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Working Safely in Laboratories

Basic Principles and Guidelines

Fachbereich “Rohstoffe und chemische Industrie” der DGUV

Working Safely in Laboratories –
Basic Principles and Guidelines

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Working Safely in Laboratories

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"Working Safely in Laboratories" (DGUV Information 213-851) is a new and updated version of the "Guidelinesfor Laboratories" that have been established for decades.

This publication incorporates the health and safety regulations for laboratories updated by the Sachgebiet "Laboratorien" in the Fachbereich "Rohstoffe und chemische Industrie" of the Deutsche Gesetzliche Unfallversicherung (DGUV). Text printed in bold has been adopted into state legislation in the February 2008 edition of TRGS 526 "Laboratorien" by the AGS (German Committee on Hazardous Substances). The sections in bold are followed by additional non-bold explanatory text providing details for proprietors and insured persons.

Wherever possible, there is no gender bias. Where this is unavoidable, the relevant form of address also refers to the other gender.

The terminology used in the Hazardous Substances Ordinance (GefStoffV) of 19 November 2016 will be specified in the explenations.

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Introduction

The “Guidelines for Laboratories” (DGUV Information 213-851, previously BGI/GUV-I 850e, BGR/GUV-R 120, ZH 1/119 and GUV 16.17) have been tried and tested in daily practice for many years. In 2000, the AGS therefore adopted the provisions of these “Guidelines for Laboratories” into its technical rules and regulations within the framework of the cooperation model in the form of TRGS 526 “Laboratorien”. Updates are the responsibility of the Sachgebiet “Laboratorien” (Subcommittee “Laboratories”) of the Fachbereich “Rohstoffe und chemische Industrie” (Expert Committee “Raw materials and chemical industry”) within the DGUV (German Social Accident Insurance), in consultation with the AGS (German Committee for Hazardous Substances).

The DGUV Information “Working Safely in Laboratories” takes into account the current status of laboratory technology, new discoveries from day-today laboratory practice and changes to the regulatory landscape, in particular the amended German ordinance on hazardous substances, the Gefahrstoffverordnung (GefStoffV).

“Working Safely in Laboratories” was compiled by the Arbeitskreis “Laboratorien”*) for more than 60 years. The following experts were included in this working group, ensuring an ideal socio-political balance:
Thomas H. Brock (Chairman of the Subcommittee “Laboratories” of the Expert Committee “Raw material and chemical industry” of the DGUV and author to whom correspondence should be addressed, BG RCI), Ursula Aich (Regierungspräsidium Darmstadt), Rudolf Ahrens (BG Gesundheitsdienst und Wohlfahrtspflege), Erika Althaus (BG Gesundheitsdienst und Wohlfahrtspflege), Albin Berger (BASF), Matthias Beyer (DKFZ), Albrecht Blob (Bayer Technology Services), Astrid Brandis-Heep (Max Planck Society), Wolfgang Bronner (Roche Diagnostics), Burkhard Crone (Saarland University), Robert Crueger (Bremen University), Stefan Dreller (DGUV), Christine Ebenbichler (Roche Diagnostics), Horst Fischer (BDI), Klaus-Dieter Ginzel (VCI), Michael Glück (BG RCI), Ulrike Götz (Henkel), Barbara von der Gracht (Amt für Arbeitsschutz), Herta Hartmann (Bayer), Heinz-Werner Hennig (Industriepark Wolfgang), Markus Hoffmann (Heidelberg University), Ludger Hohenberger (UK Nordrhein-Westfalen), Martin Holoch (UK Baden-Württemberg), Wolfgang J. Hönle (Max Planck Society), Robert Kellner (DGUV), Andreas Kleineweischede (Verwaltungs-BG), Dieter Kleuser (BASF), Renata Körfer (DIN), Thomas Kükenhöhner (BASF), Martin Kümmerlin (BG Handel und Warenlogistik), Klaus Lahme (Evonik Industries), Elke Laibacher (DGB), Erich Leidl (Kommunale Unfallversicherung Bayern), Dirk Leonhardt-Nass (Bayer), Dominik Naumann (Infraserv), Lothar Neumeister (BG Energie Textil

* The Arbeitskreis “Laboratorien” (working group on laboratories) in the former Fachausschuss Chemie (expert committee for the chemical industry) has been incorporated in the Subcommittee “Laboratories” of the “Raw materials and chemical industry” Expert Committee of the DGUV (German Social Accident Insurance).

Elektro und Medienerzeugnisse), Adolf Nuber (BASF), Richard Ortmann (DGB), Kirsten Petitjean (Merck), Hermann Philipp (BASF), Klaus Pohl (Verwaltungs-BG), Dietrich Reichard (Bonn University), Bruno Reinprecht (Infracor), Gert Richter (Waldner), Sabine Rießen (Merck), Ulrich Saal (Merck), Benjamin Schädel (BG RCI), Harald Schulze-Halberg (BG RCI), Ulrich Seifert (Fraunhofer-Gesellschaft), Bruno Sigg (Waldner), Martin Sobottke (DGUV), Christina Spassova (BG RCI), Ralf Steinberg (MPI für Kohlenforschung), Reinhard Stockmann (IFA), Kurt Timm (BG RCI), Markus Ullmann (Regierungspräsidium Darmstadt), Arno Weber (Hochschule Furtwangen), Gitta Weber (Infraserv), Matthias Weigl (BG Nahrungsmittel und Gastgewerbe), Roswitha Wegner (UK Baden-Württemberg), Stefan Weis (IG BCE), Norbert Wiegand (Industriepark Wolfgang), Birgit Wimmer (Kommunale Unfallversicherung Bayern), Burkhard Winter (DIN), Ullrich Zwernemann (Schering).

The draft of the updated laboratory guidelines was presented to the members of the former Fachausschuss Chemie and the DGUV for comment as required by Chapter 4, no. 2 of the BG statement of general principle "Präventionsausschüsse des Hauptverbandes der gewerblichen Berufsgenossenschaften" (BGG 900) and by no. 6.5.3 of the "Richtlinien für die Arbeit der Fachgruppen des Bundesverbandes der Unfallkassen" (GUV 60.1). The working group of the former Fachausschuss Chemie discussed the comments received and the result was considered in consultation with the DGUV's health and safety department. The document thus represents a consensus of expert opinion and describes the generally accepted state of the art.

Due to renumbering of the system of rules and standards maintained by the DGUV German Social Accident Insurance in 2014, BGI/GUV-I 850-0e has been assigned the number DGUV Information 213-851.

Any queries relating to "Working Safely in Laboratories" can be sent to: laboratorien@bgrci.de.

The latest version of the "laboratory guidelines" can always be accessed online, as all necessary revisions are incorporated into this version as soon as they have been approved. All revisions/amendments will then be incorporated in a new print edition of DGUV Information 213-851 "Working Safely in Laboratories". The online version of the "laboratory guidelines" is available in both German and English at:

- http://www.laborrichtlinien.de and
- http://www.guidelinesforlaboratories.de

Additional information and further support in and around the topic of "laboratories" can be found on the website of the German Social Accident Insurance Institution for the Raw Materials and the Chemical Industry (BG RCI) at http://laboratorien.bgrci.de.

1 Scope of application

This DGUV Information applies to laboratories in which preparation, analysis or applications engineering work involving hazardous materials and/or substances, hereinafter referred to simply as materials, is performed using chemical, physical or physicochemical methods. For hazards resulting from activities with biological agents in laboratories, the Technische Regel für Biologische Arbeitsstoffe "Schutzmaßnahmen für gezielte und nicht gezielte Tätigkeiten mit biologischen Arbeitsstoffen in Laboratorien" (TRBA 100) should also be adhered to.

According to Art. 2 para. 1 of the Gefahrstoffverordnung, the following are deemed to be hazardous materials:

1. hazardous substances and preparations according to Article 3,
2. explosive substances, preparations and articles,
3. substances, preparations and articles from which substances according to number 1 or number 2 can arise or be released during their manufacture or use,
4. substances and preparations which do not satisfy the criteria of numbers 1 to 3 but which may endanger the health and safety of workers on account of their physico-chemical, chemical or toxic properties and the manner in which they are present or used at the workplace,
5. all substances which have been assigned an occupational exposure limit.

This relates to typical laboratory chemicals such as pure materials, solutions, suspensions or gases that are used as starting or auxiliary materials, analytical standards, reagents or solvents. It also relates to intended reaction products, by-products and contamination, including unexpected reaction products. Hazardous materials may also be released during work with materials, preparations and products that are not classified as dangerous, for example hazardous materials confined in a matrix if the matrix is broken down by a processing step such as dissolving or grinding. Materials that do not have any dangerous features but do have properties that can cause hazards are also deemed to be hazardous materials. Examples include unstable materials or materials that can result in a hazard if they come into contact with each other or due to their temperature and thermal capacity, such as hot molten salts and cryogenic liquefied gases. Another relevant hazard is the asphyxiating effect of many gases. Even materials that initially appear harmless may be hazardous. One example is cellulose powder, which may explode when mixed with air.

Laboratories are workrooms in which specialists or instructed persons conduct experiments to research or apply scientific processes. For the purposes of this DGUV Information, the terms laboratory and lab are

equivalent (1). They include chemical, physical, medical, microbiological and genetic engineering laboratories. Other methods from fields such as molecular biology may also be applied in such laboratories. The relevant rules and regulations should be observed as regards the hazards resulting from such methods. This DGUV Information is only able to cover the key methods, technologies and processes. Further hazards – electrical, mechanical or resulting from biological agents, for example – will often need to be assessed and measures taken to provide protection against them.

This DGUV Information explains the DGUV Vorschrift 1 "Grundsätze der Prävention" and the Gefahrstoffverordnung for laboratory activities. Other relevant legal norms are also to be observed. These include the Arbeitsstättenverordnung (ArbStättV), the Biostoffverordnung (BioStoffV), the Gentechnik-Sicherheitsverordnung (GenTSV), the Betriebssicherheitsverordnung (BetrSichV), the Strahlenschutzgesetz (StrlSchG), ordinances relating to waste, the Jugendarbeitsschutzgesetz (JArbSchG) and the Mutterschutzgesetz (MuSchG). The Bibliography (Annex 5) contains a list of the relevant legal norms and rules of engineering. Hazard characteristics such as toxic, inflammable and corrosive are used as stipulated in the currently valid version of Directive 67/548/EEC.

For details on other hazards and protective measures, see Section 5 and the BG RCI Merkblätter A 016 "Gefährdungsbeurteilung – Sieben Schritte zum Ziel" and A 017 "Gefährdungsbeurteilung – Gefährdungskatalog". See also DGUV Regel 113-018 "Unterricht in Schulen mit gefährlichen Stoffen", DGUV Information 213-039 "Tätigkeiten mit Gefahrstoffen in Hochschulen", DGUV Information 213-026 "Sicherheit im chemischen Hochschulpraktikum – Eine Einführung für Studierende" and the DGUV Information 213-855 "Gefährdungsbeurteilung im Labor".

In addition to the Technische Regel für Biologische Arbeitsstoffe (TRBA) "Schutzmaßnahmen für Tätigkeiten mit biologischen Arbeitsstoffen in Laboratorien" (TRBA 100), other TRBAs and the DGUV Information 213-086 "Sichere Biotechnologie – Biologische Laboratorien – Ausstattung und organisatorische Maßnahmen" are also to be observed for laboratory work with biological agents.

2 General

Laboratories must be designed and operated in line with the relevant regulations and the state of the art. The specific activities of insured persons in laboratories, in particular involving hazardous materials, require specific protective measures of a structural, technical, organizational or personal nature.

In particular in laboratories, only the measures required to control or eliminate the hazards identified based on the results of hazard assessments need to be taken. As regards the ranking of protective measures, technical measures take precedence over organizational and personal measures. Personal and organizational protective measures (in particular safety glasses, lab coats and protective gloves) are essential in laboratories given the large amount of manual work and the frequently changing activities.

In addition to the Gefahrstoffverordnung, this DGUV Information also provides concrete details of other regulations that it is vital to comply with in order to provide protection against hazardous materials in laboratories.

Deviations from the rules of engineering are permissible if the same degree of safety is ensured by other means. Proof must be provided in each individual case.

Generally accepted rules of engineering include the Technische Regeln für Gefahrstoffe (TRGS), rules and information documents from the statutory accident insurance institutions, DIN standards and VDE regulations listed in the Bibliography in the versions as amended.

The technical solutions described in this DGUV Information do not exclude other solutions that are at least as safe which may also be embodied in the rules of engineering of other Member States of the European Union or other states party to the Agreement on the European Economic Area.

Test reports from test laboratories licensed in other Member States of the European Union or other states party to the Agreement on the European Economic Area are to be regarded in the same way as German test reports if the tests, testing methods and design requirements on which they are based are equivalent to those of a German laboratory. This applies in particular to laboratories that meet the requirements laid down in standard DIN EN ISO/IEC 17025 “Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien (ISO/IEC 17025:2005)”.

Hazard assessments for laboratory work normally require some general measures to be taken. The relevant structural measures are described in Section 6, while organizational and personal measures are described in Section 4. Additional measures will also be required, depending on the laboratory's specific use. Some of these are described in Section 5. In addition, reference is made to further regulations and information documents (see Bibliography).

Further assistance is available online from the Sachgebiet "Laboratorien" of the Fachbereich "Rohstoffe und chemische Industrie" of the DGUV on http://laboratorien.bgrci.de.

3 Hazard assessment and substitution check

3.1 Procedure

Special features of laboratories

Art. 7 of the GefStoffV and Art. 5 of the ArbSchG define the basic rules applying to hazard assessments for work involving hazardous materials. These rules are put into universally valid concrete form in TRGS 400 "Gefährdungsbeurteilung für Tätigkeiten mit Gefahrstoffen". This section therefore concentrates on special features and the specific situation of laboratories.

Environmental protection should also be taken into account in hazard assessments.

Safety factors

Due to the different types of laboratories (analytical laboratories performing standard tests, research laboratories) and the large number of activities generally performed there with various hazardous materials, the otherwise standard approach of basing protective measures on the relevant material properties and activities cannot be applied in many cases. Factors such as the building, its facilities, procedures, operation and equipment, and the qualifications of lab staff are key in determining laboratory safety. The hazards associated with work in laboratories are minimized by combining technical, organizational and personal measures. The laboratory building and equipment therefore largely determine the activities that can be performed there.

Work in fume hoods

Work in fume hoods is vitally important in laboratories because it offers effective protection against the effects of physicochemical properties such as the formation of potentially explosive atmospheres or the effects of shattered glass etc. flying through the air, and against toxic hazards.

New materials

Any activities with new materials or materials that have not yet undergone sufficient testing may only be performed in fume hoods or in equipment offering a similarly high level of protection.

Typical hazards in laboratories

The following hazards resulting from hazardous materials are typically encountered in laboratories:

1. **Fire and explosion hazards resulting from flammable solids, liquids and gases.**
2. **Risk of solids, liquids or gases causing damage to health.**
3. **Risk of unknown, violent or reactions out of control.**
4. **Hazards affecting the eyes and skin as a result of caustic and irritant substances.**

Other hazards

Employees working in laboratories are also often subjected to stress or put at risk by other factors, in particular:

1. Inadequate lighting or lighting that is not appropriate for the visual task being performed.
2. Unfavorable ambient conditions.
3. Risk resulting from containers at an overpressure or underpressure.
4. Risk resulting from hot or cold surfaces and media.
5. Noise generated by equipment and installations.
6. Mechanical hazards of equipment and installations.
7. Hazards affecting the skin caused by wet work, in particular through wearing gloves.
8. Risk of slipping on wet surfaces, risk of tripping.
9. Stresses affecting the locomotor system as a result of performing repetitive activities or adopting awkward postures.
10. Stress caused by repetitive activities, time pressure, isolation and high levels of concentration.
11. Strain caused by personal protective equipment.

All aspects that can have a direct or indirect impact on safety are to be taken into account in the hazard assessment. For example, the ergonomic aspect of lighting has a significant effect on safety when working with hazardous materials because poor visibility – for example in a fume hood – increases the risks involved in working with such materials.

Avoiding the stresses of hazardous materials

Measures to protect against hazardous materials must be taken so that, as far as possible, they do not result in any additional hazards or stresses for insured persons. If this is not possible – and after alternative measures have been considered – the relevant activity must be designed so as to minimize the overall risk to employees.

Special effects

It should also be taken into account that, in addition to work with hazardous materials, special effects can also result in hazards. These may be caused, for example, by

1. Ionizing radiation
2. Electromagnetic fields
3. Optical radiation (UV, laser, IR)
4. Biological agents

Interaction of hazards

Part of the hazard assessment should therefore be to check whether hazardous materials can interact with these special effects during the relevant activities, resulting in an increased risk (for example, ignition of flammable air/vapor mixtures due to laser radiation). It should also be ensured that measures to protect employees against hazardous materials are compatible with measures to protect against other effects. Consequently, it may be useful to enlist the help of appropriate experts from other fields when performing the hazard assessment (a radiological safety officer, for example).

The contents of Art. 7 have been incorporated in Art. 6 of the GefStoffV 2010.

Basic conditions for working safely

The measures required to work safely during normal laboratory operations based on the general hazard assessment as per the Gefahrstoffverordnung can be deemed to be in place if the following basic conditions are met:

- Building and equipment as stipulated in this DGUV Information and the relevant regulations
- Use of specialist staff
- Working in accordance with the relevant rules of engineering and the state of the art
- Working on a laboratory scale
- Compliance with this DGUV Information

A safety concept for standard laboratory work is drawn up based on these conditions. If it is adhered to, there is no explicit need to keep performing further hazard assessments for individual tests. Complying with this concept therefore makes work much easier. As a result, this DGUV Information represents a stipulated measure as defined in No. 5 of TRGS 400 "Gefährdungsbeurteilung für Tätigkeiten mit Gefahrstoffen".

If, on the other hand, even one of these basic conditions is not complied with, a comprehensive "Gefährdungsbeurteilung ohne vorgegebene Maßnahmen" [hazard assessment without stipulated measures] as detailed in No. 6 of TRGS 400 is to be performed and the additional measures required are to be determined. Hazards not covered by this DGUV Information require an extended hazard assessment.

Intrinsic safety concept for laboratories

In addition to the specific area of hazardous materials, this also applies to all other hazards. Due to the wide variety of different activities with all kinds of hazardous materials, an intrinsic safety concept is followed in the laboratory that takes in the building, facilities, procedures, operation and equipment. The safety concept is essentially based on the requirements of Sections 2, 3, 4, 6 and 7 of this DGUV Information. If necessary, additional measures can be taken in accordance with Section 5 to enable incidents and exposure to be controlled. Accordingly, laboratories are normally run in such a way that even activities with toxic materials can be performed without additional measures. Unexpected events cannot normally be ruled out completely in a laboratory. Consequently, technical measures – in particular to limit and control the damage caused by incidents – play a key role. A lower level of intrinsic safety is only appropriate if hazardous work can be ruled out on a long-term basis.

As the intrinsic safety of laboratories is heavily dependent on the building and equipment, upon commissioning it is necessary to check whether the planner (architects, engineers) possesses sufficient spe-

cialist competence with regard to the occupational safety regulations and in particular to the Ordinance on Hazardous Substances (Gefahrstoffverordnung). In particular, the planner should be able to assess consequences arising from the interaction between occupational safety, environmental protection, convenience and sustainability (31).

When awarding contracts, it is recommended to reach agreement that object-related documentation will be handed over together with the building.

Given the often complex links between different types of hazards in laboratories, several hazards are controlled simultaneously by a series of technical, organizational and personal measures.

Appropriate measures also need to be taken when performing work involving hazards that result from the physicochemical properties of materials. These are often the same measures that reduce hazards resulting from toxic properties.

Activity-based individual and group assessments

Hazard assessment is an activity-based process. Activities can often also be assessed together in groups of comparable activities. For this purpose, the possible exposure and material properties must be comparable, as must the type and extent of substances that may escape. The corresponding protective measures are taken as required and as far as practicable for individual activities, individual workstations, groups of workstations, work areas or entire buildings. Some protective measures can be taken immediately before activities are performed, for example by installing a shield. Others, on the other hand, need to have been taken before this point as they are difficult and time-consuming to retrofit. Laboratory ventilation with fume hoods is one example.

Taking process conditions into account

Process conditions, in particular exposure, should also always be taken into account in hazard assessments. In addition to the hazard of exposure through inhalation, the assessment must also include dermal and oral exposure and exposure resulting from physicochemical material properties. It may be necessary to consider the possible incorporation of hazardous materials following mechanical injuries such as needlestick injuries. In many cases, the typically small quantities of materials used in laboratories compared to industrial operations do not mean that hazard assessments can be approached with the assumption that the hazard as referred to in Art. 6 para. 13 of the Gefahrstoffverordnung is low. The large number of steps to be performed manually and special process conditions offer significant scope for exposure and accidents. However, even high risks are reduced effectively by the concept of hazard control in the laboratory and possible additional measures required. For example, it can be assumed that the risk is low if a solution is acidified with a few milliliters of diluted acetic acid, but this does not apply

if the same amount of red fuming nitric acid is added. If the same quantity of 40 % hydrofluoric acid is added, this even represents a high risk. By taking the relevant protective measures, however, all three activities can be performed safely.

Accident assessment

The hazard assessment must also include accidents. The ability to control events and the impact that workstations have on each other are particularly important in large laboratories. For example, additional containment systems may need to be provided in fume hoods in case there is a fire.

Flexible use

Protection objectives must still be achieved despite the increasingly flexible use of laboratory buildings and facilities. This applies in particular to the configuration of workstations. Measures can be disregarded if the work to which they relate is not carried out, provided the hazard assessment indicates that there is no corresponding hazard and the legal framework permits this. If there are changes in use, retrofitting may be necessary before the relevant work can start. This requirement can also apply to individual tasks for which a laboratory of a particular kind is not designed and which, consequently, cannot be carried out in the normal way. It is therefore advisable to predict as accurately as possible the tasks, including future tasks, to be performed in the laboratory and at least allow for appropriate retrofitting options.

Hazard assessments must be performed by specialists. If the proprietor does not have the appropriate know-how, he must consult a specialist.

Standard procedures

Many laboratory activities are covered by standard procedures for hazard assessment purposes. The conditions on which the assessment is based must be clearly defined, in particular as regards the quantities used, the procedures assessed and the hazard features taken into account. A separate assessment is only required if the activity does not fit in with the relevant standard procedure. Irrespective of this, the hazard assessments of such standard procedures must be kept up-to-date.

Standard procedures (clusters) can be freely selected in such a way as to enable the individual laboratory activities to be assigned to them as appropriately as possible. One example of a standard procedure is preparing samples for gas chromatography. Most of the relevant activities can be included in this. If there are special additional steps involved in sample preparation – such as derivatization with a particularly hazardous reagent – this aspect also needs to be assessed. This approach enables hazard assessments to be performed very efficiently, as all that then needs to be checked is whether the selected assessment is appropriate for the standard procedure, and additional work is only performed when actually needed. See (3) for samples.

In the context of the Gefahrstoffverordnung, 2.5 liters can represent a small quantity. However, before a hazard can be assessed as low, the type and extent of exposure must also be assessed as low. If work is carried out in laboratories in accordance with the rules of engineering and the relevant regulations, exposure will normally only be of a low level. However, possible exposure in the event of an accident must also be taken into account. Fire and explosion hazards normally require additional measures.

In principle, it is possible to apply such measure-based concepts to individual activities or entire areas such as a complete laboratory. Help is available from a number of sources, including (4) and (5). For example, a large number of technical aspects such as ventilation locations must be taken into account as early as the planning stage for entire areas or buildings. On the other hand, many measures can be implemented for individual employees or workstations so as to meet their specific requirements at any particular time.

Modular measure-based concept

The basic operating requirements in Section 4 and the technical measures in Section 6 represent the building blocks for safety in laboratories. If laboratories meet these requirements, activities referred to in Art. 9 of the Gefahrstoffverordnung can normally be performed without additional measures provided the quantities lie within the scope referred to above. They usually also satisfy the requirements relating to protective measures as stipulated in Art. 11 of the Gefahrstoffverordnung, and to measures taken against hazards resulting from dermal or oral exposure. In the case of activities covered by Arts. 7 or 8 of the Gefahrstoffverordnung, some of the measures detailed in Sections 4, 5 and 6 can be dispensed with following an appropriate hazard assessment – provided a law, ordinance or DGUV regulation does not stipulate that there are to be no exceptions. Activities with carcinogenic, mutagenic and reprotoxic (CMR) materials or involving special apparatus, procedures or hazardous materials require further protective measures. This applies in particular to those referred to in Section 5. However, these measures do not replace the hazard assessment, in particular as regards dermal/oral exposure and physicochemical material properties. The relevant formal requirements of the Gefahrstoffverordnung must be complied with – for example, the obligation to document a substitution check. Technical, organization and personal protective measures are to be selected from the relevant paragraphs 7–10 to the extent possible and required.

To ensure measures are effective, insured persons must, when carrying out their work, adhere to the measures defined by the proprietor in the hazard assessment.

See TRGS 402 "Ermitteln und Beurteilen der Konzentrationen gefährlicher Stoffe in der Luft in Arbeitsbereichen". For work involving carcinogenic, mutagenic and reprotoxic materials, see Section 5.1.7.

For fire and explosion hazards, see Section 4.12.

Lab staff may also work outside the laboratory. In such cases, it may be necessary to take measures other than those described here. For example, an extended hazard assessment may be necessary.

3.2 Obtaining information

Criteria for sources of information

The labelling of materials and the relevant material safety data sheet serve as the initial sources of information. In particular in the field of research and when working with materials that are unfamiliar to the user, have not been thoroughly investigated or are not commercially available, additional information must be obtained. Experts, specialist literature and the Internet are particularly useful sources of information. It is important to remember that such sources can also provide incorrect details. Preference should therefore be given to sources that are known from experience to contain valid data. If specialist literature is used, more recent findings and findings from journals and books with a good reputation – ideally subject to quality assurance measures ("peer reviewed") – are to be given preference. Information from Internet sources should only be used if it originates from trustworthy providers. The person using the data must also always check its plausibility based on his own expertise. See also TRGS 400.

Main risk of hazardous materials

The main emphasis in laboratories is focused on the impact that hazardous materials have. Further hazards result from the use of appliances, which must also be assessed.

It is advisable to use databases with valid data such as the GESTIS-database on hazardous substances of the IFA (Institute for Occupational Safety and Health of the German Social Accident Insurance) (6) or the GisChem hazardous material database (7).

Directory of hazardous materials

When keeping a directory of hazardous materials, it is advisable not to exclude those materials whose use represents only a low-level hazard at this particular moment in time. The directory would otherwise have to be adapted as soon as there were any changes or new uses. In addition, a directory of hazardous materials that has the advantage of including the few laboratory chemicals that are not hazardous provides a rapid overview of stocks and purchasing/disposal requirements. See (3) for an example.

See the DGUV Information 213-855 "Gefährdungsbeurteilung im Labor".

3.3 Determining levels of exposure

3.3.1 General

TOP measures to minimize hazards

The basis for laboratory safety is provided by the building itself, by the Technical equipment and by the Organizational and Personal protective measures (TOP). These measures minimize the hazards, even with materials that are new or have not yet been sufficiently investigated.

Assumption that exposure does not exceed the permissible level

The proprietor can generally assume that the exposure to hazardous materials does not exceed the permissible level provided that:

1. **expert and reliable staff**
2. **work in accordance with the relevant regulations and the state of the art**
3. **and in particular comply with this document and standard laboratory conditions (see Section 3.3.3)**

(see Eisenbarth, P., Kleuser, D., Bender, H.: Expositionssituation in Laboratorien der chemischen Industrie, Gefahrstoffe – Reinhaltung der Luft, Vol. 58, No. 10, 381–385, 1998).

