Luft)**

Even where multiple substances from the same class are present, the inorganic particulate matter listed hereunder may not exceed the following mass concentrations or mass flows in the waste gas in total:

... 

**Class II:**
Nickel and its compounds, stated as Ni
Mass flow 2.5 g/h or mass concentration 0.5 mg/m³.

**Class III:**
Chromium and its compounds, stated as Cr
Mass flow 5 g/h or mass concentration 1 mg/m³.
Carcinogenic substances (Chapter 5.2.7 TA Luft)
Stricter requirements than those in Chapter 5.2.2 TA Luft apply to carcinogenic chromium and nickel compounds. Even where multiple substances from the same class are present, the substances listed hereunder may not exceed the following mass concentrations or mass flows in the waste gas in total as a minimum requirement:

**Class I:**
Chromium(VI) compounds, stated as Cr (except for barium chromate and lead chromate; Chapter 5.2.2 TA Luft applies to these compounds). Mass flow 0.15 g/h or mass concentration 0.05 mg/m³.

**Class II:**
Nickel and its compounds, stated as Ni (except nickel metal, nickel alloys, nickel carbonate, nickel hydroxide and nickel tetracarbonyl; Chapter 5.2.2 TA Luft applies to these compounds). Mass flow 1.5 g/h or mass concentration 0.5 mg/m³.
8 Waste

8.1 Provisions (Waste Management Act KrWG, GefStoffV)

The following types of waste may occur in the filter system after the extraction of welding smoke:

- Filter materials coated with dust
- Cleaned and separated dust in dust extraction systems
- Sludge (e.g. after wet cleaning of the electrostatic precipitator)

The 2012 Waste Management Act (KrWG) and the associated regulations provide the basis for the disposal of welding and combustion dust and sludge. Avoiding waste is the top priority, followed by recycling materials and energy and environmentally friendly disposal. The types of waste are listed in the Waste Catalog Regulation by origin.

<table>
<thead>
<tr>
<th>Waste key</th>
<th>Description in accordance with the AVV</th>
<th>Waste type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 02 07*</td>
<td>Solid waste from gas treatment containing dangerous substances</td>
<td>Hazardous waste</td>
</tr>
<tr>
<td>10 02 08</td>
<td>Solid waste from gas treatment other than those mentioned in 10 02 07</td>
<td>Non-hazardous waste</td>
</tr>
<tr>
<td>10 02 13*</td>
<td>Sludges and filter cakes from gas treatment containing dangerous substances</td>
<td>Hazardous waste</td>
</tr>
<tr>
<td>10 02 14</td>
<td>Sludges and filter cakes from gas treatment other than those mentioned in 10 02 13</td>
<td>Non-hazardous waste</td>
</tr>
<tr>
<td>12 01 02</td>
<td>Ferrous metal dust and particles</td>
<td>Non-hazardous waste</td>
</tr>
<tr>
<td>15 01 10</td>
<td>Packaging containing residues of or contaminated by hazardous substances</td>
<td>Hazardous waste</td>
</tr>
<tr>
<td>15 02 02*</td>
<td>Absorbents and filter materials, including oil filters not otherwise specified, wipes, protective clothing contaminated by hazardous substances</td>
<td>Hazardous waste</td>
</tr>
<tr>
<td>15 02 03</td>
<td>Absorbents, filter materials, wipes and protective clothing other than those mentioned in 15 02 02</td>
<td>Non-hazardous waste</td>
</tr>
</tbody>
</table>

* Waste keys with asterisks apply to hazardous waste.
8.2 Measures

The waste owner, i.e. usually the waster generator, is responsible for the waste. The waste generator is responsible for proper and safe disposal of the waste (recycling or removal). The waste must be disposed of in a sealed container.

Waste generator
The plant operator of a filter plant, who has to dispose of the separated dust as waste.

Waste
Substances or objects that the owner discards, plans to or is required to discard.

Sealed container
To prevent the separated dust from:
• entering the atmosphere (environment)
• entering the ground water (water hazard, environment)
• coming into contact with people: respiratory tract, mouth (stomach, intestines), skin resorption.

Disposal
Recycling or removal of waste.

Recycling
• Material recycling (extraction or use of materials from waste)
• Energy recycling (use of waste as a substitute fuel)

Removal
Essentially all processes that are not recycling; often land fill or combustion without energy generation.

Proper
Compliant with the statutory provisions.

Harmless
No impairment for the public or the environment.

The waste owner can also commission third parties, such as disposal companies, to meet his obligations. Specialist disposal plants meet certain quality standards and are certified.
However, the waste generator is responsible for the entire disposal chain, from waste production to transport and disposal.

When classifying dust, the pivotal question is how to classify the dust correctly. The Waste Catalog Regulation (see Table 3) provides assistance.

The situation is simple when a plant only processes “black” material (non-alloy or low-alloy steels) or the plant is able to separate the dust into “black” and “white” (high-alloy steels) material.

The waste key 120102 can be assigned to the “black material”. This non-hazardous waste is not generally subject to obligatory verification in accordance with § 2 of the Verification Regulation, but is subject to obligatory registration in accordance with § 23 of the same. The material can be reused, e.g. as scrap iron.

However, if the welding dust contains non-iron metals, especially hazardous chromium/nickel parts, the hazardous waste key (with asterisk) in accordance with Table 3 may be appropriate when the limits from § 3 of the Waste Catalog Regulation are exceeded.

Declaration and identification analyses (see also the 2001 Waste Disposal Regulation) provide certainty about the composition of the dust.