Assessment of exposure

If a high level of exposure cannot definitely be ruled out, the relevant level is to be determined by means of appropriate assessment methods such as calculation and in particular by drawing comparisons with similar laboratory workstations. Such assessment methods must be equivalent to a measurement. If it is not possible to assess the level of exposure in this way, measurements must be performed to provide evidence of compliance with the limit values. Provided this DGUV Information is adhered to, it can also be assumed that fire and explosion hazards are effectively reduced.

3.3.2 Qualification of laboratory personnel

Expertise of laboratory personnel

Laboratory personnel must have the necessary expertise for their work. This is determined by the type and duration of their relevant training, general professional experience in the relevant field and experience of the activities to be performed. The relevant requirements depend on

1. **The hazardous materials used.**
2. **The quantities of hazardous materials.**
3. **The material properties.**
4. **The type and number of activities.**
5. **The type and number of appliances (for example, apparatus, equipment and installations).**
6. **The reaction process (for example, possibility of reactions getting out of control, pressure buildup).**

Changing lab users

If the people using the laboratory change frequently, for example in the case of student placements, protective measures that are dependent on people and their actions can be expected to be less effective than if they are performed by expert and experienced laboratory personnel. The frequency and intensity of instruction sessions have to be adapted accordingly. To be on the safe side, it may be necessary to replace measures performed by individuals with automatic protective measures. For example, it is not advisable to employ manual selection of ventilation levels in the case of student placements as this would jeopardize the effectiveness of the protective measure.

3.3.3 Standard laboratory conditions

Boundary conditions for material use

For the purposes of this DGUV Information, the following boundary conditions apply as standard laboratory conditions for procedures and quantities relating to the use of toxic, highly toxic, carcinogenic, mutagenic or reprotoxic hazardous materials:

1. **Activities involving hazardous materials during which dangerous concentrations or quantities of such materials can occur in the workplace atmosphere must be performed in appropriate fume hoods whose effectiveness has been verified or in facilities that offer a comparable level of safety, such as vacuum equipment.**
2. **The maximum quantity used in each case is adapted to the potential hazard posed by the material in question:**
   - **Liquids are limited to 2.5 l in each case.**
   - **Toxic, carcinogenic, mutagenic or reprotoxic liquids are limited to 0.5 l in each case.**
   - **Highly toxic liquids are limited to 0.1 l in each case.**
   - **Solids are limited to 1 kg in each case.**
   - **Toxic, carcinogenic, mutagenic or reprotoxic solids are limited to 0.5 kg in each case.**
   - **Highly toxic solids are limited to 0.1 kg in each case.**
   - **If there is no central gas supply for gases such as nitrogen, argon, hydrogen and propane, the smallest possible container size is to be used (maximum: 50 l compressed-gas cylinder). Lecture bottles or small steel cylinders are to be used for highly toxic, carcinogenic, mutagenic or reprotoxic gases. If this is not possible, the compressed-gas cylinders used must not be larger than 10 l. Replacement cylinders must be stored outside of the laboratory.**

Additional measures

In the case of activities involving particularly dangerous hazardous materials, additional measures are required even if the limits on quantities specified above are complied with. Examples include working with a highly unstable or explosive material such as nitroglycerine or using a large quantity of a carcinogenic alkylation agent such as dimethyl sulfate in glass apparatus.

Experience shows that the batch quantities referred to above can be processed safely using typical laboratory apparatus.

A general limit on quantities per piece of apparatus to 2.5 l for liquids and 1 kg for solids therefore also enables materials to be controlled that lie below the hazard level for toxic materials within the system of measures set out in this DGUV Information.

Applying the limits referred to in this section to all hazardous materials, including those that do not feature the above-mentioned hazards, has therefore proven to be good practice.

See also Sections 4.13 and 4.15.1.

3.3.4 Use of larger quantities

Additional measures

If the work involves larger quantities of hazardous materials than those referred to here is performed in laboratories, this is to be taken into account in the hazard assessment since it cannot be assumed that events or exposure can be controlled using the measures described in this DGUV Information without a more extensive assessment. Additional measures are often required over and above those contained in this DGUV Information. The hazard assessment reveals whether the work can be performed in the laboratory and, if so, which additional measures are required, or whether this is not possible and the work must be done in an appropriately equipped pilot plant, for example due to explosion protection considerations.

See also Section 4.13.

3.4 Special features of laboratories

3.4.1 Emergencies and faults

Large laboratories

The hazard assessment must also include emergencies and faults. The ability to control events and the impact individual workstations have on each other are particularly important in large laboratories. For example, additional containment systems may be required in fume hoods in case there is a fire.

See also Art. 13 of the Gefahrstoffverordnung.

3.4.2 Incorporation of hazardous materials due to injuries

Low risk in laboratories

It may be necessary to consider the possible incorporation of hazardous materials following mechanical injuries such as needle-stick injuries or injuries resulting from broken glass. The quantities encountered in laboratories are typically smaller than in commercial/industrial applications. But because of the fact that the many manual operations and special process conditions result in an elevated risk of exposure the risk is often not assumed to be below the level referred to in Art. 7 para. 9 of the Gefahrstoffverordnung.

The contents of Art. 7 para. 9 have been incorporated in Art. 6 para. 13 of the GefStoffV 2015.

3.4.3 Third-party activities in laboratories

Cleaning/maintenance staff and visitors

Work by outside companies and other people that fall outside the scope of instruction given to laboratory personnel must be factored into the hazard assessment. This applies in particular to cleaning staff, building services staff, maintenance companies and visitors. It may be necessary to take special measures for such activities, for example provide separate instruction or interrupt certain activities in the lab.

See Art. 15 of the Gefahrstoffverordnung.

3.4.4 Taking special activities into account

Exposure despite technical measures

Activities for which the possibility of exposure is presumed still to exist even after all technical measures have been exhausted must also be included in the hazard assessment. Examples include maintenance work and cleaning work on contaminated ventilation or lab equipment. Other activities such as operating and monitoring activities should also be taken into account if they can put insured persons at risk from hazardous materials.

3.4.5 Accommodating persons with disabilities in the laboratory

3.4.5.1 Background

Inclusion

The range of disabilities that can impact a person is quite extensive. This makes it very difficult to find suitable solutions that would enable the performance of laboratory work in all cases or to formulate generally applicable rules. Modifications can be made, for example structural ones; however, which modifications are necessary and how extensive they need to be must be planned well in advance. In general, it will be necessary to carefully consider each case individually. There will certainly be cases in which the workplace can be retrofitted with little effort and expense to ensure safety at the workplace for a person with disabilities, but in other cases, or if a person has several disabilities, this may seem very difficult or even impossible.

Persons with disabilities can carry out activities in laboratories without endangering either themselves or others if certain conditions are met. Appropriate measures are to be identified and documented when carrying out the hazard assessment; the assessment must be tailored to reflect the special circumstances of the case in question. This is also in the event of a possible later disability, for example disease, necessary. The feasibility, practicability and effectiveness of the necessary organizational measures as well as the ability of all persons to cooperate must be considered.

An important component of any laboratory safety plan is the prompt recognition of potentially dangerous situations by the persons – with and without disabilities – working in the laboratory to ensure that they can react quickly enough to prevent an accident or adverse health effects.

Should the presence of persons with disabilities in the laboratory markedly curtail the effectiveness of this plan, different methods must be implemented to achieve the required level of safety. However, this is not always possible without endangering the health of the person with disabilities or that of other people in the laboratory.

A number of possible solutions are available that need to be assessed for their feasibility in the case in question. The hazard assessment must therefore evaluate whether the following requirements are met:

- In the event of a dangerous situation, would the persons be able to rescue themselves or be rescued by others at any time?
- Can hazards and dangerous situations be recognised reliably and in time (colour recognition, labels, sounds and noises, alarm signals, etc.)?
- Is safety equipment readily accessible at all times (the criteria include the accessibility and reachability of emergency stop equipment, the accessibility and efficacy of emergency showers and alarm devices, etc.)?
- Has the risk of hazards to other persons been eliminated, such as those arising from unexpected reactions or the restricted physical abilities of persons with disabilities? (Other persons include both other employees working in the laboratory as well as third parties such as service staff or guests).
- Has everyone understood the instructions given by the laboratory manager or by safety experts by order of the manager?

In general, these questions can only be answered in collaboration with an expert for occupational safety. These include occupational safety officers and occupational physicians, union representatives (for example works councils), the statutory accident insurance organisations and other advisory bodies. It is recommended that the persons with disabilities help decide on the best course of action for meeting safety requirements. The persons providing guidance must have sufficient know-how in this area.

Examples of various measures are provided below. Depending on the respective disability, their implementation may be necessary in addition to other general safety measures. Modifications may have to be made depending on the specific conditions that are found in the respective laboratory.

3.4.5.2 Technical and structural measures

- Structural modifications: access and evacuation routes (for example: ramps for wheelchair users, walkways without thresholds and steps, handrails for stairs and corridors for persons with restricted mobility, grab handles and door openers) and accessibility and usability of lifts, staff rooms and sanitary facilities
- Escape and evacuation routes and office and laboratory doors of sufficient width and power-operated door openers (doors need to open in the direction of escape)
- Furnishings modified for the respective disability (see Figure 1)
- Purchase of assistive equipment

Fig. 1: Height-adjustable fume hood with knee space. The cabinets are on wheels and can be removed as needed to make room for a seated person (in a wheelchair). The important controls can be reached from a seated position. The ventilation system is not only equipped with an acoustic alarm signal, but also with two visual alerts (at eye level and above the sash). In addition, a person working at this unit is given a mobile safety device for single-user workplaces with an alarm button that is accessible at all times.

- Devices and equipment, in particular safety equipment (emergency stop switches and alarm buttons, emergency showers and actuating elements, fire extinguishers, light switches, telephones, etc.) must be recognisable, accessible and easy to operate at all times. Ergonomic design principles must be observed.
- The person with disabilities must be able to quickly and clearly perceive all acoustic, visual and olfactory alarm signals and other safety information. Should a particular type of broadcasting channel be ineffective in a specific case, the signals must be relayed using an alternative form of communication, for example via a visual alarm that is activated together with an acoustic signal.

3.4.5.3 Organisational measures

- Adjustment of working hours, with consideration taken of the special issues that may arise for persons working alone
- Adjustment of the job description with consideration taken of the capability in question

- Assignment or development of a workplace that is easier both to reach and to leave in the event of an emergency evacuation and better meets the requirements of the facility
- Taking into consideration leaves of absence, for example for rehabilitation measures
- Operating instructions, instructions, plans, manuals and notices that are tailored to the specific situation
- Availability of assistance for certain tasks by appropriate and specially trained persons
- Availability of a sufficient number of assistants who have been outfitted with the proper equipment in the event of an evacuation
- Regular drills and training, in particular to practice evacuating the facility
- Instructional and training sessions to promote understanding on all sides, for example to enable persons without mobility problems to learn how to navigate around the laboratory in a wheelchair and identify potential problem areas
- If possible, designing the practical laboratory work that is carried out to fulfil the requirements of a traineeship or university degree programme in such a way as to avoid exposing persons with disabilities to additional hazards, for example by reducing the quantity of substance used or by substituting hazardous substances without having an effect on the success of the learning process
- Transfer of individual duties to other persons. In the case of a professional training or university degree programme, this must be done without jeopardizing the acquisition and understanding of the course content and the required skills

3.4.5.4 Personal protective measures

Appropriate personal protective equipment, for example laboratory coats for persons in wheelchairs that provide as much coverage as those worn by a standing individual. At the same time, it is imperative that the coats can be removed without delay in the event of contamination or fire (as the effectiveness of emergency showers has yet to be evaluated for persons in wheelchairs, other measures should be taken to minimize the risk of hazards that would necessitate their use).

Mobile communication devices carried by and accessible to the person at all times are required, to ensure that the person can be notified of an emergency at all workplaces and in all areas of the building or premises (for example: mobile phones, walkie-talkies, vibrating alarms, etc.).

3.5 Taking the course of the reaction and new materials into account

By-products and contamination

In addition to the materials actually being used, the hazard assessment must also include materials of which is known or assumed that they may be produced during the normal course of the reaction or if the reaction takes an unexpected course. Even if the course of the reaction is as expected, by-products are created in addition to the main product. These must be factored into the risk assessment and appropriate protective measures taken.

Working with new materials

New materials whose properties are not sufficiently well known (acutely toxic, chronically toxic and physicochemical properties) must be handled with great care. Acutely toxic and caustic and, possibly, chronically toxic effects should normally be assumed as an absolute minimum when arriving at protective measures. These materials can also be flammable or even spontaneously flammable and form explosive mixtures. Great care must be taken to avoid contact with the skin, inhalation and any other form of incorporation. Similar precautions apply to hazardous materials that have not yet undergone complete testing.

For example, particularly dangerous reactions with a risk of hazardous materials being released or exploding can be expected with nitration, oxidation, synthesis of unstable or metastable compounds, polymerization, diazotization and exothermic reactions in general.

The best way to prevent inhalation is to work in a fume hood. Working in a closed system or glove box also prevents contact with the skin.

Information on hazards in publications

Scientific publications normally only refer to the hazardous properties of new materials that become apparent. These are generally restricted to a low flashpoint, sensitivity to air, water, temperature or impact, spontaneous flammability and explosive properties. Even indications such as these virtually never appear in older publications. Dangerous properties of educts are normally not referred to either. Material safety data sheets, details on labels and data pools for obtaining information must be used for bought-in chemicals.

Nanomaterials

To be on the safe side, activities in laboratories involving nanomaterials with properties that are not sufficiently well known are also treated as activities with new materials when defining protective measures. This applies even if nanoparticles may be released only during processing. For further practical guidance regarding this, please refer to (26), (27), (28), (29), (30).

The “Nanorama laboratory” is also available for safe handling of nanomaterials (http://nano.dguv.de/nanorama/bgrci/en/). This interactive e-learning application provides information on how to work safely with both nanomaterials and equipment that is used to produce or process nanomaterials. In connection with the risk assessment, it enables exposure to be estimated and provides information regarding the necessary protective measures when working with nanomaterials in laboratories.

3.6 Substituting hazardous materials

Substitute materials and procedures

As part of the hazard assessment, a check must be conducted to determine whether substituting hazardous materials or procedures will reduce the hazards. When deciding whether to substitute a material, the overall hazard resulting from the material properties, the procedures and the possibility of exposure is to be assessed. See also TRGS 600.

Examples of substituting hazardous materials with less dangerous ones include using cyclohexane or toluene instead of benzene as a water entrainer, using tert.-butyl methyl ether – which has no tendency to form peroxides – instead of diethyl ether, replacing acetone with butanone-2, and substituting n-hexane with cyclohexane, heptane or octane.

The lowest-risk materials that serve the teaching purpose should be used for training.

Materials and procedures that cannot be substituted

Hazardous materials used in chemical reactions or processes cannot normally be substituted. This also applies to analytical standards for determining hazardous materials. Extensive development work, including time- consuming validation processes, is normally required before alternative analytical methods can be used. In addition, licensing procedures or standardization work may be needed to switch the analytical procedure.

Before making a substitution, the hazards of a replacement in the actual procedure compared to those of the material to be replaced are to be checked in addition to the material properties. Both toxic and physicochemical properties must be evaluated. Substituting a material with one that is less toxic but has a higher vapor pressure or involves additional fire and explosion hazards may increase the overall risk.

Substitution is more straightforward in routine work than for activities with frequently changing tasks, such as in the field of research, and should be preferred.

One such substitution that has been used for many years involves substituting benzene with cyclohexane and toluene as a water entrainer and also as a solvent for recrystallization. One current focus of research is transferring organo-chemical reactions to aqueous systems. Extractions with hot solvents can often be performed in closed apparatus. Other examples of laboratory substitutions include using benzyl bromide instead of benzyl chloride, replacing blue gel with orange gel, substituting chromium (VI) oxide oxidations with other procedures described in literature and using trimethylsilyldiazomethane instead of diazomethane. Other alkylation agents besides sulfuric acid ester can be used, such as iodomethane, alkyl sulfonic acid ester or dimethyl carbonate. In a number of reactions, hexamethylphosphoric triamide can be replaced by 1,3-dimethyl-2-imidazolidinone, 1,3-dimethyltetrahydro-2(1H)-pyrimidinone, dimethyl sulfoxide, 1-methyl-2-pyrrolidone or tetrahydrothiophen-1,1- dioxide. While bis(chloromethyl) ether can only be used in a very small number of cases, chloromethyl methyl ether serves as a protection group reagent. If this needs to be manufactured, a method should be selected that does not form any bis(chloromethyl)ether as a by-product. Possible alternatives are (2-methoxyethoxy)-methyl chloride with a much lower vapor pressure and (2-chloromethoxyethyl)-trimethylsilane. The use of N-nitroso-N-methylurea in the preparation of diazomethane can be dispensed with by using N-methyl-N-nitroso-4-toluene sulfonic acid amide. Detailed information and literature can be found in (8).

Analytical substitutions are also possible. For example, it is advantageous to replace the photometric method for determining formaldehyde with pararosaniline by an HPLC method.

The synthesis of crystal violet, which is a popular teaching case, can be replaced by the synthesis of ethyl violet to avoid the carcinogen Michler's ketone.

Alternatives can also be found for substitution of hazardous cleaning agents.

See also Section 4.17.

Procedures can also be substituted. In particular when small quantities are involved, for example, phosgene can be generated from di/triphosgene in a process that is easy to control and can be interrupted at any time instead of using phosgene from compressed-gas cylinders.

It should be noted that replacing a substance, its application or a procedure does not necessarily remove all hazards. It is even possible that one hazard is reduced while other new hazards arise, for example if a

toxic, incombustible substance is replaced by a less toxic but combustible substance. Although, when diazomethane is replaced by trimethylsilyldiazomethane, dangerous decay is avoided, the toxicity remains.

Product development

For product development purposes, the question of whether hazardous materials are used that could be problematic at later stages of development, production or marketing should be considered as early as the laboratory phase.

3.7 Employment restrictions

Young people, women and mothers

Employment restrictions relating to young people, women of childbearing age, pregnant women, and breastfeeding mothers must be observed. Please refer to the employment bans in Art. 22 of the Jugendarbeitsschutzgesetz, Arts. 4 and 6 of the Mutterschutzgesetz and Arts. 3 to 5 of the Verordnung zum Schutze der Mütter am Arbeitsplatz.

See also the BG RCI Merkblatt M 039 "Fruchtschädigende Stoffe – Informationen für Mitarbeiterinnen und betriebliche Führungskräfte".

3.8 Documentation

Documenting and updating the hazard assessment

Irrespective of the number of insured persons and before work starts, the proprietor must document the hazard assessment. He must indicate what hazards may occur at the workplace and what measures need to be taken in accordance with the third and fourth sections of the Gefahrstoffverordnung. No detailed documentation is required for activities with a low risk as per Art. 7 para. 9 of the Gefahrstoffverordnung. In all other cases, clear justification is to be provided for the absence of detailed documentation. The hazard assessment must be updated if significant changes make this necessary or if the results of the preventive occupational medical care assessment indicate that an update is necessary.

If there is more than a low risk, the result of the substitution check has to be documented. If this check reveals that substitution as stipulated by TRGS 400 and 600 is not possible with activities for which additional protective measures are required in accordance with Art. 10 of the GefStoffV, the considerations on which the check was based must also be documented in a verifiable form.

The contents of Art. 7 para. 9 have been incorporated in Art. 6 para. 13 of the 2015 Hazardous Substances Ordinance (GefStoffV) and the contents of Art. 10 of the 2010 Hazardous Substances Ordinance into Art. 9.

Documentation in the directory of hazardous materials

The substitution check can be documented as an annex to the hazard assessment in the directory of hazardous materials. A comment on performing the check and the reason for substitution not going ahead if this is the case are also added. If the reason is straightforward and objectively argued, for example using a material as a starting material to perform chemical reactions on this molecule, a general reference to such a text is normally sufficient for the relevant material. Separate details are then only required where the reason cannot be traced back to such a straightforward situation.

See Art. 6 para. 8 of the Gefahrstoffverordnung.

4 Generally valid operating instructions

4.1 Operating instructions

Operating instructions for hazardous materials and appliances

The proprietor must prepare operating instructions that take into account the hazardous materials and appliances used, describe the hazards for humans and the environment occurring in the laboratory and stipulate the protective measures and rules of conduct that are generally required. Operating instructions must be written in a language and form that the insured persons can understand and are to be documented. It must be ensured that operating instructions are accessible in the laboratory at all times and that they include instructions on the appropriate conduct in dangerous situations and on first aid measures. See Art. 14 of the GefStoffV and TRGS 555 "Betriebsanweisung und Information der Beschäftigten".

General operating instructions

The general operating instructions ("Laborordnung") contain the basic, concrete stipulations in a clear format. It may be necessary to consider other relevant legislative provisions in addition to this DGUV Information.

Individual and group operating instructions

In addition to being familiarized with the operating instructions for hazardous materials, insured persons must also be acquainted with the methods and procedures that need to be applied with regard to safety and the use of hazardous materials. These may be described in individual operating instructions or included in the general operating instructions.

The proprietor must prepare separate operating instructions for particularly dangerous work with hazardous materials or apparatus. Examples include the operating instructions for fume hoods, centrifuges or experimental autoclaves that could result in a hazard if operated incorrectly. Compiling group operating instructions for hazardous materials in laboratories has proved to be a valuable course of action over the years. Individual instructions are required for particularly hazardous materials and materials with a combination of risk factors that renders any meaningful assignment to a single group impossible. Examples include highly toxic, carcinogenic, mutagenic, reprotoxic, spontaneously flammable and explosive materials.

The hazard-related contents of operating instructions must also be accessible to non-German speakers in the laboratory, such as visiting scientists from other countries.

Documentation and availability

Operating instructions and material safety data sheets represent an important source of information and provide key evidence for preliminary investigations by the public prosecutor. It is therefore vital to prepare this documentation with the necessary care. Operating instructions can also be made available in electronic form in addition to a written, signed hard copy as long as it is ensured that insured persons have direct access. Material safety data sheets may be provided in written or electronic form. If they are in electronic form, it must be ensured that all employees have access to them if required. Should an electronic medium not be available – for a temporary period – an alternative source must be used or work must be suspended for this period. Assistance with instruction on hazardous materials can be found, for example, in (9) and BG RCI offers web-based help with preparing operating instructions (10).

See also Art. 14 of the Gefahrstoffverordnung.

4.2 Instruction

Operating instructions and instruction sessions

The proprietor must ensure that insured persons working in laboratories receive instruction. He may transfer this task to an appropriate person. This document, existing operating instructions and operating instructions for apparatus and equipment represent the main basis for instruction. See TRGS 555 in this connection.

Insured persons must receive their instruction before they start work and thereafter at appropriate intervals – at least once a year – and before they use hazardous materials, facilities and appliances for the first time.

Insured persons must be provided with detailed and appropriate instruction on general and work-related hazards in the laboratory and on measures to avoid these hazards. This must be provided verbally and with reference to their specific workplace. This also includes general advice on occupational medicine/toxicology if the work involves hazardous materials. See Section 4.7 to establish whether a doctor needs to be involved in the instruction process.

Women of child-bearing age, pregnant women, breastfeeding mothers and young people are also to be informed of the possible hazards and employment restrictions/bans.

If staff from outside companies perform activities such as repair or cleaning work, it is important to ensure that they are instructed in the hazards and the necessary protective measures before they start work. The outside company is to be briefed accordingly.

Documentation

The content and time of instruction must be recorded in writing and confirmed with the signature of those persons receiving instruction.

The proprietor must ensure that this DGUV Information, the material safety data sheets and the operating instructions are made accessible at an appropriate location in the laboratory or handed out to the insured persons.

Electronic documents

This DGUV Information and operating instructions may also be made available in electronic form, for example as a file in a network, provided all insured persons have access to it. This document is the English version of DGUV Information 213-850.

Documents may be sent, for example, to laboratory supervisors or graduate assistants. It is advisable to send documents in written form.

See Arts. 4 and 12 of the accident prevention regulation DGUV Vorschrift 1 "Grundsätze der Prävention" and Art. 14 of the Gefahrstoffverordnung.

See also BG RCI Merkblatt M 039 "Fruchtschädigende Stoffe – Informationen für Mitarbeiterinnen und betriebliche Führungskräfte". Electronic version of DGUV Information 213-851 see for example Kompendium Arbeitsschutz.

Type, scope and effectiveness of instruction

To connect instructions with actual work scenarios is a beneficial alternative to the use of block courses. It is important that no employees are left out, for example if they are on vacation or off sick. In such cases, the instruction has to be repeated for the absentees. Written instructions can only support verbal instruction, not replace it. Other vital requirements include documenting the contents and timing of instruction sessions, recording the names of those present and requesting them to sign the relevant document. It is also necessary to ensure that the contents are understood and followed. Instruction will be more readily accepted if it is geared towards the hazard assessment, actual events and accidents, and employees' own experiences.

The use of equipment such as fume hoods, autoclaves, centrifuges or syringes can also be hazardous and, consequently, relevant instruction is required. Appropriate operating instructions are helpful in this respect.

Practical drills

Drills such as rescue operations, evacuating workplaces in the event of a dangerous situation occurring, operating fire-extinguishing equipment, and using emergency showers and personal protective equipment can be useful additions to instruction sessions and provide some variety.

Please refer to the other briefing, instruction and documentation obligations set out in Art. 14 of the Gefahrstoffverordnung.

4.3 General principles for working in laboratories

4.3.1 Avoiding hazards

Housekeeping

The proprietor must organize work so as to avoid or minimize hazards. He shall ensure that insured persons keep laboratories tidy and must provide sufficient storage facilities close to the workplace for this purpose.

Limiting exposure

The duration and extent of exposure to hazardous materials must be limited and workplace limits must be observed. Contact with the skin should be avoided.

Marking

Health and safety markings must comply with ASR A1.3 and the accident prevention regulation "Sicherheits- und Gesundheitsschutzkennzeichnung am Arbeitsplatz" (BGV A8, GUV-V A8).

The accident prevention regulation "Sicherheits- und Gesundheitsschutzkennzeichnung am Arbeitsplatz" (BGV A8, GUV-V A8) was replaced by the Technische Regeln für Arbeitsstätten ASR A1.3 "Sicherheits- und Gesundheitsschutzkennzeichnung".

Tidy workbenches, fume hoods, cabinets and shelves make a major contribution to safety at work. Hazardous materials must be stored clearly arranged.

4.3.2 Assigning work

Capability

The proprietor may only assign work to persons who have received instruction and are capable of complying with the health and safety regulations and measures to be observed. Insured persons may only carry out work involving hazardous materials and equipment if this is necessary to perform their tasks. The number of persons exposed to hazardous materials is to be limited to the level that is necessary.

Persons who – on the basis of their specialist training, know-how and experience and their knowledge of the relevant regulations – can assess the work assigned to them and recognize possible hazards are considered to have the necessary capability. Several years of work in the relevant field can be deemed equivalent to specialist training.

An instructed person is a person who has undergone instruction – through on-the-job training if necessary – in the tasks assigned and the possible hazards of improper conduct and has been instructed in the necessary safety devices and protective measures.

Examples of work involving a high risk of hazards include activities with new materials and materials with as yet unknown properties (testing not complete), work with carius tubes, experimental autoclaves, compressed-gas cylinders, compressed gases, vacuums, cryogenically liquefied gases and flammable liquids, and work with explosive materials and materials that are harmful to health. Under specific conditions, the work described in this section can also be hazardous work performed alone.

See Arts. 8, 15 and 17 of the DGUV Vorschrift 1 "Grundsätze der Prävention" and DIN 31000; VDE 1000 "Allgemeine Leitsätze für das sicherheitsgerechte Gestalten von Produkten".

4.3.3 Working alone

Permissibility and safeguarding of work performed alone

During the hazard assessment, it is to be ascertained whether work can be performed alone. The hazard assessment indicates any additional organizational and technical measures required. If sufficient safeguards cannot be provided for work to be carried out alone, this is not permitted.

Safeguards for work performed alone

Monitoring must be organized so as to ensure that help is provided sufficiently quickly in a hazardous situation. The type of monitoring depends on the type of hazard, which is to be established by the hazard assessment. The following in particular should be included in the assessment:

- type, quantity or concentration of materials (for example, toxic, asphyxiating, cryogenic)
- likelihood of an accident occurring
- type and severity of possible injury
- ability to take action after an accident
- availability and operational readiness of emergency response teams.

See Art. 8 of the DGUV Vorschrift 1 "Grundsätze der Prävention" and the DGUV Regel 112-139 "Einsatz von Personen-Notsignal-Anlagen".

See also (11).

4.3.4 Reporting defects

Rectifying defects and hazardous conditions

Insured persons must promptly rectify defects, damage, hazardous conditions and other hazards that occur in laboratories. If this is not part of their remit or they do not have the necessary capabilities, they must report the defects to the proprietor or their superior immediately.

Only qualified personnel are allowed to repair electrical equipment.

Safety facilities

It is particularly important that safety facilities do not have any defects. Examples of such defects or hazardous conditions include inaccessible fire extinguishers, blocked emergency showers and eye-wash units, defective flow monitoring devices on fume hoods, defective electrical plug and socket devices and unsecured compressed-gas cylinders.

See Art. 16 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.3.5 Monitoring and safeguards

Monitoring ongoing experiments

Unless there is an emergency, insured persons may only leave their workstation if permanent monitoring of their experiments is not necessary or if another insured person with the necessary knowledge and capabilities is available to take over. Experiments that cannot be interrupted at the end of normal working hours may only be performed without continuous supervision if they cannot be timed so as to avoid this and if appropriate protective measures are taken to reliably prevent the occurrence of hazardous situations.

"Night laboratories"

With many experiments, it is necessary to be able to take rapid action against hazards that become apparent such as reactions out of control or malfunctions. Where this cannot be done by one person, it has proved acceptable to carry out such experiments in specially protected rooms ("night laboratories") with an automatic early-warning system or a device to limit the amount of damage.

Safeguarding media and utilities

Safeguards include closing the valves of pipes conveying media such as gas, water and vapor. If possible, main valves should also be closed, master switches should be switched off and the mains plugs of devices that could cause a fire should be pulled out.

4.3.6 Effectiveness of protective measures

Checking the effectiveness of protective measures

The effectiveness of protective measures can be assessed based on the specifications of TRGS 500 "Schutzmaßnahmen" and TRGS 402 "Ermitteln und Beurteilen der Konzentration gefährlicher Stoffe in der Luft in Arbeitsbereichen". Technical equipment in laboratories is normally deemed to be effective if it passes the regular safety inspections. It may be necessary to assess exposure to hazardous materials in specific cases where working conditions differ from normal laboratory practices, for example exceeding the limits on quantities specified in Section 3.3.3 or using equipment, apparatus or laboratory facilities in a way that does not constitute normal operation.

If, by way of exception, fume hoods need to be operated with the sash open for a particular procedure, a separate assessment is required.

If effectiveness cannot be evaluated using other methods, appropriate measuring procedures should be used. Given that no limit values or measuring procedures are available for many hazardous materials in laboratories, measurement and evaluation based on indicator components is recommended.

4.3.7 Two-way information

Taking people in the vicinity into account

Before performing hazardous activities, it is particularly important to notify insured persons working in the immediate vicinity of the specific hazards and protective measures. This applies in particular if several people are using a fume hood at the same time.

Maintenance work

The content of maintenance work is to be agreed in good time so that it can be carried out safely without any obstacles. This relates, for example, to maintenance work on fume hoods and emergency showers.

4.3.8 Notifying superiors of damage to health

Reporting and duty of disclosure

In the event of disorders such as skin irritations and rashes, the proprietor or his authorized representative is to be informed if it is suspected that this could be caused by hazardous materials at the workplace. The duty of disclosure as detailed in Section 4.22 must be complied with.

4.3.9 Emergency measures

Emergency measures, escape and rescue plan

Emergency measures are to be established for faults, accidents and emergencies, in particular an escape and rescue plan and an alarm plan for fires. In such cases, only those persons required to restore the normal operation conditions are allowed to stay in the relevant areas. All other persons must leave immediately. The necessary measures are to be taken to eliminate hazards for people working in these areas, in particular special apparatus, safety devices and personal protective equipment. The proprietor must set up the warning and other communication systems required to indicate an elevated risk to health and safety so that appropriate action can be taken. Appropriate safety drills are to be performed at regular intervals so that it can be assumed the system works effectively in case of emergencies. Fire safety regulations complying with the relevant country's legislation are to be compiled.

Emergency services and fire department

These details can be given to the accident and emergency services, such as the fire department, or kept available at a suitable location for immediate information. It must be possible to take the necessary remedial and safety measures in a timely manner.

An example of an escape and rescue plan is provided in Annex 1 and in (3). The plan must be displayed at a clearly visible, central location.

See also Art. 22 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.4 Clothing and footwear

4.4.1 Work clothes and protective clothing

Obtaining lab clothes and their properties

Appropriate work clothes and protective clothing are to be worn when working in laboratories. This normally consists of a long lab coat with long, close-fitting sleeves and a cotton content of at least 35 %. The proprietor must provide such clothing to insured persons employed as defined in Art. 2 of the ArbSchG.

Street clothes alone are not suitable for a laboratory setting because they do not provide adequate protection when carrying out laboratory work. Adequate protection is offered by a laboratory coat (also called a lab coat) with close-fitting sleeves that falls below the knees and covers the lower arms. The coat must have snap fasteners and be made of a fabric that contains at least 35% cotton during its entire service life or be made of a special flame-retardant fabric.

It may be necessary to wear clothing with long sleeves and legs underneath the laboratory coat.

Laboratory coats must be worn fully snapped at all times. In the event of an incident, the fabric of the coat should be able to hold back splashes of hazardous substances for the length of time required to prevent or greatly reduce contact with the skin by the immediate removal of the coat. Should a person's coat catch fire, the immediate removal of the coat (snap fasteners!) can often keep the fire from spreading to their clothing.

When leaving the laboratory, the laboratory coat must remain in the laboratory area. This minimizes the potential of spreading contamination to other areas (see Section 4.6.1) and facilitates movement between different work areas.

The laboratory coat protects street clothes from contamination when working with hazardous substances. Street clothes are often made with a high fraction of synthetic fibres. The cotton content of the laboratory coat reduces the unfavourable properties of synthetic fabrics in terms of fire resistance and wettability. All clothing worn in the laboratory (besides the laboratory coat) should be made of fabrics that would not pose an increased risk to the insured person in the event of fire through their combustion and melting properties. This is compulsory for accessories such as shawls, scarfs and other items of clothing. Furthermore, these may only be worn close to the body and in such a way that they can be removed quickly.

Should the work clothes of other persons temporarily working in the laboratory, such as skilled workers or service technicians, be at risk of being contaminated with hazardous substances, these persons should also wear a laboratory coat over their work clothes. It is important to prevent the spread of contamination.

For protective clothing see Section 4.5.5. See also DGUV Rules 112-189/112-989 "Benutzung von Schutzkleidung" (Use of protective clothing).

For activities involving biological agents and in the case of a risk of infection, please refer to the technical rules for biological agents "Protective measures for activities involving biological agents in laboratories" (TRBA 100) and DGUV Information 213-086 "Sichere Biotechnologie – Biologische Laboratorien – Ausstattung und organisatorische Maßnahmen". For activing teratogenic substances, please refer to the information leaflet published by the German Social Accident Insurance Institution for the raw materials and chemical industry (BG RCI): Merkblatt M 039 "Fruchtschädigende Stoffe – Informationen für Mitarbeiterinnen und betriebliche Führungskräfte" (Teratogenic substances – information for employees and managers).

4.4.2 Footwear

Requirements relating to shoes

Only sturdy, closed and slip-proof footwear may be worn in laboratories.

This normally means closed street shoes or lab shoes (Fig. 2). In addition to ensuring a secure fit and preventing slipping, such shoes also protect against any hazardous materials that may drip or fall.

Fig. 2: Lab shoes

4.5 Personal protective equipment

4.5.1 General

Obtaining and using personal protective equipment

The proprietor must provide insured persons with sufficient and appropriate personal protective equipment for the work they perform, having consulted them beforehand. Insured persons must use this personal protective equipment as stipulated.

4.5.2 Eye protection

Obligation to wear safety glasses

The proprietor must ensure that all persons in the laboratory always wear framed glasses with adequate side protection.

As an exception to this rule, no eye protection is required if hazards to eyes can be ruled out permanently based on the processes and activities performed. This is to be documented in the hazard assessment.

When performing work involving particular hazards to the eyes, other suitable eye protection equipment must also be worn.

Additional eye protection measures

If filling liquids is likely to be hazardous, goggles must be worn. If there is a risk of caustic burns when opening containers, a visor and hand protection must be worn in addition to the safety glasses/goggles.

Framed glasses with side protection (framed safety glasses) and additional protection for the area above the eyes have proved very effective. Other eye protection devices include goggles. For further protection against splashes visors may be necessary together with framed safety glasses or goggles under them. There are safety glasses with corrective lenses for people who wear glasses.

See also the DGUV Regeln 112-192/112-992 "Benutzung von Augen- und Gesichtsschutz".

A danger of caustic burns exists, for example, when opening bulging containers, closures that are stuck or laboratory storage bottles for daily use. Built-up pressure may cause harmful compounds (the original substance, decomposition, oxidation or hydrolysis products) to leak out. It is also good practice to wear appropriate protective gloves and clothing.

See the DGUV Regeln 112-192/112-992 "Benutzung von Augen- und Gesichtsschutz", 112-195 /112-995 "Benutzung von Schutzhandschuhen" and 112-189/112-989 "Benutzung von Schutzkleidung".

Respiratory devices may be required in particular cases.

See the DGUV Regel 112-190 "Benutzung von Atemschutzgeräten" and the DGUV Information 213-070 "Reizende Stoffe/Ätzende Stoffe". Framed safety glasses are normally adequate when the hazard is low, for example when filling from laboratory storage bottles for daily use.

Fig. 3: Storage box for safety glasses for visitors at the entrance to a laboratory area; glasses are cleaned after use and kept in plastic bags

4.5.3 Hand protection

Selection and use of protective gloves

When performing work associated with particular hazards for the hands, suitable protective gloves must be worn. These must be selected in accordance with their intended use and checked for damage each time they are worn. Damaged gloves or gloves that have become unusable in some other way are to be replaced immediately. For the selection of appropriate protective gloves and skincare products, see Section 7 of TRGS 401.

Penetration of glove material

Many hazardous materials can diffuse into the glove material, sometimes astonishingly quickly. Protective gloves should therefore be selected in line with the manufacturer's indications on resistance. Protective gloves for laboratory use should normally only offer protection against brief contact through splashes. If lengthier contact is unavoidable or if work involves hazardous materials that penetrate the glove material very quickly, particular attention must be paid to glove selection. In such cases, it is advisable to obtain written confirmation from the manufacturer that gloves are suitable for the intended use. For example, substances such as dimethyl mercury or acetone penetrate a number of glove materials very quickly (within seconds in the case of some materials).

Problems associated with wearing gloves

Wearing gloves frequently and for long periods is bad for the skin and can lead to skin disorders. Unnecessary wearing is not permitted.

See also (12), (13) and the details on preventive occupational health care in Section 4.7.2.

In view of the risk of allergic reactions to latex, powdered or protein-rich latex gloves may not be worn.

See TRGS 401 "Gefährdung durch Hautkontakt – Ermittlung, Beurteilung, Maßnahmen". In the 2008 version, the relevant section is 6.4 rather than 7.

Spreading of contamination

Care should be taken not to spread contamination. For example, light switches, door knobs, taps on wash basins, telephone receivers, keyboards and writing implements should not be touched with used gloves.

See the DGUV Regeln 112-195/112-995 "Benutzung von Schutzhandschuhen" and BG RCI Merkblatt A 023 "Hand- und Hautschutz" plus the DGUV Information 212-007 "Chemikalienschutzhandschuhe".

In many cases, details on protective gloves can be found on manufacturers' websites.

4.5.4 Respiratory devices

Use of respiratory devices in the lab

If hazardous materials can occur in dangerous concentrations, appropriate respiratory devices must be provided. If there is a possibility that workplace limits for hazardous materials may be exceeded, respiratory devices must be used. Laboratory procedures should be designed so that respiratory devices do not normally need to be used. If they are unavoidable in particular cases, not only the exposure of directly insured persons should be considered, but also possible exposure of other insured persons, for example at adjacent workstations. Wearing respiratory devices must not be a permanent measure and must not be allowed to replace technical and organization protective measures.

Respiratory devices for emergencies

Dangerous concentrations of hazardous materials can occur unexpectedly, for example if hazardous materials are spilt. When working with highly toxic gases, it may be necessary to:

- carry escape respirators (such as air-filtering escape respirators)
- place a sufficient number of escape respirators near hazardous locations
- use respiratory devices.

See the DGUV Regel 112-190 "Benutzung von Atemschutzgeräten".

4.5.5 Protective clothing

Selection and use of protective clothing

The proprietor must provide insured persons with suitable clothing for the respective activity and insured persons must wear this clothing.

Appropriate protective clothing for an elevated fire hazard is made, for example, of flame-resistant fabrics or cotton that is sufficiently flame-resistant. Garments worn underneath protective clothing should be made of textiles that do not melt (see also Section 4.4.1). PVC-coated fabric is one example of a suitable protective clothing material for work involving large quantities of caustic liquids.

For details on the protective clothing to be worn in medical laboratories, see the Technische Regeln für Biologische Arbeitsstoffe "Schutzmaßnahmen für Tätigkeiten mit biologischen Arbeitsstoffen in Laboratorien" (TRBA 100) and "Biologische Arbeitsstoffe im Gesundheitswesen und in der Wohlfahrtspflege" (TRBA 250). As regards the obligation to wear protective clothing, see Art. 15 para. 2 of the Arbeitsschutzgesetz.

4.6 Hygiene

4.6.1 General measures

Hygiene measures and avoiding contamination

Appropriate hygiene measures are to be taken. Workplaces must be kept free of contamination and cleaned on a regular basis.

Chemical contamination that is not removed represents a hazard through unintentional contact and inadvertent incorporation. In addition, there is a risk of slipping in puddles of water or oil residue. Special chemical binders quickly soak up puddles. If wearing gloves, care should be taken not to spread contamination inadvertently in the laboratory, for example on the sashes of fume hoods, telephone receivers, keyboards, door knobs, fittings and writing implements.

Work clothing may not be worn in clean areas such as office or conference rooms, libraries, seminar rooms, break rooms, staff kitchens, canteens or cafeterias.

Hair

Long hair and beards that pose a potential hazard, for example through contamination and thermal or mechanical effects, have to be secured tightly (tied back, pinned up, hair nets, head scarves, etc.). The head coverings themselves may not pose a potential hazard.

4.6.2 Food, beverages and cosmetics

Bans on food, beverages and cosmetics

No food or beverages may be taken into laboratories where work involves hazardous materials, nor should cosmetics be used. Appropriate staff areas must be provided for storing and consuming food and beverages.

No containers that are normally intended for food or beverages should be used for chemicals. Food and beverages must not be kept in the same location as chemicals.

Food and beverages must not be prepared or kept in chemical or laboratory containers. They should only be heated using the equipment intended for this purpose. Only designated refrigerators that are labelled accordingly should be used to keep food and beverages cool.

See Art. 8 para. 5 of the Gefahrstoffverordnung.

For activities with biological agents, see the Technische Regeln für Biologische Arbeitsstoffe "Schutzmaßnahmen für Tätigkeiten mit biologischen Arbeitsstoffen in Laboratorien" (TRBA 100).

4.6.3 Skin protection

Skin protection and skincare measures

The proprietor must prepare skin protection plans and insured persons must follow them.

Hands may also be exposed to hazards during cleaning work. Organic solvents must not be used to clean the hands or skin. Abrasive skin cleaners (such as scrubs) should only be used if the level of soiling makes this absolutely necessary. Appropriate liquid soaps and skin protection products must be provided. In particular if hands are washed frequently or gloves are worn for lengthy periods, skin can be damaged over the long term, but it is possible to prevent this by taking appropriate skin protection and skin care measures. A sample of a hand and skin protection plan explaining the use of the various skin protection materials can be found in Annex 2 and in (3). Skin cleaning, skin care and skin protection products may also be used in the laboratory.

4.6.4 Storing work clothes and protective clothing

Spreading contamination via clothing

If work involves a risk of contamination, the proprietor is obliged to provide separate storage facilities for work clothes/protective clothing and street clothes.

One possible method for keeping the areas separate is to store laboratory coats or protective clothing in a suitable place in the entrance area to the laboratories. Lockers with divided or variably arranged compartments have proven to be effective.

Work clothing that is assumed to have been or has clearly been contaminated with hazardous substances should immediately be removed for dry cleaning. Collection bins are to be set up for this purpose.

4.6.5 Cleaning work clothes and protective clothing

Cleaning and disposing of clothing

Work clothes and protective clothing worn during activities involving hazardous materials must be cleaned by the proprietor. If necessary, they are to be disposed of in accordance with regulations and replaced by the proprietor.

Work clothes which are contaminated with hazardous substances should not be taken home.

Legislation of the German federal states govern how costs are covered at state universities.

See also TRGS 500 "Schutzmaßnahmen", No. 6.4, 9.1.4 and 9.1.5.

4.6.6 Respiratory device hygiene

Maintenance, inspection and hygiene

The proprietor must take appropriate measures to ensure that respiratory devices work properly and are subject to good hygiene conditions.

Facepieces that are in use must be regularly cleaned, disinfected and checked to ensure they are in good working order. Maintenance intervals are set according to the working conditions, the instructions in the manufacturer's user manual or the DGUV Regel 112-190 "Benutzung von Atemschutzgeräten". If circumstances demand that respiratory devices are worn by a number of people in succession, the proprietor must ensure that they are cleaned, disinfected and inspected each time they are used by a different person.

See also the DGUV Regel 112-190 "Benutzung von Atemschutzgeräten".

4.7 First aid and occupational medicine

4.7.1 First aid

4.7.1.1 General

Defining measures

First aid measures must cover all possible injuries and damage to health in laboratories. In-house and external accident and emergency services must be provided with details of the emergency measures relating to the hazardous materials in the laboratory. Appropriate information must be provided in advance to these services to enable them to prepare the relevant measures.

Effectiveness of the rescue chain

It must be ensured that the entire rescue chain works efficiently. The necessary information must be available on site together with effective first aid, and further on appropriate care must be provided quickly at the hospital. Besides the relevant details (including information on treatment), this may also include antidotes. In addition, the procedure to follow should be agreed with any hospital that may be required to treat insured persons before the relevant work starts so that they also have the necessary information on the hazards involved, on measures to identify hazards, and on safety precautions. One of the works doctor's fundamental tasks is to help organize first aid at the company. Any delay or, worse still, mistake with treatment represents an acute risk to life and limb for accident victims.

It has proved effective to provide first aiders with additional training geared towards specific laboratory requirements. First aid facilities should be planned together with the works doctor.

Fig. 4: First aid equipment at a central location

Possible injuries include caustic burns to the eyes and skin, cuts, burns and scalding.

See also Art. 4 and Chapter 4, section 3 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.7.1.2 Obligation to provide information

First-aid notices

The proprietor must display first aid instructions approved by the statutory accident insurance companies. These must be appropriate for the relevant hazards and be displayed at suitable locations. The notices must at least include details on the number(s) to call in the event of an emergency, the first aid equipment available and the names of first-aiders, a doctor and the designated hospital. These details should be kept up-to-date. See, for example, DGUV Informationen 204-006 and 204-022.

See also the DGUV Informationen 204-006 "Anleitung zur Ersten Hilfe" and 204-001 "Erste Hilfe (Plakat, DIN A2)".

4.7.1.3 First aid equipment

Materials, equipment and antidotes

Appropriate first aid equipment must be provided. The proprietor must ensure that sufficient dressings and the necessary equipment are kept in first aid boxes or cabinets. In the case of work with highly toxic and toxic materials, antidotes to possible poisoning are also kept in first aid boxes or cabinets if they can be used for first aid measures without the involvement of a doctor. Items that are for use by a doctor only must be

stored separately under lock and key. First-aiders are to be provided with basic and advanced training appropriate to the hazards at the company.

For details on the contents of first aid boxes, see the DGUV Information 204-022 "Erste Hilfe im Betrieb".

Antidotes or products limiting the effects of exposure must be provided in consultation with the works doctor if work involves hazardous chemicals such as hydrofluoric acid, hydrocyanic acid and phenol or substances that are caustic to or irritate the respiratory tract.

See also BG RCI Merkblätter of the M-series and chapter "Erste Hilfe" from GisChem and chapter "Occupational health and first aid" from GESTIS.

4.7.1.4 Measures

Decontamination of persons

The parts of the body that came into contact with hazardous materials have to be washed immediately and thoroughly with water and, if appropriate, soap. Under no circumstances should solvents or other hazardous materials be used for this purpose. Items of clothing contaminated with hazardous materials, including undergarments, tights and shoes, must be removed immediately. Contaminated items of clothing should be dealt with so as not to put anyone else at risk.

If persons were contaminated with or if they incorporated substances that are harmful to health or if this is suspected to be the case, they are to be taken to the doctor straight away. The person's superior must always be notified immediately.

If a large area of the skin came in contact, immediate and thorough use of the emergency shower is advisable. It may help to use polyethylene glycol (Lutrol®, for instance) to remove water-insoluble, viscous or fatty hazardous materials from the skin.

The doctor must be informed about the type of effect the material has. This can be done, for example, over the phone, by sending a note with the person affected or by having an expert accompany this person. It can be a good idea to transport the person lying down. After inhaling substances such as ammonia, chlorine, nitrous gases or phosgene, even persons who appear to be capable of walking should be transported lying down because of possible subsequent effects.

If appropriate, items of clothing should be subjected to preliminary cleaning or disposed of.

See Section 6.6.

4.7.2 Occupational medicine

Preventive medical examinations and other measures relating to occupational medicine

The proprietor must ensure that preventive occupational medical examinations are performed regularly if:

1. **The limit for the workplace is exceeded when working with the hazardous materials referred to in Annex V point 1 of the GefStoffV.**
2. **Work involves the hazardous materials referred to in Annex V point 1 of the GefStoffV, if they can be absorbed by the skin and if they are hazardous when they get in contact with the skin.**
3. **Work referred to in Annex V point 2.1 of the GefStoffV is being performed.**

The preventive occupational medical examination referred to above is a prerequisite if the employee in question is to perform or continue to perform the relevant work.

The proprietor must offer insured persons preventive occupational medical examinations:

1. **For all work involving exposure to the hazardous materials referred to in Annex V point 1 GefStoffV.**
2. **For the work listed in Annex V point 2.2 of the GefStoffV.**

The follow-up examinations referred to in Art. 15 para. 2 clause 1(4) of the GefStoffV are to be offered if work involves exposure to carcinogenic or mutagenic materials and category 1 or 2 preparations.

If insured persons have contracted an illness that can be traced back to work with hazardous materials, they must immediately be offered preventive occupational medical examinations as referred to in Art. 15 para. 2 clause 1(5) of the GefStoffV. This also applies to insured persons involved in comparable activities if there is cause to suggest that they may also be at risk.

Biomonitoring

Biomonitoring shall form part of the preventive occupational medical examinations provided there are appropriate recognized procedures and values for assessment purposes, in particular biological limit values.

Occupational medical/ toxicological advice

The proprietor must ensure that insured persons are provided with occupational medical/toxicological advice as stipulated in Art. 15 para. 3 of the GefStoffV. They must be informed of the preventive medical examinations available and of the specific health risks that apply. This should form part of the annual instruction referred to in Art. 14 para. 2 of the GefStoffV.

The doctor performing the preventive medical examinations, as referred to in Art. 15 para. 3 of the GefStoffV, must be given all the necessary details on conditions at the workplace, in particular the results of the hazard assessment, and is allowed to inspect the workplaces. If the doctor so requests, he must also be given access to the directory referred to in Art. 14 para. 4 point 3 of the GefStoffV.

The contents of Art. 15 para. 3 have been incorporated in Art. 14 para. 2 of the GefStoffV 2010. Furthermore, the regulations on occupational medicine from the GefStoffV (Arts. 15, 16 and Appendix V) have been incorporated in the Verordnung zur arbeitsmedizinischen Vorsorge (ArbMedVV).

Preventive occupational health care may also be required, for example, if wet work – including wearing gloves for long periods – poses a hazard to the skin.

Rules, regulations and information on occupational medicine are drawn up by the Ausschuss für Arbeitsmedizin.

In addition to its advisory function, preventive occupational health care includes mandatory health care, optional health care and elective health care. The obligation to ensure that preventive measures relating to occupational medicine are taken and the obligation to provide information and documentation are regulated by Art. 14 of the Gefahrstoffverordnung and the Verordnung zur arbeitsmedizinischen Vorsorge. There is no obligation to perform preventive occupational health care for low-risk activities. The measures referred to in Art. 8 of the Gefahrstoffverordnung are sufficient in such cases.

4.8 Fire protection

4.8.1 Fire extinguishing facilities

Equipping with fire extinguishers

The proprietor must provide fire extinguishing equipment in laboratories. The only circumstances under which additional fire extinguishers as referred to in the Arbeitsstättenverordnung and ASR 13/1,2 are not required in the laboratory are if no materials that fall under one of the following risk phrases are used: "May cause fire", "Contact with combustible material may cause fire", " Explosive if mixed with combustible material", "Flammable", "Highly flammable", "Extremely flammable", "Contact with water liberates extremely flammable gases" and "Spontaneously flammable in air". This must be documented in the hazard assessment. The locations of fire extinguishing equipment should be marked by fire-

fighting sign F04 “Feuerlöschgerät” [fire extinguisher]. Easy access to fire extinguishing equipment must be ensured at all times.

ASR 13/1,2 has been replaced by “Maßnahmen gegen Brände” (ASR A2.2).

See also Section 4.9.1.

Marking the floor area below extinguishing equipment, for example with yellow and black stripes, has proved effective.

Selection of extinguishing agents

Selecting the right extinguishing agent is vital for effective fire-fighting in laboratories. This depends on the type and properties of burning substances. DIN EN 2 “Brandklassen” and DIN EN 3-7 “Tragbare Feuerlöscher – Teil 7: Eigenschaften, Leistungsanforderungen und Prüfungen” should be complied with. Portable fire extinguishers must be provided in laboratories to fight fires. See also the ASR A2.2 “Maßnahmen gegen Brände”. It can be advantageous to use special extinguishing agents such as perfluorinated alkyl compounds in laboratories with fixed fire-fighting installations because these agents have only a low tendency to react with the chemicals in the laboratory and because it is possible to breath properly in the area flooded with these extinguishing agents and because they are sufficiently environmentally friendly.