For financial reasons, operating procedures shall be arranged in such a way that the different types of dust are collected separately. They shall be stored in an environmentally safe way.
9 Fire and explosion protection

9.1 Provisions

§11 and Annex I, No. 1 of the GefStoffV contain provisions on avoiding fire and explosion hazards. In accordance with this, the following applies:

- Hazardous quantities or concentrations of hazardous substances shall be avoided
- Ignition sources shall be avoided
- The damaging effects of fires or explosions on the health and safety of employees shall be reduced

9.2 Measures

Welding smokes from metallic materials are usually thoroughly oxidized and not flammable.

However, individual processes, especially processes which use inert shield gases, may release non-oxidized metal particles. These are flammable.

Oils, greases, paints, metallic coatings (e.g. galvanization) and films on work pieces increase the flammability of the welding smokes.

Where there are dust/air mixtures in critical concentrations, explosive combustion can occur when ignition sources (e.g. sparks) or static discharges are present.

If these preventative measures are not sufficient, additional measures, such as the installation of an extinguishing system, shall be taken.

The VDMA Guide “Dust Extraction Systems – Fire and Explosion Protection”, VDMA Specification 24180, VDI 2263 Part 6 and VDS 3445, for example, provide detailed information on measures to take when using welding smoke separators.

The GESTIS-DUST-EX database provided by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) contains information on the combustion and explosion parameters of various dusts/smokes. The limits of applicability shall be taken into account when applying the explosion parameters listed there. In case of doubt, investigations in accordance with recognized processes should be conducted with the relevant dusts/smoke particles.
10 Relevant laws, provisions, regulations

Waste Disposal Regulation (AbfAbIv)
Regulation on the environmentally friendly deposit of settlement waste

Waste Catalog Regulation (AVV)
Regulation on the European Waste Catalog

Occupational Safety Act (ArbSchG)
Law on the execution of occupational safety measures in order to improve the safety and health protection of employees at work

Ordinance on Hazardous Substances (GefStoffV)
Regulation on protection against hazardous substances

BGI 790-012
Tungsten inert gas (TIG) welding

BGI 790-014
Soft soldering with a soldering iron on electric and electronic subassemblies or their individual components (iron soldering)

BGR 121
Workplace ventilation – ventilation measures

BGR 220
Welding fumes

DIN EN ISO 15012-1
Health and safety in welding and allied processes – Laboratory method for sampling fume and gases – Part 1: Requirements for testing and marking of separation efficiency

GESTIS-DUST-EX
Database of the combustion and explosion parameters of dusts
http://www.dguv.de/ifa/de/gestis/expl/index.jsp

GESTIS Substance Database
Information system on hazardous substances of the German Social Accident Insurance
http://www.dguv.de/ifa/de/gestis/stoffdb/index.jsp

ISO 11014
Safety data sheet for chemical products – Contents and structure

Waste Management Act (KrWG)
Law for promoting life cycle management and ensuring that waste is managed in an environmentally friendly way

TA Luft
First general administrative provision on the Federal Immission Control Act (Technical instructions on air quality control)

TRGS 402
Identification and assessment of the risks from activities involving hazardous substances: inhalation exposure

TRGS 505
Technical Rule for Hazardous Substances – Lead
TRGS 528
Welding Work

TRGS 900
Occupational exposure limits

VDI 2262 Part 3
Workplace air – Reduction of exposure to air pollutants

VDI 2263 Part 6
Dust fires and dust explosions – Hazards – Assessment – Protective measures – Fire and explosion protection in dust extraction systems; Examples

VDI/DVS 6005
Ventilation systems for welding workplaces

VDMA 24180
Dust Extraction Systems – Fire and Explosion Protection

VDS 3445
Pamphlet on damage prevention – Fire protection in dust extraction systems

11 VDMA Air Pollution Control department

The Air Pollution Control department is comprised of around 90 companies that manufacture extraction systems and units for a wide variety of user industries against the background of occupational health and safety and environmental protection. The air-handling and dust extraction sector continually develops innovative technical solutions for compliance with the legal requirements, offering a wealth of possibilities for separating dusts, smokes/fumes, aerosols and gases.

Under the umbrella of the VDMA, the member companies cooperate in various working groups, such as the Aerosols, Welding Fume Extraction, Dust Extraction Technology and Wood Dust Extraction working groups with their various sub-groups. Regardless of their role as competitors on the market, in these committees the member companies focus on similar current and long-term issues in everyday business, discuss them and attempt to develop joint solutions. They develop information brochures and VDMA specifications and provide opinions on guidelines and standardization projects. They use their collaboration as platforms for the mutual exchange of information and for expanding their knowledge. The regular meetings also provide advanced training for company staff, as recognised experts are invited to present specific issues of concern.

Apart from this guide on welding fume extraction, the department publishes the following publications:

- Product directories
- Guide: Air recirculation
• Guide: Capturing air pollutants
• Guide: Manual cooling lubricants – Separating and filtering
• Guide: Dust extraction systems – Fire and explosion protection
• Leaflet: Design of extraction systems for wood dust and shavings
• VDMA Air Filter Information (2012-06) Overview of filter classes in ventilation, air-conditioning and dust extraction systems
• Smoke Extraction policy paper (2012-09)
• VDMA Specification 24177 Fans for smoke and heat control of buildings in the event of fire
• VDMA Specification 24180 Dust extraction systems – Fire and explosion protection
• VDMA Specification 24188 Smoke protection measures for stairwells – Smoke removal, smoke dilution, smoke control
• ATEX-Guide: Explosion protection in dust extraction systems – Filtering separators –
• Inspection log: Extraction and filter systems
• Dust extraction technology: List of relevant standards and guidelines
• Conference reports, e.g. "Current developments in smoke extraction"
• Business reports of the Air Pollution Control department

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