It may also be necessary to provide extinguishing sand, special extinguishing agents, fire blankets and items to smother the fire. In most cases, carbon dioxide extinguishers are sufficient for fighting fires in laboratories. They do not leave any residue behind and therefore do not soil the room. They do not cause any damage to sensitive equipment, are chemically indifferent to a large extent and can also be used for electrical equipment.

Under no circumstances fires involving alkaline metals, metal alkyls, lithium aluminum hydride, silanes or similar substances may be tackled with water or foam extinguishers. A suitable extinguishing agent for a sodium fire, for instance, is extinguishing sand or metal fire powder. Carbon dioxide or extinguishing powder should be used for flammable liquids, and carbon dioxide should be used for live electrical equipment.

See also the ASR A2.2 “Maßnahmen gegen Brände” and ASR A1.3 “Sicherheits- und Gesundheitsschutzkennzeichnung” (renumbered signs: F04 “Feuerlöschgerät” [fire extinguisher] is now F003 “Löschschlauch” [extinguishing hose], F005 “Feuerlöscher” [fire extinguisher] and F007 “Mittel und Geräte zur Brandbekämpfung” [fire-fighting agents and equipment]).

4.8.2 Extinguishing drills

Operating fire extinguishers

Insured persons should be familiarized with the operation of the extinguishers in regularly repeated instruction sessions and practical drills.

See Art. 22 para. 2 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

Extinguishing agent manufacturers, fire departments and a number of service providers often offer instruction of this kind.

4.8.3 Conduct in the event of a fire

Fire-fighting and fire department operations

The fire department must be called immediately in the event of a fire. On arrival, fire department staff should be briefed by well-informed persons who are familiar with the site. Until the fire department arrives, the fire extinguishers available are used to tackle the fire in its initial stages – provided this is possible without putting anyone at risk. Anyone not required for extinguishing or rescue work must leave the danger zone and go to the designated assembly point.

It is important to check that everyone from the area affected by the fire is at the assembly point. Fire drills are to be performed and rules must be established for checking the evacuation procedure.

4.8.4 Fire-fighting

What to do if a person catches fire

Fires on clothing should be put out using fire extinguishers or emergency showers. In the event of a fire, the extinguisher that can be reached quickest should be used.

Fire blankets alone are not sufficient if a person catches fire, but tackling the fire immediately must always take top priority as the number one life-saving measure. Foam, powder and carbon dioxide extinguishers, for example, have proved effective in this respect. Any concerns regarding cold burns or asphyxiation of the person on whom extinguishing attempts are focused and the fear of those fighting the fire that they are putting themselves at risk are of secondary importance. The fact that anyone who catches fire will naturally tend to panic should be taken into account for all extinguishing measures.

Regular instruction sessions and drills on operating fire extinguishing equipment to tackle fires in their initial stages must be performed regularly.

See also Art. 22 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.8.5 Compressed-gas cylinders in the event of a fire

Fires involving gases

Fires involving liquefied and compressed gases from compressed-gas cylinders are normally extinguished by closing the cylinder valves (cutting off the gas supply). If this immediate measure cannot be implemented without risk (for example, with fires near the cylinder valves), the fire must be tackled with powder or carbon dioxide fire extinguishers so that the cylinder valves can be closed as soon as the fire has been put out.

Cylinders that have been heated by a fire can be cooled with water from a protected location. With very hot cylinders (evident from the vaporizing water), the area must be evacuated immediately due to the risk of explosion. Compressed-gas cylinders that have been exposed to a fire must be taken out of service, labelled appropriately and sent to the filling company.

4.9 Storage and availability of hazardous materials

4.9.1 General specifications

Safe storage

Hazardous materials must be kept/stored so that they do not pose a risk to human health or the environment. Hazardous materials may only be kept in containers made from materials that can withstand the stresses to be expected, and the contents must be indicated on these containers. Hazardous materials must be stored in such a way that no hazardous reactions are possible if the containers are damaged.

Marking of containers

In laboratories, laboratory storage bottles containing hazardous materials in the quantities needed for daily use must be marked at least with the designation of the material/preparation and the preparation's ingredients, together with the hazard symbols and the associated hazard designations. The safety measures to be observed must also be indicated. If the details relating to risks and the safety measures to be observed can be obtained directly from the relevant operating instructions and the material safety data sheet, it is sufficient to mark the name of the material or preparation along with the hazard symbol and associated hazard designation.

Hazardous materials in containers which give off vapors that are corrosive or harmful to health must be kept at locations with extraction systems in continuous operation.

Not all laboratory chemicals are necessarily hazardous materials, but it is advisable to take such chemicals into consideration too.

Storage bottles for daily use

Storage bottles for daily use do not normally have a nominal volume greater than 1 l. Stocks of chemicals at the workplace should be kept as low as possible. It is necessary to provide a designation with a generally applicable, unambiguous nomenclature. Additional details such as the date when the container was first opened are also useful. Abbreviations may not be used as the sole indication of contents. It must be possible to identify hazards emanating from apparatus and pipes as a result of hazardous materials.

The labelling of containers of hazardous materials has been revised with the CLP directive. It is already compulsory to market pure materials with the new labelling, and this will also be the case for mixtures in 2015 at the latest. The Gefahrstoffverordnung permits the continued use of the old labelling system (black symbols on an orange background with hazard characteristics) for containers used internally in the laboratory, however here too, the new system shall preferably be applied. Simplified labelling is still possible in laboratories. A proven method is to label laboratory containers with pragmatic but informative labelling that reminds the user of the known necessary protective measures to be taken immediately before use. Therefore, alongside the substance designation, the labelling includes (selected) pictograms and hazard acronyms. Annex 4 contains detailed information on this. Please also refer to http://www.guidelinesforlaboratories.de and http://www.einfachelaborkennzeichnung.de. If applicable, you may also have to consult the operating instructions and safety data sheet.

See Art. 8 of the Gefahrstoffverordnung and Section 9.2 of the Technische Regeln für Gefahrstoffe "Einstufung und Kennzeichnung von Stoffen, Zubereitungen und Erzeugnissen" (TRGS 200).

Container sizes

Purchasing laboratory chemicals in ready-to-use container sizes has proved to be an effective solution. The initially higher purchasing costs are normally offset by the savings made in particular through the need for less storage space, reduced disposal costs and a lower hazard potential posed by small containers.

Storing chemicals together

Storing chemicals together may not result in any additional hazards. It is advisable to prepare a manual with details on how to store items together.

See also Art. 11 of the Gefahrstoffverordnung, TRGS 510 "Lagern von Gefahrstoffen in ortsbeweglichen Behältern".

Properties of containers

There may be a hazardous reaction between containers and their contents. For this reason, aluminum containers must not be used for materials and preparations containing chlorinated hydrocarbons, glass containers must not be used for materials/preparations containing hydrofluoric acid, etc.

Note that there is a risk of brittleness (for example, due to the loss of plasticizers or the action of the sun), diffusion and deformation when storing chemicals in plastic containers. The date of manufacture is normally indicated on the base. If a cracking sound is heard when handling containers, it is a clear sign that their service life has been exceeded.

Laboratory storage bottles made of glass with a plastic coating have proved an effective option.

Certain chemicals need to be stored in bottles protected against the light to prevent light-induced hazardous reactions. If bottle contents can generate overpressure (for example, due to the emitting of gases out of solids or the decomposition of solids to gases), pressure relief should be ensured.

One example of an additional safeguard against hazardous reactions generated if bottles break involves putting bottles in non-breakable, resistant outer containers. This applies, for example, to concentrated perchloric acid and nitric acid.

Other container-related hazards

It is advisable to use cabinets – with corrosion-resistant pans – that are connected to the ventilation system. Containers that give off corrosive vapors may not be kept in safety cabinets for flammable liquids. Fume hoods may not be used to store hazardous materials. In the event of an accident, chemicals stored in fume hoods can create a significant additional hazard. Acidbottles with caps are not a suitable alternative. It should be noted that the ground joints of these bottles, like those of pipette bottles with ground-in pipettes, jam very easily and lead to a high hazard through breakage.

4.9.2 Setting down safely

Setting down and removing containers

Containers with hazardous materials in them may only be stored on shelves, in cabinets and in other facilities up to a height at which they can be set down and removed safely.

Spontaneously flammable materials

Materials that are spontaneously flammable at room temperature due to the effects of air or moisture must be kept separately from other explosive, oxidizing, highly inflammable, easily inflammable and in-

flammable substances and safe from the possible transmission of fire. If they are needed on an ongoing basis, limited quantities necessary for the immediate continuation of work may be kept at the workplace during working hours.

As a rule, containers that need to be carried with both hands cannot be set down or removed safely above reaching height (approx. 175 cm). The associated hazard of dropping the containers is exacerbated by the possibility of containers holding hazardous materials breaking or leaking.

See "Kleine ergonomische Datensammlung" by the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin [Federal Institute for Occupational Safety and Health].

Materials that are spontaneously flammable at room temperature under the action of air or moisture include aluminum alkyls, lithium aluminum hydride, white phosphorus and pyrophoric metals.

4.9.3 Access

Prevention of misuse

Precautions must be taken against misuse or incorrect use of hazardous materials. Highly toxic and toxic materials and preparations must be kept under lock and key or stored where only instructed persons or those with the necessary expertise have access to them. Repair and cleaning staff must be instructed about the hazards and protective measures before working in the relevant areas and are to be supervised as appropriate. The proprietor must ensure that materials subject to the Betäubungsmittelgesetz [Narcotics Act] are kept under lock and key. Access to narcotics is only possible via the responsible person.

Access arrangements and protection plan

It is advisable to establish appropriate access arrangements. Unauthorized persons may not enter the rooms and additional marking of access points with an appropriate notice is recommended. If appropriate access restrictions are not possible, these materials must be kept in lockable cabinets. The regulations contained in transport legislation also apply to activities with materials and preparations, radioactive substances and biological agents before or after transport operations. For example, there must be a protection plan in place for a number of these materials in accordance with the ADR (14) and appropriate measures must be taken to protect against unauthorized access. There are also particular obligations associated with the regulations on the monitoring of base materials.

See the Betäubungsmittelgesetz (BtMG), the Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB), Grundstoffüberwa-

chungsgesetz (GÜG) and the Ausführungsgesetz zum Chemiewaffenübereinkommen (CWÜAG).

See also the DGUV Information 213-052 "Beförderung gefährlicher Güter".

4.9.4 Inventory checking

Checking hazardous materials and their containers

The proprietor must ensure that all hazardous materials and preparations kept in the laboratory are checked at least once a year to ensure that they are in good condition. Hazardous materials that are no longer required or have become unusable must be disposed of appropriately.

Hazardous materials can undergo dangerous changes during storage. For example, even limited contact with air can cause many organic liquids to form explosive peroxides when left standing. This also happens in closed bottles, sometimes even in the dark.

Alkaline metals and alkaline metal amides are covered by highly reactive layers that can lead to explosions when handled.

Chemicals/preparations in containers that are no longer in an acceptable condition cannot be stored safely. They must be disposed of or – if possible – transferred to suitable containers.

See also Section 4.16.2.

4.10 Transferring and transporting hazardous materials

4.10.1 Transfer

Protective measures during transfer

Transferring or transporting hazardous materials can give rise to hazards resulting from gases, vapors, suspended matter or splashes, or to quantities of these materials being released. Transferring or transporting large quantities can be particularly hazardous. Suitable devices are to be used when transferring hazardous materials from barrels, carboys, canisters or other containers.

When filling into narrow-necked vessels, funnels should be used and care is to be taken that air can escape freely whilst pouring. For example, a glass hook can be suspended between the funnel and the open-

ing so that no bubbles are pressed up out of the funnel. Funnels made from plastic or glass with a molded core that can be inserted directly into a ground glass socket have proven effective for solids.

Suitable devices include pumps, carboy inclinators, safety siphons and self-closing valves. They prevent splashing or spillage of hazardous materials resulting from the difficulty in controlling initial tipping. Containers in barrel or carboy inclinators must be secured so that they do not slide out during tipping. For measures to guard against electrostatic charging, see Section 4.12.2.

See also Sections 4.12.2 and 5.2.4.

See also BG RCI Merkblatt T 025 "Umfüllen von Flüssigkeiten – vom Kleingebinde bis zum Container".

4.10.2 Emptying at overpressure

Requirements relating to containers and gases

Only inert gases may be used to produce the overpressure when filling flammable liquids. Barrels and cans for liquids may only be emptied at an overpressure of up to 0.2 bar if they are not specified as being suitable for higher pressures. The barrel or can must be suitable for the intended pressure and be in perfect condition. If overpressure is used, the pressure line must be equipped with a pressure gage and a safety valve or some other device to limit the pressure.

Gases deemed to be inert for this purpose include nitrogen, carbon dioxide and the rare gases.

See also Sections 4.12.2 and 5.2.4.

4.10.3 Transport

Transport aids

Breakable containers must be supported at the base when they are being carried. Such containers may only be transported into other rooms using aids that ensure safe holding and carrying.

Containers taken out of cooling appliances or cold rooms may be very slippery due to condensation.

Tensions or other defects in glass containers may result in the neck breaking off.

Fig. 5: Bucket for transporting bottles

Transport aids include buckets (Fig. 5), carrier boxes or trolleys, preferably equipped with pans.

Hazardous materials in elevators

Volatile hazardous materials may not be transported with people in elevators. Such materials include solvents and cryogenic liquefied gases.

4.11 Release of gases, vapors or suspended matter

4.11.1 Work in fume hoods

Use of fume hoods

Work during which gases, vapors or suspended matter may be generated in hazardous concentrations or quantities may only be performed in fume hoods. Sashes are to be kept closed during such work.

Work during which gases, vapors or suspended matter may be generated in hazardous concentrations or quantities may only be performed outside fume hoods if it is ensured by means of appropriate measures or by the type of work that insured persons are not endangered by these materials.

Working in a fume hood, especially in accordance with this DGUV Information, generally prevents unacceptably high levels of exposure in the laboratory. If possible, work with toxic and highly toxic materials should be carried out in closed laboratory apparatus in the fume hood or comparable facilities. In addition to procedure-related release of materials in the fume hood, this generally also ensures that any materials released as a result of faults and accidents are kept under safe control.

The ability to control the materials released depends in particular on the quantities involved, the material properties and the procedure used. Materials released may include vapors produced when transferring a solvent, nanoparticles that are torn from the matrix and released when working on a compound material, or a cloud of gas that may escape if a ground joint starts leaking.

The sash may only be left open during work in exceptional cases if good reasons exists for this and only after a preceeding hazard assessment. This is because leaving the sash open significantly reduces the containment capacity. The amount of noxious substances escaping may therefore be higher. In addition, the person using the fume hood is not protected against splashing hazardous materials or flying broken glass.

Suitability of fume hoods

Fume hoods are normally suitable if they have the properties required by DIN EN 14175 “Abzüge” and satisfy the criteria relating to containment capacity and the ventilation inspection in the DGUV Information 213-857 “Laborabzüge – Bauarten und sicherer Betrieb”.

Other protective measures to control released materials

Depending on the states of mater and the hazardous properties of the materials, appropriate measures may include using safety hoods, closed (vacuum-sealed) apparatus, glove boxes, downstream cooling traps or gas scrubbers. Effective extraction at source (local suction) can also help minimize exposure (Fig. 6).

To reduce emissions, noxious substances produced in the fume hood should also be captured at the point where they escape/occur (Fig. 7) and removed if possible, for example through absorption in a gas scrubber.

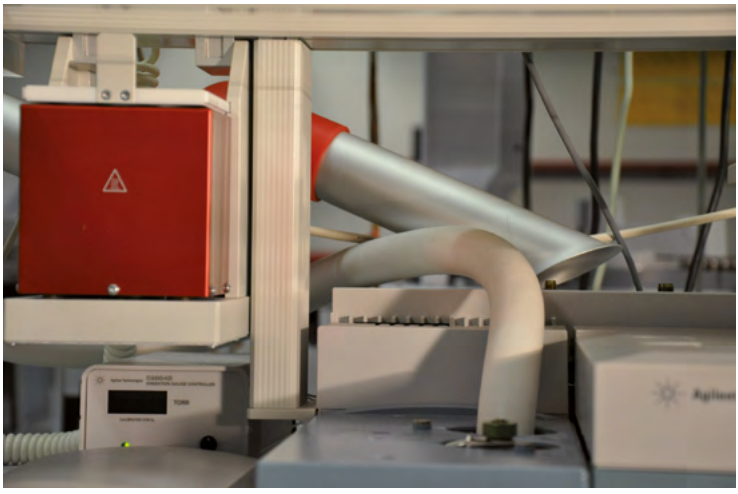


Fig. 6: Extraction at source at a gas chromatograph with a freely positionable articulated tube

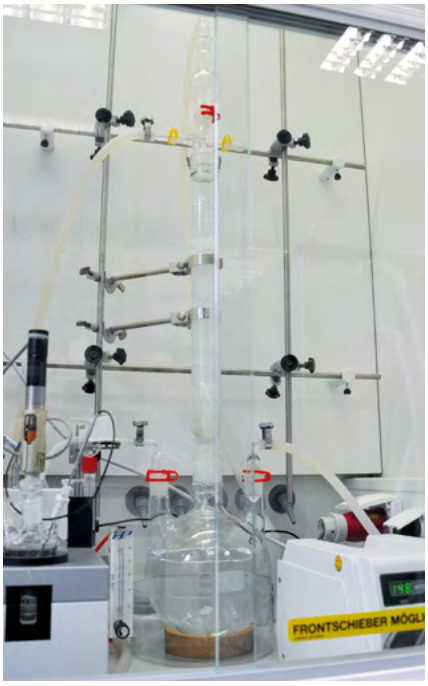


Fig. 7: Gases can be retained very efficiently in a gas-washing tower. A scrubbing column with packings is shown here. In this system, the gas is fed in counterflow via the absorption solution pumped in the circuit

4.11.2 Unintentional release of materials and accidents

Procedure in the event of accidents that are imminent or have already occurred

If substances escape in unexpected and possibly hazardous concentrations or quantities, the area at risk must be evacuated and those in the vicinity must be alerted.

This also applies if there are initial signs of decomposition during the course of a chemical reaction or distillation process. The heating and the ignition sources in the surrounding area have to be switched off from a safe location.

This not only relates to the release of hazardous materials, but also to other substances and preparations that could represent a hazard to health, such as gases with asphyxiant effects or hot/cryogenic liquids.

Protective measures while rectifying the situation

The hazardous situation may only be rectified if the personnel taking action to remedy the situation do not put themselves in danger and only if they take appropriate protective measures. This also applies to the removing of contamination. The personal protective equipment required is to be kept at an easily accessible location where it can be reached without risk at all times, for example in the corridor outside the laboratory.

The protective measures specified in the operating instructions in the section entitled “Verhalten im Gefahrfall” [conduct in the event of a hazard] are to be complied with when removing liquids or solids that have been released. Generally speaking, it is advisable to have chemical binders on hand to absorb liquids if necessary. For oxidizing materials (such as nitric acid and bromine), special chemical binders that cannot react with these materials should be made available (Fig. 8). There are very effective commercially available binders for certain materials such as mercury.

Reactions out of control

Reactions that got out of control become apparent – although not in all cases by any means – in the form of a sudden increase in gas generation or heating (possibly boiling), and also occasionally in the form of changes in color nuances or precipitates.

Switching off the power supply

The power supply should be switched off from a safe location, for example at a remote circuit-breaker or RCD (residual current device (15)). The individual apparatus components should be connected to the power supply in such a way that components which are key to controlling the reaction – such as the cooling system or stirrer – do not have to be switched off at the same time. It is also advantageous in such cases if gas supplies can be shut off from a safe distance.

See also Section 4.3.7.

Fig. 8: Chemical binders

4.12 Work with flammable materials

4.12.1 Explosion protection measures

Preventing or controlling explosions

If the formation of hazardous explosive mixtures cannot be prevented by means of primary protective measures when working with flammable liquids, gases or dusts, measures must be taken to prevent ignition. If this is not possible either, the effects should be limited to a level that does not result in damage. Measures to prevent the formation of explosive atmospheres (or mixtures) include replacing flammable solvents with non-flammable equivalents and using solvents with a flashpoint that is far enough above processing and surface temperatures to be safe.

Measures to prevent the formation of explosive atmospheres (mixtures) in potentially hazardous quantities include extracting flammable gases, vapors or dusts at the point where they originate or escape, and working in fume hoods that comply with DIN EN 14175 "Abzüge". See "Vermeidung oder Einschränkung gefährlicher explosionsfähiger Atmosphäre" (TRBS 2152, Teil 2).

Measures to prevent the ignition of explosive atmospheres (mixtures) include avoiding open flames, using devices and protective systems according to 11. Verordnung zum Produktsicherheitsgesetz and avoiding electrostatic charging. See "Gefährliche explosionsfähige Atmosphäre – Vermeidung der Entzündung gefährlicher explosionsfähiger Atmosphäre" (TRBS 2152, Teil 3) and "Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen" (TRBS 2153) or DGUV Information 213-060 "Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen".

Explosion zones in the lab

A hazard analysis as detailed in the Gefahrstoffverordnung is to be performed before starting work. This will normally indicate that explosion zones do not need to be designated in the lab, which means that a explosion protection document is not needed. If experiments are performed with flammable liquids in a fume hood at or below the normal pressure and at temperatures above the flashpoint with the "small quantities" normally used in laboratories, it can normally be assumed that, when operating at full capacity, the exhaust airstream ensures sufficient dilution inside the fume hood and no explosion zone according to Anhang I, Nummer 1, Nr. 1.7 Gefahrstoffverordnung needs to be designated. With some work, however, the hazard assessment may indicate that explosion zones do need to be designated and there is therefore an obligation to maintain an explosion protection document.

See also Arts. 6 and 9 plus Anhang I Nummer 1 of the Gefahrstoffverordnung, Arts. 3 and 22 of the DGUV Vorschrift 1 "Grundsätze der Prävention" and the DGUV Information 213-857 "Laborabzüge – Bauarten und sicherer Betrieb".

4.12.2 Ignition hazards due to electrostatic charging

Measures to protect against electrostatic charging

Appropriate protective measures must be taken when working with ignition hazards resulting from electrostatic charging. See TRGS 720 to 722 for such measures.

Ignition hazards resulting from electrostatic charging may exist:

- In the case of flammable liquids, for example, when being transferred from one container to another, flowing rapidly in hoses or being sprayed (this also applies to flammable liquid waste).
- In the case of flammable dusts and granules, for example, during fluidizing, grinding, mixing, transporting and sieving (in particular in applications engineering).

Appropriate protective measures include:

- Grounding conductive vessels and appliances.
- When transferring liquids that are electrostatically non-conductive (such as gasoline, toluene, ether or carbon disulfide), appliances and vessels should be combined that are either only conductive or only non-conductive. No electrostatically non-conductive flammable liquids should be filled into vessels made of electrostatically non-conductive materials such as plastic. Plastic containers with a nominal volume of up to 5 l are an exception to this rule because the volume is reasonably small.
- Electrostatically non-conductive liquids are to be poured out slowly and not in free fall. The stem of the funnel should be positioned close to the bottom of the vessel.

Ground connection and conductivity of floors

It has proved good practice to provide a common grounded connection point for grounding conductive vessels and appliances (such as funnels, siphons, hoses, structures and racks).

It is helpful if the floor or tread surface and shoes also permit sufficient dissipation of the charge. This prevents possible discharge sparks at locations where ignitable mixtures are present.

See the BG RCI Merkblatt T 025 "Umfüllen von Flüssigkeiten – vom Kleingebinde bis zum Container" and DGUV Information 213-060 "Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen".

4.13 Work involving large quantities of hazardous materials

Special protective measures for large quantities of hazardous materials

Work involving large quantities of hazardous materials in laboratories requires special protective measures. However, if it is believed that these measures cannot safely control accidents. Therefore pilot plants with the relevant safety facilities – in particular for fire and explosion protection – or other comparable facilities must be used.

It is not possible to rule out the unintentional release of large quantities of hazardous materials as a result of glass breaking, in particular with thin-walled glass vessels. Such vessels include round-bottomed flasks, flat-bottomed flasks, Erlenmeyer flasks and beakers. When working with highly and easily inflammable liquids, a fire suppression drip pan is to be used, for example with a honeycomb grid insert or a suitable filling.

Using thick-walled or coated glass vessels has proved effective. The risk of breakage can also be reduced by using metal or plastic containers.

Further protective measures can include:

- working in fume hoods
- automatic extinguishing systems and early-warning fire alarm systems
- explosion-protected appliances
- heating equipment with an additional over-temperature cut-off device.

See Sections 4.12 and 5.1.1.

For measures against superheating, see Sections 5.1.6.2 and 5.2.6.6.

4.14 Open evaporation

Open evaporation of flammable liquids

The open evaporation or heating of flammable liquids should be avoided as far as possible. If it cannot be avoided, it must be done in a fume hood with the sash closed.

As far as possible, vapors should be captured at the escape point and routed directly to the exhaust air duct. To enhance the level of protection, ignition sources, in particular open flames, should be avoided.

4.15 Storage and provision of flammable liquids

4.15.1 Limiting quantities at the workplace

Limiting quantities of flammable liquids

Flammable liquids with a flashpoint below 55 °C that are kept at the workplace for daily use may only be stored in vessels with a nominal volume not exceeding 1 l. The number of such vessels should be as low as possible. If larger quantities of flammable liquids are required on a regular basis in laboratories, they may be kept in non- breakproof vessels with a nominal volume of up to 5 l or in other vessels with a nominal volume of up to 10 l at a protected location, for example a safety cabinet as specified in DIN EN 14470-1:2004.

Plastic containers with a nominal volume exceeding 5 l are only suitable for flammable liquids with a flashpoint of up to 35 °C if they have sufficient electrostatic discharge capability.

See the DGUV Information 213-060 "Vermeiden von Zündgefahren infolge elektrostatischer Aufladungen" and the examples in the DGUV Regel 113-001 "Explosionsschutz-Regeln (EX-RL)".

An example of a non-breakproof vessel is a glass bottle.

Commercially available safety vessels made of stainless steel with a flashback arrester and pressure relief have proved effective, as have plastic containers with sufficient discharge capability.

Cabinets to DIN EN 14470-1 "Feuerwiderstandsfähige Lagerschränke – Teil 1: Sicherheitsschränke für brennbare Flüssigkeiten" have proved to be effective for storing flammable liquids. Such cabinets are best installed near the workplace.

See the Technische Regeln für Gefahrstoffe TRGS 510 "Lagern von Gefahrstoffen in ortsbeweglichen Behältern".

See also Section 4.9.1.

4.15.2 Washing liquids

Containers for washing liquids

No containers made of thin-walled glass may be used for easily inflammable washing liquids in daily use.

Materials such as acetone and isopropanol are used as washing liquids.

Wash bottles made of plastic are suitable containers, but not for liquids that raise toxicological or other concerns such as chlorinated hydrocarbons or ether.

There is a risk of dripping with plastic wash bottles.

4.15.3 Handling emptied containers

Special measures for handling emptied hazardous material containers

Emptied containers that held hazardous materials, in particular flammable liquids, must be properly cleaned before being disposed of or reused for some other purpose. If containers are disposed of without first being cleaned, the relevant waste code is to be used.

If containers are used for waste solvents, the hazard resulting from the explosive atmosphere inside the container is to be taken into account. This applies in particular to containers that have not been cleaned.

See Section 4.17.

4.16 Waste management

4.16.1 Collection and transport

4.16.1.1 Collection

Avoiding chemical reactions and leaks

The individual types of waste should be collected separately so as to rule out hazardous reactions. Containers of a suitable size and design that can be transported safely by insured persons must be provided for collecting the individual types of waste. In particular, they must be able to withstand the chemical and mechanical stresses to be expected from the materials they contain.

All waste is to be collected in accordance with the regulations on waste and hazardous materials. When made available for disposal, no potentially hazardous concentrations or quantities of hazardous materials may be released out of the containers.

Waste containers should not be filled to the top. They must be regularly emptied or disposed of. The number of containers and their capacity should be kept to a minimum.

Deposits in disposal pipes leading to waste containers may cause hazards.

See Section 4.9.1.

4.16.1.2 Chemically contaminated appliances

Contamination hazards due to needle-stick injuries and cuts

Only robust containers that cannot be pierced are to be used for pointed, sharp or fragile objects. These containers may only be emptied by being tipped out. Suitable protective gloves are to be worn for this purpose.

Transferring the contents of such waste containers to other containers should be avoided wherever possible.

There are special containers for disposing of needles and syringes. Due to the hazard of needle-stick injuries, needles should not be pulled out by hand or returned to their protective sleeve without appropriate aids.

4.16.1.3 Waste collection containers

Installing and using containers

Waste containers for hazardous material waste should be stored in the laboratory in such a way that they do not impair normal laboratory work or result in a hazard.

In order to avoid electrostatic charges, both the funnel and the waste container must be connected to a potential equalizer during the filling of highly inflammable, easily inflammable or inflammable hazardous liquid waste. This does not normally apply to containers with a nominal volume of up to 5 l.

When providing and filling these waste containers, it is important to ensure that no hazardous gases or vapors in dangerous concentrations or quantities can get into the laboratory air. Containers are to be labelled as stipulated in Art. 8 of the GefStoffV.

Such containers are best kept in storage spaces for waste, in safety cabinets or outside the laboratory in appropriate storage rooms.

In order to ensure safe filling of hazardous liquid waste, the funnel should be attached securely to the waste container. Adequate ventilation must be ensured and electrostatic charges must be avoided. With certain conditions such as very dry air, unacceptably high electrostatic charges may even build up in containers with a nominal volume of less than 5 l. Empty PE containers for cleaning solutions (such as liquid soaps) are not normally suitable for the disposal of waste solvents. Fume hoods should not be used to store waste.

Waste containers are to be labelled according to the Technische Regeln für Gefahrstoffe TRGS 201 “Einstufung und Kennzeichnung bei Tätigkeiten mit Gefahrstoffen”. Labels should be resistant and adhere firmly to the container.

Waste containers for transport outside the establishment must comply with the regulations for the transport of hazardous materials. Disposal routes are to be agreed with the person responsible for disposal since concepts can differ.

4.16.2 Waste disposal

Conversion and destruction

Waste that cannot be disposed of by third parties owing to its chemical properties has to be destroyed safely in the laboratory or converted into a form that can be transported. Special operating instructions must be written for this purpose.

Hazardous waste should be disposed of at such time intervals that the storage, transport and destruction of these materials cannot cause a hazard. Workplaces must be inspected at least once a year for hazardous waste and this is to be disposed of to prevent the creation of contaminated sites.

See (16), (17) and (18).

See also Section 4.9.3.

4.17 Cleaning

Hazard resulting from residue

Persons charged with washing tasks may not be exposed to any hazard due to residues. In particular, containers and apparatus must be precleaned by the user before being taken to the location where washing takes place.

Cleaning agents

Cleaning agents with a strong reaction may only be used if other cleaning agents have proved unsuitable. Prior to their use, it is to be ensured that any residue in the containers cannot lead to hazardous reactions with the cleaning agent. Such tasks may only be performed by laboratory personnel, in a fume hood if necessary.

Washing with organic solvents should be avoided if possible.

Cleaning agents with a strong reaction include concentrated nitric acid, concentrated sulfuric acid and strong alkalis. Less hazardous alternatives should be used instead of chromium sulfuric acid, which has carcinogenic and environmentally harmful effects.

Alkaline permanganate solution has proved effective for oxidative breakdown. To prepare this, add 20 % sodium hydroxide solution to the same quantity of saturated potassium permanganate solution in the container to be cleaned. Other possible alternatives include sulfuric acid/hydrogen peroxide, potassium hydroxide/hydrogen peroxide or special laboratory cleaning agents. Mechanical cleaning often achieves the desired result and is particularly effective in an ultrasonic bath.

In many cases, the cleaning agents with a strong reaction referred to above can be replaced by milder alternatives such as solutions with special commercially available detergents.

4.18 Safety devices

4.18.1 Operation of safety devices

Blocking access to or tampering with safety devices

Safety devices may not be made ineffective.

This includes depositing items in areas that must be kept free for safety purposes, for example underneath emergency showers or in front of fire extinguishers.

Settings for flow rates and the alarm system of fume hoods may only be adjusted by persons with the necessary expertise who are authorized by the proprietor

See Arts. 15 to 17 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.18.2 Work on safety devices

Coordination between all those involved

The proprietor must ensure that the laboratory supervisor has been consulted prior to the work on safety devices and their supply and disposal lines. Also appropriate notices must be placed on the safety devices for the duration of this work. He must also make sure that insured persons are informed about the restrictions associated with the work.

It is advisable to use a permit procedure. An example can be found in (3). Laboratory activities may need to be interrupted for the duration of work.

4.19 Bans on manufacture and use

Bans on materials

In accordance with Annex IV of the GefStoffV, certain materials, preparations and products are subject to bans on manufacture and use. This applies in particular to hazardous materials that:

1. **Have carcinogenic or mutagenic properties.**
2. **Are highly toxic or toxic.**
3. **Can harm the environment.**

Unless stipulated otherwise in Annex IV of the Gefahrstoffverordnung, bans on manufacture and use do not apply to materials used in the quantities required for research, analytical and teaching purposes.

The contents of Annex IV of the GefStoffV have been replaced by Regulation (EC) No. 1907/2006. See Art. 16 of the GefStoffV 2010.

4.20 Ergonomics

4.20.1 General requirements

Ergonomic principles

The ergonomic design of workstations, processes and equipment should be taken into account during planning and procurement activities.

Bench heights

The heights of workbenches depend on the type of work (sitting or standing) and range from 720 mm (sitting) to 900 mm (standing). Height-adjustable workbenches can be adapted to different body sizes, thereby improving ergonomics.

Monotony

Monotonous activities should be avoided as far as possible. They can cause poor concentration and signs of fatigue that may pose risks when working with hazardous materials.

Chairs and standing aids

Ergonomically designed chairs – if appropriate with foot rests – have proved helpful for work that involves remaining seated for long periods. Standing aids are recommended for work that involves standing for long periods.

Overexertion due to monotonous movements

Work that involves monotonous movements over a long period of time, such as pipetting with mechanical pipettes, can lead to overexertion which causes tendopathy. Pipette operation that is adapted as closely as possible to natural finger movements and is as smooth as possible prevents complaints resulting from frequent use. Motorized pipettes may also be used for regular pipetting processes.

Fig. 9: If no space is available to perform maintenance work behind bulky or heavy equipment, such equipment can also be made mobile. In the figure, a GC/MS device and thermodesorber are installed together on a table that is suspended from the ceiling (observe tensile loads) using a rail system. If necessary, this can then be moved forwards far enough to allow work to be performed behind the device. Mobile tables are pushed under to secure.

See DIN EN 14056 "Laboreinrichtungen – Empfehlungen für Anordnung und Montage" and DIN EN 13150 "Arbeitstische für Laboratorien – Maße, Sicherheitsanforderungen und Prüfverfahren".

See also "Kleine ergonomische Datensammlung" by the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin [Federal Institute for Occupational Safety and Health] and the DGUV Information 215-410 "Bildschirm- und Büroarbeitsplätze – Leitfaden für die Gestaltung".

4.20.2 Lighting and emergency lighting

4.20.2.1 Lighting

Strength and quality of lighting

The lighting of laboratory workstations must be designed to ensure safe work and timely identification of hazards at all times. The minimum illumination level for laboratories is 300 lx and 500 lx at individual workstations. Uniform lighting without shadows must be ensured at all times. The lighting for on-screen work must comply with the requirements of the Bildschirmarbeitsverordnung, in particular with regard to anti-glare and anti-reflection properties.

The contents of the Bildschirmarbeitsverordnung have been integrated into the Arbeitsstättenverordnung.

Depending on the type of work, it is advisable to have an illumination level of more than 500 lx at desks.

In principle, laboratory workplaces must receive sufficient natural light and allow visual contact to the outside, as far as this can be made possible. In order to ensure that hazards are detected in time, the lighting must be appropriate to the visual demands of the task being performed and adapted to the eyesight of personnel.

The intensity of illumination must be increased if, for example, the visual function is critical to the workflow and accuracy or increased concentration are of importance. The same is true when the task involves details that are small or of low contrast. Special measures are also necessary to compensate for age-related or individual visual impairments.

Attention must be paid to uniformity of lighting. The illuminance at any position within the work area may not fall below 0.6 times the average illuminance. The lowest measured illuminance may not be found within the area of the main visual task.

Proper direction of light and shadiness make it easier to recognise the shape and surface structure of objects. Shadows that hide potential hazards may not increase the risk of an accident.

Work areas, workbenches and screens must be free of distracting reflection and glare.

See Arbeitsstättenverordnung, the Technische Regeln für Arbeitsstätten ASR A3.4 "Beleuchtung", DGUV Information 213-210 "Natürliche und künstliche Beleuchtung von Arbeitsstätten" and DGUV Information 215-211 "Tageslicht am Arbeitsplatz – leistungsfördernd und gesund".

See also DIN EN 12464-1 "Licht und Beleuchtung – Beleuchtung von Arbeitsstätten: Arbeitsstätten in Innenräumen".

4.20.2.2 Emergency lighting for escape routes

Emergency lighting

Special measures are required to ensure safe evacuation from the workplace and to prevent accidents in the event of a malfunction of the general lighting system.

Escape routes must be equipped with emergency lighting in those areas where there would be insufficient natural light and safe evacuation from the workplace might not be possible in the event of a malfunction of the general lighting system. This must be assessed based on the

respective use of each laboratory workplace. Decisive are workplace occupancy, the number of floors and how clearly the escape route is laid out, on the one hand, and areas of increased hazards, on the other hand. Practical training laboratories should be equipped with uninterrupted emergency lighting to a safe area.

To clearly designate an emergency route to a safe area, emergency signs, which must be installed at all emergency exits and exits along the emergency route, shall at the very least have high afterglow luminance and, should escape routes require emergency lighting, be lit or backlit. One or more lit or backlit emergency direction signs shall be installed if an emergency exit is not immediately visible.

See ASR A2.3 "Fluchtwege und Notausgänge, Flucht- und Rettungsplan", ASR A3.4/7 "Sicherheitsbeleuchtung, optische Sicherheitsleitsysteme".

4.20.2.3 Emergency lighting for particularly hazardous work areas

Emergency lighting shall be installed at all workstations at which the safety and health of personnel would be at increased risk in the event of a malfunction of the general lighting system. Its purpose is to facilitate safe evacuation from the laboratory and ensures that in the event of a lighting malfunction, test apparatus can, for example, be returned to a safe mode.

In laboratories, for example, increased hazard is expected in controlled areas designated for work with radioactive substances, in S3 laboratories, in Ex areas and while working with toxic gases.

See also Arbeitsstättenverordnung, ASR A1.3 "Sicherheits- und Gesundheitsschutzkennzeichnung", ASR A2.3 "Fluchtwege und Notausgänge, Flucht- und Rettungsplan", ASR A3.4 "Beleuchtung", ASR A3.4/3 "Sicherheitsbeleuchtung, optische Sicherheitsleitsysteme", DGUV Information 215-210 "Natürliche und künstliche Beleuchtung von Arbeitsstätten", DIN EN 1838 "Angewandte Lichttechnik – Notbeleuchtung".

4.20.3 Ambient climate

Ambient temperatures and ventilation

Wherever ppossible, large flows of heat from equipment in laboratories must be captured at the point of release and routed outside if they could cause a hazard by increasing the ambient temperature. Incoming air should be provided without creating any drafts.

A hazard may be caused by rising vapor pressures and a resultant increase in the release of hazardous materials.

Air vents with a large surface or diffusers have proved effective in this respect.

4.20.4 Workstations with screens

Workstations with screens and equipment systems

Workstations with screens are to be designed ergonomically in terms of the workplace and software. Ergonomic principles must be applied appropriately for computer screens that form part of equipment systems.

Computers may be an integrated part of laboratory equipment systems or set up at desks. They are not deemed to constitute workstations with screens when they form part of equipment systems, but ergonomic principles should nevertheless be taken into account as appropriate.

For guidelines on the ergonomic design of such workstations, see also the Arbeitsstättenverordnung, DGUV Information 215-410 "Bildschirm- und Büroarbeitsplätze – Leitfaden für die Gestaltung" and BG RCI Merkblatt T 044 "Bildschirmarbeitsplätze".

During the hazard assessment, it must be remembered that persons working at such workstations could be put at risk by activities in the vicinity, for example as a result of splashes or flying broken glass. Such hazards can be avoided, for example, by installing transparent partitions to protect against flying broken glass and splashes.

4.21 Activities of external personnel in the laboratory

Persons from outside the laboratory, coordination

Work by external personnel is only permissible in laboratories if hazards emanating from the laboratory have been eliminated beforehand or suitable protective measures and rules of conduct have been determined and the external personnel have been instructed accordingly. Proprietors must ensure that the insured persons working for them follow the safety-related rules of conduct. Only companies with the specialist knowledge required for the work may be used. As regards the coordination of work, Art. 17 of the GefStoffV is to be complied with. For the purposes of this document, external personnel are insured persons from other companies, insured persons from other departments of the company who are not laboratory staff, and visitors.

The contents of Art. 17 have been incorporated in Art. 15 of the GefStoffV 2010.

External personnel in laboratories include repair and cleaning staff, service personnel from other companies and employees of other external service providers.

See Art. 13 of the Betriebssicherheitsverordnung, Art. 15 para. 1 of the Gefahrstoffverordnung and Arts. 5 and 6 of the DGUV Vorschrift 1 "Grundsätze der Prävention".

4.22 Notifying the authorities

Notification obligations

According to the Gefahrstoffverordnung, proprietors must notify the responsible authorities in certain cases.

The proprietor must notify the responsible authorities immediately of any accident or failure during work with hazardous materials that has resulted in serious damage to the health of insured persons. He must also report illnesses and fatalities if there are concrete causal links to the work with hazardous materials. The notification must include precise details of the work and the hazard assessment.

Without prejudice to Art. 22 of the Arbeitsschutzgesetz, the responsible authorities are to be provided with the following details if they so request:

1. **The result of the hazard assessment and the information on which the assessment was based, including the relevant documentation.**
2. **Activities during which insured persons have actually or possibly been exposed to hazardous materials and the number of insured persons involved.**
3. **Responsible persons according to Art. 13 of the Arbeitsschutzgesetz.**
4. **The protective and preventive measures implemented, including operating instructions.**

In the case of work involving category 1 or 2 carcinogenic, mutagenic or reprotoxic hazardous materials, the proprietor must also provide the responsible authorities with the following information if they so request:

1. **The result of a substitution check.**
2. **Pertinent information on work done and industrial procedures used, the reasons for using these hazardous materials, the quantities of hazardous materials manufactured or used, the type of protective equipment to be used, the type and extent of exposure, and incidences of substitution.**

If so requested, the proprietor is to provide the responsible authorities with a copy of the Vorsorgekartei [prevention file] referred to in Art. 15 para. 5 of the GefStoffV.

The contents of Art. 15 para. 5 of the GefStoffV have been incorporated in the ArbMedVV.

5 Special operating instructions

5.1 Laboratory activities

5.1.1 Work involving spontaneously flammable materials

Spontaneously flammable materials

Work involving spontaneously flammable materials must be done in a fume hood. All flammable materials that are not needed immediately for work to continue uninterrupted must be removed from the fume hood. Suitable extinguishing agents should be kept available.

Spontaneously flammable materials include many metal alkyls, lithium aluminum hydride, silanes, short chain phosphanes, finely distributed (pyrophoric) metals (Fig. 10) and white phosphorus. Some hydrating catalysts – such as palladium on carriers or Raney nickel – take on pyrophoric properties when drying after use.

Fig. 10: Pyrophoric iron being shaken out of an inert gas ampoule

5.1.2 Work involving peroxide-forming liquids

Formation of organic peroxides

Liquids that tend to form organic peroxides must be examined for the presence of peroxides prior to distillation and evaporation, and the peroxides must be removed. Such liquids have to be stored protected from the light – in particular UV radiation.

Numerous organic compounds, especially solvents, form peroxides when they come in contact with oxygen in the air. The peroxides formed have low volatility and become enriched, in particular during distillation in the distillation boiler, where they can decompose and cause explosions. Typical examples of peroxide-forming compounds are ethers such as diethyl ether, diisopropyl ether, dioxane, tetrahydrofuran, cumol, and unsaturated hydrocarbons such as tetralin, dienes and aldehydes, ketones and solutions of these materials. See (19) and (20) in this connection.

However, peroxide formation cannot be prevented with absolute certainty by protecting liquids from the light during storage. Some peroxides, such as those of diisopropyl ether, also form in the dark. The only effective solution is storage under exclusion of oxygen with regular

checking of the peroxide contents. Some of the formed peroxides can be sensitive to vibration.

Inhibitors are frequently added to commercially available peroxide formers to prevent peroxide accumulation until they are used. After certain cleaning operations such as distillation, these inhibitors are separated off and are no longer effective.

5.1.3 Work involving explosive materials

5.1.3.1 Protective measures

Explosive materials and mixtures

Explosive materials and mixtures may only be handled in the smallest possible quantities and only in adequately protected workplaces. Appropriate technical, organizational and personal protective measures must be taken. Overheating, proximity to flames, sparking, impacts, friction and hazardous enclosure (damming) are to be avoided. Stocks of explosive materials and mixtures must be kept to a minimum. They are to be protected from the influence of flames and heat and kept under lock and key away from workplaces – if at all possible in a separate room. They may not be stored with flammable hazardous materials or compressed gases, even in safety cabinets.

Explosive materials include numerous organic nitroso and nitro compounds, nitric acid ester, diazo compounds, radicals, hydrazoic acid, their salts and esters, salts of fulminic acid, of acetylene and its derivatives, heavy metal perchlorates, nitrogen chloride, organic peroxides, peroxy acids and chalcogen-nitrogen compounds. These materials may be subject to explosives legislation.

Mixtures of oxidizing compounds such as nitrates, chromates, chlorates, perchlorates, fuming nitric acid, concentrated perchloric acid and hydrogen peroxide solutions (in particular concentrations exceeding 30 %) with flammable or reducing materials may have the properties of explosive materials. For example, fuming nitric acid reacts explosively with acetone, ethers, alcohol and oil of turpentine.

Metal powders that contain hydrogen as a result of the reduction, hydrogen peroxide with H_2O_2 contents above 30 %, heavy metal ions contained therein and halogen hydrocarbons in contact with alkali metals can also result in explosion hazards.

Appropriate technical protective measures include working in fume hoods with the sash closed or at adequately protected workstations. Additional shielding in the form of safety screens and protective walls can limit the effects of explosions (deflagration or detonation).

The number of people in the area at risk should be limited to the bare minimum through organizational measures. A further measure is minimizing the amounts of materials, taking into account that even the tiniest amount (just a few mg) of some materials (such as nitrogen triiodide, fulminates, heavy metal azides or Se_4N_4) can represent a significant hazard.

Visors that also protect the sensitive neck and chest areas have proven to be effective personal protective equipment, as have thick leather aprons and thick, long leather gloves.

Dusts of flammable but non-explosive solids can also result in explosion hazards.

See the DGUV Regel 113-017 "Tätigkeiten mit Explosivstoffen", the DGUV Vorschrift 13 "Organische Peroxide", and the "Erste Verordnung zum Sprengstoffgesetz" (1. SprengV).

5.1.3.2 Ammoniacal silver salt solutions

Silver fulminate

Ammoniacal solutions containing silver salt must be processed immediately after preparation.

When working with ammoniacal solutions containing silver salt, it must be borne in mind that a black precipitate containing silver (Berthelot's or black silver fulminate) forms after some time. Unlike conventional silver fulminate, this compound – which has not been clearly characterized to date – is extremely difficult to handle because it can explode violently if simply touched, stirred or shaken, and even during drying of the solution. Highly explosive silver amide forms with liquid ammonia. Silver parts of the apparatus must therefore not come into contact with liquid ammonia. Mercury also forms an explosive nitride with ammonia.

5.1.3.3 Acetylides

Heavy metal acetylides

On no account may acetylene come into contact with copper or copper alloys with a Cu content exceeding 70 %. Parts of the apparatus that come into contact with acetylene during chemical reactions must not be made of alloys with even a small copper content.

When working with acetylene, it must be borne in mind that it forms acetylides with many heavy metals and that these can explode very easily. Copper pipes should therefore never be used to supply acetylene for atom absorption spectroscopy.

See the Technische Regeln für Acetylenanlagen und Calciumcarbidlager TRAC 204 "Acetylenleitungen".

5.1.3.4 Perchlorates

Organic perchlorates

When working with perchloric acid, it must be ensured that explosive perchlorates cannot form in an uncontrolled fashion.

This can happen, for example, if perchloric acid acts on wood (laboratory furniture). This is particularly dangerous with fume hoods for fuming off where perchloric acid could have penetrated into the wood. Special disposal measures are required here. The use of fume hoods as detailed in DIN 12924-2 "Laboreinrichtungen Abzüge – Teil 2: Abrauchabzüge" or DIN EN 14175-7 "Abzüge – Teil 7: Abzüge für hohe thermische und Säurelasten (Abrauchabzüge)" is normally required for fuming off.

5.1.3.5 Alkali metals and alkali metal amides

Alkali metals and their amides

Alkali metals and their amides must be stored so as to prevent admission of components in the air.

Over the time alkali metals and their amides form highly reactive compounds when combined with components in the air. This also occurs slowly in tightly sealed vessels and under protective liquids. Potassium, for example, forms yellow-orange crusts comprising a mixture of potassium hydroxide monohydrate and potassium hyperoxide. Fig. 11 shows a piece of potassium that is already highly oxidized. Potassium hyperoxide is an extremely strong oxidizing agent which forms, when in contact with organic liquids, explosive mixtures which are sensible to mechanical pressure. In addition, potassium hydroxide monohydrate releases its water violently when heated. This then comes into contact with the metallic potassium. It may no longer be possible to destroy such contaminated materials without risk.

Fig. 11: A highly oxidized piece of potassium (21)

5.1.4 Dealing with ionizing radiation

Radioactive materials

When working with open radioactive materials, it is important that quantities, activities and exposure times are minimized. The level of exposure is to be kept to a minimum through technical measures. Radioactive materials must be kept in an appropriate manner under lock and key. They may only remain at workplaces in the quantities and for the activities and time required by the relevant procedure. Radiation sources require state-of-the-art operation. Access to the relevant workplaces is to be restricted to the persons directly involved with these activities. Pregnant women may not work in areas exposed to radiation. People under the age of 18 may only perform such activities if this is necessary to achieve their training objective. See also the Strahlenschutz- and the Röntgenverordnung.

The Strahlenschutz- and Röntgenverordnung have been incorporatd in the Strahlenschutzgesetz (StrlSchG).

When working with open radioactive materials, hygiene measures to prevent incorporation and the spread of radioactivity are extremely important. Even low-energy radiation sources with a limited range represent a significant incorporation hazard. Radiation sources may also be installed in equipment, for example in the electron capture detector used in gas chromatography. Regular checks are required to ensure there is no contamination.

All contact between the skin and open radioactive materials must be avoided. Appropriate protective gloves provide protection against both contact with the skin and α-radiation. Special radionuclide fume hoods as specified in DIN 25466 “Radionuklidabzüge – Regeln für die Auslegung und Prüfung” are available in addition to glove boxes for work with open radioactive materials with a relevant vapor pressure – such as tritium – or materials that are carried in the air in the form of dust or atomize. During work with hazardous materials in such equipment, it is to be borne in mind that they do not have divided sashes or access openings. The containment capacity must therefore be ensured by keeping the entire sash closed as far as possible.

Transport must take place in suitable containers and radioactive materials must be disposed of separately from other waste.

Radiation protection officers are to be appointed if necessary to ensure radiation protection. Authorization must be obtained for work with open and enclosed radioactive materials exceeding the permitted limits, when operating X-ray equipment and sources of stray radiation of unauthorized designs, and when using X-rays on humans for research

purposes as referred to in Chapter 2, Section 2 and 5 Strahlenschutzgesetz (StrlSchG).

See also the Strahlenschutzgesetz (StrlSchG).

5.1.5 Drying of solvents

Drying agents

Pre-drying with less reactive drying agents should be used before resorting to chemically highly reactive drying agents.

Molecular sieves, water-free copper sulfate, calcium chloride or potassium hydroxide should preferably be used as drying agents. If it is necessary to use alkali metals or alkali metal alloys, special safety measures must be taken. Possible hazardous reactions between solvents and drying agents must be taken into account. For example, halogenated hydrocarbons may not be dried by means of alkali metals.

Particular safeguards are required for circulation apparatus because they operate for long periods.

Used drying agents must be replaced and residue removed immediately.

See also Sections 4.3.5, 5.1.2 and 5.2.7.3.

5.1.6 Working with evacuated equipment

5.1.6.1 Thin-walled glass vessels

Protection against implosion

Thin-walled glass vessels may only be evacuated if they are of a suitable shape for this purpose. Before any evacuation of glass vessels, they must be checked visually for any damage that may affect their strength. Evacuated glass vessels may not be heated on one side. Appropriate measures are to be taken to protect against flying broken glass due to implosion.

Thin-walled glass vessels that are suitable for evacuation include round-bottomed flasks, tapered flasks and condensers. Unsuitable vessels include Erlenmeyer and flat-bottomed flasks. A visual check prior to each evacuation process is used to reveal visible damage that may affect the strength of vessels, for example in the form of cracks, scratches, chips, chill marks and folds, seeds and cords, bubbles, airlines and blisters, and spots of "burnt" glass. Suitable measures to protect against flying broken glass include using safety screens, nets, perforated plates, protective curtains (also on the rear side of the apparatus if necessary), protective hoods and working in a fume hood. Lining with plastic or applying adhesive film has proved effective for items such as desiccators and filter flasks.

5.1.6.2 Vacuum distillation

Distillation in evacuated equipment

It must be ensured that there is no superheating during vacuum distillation. Distillation vapors that have not condensed must be condensed out or removed safely by some other means. The apparatus must be evacuated before the heating starts and may not be vented until after it has cooled down. This must be possible without removing the safety devices. If there is a risk that the distillation residue decomposes in the presence of oxygen, only inert gas may be introduced to reduce tension.

Stirrers and capillaries for the suctioning through of air or inert gases have proved an effective means of preventing superheating during vacuum distillation. Vacuum boiling stones or boiling beads may also be used. For the use of cooling traps to condense vapors, see Section 5.2.10.

See also Section 5.2.6.6.

5.1.7 Working with category 1 and 2 carcinogenic, mutagenic and reprotoxic materials

Protective measures for work with CMR materials

Before starting work with such materials, it is important to check whether they can be replaced with less hazardous ones. If there is no suitable alternative material or procedure, a closed system is best selected for the work. If it is technically impossible to use a closed system, appropriate measures must be taken to minimize the hazard.

For the purposes of this document, closed systems include:

- **apparatus which stand in a closed fume hood which are not operated open**
- **vacuum apparatus**
- **glove boxes**
- **and**
- **apparatus with sealed connections where all openings are connected to an effective extraction system.**

The following measures in particular should be taken within the framework of Art. 11 of the Gefahrstoffverordnung:

1. **Young persons, pregnant women and mothers who are breastfeeding may only work with carcinogenic, mutagenic or reprotoxic materials if this is compatible with the provisions of the Jugendarbeitsschutzgesetz, the Mutterschutzgesetz and the associated ordinances, especially the Mutterschutzrichtlinienverordnung.**
2. **Danger areas are to be cordoned off and marked with warning and safety signs.**

3. **The measures relating to occupational medicine referred to in Arts. 15 and 16 of the Gefahrstoffverordnung are to be implemented or made available.**
4. **Separate operating instructions are to be prepared for carcinogenic, mutagenic or reprotoxic materials.**
5. **Quantities of materials are to be kept to the minimum required for the relevant activities. Work must be carried out in closed apparatus in a fume hood using appropriate protective gloves and any additional personal protective equipment deemed necessary by the hazard assessment. Alternatively, work may also be carried out in a sealed glove box equipped with appropriate gloves. Another option is to use such materials in permanently sealed apparatus or equipment systems such as gas chromatographs. Exhaust gases must be reliably captured and removed. This also applies to emissions in fume hoods. If no exposure via the respiratory tract is likely, effective measures against contact with the skin are sufficient.**
6. **Compressed gases must be used in a fume hood in the smallest possible quantities. If compressed-gas cylinders are placed in a safety cabinet, at least a 120-fold exchange of air per hour is required in the cabinet. Permanently sealed lines are to be used to supply these gases to apparatus and equipment.**
7. **Exposure during weighing processes is to be minimized. If necessary, scales are to be operated in a fume hood, a glove box or an effective enclosure with an appropriate extraction system.**
8. **In the fume hood, residual materials and waste are to be converted into a less hazardous form by means of a chemical reaction or, like emptied containers, taken directly for disposal without this posing a hazard.**
9. **Contaminated apparatus components are to be cleaned so that they no longer represent a hazard.**
10. **Contaminated personal protective equipment, including lab coats, is to be decontaminated or disposed of directly without this posing a hazard.**

Measurement obligation

If measurements are not, objectively speaking, sufficiently meaningful, the proprietor may decide within the framework of the hazard assessment not to perform the measurements referred to in Art. 11 para. 2 (1) of the Gefahrstoffverordnung and document why this is the case.

The contents of Art. 11 and Art. 11 para. 2 point 1 have been incorporated in Art. 10 and in Art. 10 para. 3 point 1 respectively of the GefStoffV 2010. The contents of Arts. 15 and 16 of the GefStoffV have been incorporated in the ArbMedVV.

If work is done properly in a fume hood or glove box, insured persons are not subject to exposure when working with carcinogenic, mutagenic and reprotoxic materials. Special fume hoods and enclosures are

available for weighing processes that could be affected by air currents. If safety cabinets are suitable for such gases, it is important to remember at the installation stage that an hourly 120-fold exchange of air is required rather than the 10-fold exchange of air that is otherwise sufficient.

In some cases, gas generators offer the option to generate the gases in the quantities required and to use them directly.

If the measures referred to are complied with, work will meet the requirements of TRGS 420 "Verfahrens- und stoffspezifische Kriterien (VSK) für die Ermittlung und Beurteilung der inhalativen Exposition", provided there are no other considerations.

5.2 Operation of apparatus and equipment

5.2.1 Setting up apparatus

5.2.1.1 Absence of stresses

Stresses, leaks and risk of breakage

Apparatus must be set up in an uncomplicated arrangement and free from mechanical stresses. If stands are required, they must be fastened or weighed down securely. Permanently installed lattice bar grids are preferable to stands as they offer greater stability.

Apparatus should only be installed by specialists or people who have received appropriate instruction.

The traditional Bunsen stand only offers reliable stability if great care is taken with its design. It should be ensured that the stud bolt on the stand's upright does not protrude too much. It must also be stood on a level surface. The structure's center of gravity should not be located beyond the edge of the base plate. Structures should therefore preferably be attached to lattice bar grids, in particular heavy or unwieldy apparatus.

It is advantageous to use spherical ground joints, screw-cap connections or PTFE expansion bellows to reduce the mechanical stresses associated with large apparatus.

Glass apparatus and components are normally made from borosilicate glass 3.3. The risk of breakage increases with the temperature difference in the glass, especially if there is any damage or defect in the glass.

Glass apparatus and components should therefore be checked for visible damage and defects that could affect their strength. Any glass equipment with damage or defects should be repaired or replaced.

See Section 5.1.6.1.

See also DIN 12897 "Laborgeräte aus Metall; Hebebühnen, Sicherheitstechnische Anforderungen, Prüfung".

5.2.1.2 Flow conditions

Structures in fume hoods

When setting up apparatus in fume hoods, care is to be taken that the flow conditions are influenced as little as possible. It must be possible to remove heating baths, other external sources of heat and possibly also cooling baths safely and without changing the apparatus.

This can be achieved, for example, by leaving a clearance of at least 5 cm below the apparatus for the flow of air. Sufficient distances are to be left to the exhaust air openings on the rear wall of the fume hood. An adequate distance (at least 10 cm) also needs to be left to the sash so that the flow conditions are not negatively affected. A fog generator can be used advantageously for the examination of the flow conditions, e.g. a handheld battery operated fog generator (Fig. 12).

Fire protection pans or sand baths must be propped up to ensure their stability. Fire protection pans must be located at a sufficient vertical distance from the apparatus.

See also Section 5.2.7.4.

Fig. 12: Examination of the flow conditions of a jacked-up furnace in a fume hood using a handheld fog generator

5.2.1.3 Tall apparatus

Climbing aids

Ladders or steps are to be used when setting up tall apparatus and for work on parts of tall apparatus that are out of reach.

When working on tall apparatus, there is a risk of falls resulting in personal injury and additional hazards due to apparatus being broken.

See the DGUV Informationen 208-016/208-017 "Handlungsanleitung für den Umgang mit Leitern und Tritten".

5.2.2 Working with cylindrical glass parts

Tubes, rods and thermometers

Thermometers and glass tubes or rods may not be inserted into or extracted from stoppers or hoses with bare hands.

Sufficiently resistant gloves or thick cloths are examples of suitable items to protect the hands against sharp-edged pieces of broken glass.

It is easier to insert cylindrical glass parts into stoppers, for example, if any edges are rounded off beforehand. Cover the glass parts with suitable lubricants then hold them as close as possible to the stopper. Keep them straight and rotate them while gently inserting them. Do not allow them to come into contact with surfaces or parts of the body.

Screw-type connections are best used to avoid cuts.

5.2.2.1 Glass-blowing work

Avoiding contamination during repairs

Before performing glass-blowing work, clean and dry the apparatus carefully.

Remains of chemicals left in glass apparatus that is to be repaired can be hazardous to the glass-blower's health if they come into contact with his skin or his lips during glass blowing, or are evaporated and inhaled. Residue from flammable materials, in particular solvents that are used for rinsing, can result in explosions. Particular care is required when working on glass with hydrofluoric acid.

See also the DGUV Information 213-071 "Fluorwasserstoff, Flusssäure und anorganische Fluoride".

5.2.2.2 Permissible glass temperatures

Temperature differences and risk of breakage with glass

When working with glass apparatus, the permissible temperatures and temperature differences are to be observed. When using glass apparatus, temperature differences of more than 140 °C between the vaporized liquid and the cooling liquid should be avoided.

In the case of apparatus made of borosilicate glass 3.3 as specified in DIN ISO 3585 "Borosilicatglas 3.3 – Eigenschaften", temperature differences must not exceed 140 °C. Higher temperature differences increase the likelihood of breakage, which means that additional measures need to be taken for this eventuality. This type of glass can be subjected to maximum temperatures of 500 °C if the heating and cooling speeds specified by the manufacturer are observed and the temperature change is as uniform as possible. If parts of the apparatus are heated to high temperatures – reaction tubes in a tube furnace, for instance – the stresses that occur in the glass can be reduced by using a short stretch of insulation near the heating zone to lower the temperature gradient. With very rapid cooling (cooling baths), equipment made of borosilicate glass 3.3 should not be cooled to below –80 ° C.

See also Section 5.2.1.

5.2.3 Connectors and stoppers

Connecting parts of apparatus

Tight-fitting connectors must be used for work with hazardous materials.

Connectors such as conical ground joints, spherical ground joints, flanged connections and screw-cap connections offer better sealing than rubber or cork stoppers and are resistant to virtually all chemicals. Screw-cap connectors from different manufacturers do not necessarily ensure a tight connection.

To ensure that ground joints do not come open unintentionally, these are to be secured with ground-joint clamps, springs or other appropriate devices.

Ground joints may become stuck, for example, if cold ground stoppers are inserted in hot ground sockets or flasks in which underpressure can form as a result of condensation in the gas phase are closed prematurely.

Ground joints that have become stuck can be loosened, for example, by tapping them with a wooden handle or warming them quickly but carefully with hot air or hot water. When doing so, cover the bottle with a cloth and, in the case of larger bottles, ensure there is a drip pan un-

derneath. The contents may result in additional hazards if, for example, they are under pressure or can ignite when opening using a hot-air gun.

5.2.4 Hoses and fittings

5.2.4.1 Selection

Hose connections

Hoses and fittings must be selected so as to withstand the pressures and other mechanical, thermal and chemical stresses that are to be expected. They must be checked for visible defects prior to use. Defective hoses or hose ends that have become soft or porous must be removed.

The use of glass apparatus with fragile hose connections (glass olives) and hose connectors made of glass is to be avoided wherever possible. Plug-in or screw-joint couplings should be preferred as connecting elements for hoses. If glass apparatus with glass olives is used, however, plastic screw adapters are to be used wherever possible.

Hoses must be secured against slipping. They are to be protected from the effects of excessive heat and other forms of damage.

Hoses can be secured against slipping, for example, by

- using hose clips or hose binders or
- pulling gas hoses as specified in DIN 30664-1 “Schläuche für Gasbrenner für Laboratorien, ohne Ummantelung und Armierung – Teil 1: Sicherheitstechnische Anforderungen und Prüfungen” onto a hose nozzle as specified in DIN 12898 “Laborarmaturen; Schlauchtüllen” with (nominal diameter) d_2 = 9.5 mm.

When using hose clips, there is a risk of injury (if the screwdriver slips) and a risk of the vessels to be connected breaking. Designs that allow manual operation and single ear clamps have proved effective in preventing such risks (Fig. 13 and 14).

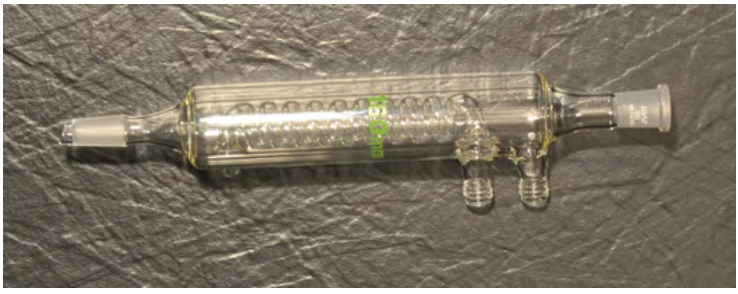


Fig. 13: Condenser with glass screw threads for cooling water connection

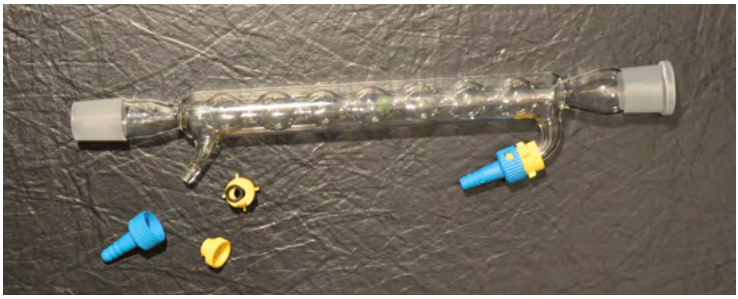


Fig. 14: Condenser with glass olives for cooling water connection with adapters for retrofitting plastic quick-action couplings

Tie wire should not be used to stop hoses slipping due to the risk of injury and limited stability it offers.

Applying or unfastening hoses frequently causes glass olives to break and results in injuries caused by sharp- edged broken pieces. This applies in particular to desiccators, filter flasks, condensers and gas-washing bottles. Pipette bottles with ground-in glass pipettes must also be handled with the necessary care as they tend to get stuck.

See DIN 12475 "Laborgeräte aus Glas – Saugflaschen, zylindrische Form", DIN 12476 "Laborgeräte aus Glas; Saugflaschen, konische Form" or DIN EN ISO 6556 "Laborgeräte aus Glas – Saugflaschen", DIN 12491 "Laborgeräte aus Glas – Vakuum-Exsikkatoren" or DIN EN ISO 13130 "Laborgeräte aus Glas – Exsikkatoren" and DIN 12596 "Laborgeräte aus Glas; Gas-Waschflaschen; Form nach Drechsel".

5.2.5 Gas burners

Laboratory gas and cartridge burners

Closable adjustment devices for the fuel gas are not permitted on Bunsen burners and related gas burners. Gas burners and similar appliances may only be connected using DVGW-tested hoses. This does not apply to cartridge burners.

Facilities must be available to store spare cartridges for cartridge burners so that there can be no increased hazard in the event of a fire.

Bunsen burners and related gas burner designs (such as Teclu, Méker, Heintz and Franke burners) may not be completely closable via taps or valves, as no gas is to remain under pressure in the gas hose between the shutoff valve and the laboratory burner after the burner has been switched off.

See DIN 30665-1 "Gasverbrauchseinrichtungen; Gasbrenner für Laboratorien (Laborbrenner); Sicherheitstechnische Anforderungen, Prüfung".

Fuel gas hoses

DVGW-tested hoses offer sufficient resistance, load-bearing capacity and tightness for laboratory requirements. Their diameters are coordinated with standardized hose nozzles on gas burners to ensure sufficient tightness without additional aids. Burners must be sufficiently stable. Hoses not tested by the DVGW, such as cooling water hoses, are not suitable for connecting gas burners.

See also Arts. 10 and 11 of the DGUV Vorschriften 79/80 "Verwendung von Flüssiggas" and the DGUV Information 213-053 "Schlauchleitungen – Sicherer Einsatz".

See DIN 30664-1 "Schläuche für Gasbrenner für Laboratorien, ohne Ummantelung und Armierung – Teil 1: Sicherheitstechnische Anforderungen und Prüfungen" and DIN 30665-1 "Gasverbrauchseinrichtungen; Gasbrenner für Laboratorien (Laborbrenner), Sicherheitstechnische Anforderungen, Prüfung".

Cartridge burners must be completely closable. As few cartridges as possible are to be kept at the workplace. One spare cartridge is normally sufficient. It is a good idea to keep cartridges in a separate storage room. Valve cartridges are recommended. Safety burners with safety pilot and automatic gas shutoff have proved effective. Burners with a sensor switch should be protected against being switched on by accident.

5.2.6 Operating apparatus

5.2.6.1 Explosion hazards

Protecting apparatus

If there is a risk of a material explosion or a heat explosion or of bursting due to an unintentional rise in pressure when operating glass apparatus, measures must be taken to protect against flying pieces of broken glass, splashes and materials that may escape.

An apparatus for procedures where a power cut may result in increased hazards must be connected to its own power circuit.

An unintentional rise in pressure may occur, for example, due to blockages in gas supply pipes, exhaust gas lines, gas scrubbers and absorption capillaries. Given that explosions or bursting are usually associated with the release of flammable or toxic materials, operation in a fume hood is normally appropriate.

See also Sections 4.11, 5.1.6, 5.2.12 and 5.2.13.

5.2.6.2 Increased hazards in the event of a power failure

Measures in the event of a power failure

If the hazards resulting from a power cut cannot be controlled, additional measures are required to keep the safety-related functions operational in line with the hazard assessment.

Many organometallic reactions, for example, can lead to increased hazards in the event of a power failure.

An apparatus, for example, has its own power circuit if its power outlet is not protected along with other power outlets through a joint safety device (such as a residual current device). As far as possible, no other laboratory device should be operated on the same power circuit as such an apparatus.

It is preferable if only the safety-related parts of the apparatus, such as the cooling system or stirrer, are operated on this circuit.

5.2.6.3 Drying capillaries and absorption vessels

Blocking of drying capillaries and absorption vessels

Care should be taken that drying capillaries and absorption vessels are not blocked and cannot become blocked during operation. It is also important to ensure that no liquid can drip from the absorption vessel into the reaction vessel.

The blocking of drying capillaries and absorption vessels with drying agents such as calcium chloride, phosphorus (V) oxide or soda lime can be prevented, for example, by mixing in inert granular or fibrous material (such as glass wool, sand or pumice stones). Silica gel has the advantage that it does not cause blockages.

5.2.6.4 Thermal insulation of hot parts

Thermal insulation

No easily inflammable materials may be used for the thermal insulation of hot parts on apparatus.

Easily inflammable insulating material (such as expanded polystyrene, card or paper towels) is not appropriate due to the resultant fire hazard. Even if only slightly wetted with a flammable liquid such as mineral oil, a fire can occur through spontaneous ignition.

Fibrous alternatives to asbestos (such as ceramic fibers) may also have carcinogenic potential. Such materials may occur, for example, in high-temperature furnaces.

5.2.6.5 Barrier vessels

Buffer and barrier vessels

When setting up apparatus, adequately dimensioned barrier vessels must be installed between vessels containing materials that may become hazardous when mixed. The correct direction of flow must be ensured.

If the pressure drops in the apparatus, this may result in liquids and azardous mixtures flowing back in. An unwanted drop in pressure may occur, for example, as a result of cooling, heating on one side, a too rapid reaction process, lowering of the upstream pressure, etc.

In addition to installing barrier vessels ("buffer vessels"), it may also prove useful to add upstream non-return valves.

Examples of materials that are hazardous when mixed include concentrated acids when mixed with bases or water, solid alkaline oxides or hydroxides – for instance in drying jars – when mixed with water or acids, and calcium chloride when mixed with alcohols.

Reaction components and mixtures feeding back into compressed-gas cylinders is particularly dangerous.

5.2.6.6 Distillation apparatus

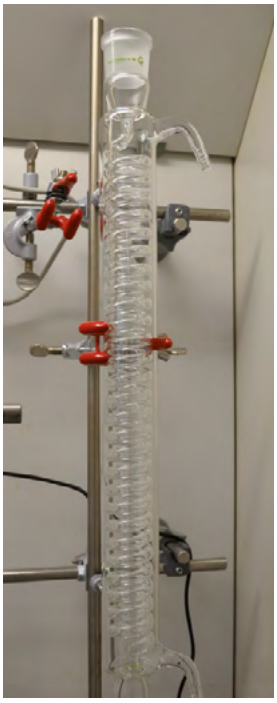
Selection and operation of distillation apparatus

The size of a distillation apparatus must be matched to the quantity and type of material to be distilled. The apparatus is to be selected so that there can be no blockage of vapor or condensation. The condenser must be sufficiently effective. A distillation apparatus must be secured firmly in place and, if necessary, supported. The flow of coolant must be monitored at the outlet of the condenser. Appropriate measures are needed in order to avoid superheating.

To avoid pressure surges during bumping, the distillation flask must never be more than ¾ full. Foaming can be reduced by using foam inhibitors or anti-foaming splash heads.

With larger flasks and/or higher fill levels, significant forces can occur on distillation receivers – distillation spiders, for instance. These must be absorbed by a device such as a lifting platform. When supporting the receiver, however, the apparatus must not be braced.

Flow monitors have proved effective for monitoring the flow of cooling water.



Items such as stirrers, boiling stones and boiling capillaries have proved to be effective means of preventing superheating. Boiling stones may not be added to overheated liquids.

In the case of distillate that solidifies easily, there is a risk of blockage and a dangerous increase in pressure in the apparatus. Reducers should not restrict the path of the gas. No product condensers may be used for back-flow apparatus (Fig. 15).

Fig. 15: Example of a product condenser: Rising vapor in the Graham condenser stops the condensation flowing back and forces it out

Fig. 16: Condenser with metal condensing coil inserted

When working with highly reactive drying agents (such as alkali metal alloys), leak-free condensers (such as metal condensing coils or metal condensers) are to be used (Fig. 16).

Ground joints are degreased by solvents especially if they act for long periods. It is advisable to use Teflon sleeves in such cases.

5.2.6.7 Mobile electrical equipment

Electrical cables and multiple sockets

Electrical cables are to be laid so that they cannot cause a hazard. It is not permitted to connect multiple socket outlets in series due to the possible loss of electrical safety and an increased fire hazard.

Hazards relating to electrical cables can, for example, result from:

- mechanical obstructions (obstacles, tripping hazards)
- the provision of a "path" for liquids that have escaped
- the stripping of live conductors due to thermal (for example hot surfaces), mechanical (for example sharp edges) and chemical effects.

If movable (multiple) sockets cannot be avoided, they should be provided with built-in safety devices (master switch, pre-fuse, residual current device (RCD (15)), overvoltage protector) and designed to be protected against splashes if necessary.

Checks and tests

A visual check of the mobile electrical equipment for damage should be carried out before work starts or before the apparatus is put into operation. A regular insulation test is performed on mobile electrical equipment as part of the regular tests required by the DGUV Vorschriften 3/4 "Elektrische Anlagen und Betriebsmittel". This is to be done by an electrician or (if appropriate measuring and test equipment is used) by a person with appropriate electrical engineering training. Laboratory personnel carry out a regular daily check on the operation of the mobile RCD.

Hazards resulting from bad contacts

Bad electrical contacts resulting, for example, from corrosion or mechanical overloading can lead to:

- local temperature increases resulting from higher contact resistance that can lead to detachable electrical connections fusing together, to ignition and to creep currents, possibly associated with loss of insulating effect
- lack of grounding (potential equalization) with undetected failure of contact protection or an RCD that no longer works
- failure of the power supply, possibly resulting in unsafe operating conditions.

When connections fuse together, this may bypass insulation and result in dangerous electric shocks.

Cable selection

The selection and use of electric cables should be adapted to the location of use and the possible stresses associated with this location. Silicone cables are suitable for external thermal stresses, while oilflex cables benefit from special protection against a chemical attack by hydrocarbons (lubricants). Safety-related equipment should be connected with cables that maintain their function in the event of a fire (such as "E90 cables"). When using equipment in humid environments and

when there is a danger of splashing, a higher electrical protection class must be selected for appliances (for example IP 67 instead of IP 44).

The use of low voltage should be considered as an alternative or addition. Isolation transformers are suitable for galvanic isolation in the event of hazards resulting from low and high voltage (protection against contact). Protection against contact with live components can also be ensured by using contactless plugs.

IEC connectors for cold, warm and hot conditions should be preferred to fixed cable connections because they are easier to replace if they were damaged and allow a more flexible adjustment of the cable length.

Electrical cables, in particular plug-in connectors, must not be wetted by water.

Unobstructed access to emergency stop switches and switches operating safety devices must be ensured.

Considering safety-related functions

Appropriate measures are to be taken in the event of dangerous faults affecting procedures and apparatus. Safety- related functions (such as stirring, cooling and valve control) are to be kept operational until safe operating conditions are restored, for example using UPS (uninterruptible power supplies), a centralized back-up power supply or energy storage devices.

Items such as thermal circuit breakers, temperature limiters and power limiters are suitable to provide protection against an overheating resulting from overloading with the risk of excessively hot surfaces (injury or fire) in the case of motors and heating sources.

5.2.7 Heating baths and heating

5.2.7.1 Heating liquid heating baths

Heating

Only electrical heating devices may be used to heat liquid heating baths and other laboratory apparatus. If it is impossible to avoid heating with open gas flames, this must take place under supervision.

Open flames are dangerous ignition sources and it is more difficult to regulate the supply of heat with these than with regulated electrical heating devices. A hot air blower can still act as an ignition source after it has been switched off.

Glass ceramic plates should be used instead of asbestos and ceramic fiber wire mesh. If the edges are damaged, these plates should be replaced due to the increased risk of breakage and injury.

5.2.7.2 Maximum operating temperature of heat carriers

Fire hazards associated with heat carriers

Only such heat carriers whose safe maximum operating temperature is known may be used for liquid heating baths and liquid thermostats. The maximum operating temperature must lie at least 20 °C below the flashpoint of the heat carrier in the case of liquid heating baths and at least 5 °C below it in the case of liquid thermostats. Metal baths should preferably be used for higher temperatures. Sand baths may only be used if the uneven temperature distribution occurring in them, particularly that caused by reheating, can cause no hazard. The sand used as the heat carrier must not have sharp edges.

It is important to use the right heat carrier for the actual task.

There is an acute fire hazard above the flashpoint and a few degrees Celsius below it. There may also be an explosion hazard due to vapors from the bath liquid mixed with air. If thermostats are operated with an open circuit by way of exception, the maximum operating temperature should be 20 °C below the flashpoint of the heat carrier. Sand baths and metal baths are particularly slow in terms of their temperature response. Unlike spherical materials, sharp-edged sand may damage the surface of glass vessels, which can then break particularly easily under the effects of stresses. This applies in particular when the vessel is being filled or evacuated or if stresses occur during heating.

See DIN EN 61010-1; VDE 0411-1 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 1: Allgemeine Anforderungen" and DIN EN 61010-2-010; VDE 0411-2-010 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 2-010: Besondere Anforderungen an Laborgeräte für das Erhitzen von Stoffen".

5.2.7.3 Temperature control

Controlling and limiting temperatures

If experiments cannot be permanently supervised, it must be ensured by means of an automatic device that, if the heating system's control device fails, overheating above the maximum operating temperature can be reliably prevented.

An additional device to limit the temperature stops baths overheating or chemicals igniting and a fire breaking out unnoticed.

See DIN EN 61010-1; VDE 0411-1 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 1: Allgemeine Anforderungen", DIN EN 61010-2-010; VDE 0411-2-010 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 2-010: Besondere Anforderungen an Laborgeräte für das Erhitzen von Stoffen" and DIN 12880 "Elektrische Laborgeräte – Wärme- und Brutschränke".

5.2.7.4 Stability

Stability and adjustability

Liquid heating baths must be set up in such a way that they stand firmly and that their height can be adjusted safely. Support rings are not suitable for height adjustment.

Laboratory lifting platforms – with remote control if necessary – have proved effective, in particular for adjusting the height below the apparatus.

Spacer blocks and similar items are normally not stable enough to prevent hot bath liquid spilling over the bench and possibly over parts of the body if they are knocked inadvertently.

See DIN 12897 "Laborgeräte aus Metall; Hebebühnen, Sicherheitstechnische Anforderungen, Prüfung".

5.2.7.5 Heat carriers

Properties of heat carriers

Heat carriers have to be selected so that they are appropriate for the task in hand. Effective measures must be taken against hazards which result from an increase in volume during heating, and from contamination and dripping water.

The following should be taken into account when using heat carriers:

- Heat carriers that are miscible with water are preferable for heating baths.
- Heat carriers that are not miscible with water must be replaced after contamination with water or the water must be extracted by boiling.
- Heat carriers that are miscible with water and those that are not must not be combined.

If a contamination happens unnoticed, these materials may represent a hazard if a person's skin comes into contact with the bath liquid. Con-

taminations with a boiling point lower than the bath temperature can lead to unexpected, violent splashing or boiling of the bath. It is advisable to check the heat carrier after each case of contamination and, depending on the contamination, to replace it if necessary.

If it overflows, bath liquid can get into the heating system and contaminate bath vessels and the system, which can lead to further hazards, including fires.

Slippery equipment surfaces represent a further source of hazards from oil baths.

Dripping water can lead to heat explosions in hot baths (oil, metal).

5.2.8 Drying in heating ovens

5.2.8.1 Explosion protection

Vapors and gases in drying ovens

If products from which hazardous explosive atmospheres can develop are dried in drying ovens, explosion protection measures must be taken.

This applies in particular to products that have been dampened by solvents, but also to those from which flammable products separate off during drying or heating. Heating cabinets and other dryers must not constitute an explosion hazard. This is achieved in particular by complying with the requirements of Art. 6 section 2.28 of the DGUV Regeln 100-500/100-501 “Betreiben von Arbeitsmitteln”.

Vacuum drying ovens and explosion-protected drying ovens may also be used, as may circulating air heating ovens provided the surface temperatures in these ovens are monitored carefully and the temperature is reliably kept below the maximum permitted level to prevent ignition. In addition to ovens for products, there are also ovens for drying equipment that are normally not suitable for use with products. Equipment which has been rinsed with organic solvents must therefore be dried in heating ovens for products.

See also DIN 12880 “Elektrische Laborgeräte – Wärme- und Brutschränke”.

5.2.8.2 Ventilation

Removal of gases, vapors and mists

Heating cabinets from which gases, vapors or mists may escape in hazardous concentrations or quantities must be connected to an adequately dimensioned venting system.

No explosive atmosphere may be allowed to form inside the drying oven and no materials that are harmful to health may escape it.

For special extraction systems see DIN 1946-7 "Raumlufttechnik – Teil 7: Raumlufttechnische Anlagen in Laboratorien (VDI-Lüftungsregeln)".

5.2.8.3 Thermally unstable materials

Hazards due to decomposition or ignition

The drying of thermally unstable materials and of materials with easily inflammable components may only take place in heating cabinets with an additional temperature safety device. The temperature set on this device must be below the decomposition or ignition temperature.

The temperature safety device should switch off the heating permanently if the selected set temperature (working temperature) is exceeded, for example if the temperature regulation device fails.

See DIN 12880 "Elektrische Laborgeräte – Wärme- und Brutschränke".

The materials to be dried must be arranged correctly inside the oven. Normally they may only stand on the grating because the walls are at temperatures above the set oven temperatures. They should not be placed close to the door opening either.

In the case of thermally unstable materials, the temperature set on the temperature safety device must be at least 20 % below the decomposition temperature and, in the case of easily inflammable materials, at least 20 % below the ignition temperature. These percentages refer to the temperatures in °C.

5.2.9 Refrigeration appliances

5.2.9.1 Refrigerators and freezers

Explosion protection

The interior of refrigerators and freezers in which hazardous explosive atmospheres can develop must not contain any ignition sources.

Hazardous explosive atmospheres can develop, for example, from open or untight vessels containing flammable liquids. Ignition sources in the vicinity of the door must therefore also be avoided. Appropriate refrigerators are available on the market. In the case of refrigerators and freezers of standard design, ignition sources can be avoided if lights and light switches are disconnected and temperature controllers are equipped with an intrinsically safe electrical circuit. Internal fans must be disconnected and the automatic defrosting system must be switched off. In re-

frigerators with automatic defrosting systems, the thawed liquid must be diverted into a collection vessel inside. This collection vessel has to be emptied when necessary. If the automatic defrosting system inside works with a heating system, this must be disconnected from the outside. The refrigerator must be defrosted by switching it off and opening the door. Locations where tubes or cables pass through the walls must be closed with silicone or similarly tight and durable materials. Converting the appliance on one's own initiative amounts to adopting the manufacturer's responsibility in the sense of the Produktsicherheitsgesetz (ProdSG).

Refrigerators and freezers contain flammable cooling agents such as isobutane in quantities of up to 1.5 kg. In addition, insulating foams contain pentane. Although no accidents caused by escaping cooling agent in the laboratory have been reported, electrical defects are a known cause of fire. DIN-Fachbericht CEN/TR 14739 provides assistance for assessing the risk posed by flammable cooling agents in household appliances. According to this, no hazard is presented by an increase in temperature.

5.2.9.2 Signs on refrigerators

Marking

Refrigerators and freezers as referred to in Section 5.2.9.1 must be marked with a sign reading "Nur Innenraum frei von Zündquellen" [Only interior free from ignition sources].

Refrigerators with an interior that is not free from possible ignition sources are to be marked with a sign reading "In diesem Kühlschrank ist das Aufbewahren brennbarer Stoffe verboten" [Flammable materials must not be kept in this refrigerator].

For the purposes of this stipulation, flammable materials are highly inflammable, easily inflammable and inflammable hazardous materials.

5.2.10 Deep cooling

5.2.10.1 Fire and reaction hazards

Hazardous reactions

When using a deep cooling bath of solid carbon dioxide and organic solvents, a hazardous reaction between the coolant and the contents of the glass vessels to be cooled must be avoided should these vessels break. Solid carbon dioxide must be added carefully to the solvents.

Acetone, for instance, may not be used as a deep-cooling medium if liquids containing hydrogen peroxide are being cooled. If the glass vessels break, explosive acetone peroxide may form that is sensitive to impacts.

Escaping carbon dioxide may very easily cause the solvent to foam over. In the case of flammable solvents, this may lead to fires if there is an ignition source in the vicinity. Isopropanol is recommended due to its low tendency to foam, but it is easily inflammable.

It is advantageous to use laboratory cryostats instead of dry ice and, if appropriate, cryogenic liquefied gases. Cryostats also permit a safe reaction process thanks to a freely selectable temperature with good temperature stability. It should be remembered that filling the liquid may pose a possible fire load.

5.2.10.2 Covering deep cooling baths

When using deep cooling baths, these should be covered as far as possible. After use, they have to remain covered in the fume hood until they reach ambient temperature and are stored afterwards into appropriate storage or disposal containers.

Covers made of aluminum foil or polyurethane have proved effective.

5.2.10.3 Dewar vessels

Implosion hazard

Dewar vessels made of glass and other glass vessels based on the same principle of operation must be equipped with a protective jacket or protected in some other way from the consequences of implosion. The glass must have a sufficiently small expansion coefficient.

Only clean and dry Dewar vessels may be filled with cryogenic liquefied gases. Scratched Dewar vessels may not be used for such gases.

Protection against the consequences of an implosion can be achieved, for example, by coating the vessel with plastic. Types of glass with a sufficiently small expansion coefficient include borosilicate glass 3.3 as specified in DIN ISO 3585 “Borosilicatglas 3.3 – Eigenschaften”.

Solid carbon dioxide may damage glass vessels.

5.2.10.4 Liquid nitrogen

Enriching with oxygen

If liquid nitrogen is used for deep cooling, its residence time in open Dewar vessels must be limited. Liquid oxygen and liquid air may not be used for deep cooling.

A brief residence time prevents oxygen from condensing into the nitrogen. Nitrogen enriched with oxygen, liquid air and liquid oxygen can form mixtures with organic materials which may detonate. Oxygen that has condensed in can only be recognized in rare cases by the slight blue coloration of the liquid nitrogen. Covering the Dewar vessel correctly can slow down the condensing in of oxygen significantly. It should be borne in mind that the cover may be damaged through embrittlement. Covers that have been lost or damaged must be replaced. Nitrogen from Dewar vessels must not be returned to storage vessels.

5.2.10.5 Low-temperature cooling baths

Preparing baths

Only small portions of cryogenic liquefied gases may be stirred into the bath liquid when preparing low-temperature cooling baths.

Otherwise, explosion-like evaporation of the cryogenic liquefied gas can occur. Splashing cryogenic liquefied gases, cold liquids and dry ice can lead to serious symptoms similar to burns.

See also Section 4.5.

5.2.10.6 Work involving liquefied gases

Hazards resulting from liquefied gases

When working with liquefied gases, measures must be taken to prevent hazards due to quickly evaporating liquefied gas.

Particular hazards include fire, explosion, frostbite and hazards resulting from toxic properties. Causes may include the breakage of a flask containing liquid ammonium or the detonative self-decomposition of liquefied acetylene. Apparatus leaks can lead to the freezing of cables and safety devices (formation of ice, condensed oxygen or nitrogen when using liquid helium), and to the rupture of apparatus components. The hazards resulting from gases that do not support breathing but have an asphyxiating effect are also often underestimated. 1 l of cryogenically liquefied gas such as nitrogen produces approximately 750 l of the gas under normal conditions and replaces the equivalent volume of breathable air. If the oxygen content in the ambient air falls significantly due to the evaporation of such gases, there is a risk of this impairing consciousness and the ability to act and react. If the oxygen content falls substantially, there is also an acute risk of losing consciousness after just a few breaths, or even of fatal suffocation. No adequate warning signs are perceptible when these gases are inhaled. It may therefore be necessary to provide monitoring devices, for example to record the oxygen content in the ambient air or to detect gases that have escaped. Cross-sensitivity and sensor aging should also be taken into account.

Additional personal protective equipment is required when filling and transferring cryogenic liquefied gases, in particular visors and aprons and liquid-tight gloves providing protection against the cold.

5.2.11 Compressed-gas cylinders and fittings

5.2.11.1 Fire protection

Installing compressed-gas cylinders

Basically speaking, compressed-gas cylinders should be installed securely outside of laboratories for fire protection purposes. If they are installed inside the laboratory, special protective measures should normally be taken, and this is essential if there is an increased fire hazard. Gases must be supplied in fixed, sealed pipelines If such protective measures are not possible or practicable, compressed-gas cylinders must be taken to a safe location once work has been completed.

The fire risk in this context depends in particular on how often an ignition source that may start a fire occurs and the fire load that is present. For example, an increased fire risk can be expected if work is carried out in a laboratory (reactions, column chromatography, rinsing, filling, transferring, cleaning and similar activities) with easily inflammable organic solvents in the presence of ignition sources such as open flames, hot surfaces or electrical equipment. The fire risk is further increased by additional fire loads that are present.

Fig. 17: Gas supply station for laboratory gases outside of the laboratory in a dedicated, well-ventilated room

Installing compressed-gas cylinders in laboratories creates hazards due, for example, to items leaking or falling down, cylinders being transported and fires resulting from cylinders bursting. All types of gas pose a fire hazard. Depending on the possible fire hazard, compressed-gas cylinders must therefore be protected by keeping them in cabinets that comply with DIN EN 14470-2 "Feuerwiderstandsfähige Lagerschränke – Teil 2: Sicherheitsschränke für Druckgasflaschen".

For storage requirements, see TRGS 510 "Lagerung von Gefahrstoffen in ortsbeweglichen Behältern".

5.2.11.2 Warning signs

Identification of laboratories containing compressed-gas cylinders

Laboratories in which compressed-gas cylinders are installed must be marked with warning sign W019 "Warnung vor Gasflaschen" [Warning: Bottled gas].

The number of the warning sign W019 "Pressurized cylinder" has been changed to W029.

The way that laboratories containing compressed-gas cylinders should be identified is described in DIN 12001-1 "Sicherheitszeichen im Labor; Warnung vor Gasflaschen".

5.2.11.3 Safeguards against external effects

Mechanical and thermal effects

Compressed-gas cylinders must be protected against mechanical effects, especially against falling down. Local overheating due to external heating must be avoided during the evaporation of liquefied gases. The temperature of compressed-gas cylinders may not exceed 50 °C. Electrical temperature control devices (such as heating bandages) must not exceed a temperature of 50 °C, even in the event of a fault. Gases that tend toward dangerous reactions in the cylinder may not be heated.

Compressed-gas cylinders can be secured against falling down by items such as chains, pipe clamps or adjustment devices.

To facilitate the evaporation of liquefied gases, it is possible to use careful external heating, for example by means of damp, hot cloths, temperature-regulated water baths or sprinkling with hot water.

Gases that tend to produce hazardous reactions include hydrocyanic acid and 1,3-butadiene.

5.2.11.4 Protection against toxic gases

Toxic gases

Compressed-gas cylinders which contain toxic, highly toxic, carcinogenic, mutagenic or reprotoxic gases must be installed in fume hoods or ventilated gas cylinder cabinets for work in laboratories.

Compressed-gas cylinders must be labelled on the shoulder with the details specified in the Gefahrstoffverordnung. The type of gas is also indicated by the color of the cylinder.

5.2.11.5 Identification of compressed-gas cylinders

Identification of compressed-gas cylinders

Compressed-gas cylinders must have the standardized European color coding specified in DIN EN 1089-3:2004, together with a label on the cylinder shoulder. This does not apply to LPG cylinders or fire extinguishers.

It should be noted that this color coding of new compressed-gas cylinders was switched to the system specified in DIN EN 1089-3 "Ortsbewegliche Gasflaschen – Gasflaschen-Kennzeichnung (ausgenommen Flüssiggas LPG) –Teil 3: Farbcodierung" as of July 1, 2006. Such cylinders purchased after this date must use the new color coding. Cylinders with this new coding have been marked with an "N" on the shoulder. The transitional period for the obligation to include this additional marking ended on July 1, 2006. From this point, the "N" is no longer needed. This means that cylinders may be in use that have the same color but different contents.

Fig. 18: Compressed-gas cylinders with (acetylene, right) and without (hydrogen, left) the "N" marking

There are a number of differences between the old and new identification systems. For example, acetylene compressed-gas cylinders are now maroon rather than yellow. Yellow is now reserved to identify toxic or corrosive gases (see Table 1). It is also possible for a cylinder to be identified using two different colors if the contents have two different hazardous properties.

	Bright green	“Inert” gas (non-toxic, non-corrosive, non-flammable, non-oxidizing)
	Yellow	Toxic or corrosive gas
	Red	Flammable gas
	Light blue	Oxidizing gas

Table 1: Color codes for compressed-gas cylinders in accordance with DIN EN 1089-3 “Ortsbewegliche Gasflaschen – Gasflaschen Kennzeichnung (ausgenommen Flüssiggas LPG) – Teil 3: Farbcodierung”

Gases that have their own color codes include acetylene (maroon), oxygen white) and dinitrogen monoxide (blue). Other differentiations can also be made for argon (dark green), nitrogen (black), carbon dioxide (gray), helium (brown) and a number of gas mixtures containing oxygen for medical use (white with an additional color). See also Fig. 19.

Gas	Shoulder color	Gas	Shoulder color
Acetylene	Maroon 	Carbon dioxide	Gray 
Oxygen	White 	Helium	Brown 
Dinitrogen monoxide (laughing gas)	Blue 	**Gas/gas mixtures** Synthetic air/compressed air for breathing purposes For oxygen concentrations between 20 and 23%	White/ black 
Argon	Dark green 		
Nitrogen	Black 	Oxygen/helium mixture For all oxygen concentrations	White/ brown 

Fig. 19: Special color coding of compressed-gas cylinders (it is no longer compulsory to mark new compressed-gas cylinders with the letter “N”).

5.2.11.6 Limits on volumes

Small cylinders and gas generators

The smallest possible compressed-gas cylinders must be used for highly toxic, toxic and carcinogenic gases.

Lecture bottles, small steel cylinders and compressed-gas cans have proved effective for reducing the hazard potential of particularly toxic gases by minimizing quantities. See Fig. 21.

Gas generators have also proved as an effective means of supplying standard gases. They are available, for example, for hydrogen, nitrogen and synthetic air. If small quantities of toxic or reactive gases such as chlorine, carbon monoxide, phosgene or phosphane are required, these can also often be generated as needed using tried-and-tested laboratory methods (3).

5.2.11.7 Oxidizing compressed gases

Explosion hazards

Fittings, pressure gages, seals and other parts for intensely oxidizing compressed gases must be kept free from oil, grease and glycerin. They may not be touched with cleaning cloths that have oil on them or with greasy fingers. Residue from solvents used for degreasing must be removed by blowing them off with oil-free air. Pressure reducer materials must be sufficiently resistant to the gas to be used. For oxygen, only approved pressure gages may be used.

Intensely oxidizing compressed gases that can ignite oil, grease, glycerin and solvent residue in fittings, pressure gages, seals and other parts include oxygen, fluorine and dinitrogen monoxide. Gases such as fluorine can cause pressure reducers to catch fire if the wrong material is selected or if they are handled incorrectly. Pressure reducers for oxygen are marked “Sauerstoff! Öl- und fettfrei halten“.

See BG RCI Merkblatt M 034-4 “Druckminderventile für Sauerstoff”.

5.2.11.8 Transferring gases

Transferring

When transferring gases in liquid form into smaller compressed-gas cylinders, overfilling must be avoided. The permissible fill level is to be checked by weighing the smaller cylinders.

5.2.11.9 Gas hoses

Securing gas hoses

Gas hoses must be fastened securely in place and the hose connectors/ connections have to be checked for tightness prior to use. Permanently integrated hoses are preferable to hoses fastened onto hose nozzles using clips or ties.

The tightness of hoses and their connectors can be tested prior to use, for example by brushing or spraying them with a suitable detergent solution or a leak detector spray.

See also DIN 4815-2 "Schläuche für Flüssiggas; Schlauchleitungen", DIN 3017-1 "Schlauchschellen – Teil 1: Schellen mit Schneckentrieb; Form A", DIN 32620 "Schlauchbinder; Spanner und Band" and DIN EN 560 "Gasschweißgeräte – Schlauchanschlüsse für Geräte und Anlagen für Schweißen, Schneiden und verwandte Prozesse".

5.2.11.10 Valves

Valve operation

Valves of compressed-gas cylinders for flammable and oxidizing gases are to be opened slowly. No torque- increasing tools may be used to open and close such valves. Compressed-gas cylinders with valves that cannot be opened by hand must be taken out of service, marked accordingly and sent to the filling company. Valves of compressed-gas cylinders must be closed after use and also after emptying.

Opening valves slowly is intended to prevent ignition of these gases and valve fires respectively. This applies to all flammable and oxidizing gases, especially hydrogen, oxygen and fluorine.

Valves of compressed-gas cylinders containing corrosive gases such as chlorine are particularly prone to seizing.

5.2.11.11 Feeding in gases

Limiting overpressure

Gases may be fed into apparatus only if it is ensured that no impermissible overpressure can build up in the apparatus. When feeding gases into liquids, equipment must be used that can reliably prevent liquids from flowing back into the line or into the removal vessel.

Impermissible overpressure may build up, for example, when needle valves are used, as these are only "flow limiters" and not pressure reducers. Safety immersion and (glass) overpressure valves have proved effective.

Fig. 20: Overpressure valve for glass apparatus

One way of preventing liquids from flowing back when gases are being fed in is to use adequately dimensioned barrier vessels. When installing barrier vessels, care must be taken to ensure the correct direction of flow.

5.2.11.12 Pressure reducers

Pressure reducers

Compressed-gas cylinders must, as far as possible, be operated with suitable pressure reducers. Pressure gages on pressure reducers may only be replaced by specialists. Screw connections that are not tight may only be tightened if the cylinder valve is closed.

Pressure reducers must satisfy particular requirements. This is ensured if equipment has a certification mark.

Fig. 21: Pressure reducer and needle valve (on the cylinder)

Needle valves and leaks

Pressure reducers (pressure-reducing valves) are not available for all gases. Needle valves are not pressure reducers. They allow the entire cylinder pressure to be exerted at the discharge end.

Persons who – on the basis of their specialist training, know-how and experience as well as their knowledge of the relevant regulations – can assess the work assigned to them and recognize possible hazards are considered to be specialists for work on pressure reducers. Several years of recent work in the relevant field can be deemed equivalent to specialist training. An instructed person is a person who has undergone instruction – through on-the- job training if necessary – in the tasks assigned and the possible hazards of improper conduct and has been instructed about the necessary safety devices and protective measures. The requirements of the Betriebssicherheitsverordnung (BetrSichV) (22) relating to qualified persons must be met.

See also DIN 477-1 "Gasflaschenventile für Gasflaschenprüfdrücke bis max. 300 bar; Bauformen, Baumaße, Anschlüsse, Gewinde" (now: DIN 477-1 "Gasflaschenventile für Flaschenprüfdrücke bis einschließlich 300 bar – Teil 1: Ventileingangs- und Ventilausgangsanschlüsse").

5.2.11.13 Leak test

Leak test and leak detection

Before working with gases that may be hazardous, the apparatus has to be examined to ensure that excess gas can escape only at the intended location.

Seals need to be checked visually before being screwed on. It is best to check the tightness of screw connections using a leak detector spray, in particular in the case of flammable, toxic or corrosive gases. A leak test can be performed, for example, by brushing or spraying with a detergent solution or using a leak detection spray.

5.2.11.14 Transport

Transport aids

Compressed-gas cylinders may only be transported with suitable aids and only with a safety cap on.

Appropriate aids include cylinder transport trolleys. It is important to ensure that such trolleys cannot tip over. The correct safety cap for the gas cylinder must be screwed fully onto the thread. Unaccompanied transport in an elevator is possible. Alternatively, a stair climber must be used. Compressed-gas cylinders should not be transported in elevators along with people.

5.2.11.15 Inspection date

Transport ban and emptying

When working with compressed-gas cylinders, attention is to be paid to the date for the next inspection.

If the inspection date has passed and the compressed-gas cylinders appear to be in perfect condition, they may continue to be used at the workplace in order to empty them. If compressed-gas cylinders containing hazardous gases have not been emptied on expiry of the inspection deadline and should be transported, for example, to the filling plant, a special transport permit is required.

See also the Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB).

5.2.12 Pressure devices and experimental autoclaves

5.2.12.1 Pressure devices

Characteristics and pressure discharge

Pressure devices for performing known reactions must be designed in such a way that they reliably withstand the mechanical, chemical and thermal stresses to be expected based on the intended mode of operation, and remain tight. In particular, they must be able to reliably withstand the permissible operating pressure and operating temperature.

Pressure must be discharged so as not to put people at risk. Inspections are to be carried out in accordance with the regulations of the Betriebssicherheitsverordnung and the associated Technische Regeln.

5.2.12.2 Experimental autoclaves

Installation and operation

Experimental autoclaves for experiments where it is not known how the reaction, pressure or temperature will develop must be installed in special chambers or behind protective walls. These must be designed in such a way that persons are protected against broken glass, other flying fragments, leaking contents and the effects of possible subsequent explosions should the autoclave fail. It must be possible to monitor and operate safety devices and measuring devices from a safe location.

Experimental autoclaves with flammable or toxic contents must be operated in ventilated chambers that are designed to withstand possible pressure surges and the momentum of flying fragments. Toxic or explosive mixtures of air, gas, vapor or dust ejected from an autoclave in the form of clouds are not restrained by protective walls. A fume hood can

only control this with very small autoclaves. If small containers are operated under pressure in appropriately designed devices such as microwave synthesis apparatus that is able to withstand the pressure surge, the materials released from a pressure relief device must be safely dissipated.

It is important to take into account that experimental autoclaves made of glass may shatter simply due to tensions resulting from defective assembly, external mechanical effects or local temperature peaks.

See also BetrSichV.

5.2.13 Carius tubes and carius ovens

5.2.13.1 Carius tubes

Use and protective measures

Sealed-off carius tubes may only be used if they cannot be replaced by other less hazardous apparatus. Appropriate protective measures must be taken when carius tubes are being sealed. Carius tubes should be placed in a steel shell immediately after sealing. After the experiment, they may not be removed from the carius oven until they are completely cool and then only in the protective shell. Carius tubes may not be removed from their protective shells until they have been depressurized.

Less hazardous apparatus includes exploratory bombs that can be screwed closed and experimental autoclaves which, if necessary, can also be equipped with inserts made of various materials that are resistant to the reaction mixture. Protective measures may include cooling the reaction mixture in the tube, evacuation or inertization of the carius tube. To prevent scratching of the glass wall, which weakens the carius tube, it helps to wrap the top and bottom using an asbestos-free cord with adequate thermal resistance. The glass tip of tubes can be removed, for example, by heating them until they are soft enough to be forced off by the internal pressure, carefully scoring them and then deftly knocking them off, or pinching them off using pincers. In all cases, the tip must be turned away from the person performing the experiment and the extraction process must take place in a fume hood that is closed as far as possible or directly in a local extraction device.

5.2.13.2 Carius ovens

Installation

Carius ovens must be installed in a way that there can be no hazard to insured persons if a carius tube shatters.

Protective walls can be used to block the possible flight path of debris.

5.2.14 Laboratory and ultra-centrifuges

5.2.14.1 Installation

Safe operation

Laboratory and ultra-centrifuges must be installed so that they can be operated safely.

Centrifuges are safely installed if, for example, they are placed on a suitable level surface and if there is a clearance of at least 30 cm around the centrifuge.

When operating ultra-centrifuges, it should be ensured that parts flying off are caught safely. If it is not possible to cover the centrifuge for operational reasons and if there is no safety device to catch flying parts, the centrifuge must be installed in a special room (protective chamber) that can only be entered when the machine is not running.

Noise levels should be taken into account when installing centrifuges.

For sample centrifuges operating instructions (German language), see (3).

5.2.14.2 Centrifuge operation

Users and documentation

Centrifuges may only be used by persons who have undergone an instruction. Instructions are to be prepared for the operation of centrifuges. A logbook must be kept for ultra-centrifuges and the names of insured persons using ultra-centrifuges must be recorded.

Explosion protection

Attention must be paid to the specific hazards encountered when working with easily and highly inflammable materials (explosion hazard). Instruments with internal chambers that are insufficiently protected against explosive atmospheres must be inerted. In the absence of inertization connections, it is helpful to render the centrifuge inert by filling and rinsing with argon or another heavy inert gas. For this purpose, the centrifuge – with the cover largely closed – is rinsed using a hose with a known flow rate for a pre-determined set of time and then closed immediately.

If centrifuges can be relocated, the operating instructions should also include details on installation, for example the clearance to be ensured for laboratory centrifuges.

See DIN EN 61010-2-020; VDE 0411-2-020 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 2-020: Besondere Anforderungen an Laborzentrifugen (IEC 61010-2-020:2006)".

See also the DGUV Regeln 100-500/100-501 "Betreiben von Arbeitsmitteln" – Section 2.11 "Betreiben von Maschinen der chemischen Verfahrenstechnik, Teil 3: Zentrifugen", the DGUV Grundsatz 313-001 "Prüfbuch für Zentrifugen" and, for old centrifuges, the withdrawn accident prevention regulation "Zentrifugen" (VBG 7z/GUV–V 7z).

5.2.15 Laser radiation

Labelling and operation

All lasers must be labelled according to their category. Only with categories 1 and 1 M this is not necessary – provided the manufacturer has included instructions in the user information.

Depending on the laser category, protective measures against the effects of direct light and the effects of stray light must be applied if the beam is unshielded. Category 2, 2M and 3A lasers may only be operated if the path of the beam is clearly and permanently marked. Areas with lasers of category 2 and above must be marked with warning sign W010 "Warnung vor Laserstrahl" [Warning: Laser beam]. Category 3B, 3R and 4 lasers may only be operated if additional protective measures are taken. These include restricted access and laser beam shielding. It may be necessary to wear laser protection glasses. Reflective objects may not accidentally find their way into the path of the beam during work. In particular, jewelry should be removed.

The responsible accident insurer and the responsible authorities must be notified when operating category 3B, 3R and 4 lasers. A laser protection officer must be appointed in writing before commissioning category 3B, 3R and 4 lasers. Insured persons must be instructed as appropriate.

Laser radiation can represent a significant hazard for the eyes and skin. In addition, high-energy laser light can trigger chemical reactions and physical processes in the laboratory and may destroy materials. Laser light may also represent an ignition source.

Lasers are split into categories 1, 1M, 2, 2M, 3M, 3R and 4 (see DGUV Vorschriften 11/12 "Laserstrahlung", the implementation guideline for Art. 2 para. 3 in accordance with the October 2003 edition of DIN EN 60825-1 (VDE 0837 Teil 1)) (23). Lasers taken into service prior to January 1, 2004 may also be designated according to the old system – 1, 2, 3A, 3B and 4 (in accordance with the March 1997 edition of DIN EN 60825-1).

Laboratories in which category 3B, 3R or 4 lasers are operated may only be entered by appropriately instructed personnel. This can be ensured through technical measures such as doors that cannot be opened from the outside without keys or code cards.

On entering laser laboratories with category 3R, 3B or 4 lasers, there should be a double door system that is free of any hazardous radiation to enable personal protective equipment to be put on.

Laser radiation is to be routed in tubes or housings. Reflective surfaces should be avoided near the path of the beam.

Laser protection glasses, protective clothing and protective gloves are to be provided and used in consultation with the laser protection officer.

5.2.16 UV radiation

Setup and operation

Ultraviolet radiation sources must be arranged and operated so as not to damage the eyes or skin of insured persons and so as to rule out damage to health resulting from ozone. It must be unambiguously apparent whether ultraviolet radiation sources are on or off.

Direct or indirect UV exposure can lead to inflammation and burning of the cornea and conjunctiva. On the skin, it can cause burning similar to sunburn. Repeated exposure can result in premature aging of the skin or even skin cancer. Hot surfaces of UV lamps can also cause burns.

Exposure to rays is best avoided by structural or other technical measures. These include the positioning of the UV radiation source appropriately so that no direct visual contact with the lamp is possible and that no-one is exposed to rays. It is often possible to cover – and even retrofit – imaging apparatus with appropriate safety shielding, for example a lightproof, non-flammable shroud such as aluminum foil. Effective interlock mechanisms that switch off the UV radiation source as soon as a shield is opened have also proved useful.

If it is not possible to prevent exposure in this way, the dose must be minimized. By marking out the radiation field or limiting the on-time or residence time, for example, it must be ensured that ultraviolet radiation has the minimum possible impact on insured persons. If there are ultraviolet double door systems, it is best to mark out on the floor the area exposed to radiation.

It may be necessary to wear protective clothing that covers the skin and possibly also to use light protection preparations.

When working in the vicinity of the lighted UV lamp, protective glasses or visors appropriate for the output and wavelength of the light source used should be worn. Looking directly into the lighted lamp should be avoided.

Ozone

Ozone may be created in particular when using high-output lamps. Ventilation measures should be taken to ensure that ozone levels remain below the workplace limit. In addition to optimized natural ventilation, for example, operation in a fume hood or installation of an effective system for extraction at source is also possible. Extracted air may not be returned to the working area.

Temperature and mercury content

Ultraviolet radiation sources can become very hot. It is important to ensure through their arrangement, insulation, cooling or warning signs that employees cannot get burnt. With UV radiation sources that contain mercury, precautions have to be taken in case the glass breaks and precautions for the disposal of the waste.

5.2.17 Rotary evaporators

Operation, peroxide test

When operating rotary evaporators, the underpressure stipulated for the relevant solvent must be complied with and the water bath temperature must not be too high. Solvents with a particularly low boiling point may only be drawn off under normal pressure. Solvents that tend to form peroxides must always be checked for any peroxides that may be present before being distilled off until dry and these should be removed. To reduce the rotary evaporator's implosion or explosion hazard, the equipment is to be completely enclosed or all glass components are to be covered with plastic. When using an automatic lifting device for the distillation receiver, it needs to be adjusted to the relevant flask size each time the flask is changed. All glass equipment used is to be checked prior to evacuation to ensure it is undamaged.

The underpressures stipulated are those indicated by the manufacturers to prevent hazardous situations due to superheating.

60 °C is normally adequate for the water bath. Solvents with particularly low boiling points such as diethyl ether, n-pentane and dichloromethane may only be drawn off under normal pressure, as otherwise their vapors will not be fully condensed and can find their way into the vacuum pump. The flask should rotate as quickly as possible to avoid superheating.

Cooling with cryostats has proved effective for ensuring reliable condensation of the solvent vapors drawn off. If this method is used, however, it should be ensured that the temperature of the coolant is always higher than the distillate's melting temperature.

It has proved useful to attach boiling diagrams and/or lists of boiling points for common solvents directly to the device.

Water jet pumps should no longer be used to generate underpressure because they allow solvent vapors to get into the waste water. Diaphragm pumps should be used instead. The exhaust air from these diaphragm pumps must be routed into a fume hood.

Each time the type of solvent to be distilled off is changed, the collection flask must be emptied. Otherwise, solvent that has already condensed may re-evaporate (if the condensed solvent has a lower boiling point or a higher vapor pressure than the new solvent added) or, if the solvents are incompatible, there may be dangerous secondary reactions (for example if acetone comes into contact with chloroform).

Items that have proved effective in providing protection against flying broken glass in the event of an implosion or an explosion include laminar PVC protective curtains that allow manual interventions while the device is in operation and still provide protection against flying glass.

5.2.18 Hot-air blowers

Ignition hazards resulting from hot-air blowers

Hot-air blowers may not be operated in the vicinity of flammable liquids or vapors.

Hot-air blowers (hot-air guns) reach temperatures of up to 550 °C, similar to those of a Bunsen burner. This applies not only to the heating wires inside the device, but also to the air outlet nozzle at the front end. It is therefore essential to ensure that hot-air blowers are not operated in the vicinity of flammable objects, liquids or vapors or put down directly next to such materials. Due to their strong air current, hot-air blowers can significantly disrupt the containment capacity of fume hoods.

The devices often have fold-out supports so that they can be put up or put down, but these do not provide adequate stability. Fixed holders at the workplace such as stand rings attached horizontally have proved effective for these devices. To reduce the high fire hazard, hot-air blowers should be kept outside of fume hoods.

5.2.19 Thermostats

Hazards resulting from temperature control media

The temperature control media in thermostats must be taken into account in the hazard assessment. The options for replacing them with less hazardous media should be explored.

5.2.20 Compressors and vacuum pumps

Installation and operation of compressors and vacuum pumps

Compressors and vacuum pumps have to be installed so as to ensure safe operation. Compressors and vacuum pumps, together with their equipment, may only be installed in working rooms if they do not represent a noise hazard for insured persons. Any escaping gases, mists or vapors with hazardous properties must be removed safely.

One requirement for safe operation involves installing compressors and vacuum pumps so that they are sufficiently accessible and the required cooling is ensured. Sufficient accessibility is ensured if compressors and vacuum pumps are installed so that they can be operated and maintained without any particular obstacles.

In general, the ambient temperature for permanently installed compressors and vacuum pumps with oil-lubricated pressure chambers and air cooling should not exceed 40 °C. For mobile installations, it should not exceed 50 °C.

To reduce noise levels, it can be useful to install rotary vane pumps that are operated for long periods on an apparatus in an adjacent room or to operate them in an enclosure. Sufficient heat dissipation must be ensured.

If they cannot be completely condensed, gases and vapors from evacuated apparatus must be captured and removed safely. Oil mist from rotary vane pumps should be precipitated.

See also the DGUV Regeln 100-500/100-501 "Betreiben von Arbeitsmitteln" – Section 2.11 "Betreiben von Maschinen der chemischen Verfahrenstechnik, Teil 2: Kompressoren und Vakuumpumpen" – and, for old compressors and vacuum pumps, the withdrawn accident prevention regulation "Verdichter" (VBG 16/GUV-V 16).

5.2.21 Ultrasound

Closed operation or operation in a fume hood

Ultrasonic baths must be operated closed if the formation of an aerosol can cause a hazard. If this is not possible, they must be operated in a fume hood.

Ultrasound can atomize hazardous materials and biological agents, for example during the removal of caked-on deposits, and put people at risk in the form of aerosols. If chemical reactions are performed in ultrasonic baths, it must be taken into account that these reactions may be accelerated.

5.2.22 Microwaves

5.2.22.1 General

Fire and explosion hazards

Possible fire and explosion hazards must be taken into account when heating with microwave equipment.

Substances in microwave ovens heat very quickly if they have a correspondingly high absorption capacity for microwave radiation. Solvents can reach their boiling point in a matter of seconds. Solids can be heated to very high temperatures. Carbon – for example formed from overheated organic material – can quickly become red-hot, thereby creating a fire hazard.

5.2.22.2 Superheating

Hazards due to superheating

Superheating must be prevented when heating liquids.

Otherwise, the resultant bumping can be strong enough to wrench the doors of standard domestic microwave ovens off their hinges and project them through the room. This is particularly so with viscous liquids – for example, when preparing gels for gel electrophoresis. To prevent this, the quantities prepared should be kept small, the Erlenmeyer flasks and glass beakers used for preparation should only be filled to a height of a few centimeters (the penetration depth at which the output falls to 50 % is approximately 2.5 cm for the most commonly applied frequency of 2.454 GHz (λ = 12.2 cm)), the output and heating period should be kept down, the preparation should occasionally be stirred and personal protective equipment (glasses, a visor that also covers the neck area as far as the closed lab coat, and gloves) should be worn.

It is advisable to use laboratory microwave equipment that has a mechanically stable housing and enables the microwave power to be controlled rather than just having the simple timer function of the basic equipment. It is also an advantage to have the option of stirring inside the oven.

5.2.22.3 Reactions in microwave equipment

Performing reactions

The equipment manufacturer's operating instructions must be followed, in particular the details on the average service life of pressure reaction vessels. A sufficiently stable design and sensors to monitor the pressure and temperature are necessary.

If flammable liquids are being heated, equipment must have additional safety devices (for example, mechanical ventilation and an explosion

sensor). If apparatus is installed that protrudes from the oven chamber, equipment must have appropriate through-holes with radiation damping.

Microwave ovenscan be used for processes such as incineration, drying, pressurized and unpressurized digestion, and continuous/batch-based synthesis (including under pressure). Many reactions take place unexpectedly quickly, which can cause the reaction to get out of control if it is not managed correctly (24). Decomposition reactions can be quicker than conventional reaction processes and lead to the formation of hazardous reaction products or to a buildup of pressure as a result of gas formation. Reaction mixtures in microwave ovens with field inhomogeneities that cause an uneven heating must be stirred particularly vigorously. Reaction mixtures without solvents or mixtures from which metallic films can separate out may cause reaction vessels to melt or explode due to intense heating of their walls.

Additional safety equipment in the device may include a mechanical ventilation or an explosion sensor. Specially designed equipment with additional monitoring functions is needed for pressurized digestion. If blowing off or bursting of a vessel can result in materials escaping from the oven chamber, these should be captured and discharged safely – destroyed if necessary – in order to prevent them from getting into the laboratory.

5.2.23 Chromatography

Gas chromatography, liquid chromatography

The radiation protection regulations must be complied with when operating gas chromatographs with an electron capture detector.

With flash chromatography in particular, the tightness and pressure stability of the connections must be ensured. Supply vessels that are under pressure have to be protected. If they burst, the escaping solvent must be captured and the surrounding area protected against flying fragments. If the apparatus cannot be operated in a fume hood, the solvent vapors escaping must be removed safely. Pressure surges should be avoided. The apparatus may only be operated if it is supervised or if it incorporates technical safeguards.

Hazardous materials escaping from gas chromatographs have to be effectively captured and removed. See Fig. 29.

For gas chromatographs where hydrogen is used as the carrier gas, explosion protection procedures are to be observed, in particular in oven chambers. Gas chromatographs with an electron capture detector contain a source of ^{63}Ni.

See the Strahlenschutzgesetz (StrlSchG).

5.2.24 Robots and automated laboratory equipment

Laboratory automation

Hazards resulting from mechanical movements – in particular those of needles and cannulae contaminated with hazardous materials – must be prevented on autosamplers, handling equipment, automatic screening and pipetting machines and other automated laboratory equipment. If necessary, there must be safeguards in the form of light barriers, light curtains, covers and doors with limit switches and similar devices. The possibility of hazardous materials escaping from damaged containers is to be taken into account.

Even dispensers and sample application devices driven with small forces can lead to hazards through needle-stick injuries and associated contamination of the wound. Prior to commissioning, the operator must check the safety instructions in the manual and take additional measures if necessary. It is not necessary to provide safeguards against crushing and shearing hazards if direct safety technology (for example, structural measures, force limitation) rule out any injuries. During the hazard assessment, however, contamination hazards resulting from needle-stick injuries involving hazardous materials or biological agents must also be taken into account.

See also DIN EN 61010-2-081; VDE 0411-2-081 "Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte: Besondere Anforderungen an automatische und semiautomatische Laborgeräte für Analysen und andere Zwecke".

5.2.25 Electromagnetic and magnetic fields

Protection against electromagnetic and magnetic fields

Areas with sources of electromagnetic radiation involving strong solenoids or permanent magnets must be marked accordingly and access has to be controlled as appropriate. There must be no unacceptably high field strengths in areas where there is a possibility of insured persons being exposed. The equipment manufacturers' documentation can be consulted in this respect. An assessment is required for modified or selfbuilt equipment. It may be necessary to measure the field strengths for this assessment. Danger areas have to be marked with warning sign W12 "Warnung vor elektromagnetischem Feld" [Warning: Electromagnetic field] or W13 "Warnung vor magnetischem Feld" [Warning: Magnetic field] (ASR A1.3). Access to danger areas must be restricted. Short-term exposure values must be complied with and personal protective equipment is to be used. During the hazard assessment, effects on antennae and ferromagnetic components that could lead to energy being applied or could generate significant mechanical forces should also be taken into account.

Field strengths can be substantial in areas with strong magnets – for NMR spectroscopy, for example. Such field strengths can also occur in neighboring rooms – including the ones located above and below magnets.

See also the DGUV Vorschriften 15/16 "Elektromagnetische Felder" and DGUV Regeln 103-013/103-014 "Elektromagnetische Felder".

Significant forces may be exerted on ferromagnetic components.

Quenching magnets

Quenching of cryomagnets must be prevented, as this can cause large quantities of liquefied cryogenic gases to evaporate within a short period and result in hazards due to the associated pressure surge. The evaporating gas also lowers the oxygen content in the room.

5.2.26 Needles and cannulae

Needle-stick injuries

Needles must be disposed of in needle containers without being touched. Cannulae should not be returned to their protective sleeve without appropriate aids.

Needle-stick injuries can occur when working with syringes and cannulae. Gloves made of cut-resistant fabrics often only offer limited protection against such injuries. In addition to the risk of infection, there is also a risk of incorporating hazardous materials. Single-use items are advantageous, provided they are sufficiently strong for the intended purpose. In some cases, cannulae, needles and septa can be replaced by threaded tubes and hoses. Hoses made of PTFE and polyethylene are normally suitable if they have a small diameter and are sufficiently rigid. See also (25).

Fig. 22: Needle disposal container

5.2.27 Stirrers

Agitator shafts

Agitator shafts can trap body parts and clothing, especially hair. For this reason, the agitator shaft must be outfitted with an appropriate means of protection.

Fig. 23: Laboratory stirrer with protective plastic sleeve

6 Technical protective measures

6.1 Avoiding hazards through technical protective measures

Safety through laboratory construction/ design and appliances

Hazards in laboratories are prevented to a very significant extent by designing and equipping workstations appropriately. This includes structural measures, the building infrastructure, laboratory equipment and the properties of devices, apparatus and other appliances.

Badly designed workstations in laboratories increase the risk of an accident and can contribute to the accidental release of hazardous materials.

See Art. 8 of the Gefahrstoffverordnung.

6.2 Workplace design

6.2.1 Operating and circulation areas

Distances

Operating and circulation areas must be adequately dimensioned.

If two to four people are working between the work areas, the minimum distance is 1.45 m. More recommendations on distances between work areas or items of equipment can be found in DIN EN 14056 “Laboreinrichtungen – Empfehlungen für Anordnung und Montage”. These recommendations are minimum figures. They should be increased if, for example,

- the space between two work areas is used not only for the circulation of the people working there, but also for other persons
- special working conditions exist, such as an increased fire or explosion hazard
- work areas are more than 6 m in length
- more than 4 people work between the areas
- there are two fume hoods opposite one another.

The distance is also to be increased if, for example, the space is permanently restricted by items such as stools, pull-out desks, equipment trolleys, racks or substructures (Fig. 24). Maintenance aisles, for example between two rows of gas chromatographs located back to back, may be less than 0.90 m wide. Routes used purely for circulation without any operating areas must be at least 0.90 m wide.

Fig. 24: Laboratory arrangement

For the design of workplaces, in particular ASR A1.2 “Raumabmessungen und Bewegungsflächen” and ASR A1.8 “Verkehrswege” are to be observed.

Internal transport routes must, as far as possible, be kept free of obstructions such as steps.

See also DIN EN 12128 “Biotechnik – Laboratorien für Forschung, Entwicklung und Analyse – Sicherheitsstufen mikrobiologischer Laboratorien, Gefahrenbereich, Räumlichkeiten und technische Sicherheitsanforderungen”.

6.2.1.1 Laboratory documentation zones

Documentation zone

Setting up zones for carrying out analyses and written work in laboratories has proven effective. These laboratory documentation zones are separate areas designated for recording and documentation activities in the laboratory. No work involving biological or chemical substances takes place in these zones. They are part of the laboratory space (for matters pertaining to the air ventilation assessment, see also Number 3.2 of DIN 1946-7 “Raumlufttechnik – Teil 7: Raumlufttechnische Anlagen in Laboratorien”) and are not located completely outside of the hazard area of the laboratory. They are situated in immediate proximity to the work spaces and work processes in the laboratory and are therefore not office workstations as set out in the Workplace Directive (Arbeitsstättenrichtlinie; ASR A1.2).

The documentation and experimental zones of a laboratory shall be separated by a large-scale, fully transparent, shatterproof glass front with glass doors. This design makes it possible to monitor laboratory experiments while working in the documentation zone safely out of

range of fragments and splashes. Further advantages are that less sound can be heard from the experimental zone and the documentation workstations can be designed ergonomically. It is recommended that the documentation zone be designed in such a way that it is also accessible via a separate entrance outside of the experimental zone.

When designing laboratory documentation zones, particular attention should be paid to Art. 3a para. 1 of the Workplace Ordinance (Arbeitsstättenverordnung; ArbStättV) taking into account the following criteria:

- Draught-free fresh air supply into the laboratory documentation zone
- Directed fresh air transfer from the laboratory documentation zone to the adjoining experimental zone
- Appropriate design of the work and movement areas in the zones
- The experimental zone and the documentation zone are to be connected by an entrance that complies with regulations (for example, a self-closing bidirectional door, double action door). Sliding doors may be installed if there is a separate circulation route in the laboratory documentation zone, this route leads to a safe area and compliance with fire protection guidelines does not require that a second emergency route from the experimental zone leads through the laboratory documentation zone (see section 6.2.3).

Since the documentation zone is part of the laboratory, the requirements laid out in section 4.6.2 apply. A hazard assessment can be carried out to determine whether the risk of spreading contamination by drinking out of original, sealable bottles can safely be ruled out if these conditions are complied with. The effectiveness of this measure is to be assessed and documented.

See Art. 3a para. 1 of the Arbeitsstättenverordnung, DIN 1946-7 "Raumlufttechnik – Teil 7: Raumlufttechnische Anlagen in Laboratorien".

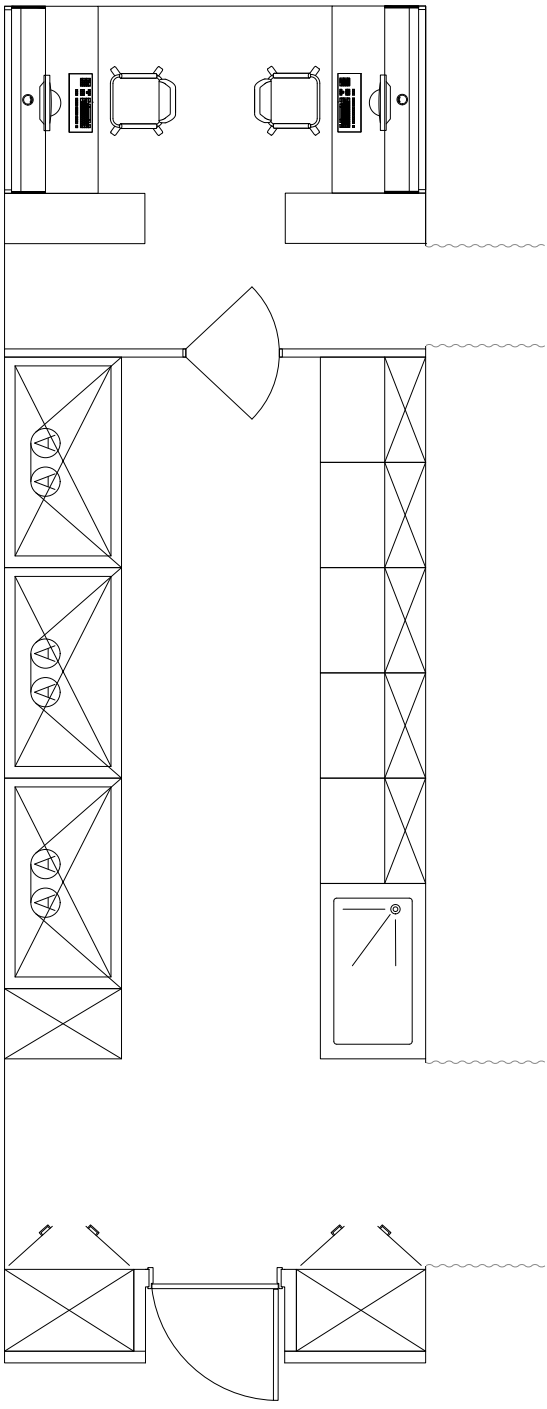


Fig. 25: A detail from a laboratory plan shows one possibility for setting up a preparative chemical laboratory workstation. A self- closing bidirectional connecting door with a damping mechanism ensures that the impact on air turbulence is minimal and negligible with respect to the circulation of people.

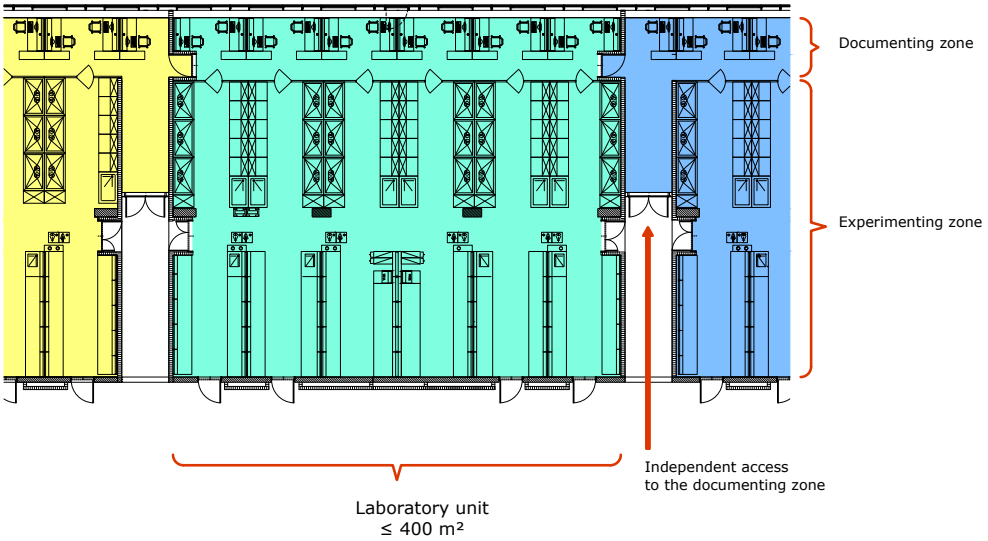


Fig. 26: Example of a laboratory plan designed to include several adjacent units with laboratory documentation zones in the 3.6 m grid.

6.2.2 Escape and rescue routes

Number and type of escape and rescue routes

Laboratories must be equipped with an adequate number of rescue routes and exits that reflects the local conditions and the materials and work methods used. Escape routes may only lead through an adjacent room if this room can be exited safely without outside help, even in the event of a hazard occurring.

It is advisable to provide a second escape option in all laboratory areas (see also the relevant building regulations). The escape route must not be more than 25 m long.

Particularly laboratories that are high fire hazard locations as defined by the technical rule TRGS 800 "Fire protection measures" and teaching laboratories are required to have two exits that are accessible from any area of the laboratory. The exits should be located as far apart as possible, be safely accessible without assistance from third parties and be fully functional at all times.

See also the Technische Regeln für Arbeitsstätten ASR A2.3 "Fluchtwege, Notausgänge, Flucht- und Rettungsplan" as well as TRGS 800 "Brandschutzmaßnahmen".

Fig. 27: Second escape possibility from a laboratory

6.2.3 Doors

Arrangement and properties of doors

Laboratory doors must open outwards and have a window. Sliding doors are not permitted. Laboratory doors should be kept closed.

Open doors may not restrict circulation routes. The remaining width must be sufficient to walk past unhindered. This may be achieved, for example, by setting the door back into the room. The window should allow an unimpaired view in both directions. Fire and smoke doors must not be propped open because, in the event of a fire, toxic smoke would quickly spread through the building and escape routes. If such doors have to be kept open, only devices approved by the building authorities may be used. Door closers have proved to be a good solution.

Self-closing bidirectional doors with a damping mechanism (but not double swing doors) may be used in laboratories in fire compartmented units along internal circulation routes as well as along emergency and escape routes. Manually operated, preferably automatically closing sliding doors may be admissible if these are not located along emergency and escape routes.

See also Art. 3 of the Arbeitsstättenverordnung with the associated Technische Regeln für Arbeitsstätten ASR A2.3 "Fluchtwege, Notausgänge, Flucht- und Rettungsplan".

6.2.4 Floors

Tightness and resistance

Floors, their coverings and cable conduits passing through them must be watertight.

This normally prevents substances that have been spilled seeping away unnoticed before they can be removed. In specific cases, laboratory floors may allow drainage. The best resistance against dripping liquefied cryogenic gases and chemicals is offered by floors with ceramic tiles. Wooden or parquet floors are not normally suitable for work involving hazardous materials.

6.2.5 Ventilation

6.2.5.1 Ventilation systems

Properties, operation and marking of ventilation and air conditioning systems

Laboratories must be equipped with technical facilities that ensure adequate ventilation at all times. It must be possible to heat incoming air if necessary and introduce it without causing a draft. Exhaust air may be routed entirely or partially via fume hoods, provided they are still able to operate at full capacity. An air exchange of 25 m^3/h per m^2 of laboratory floor area may be reduced or natural ventilation may be used if the hazard assessment indicates that this is an adequate and effective solution in the long term for the work to be performed. In laboratories with an air exchange below the normally required 25 m^3/h per m^2, work involving hazards such as flammable liquids or other hazardous materials that are volatile, generate dust or form aerosols must be kept to an absolute minimum unless other types of additional protective measures are taken. Such restrictions on use for laboratories are to be documented and the proprietor is to inform all those in positions of responsibility, including those who subsequently assume such positions. Laboratories with air exchange levels below the required value during working hours are to be marked at the entrance with "Achtung: Reduzierter Luftwechsel" [Warning: Reduced air exchange]. In specific cases,

the hazard assessment may also indicate that a higher air exchange level is required. It must be ensured that exhaust air containing dangerous quantities or concentrations of hazardous materials cannot get back into work areas. Doors must be kept closed in order to maintain proper ventilation and it must be ensured that they are not left standing open.

All ventilation plans and layouts must fulfil the requirements listed in the standard VDI 2051 "Air-conditioning – Laboratories" (VDI Ventilation Code of Practice) of the Association of German Engineers (VDI) and the German standard DIN 1946-7 "Ventilation and air conditioning – Part 7: Ventilation systems in laboratories".

Incoming and outgoing air must be routed so as to take in the entire laboratory area. Designing or installing the system incorrectly may result in "short-circuits" in the flow of air that miss out parts of the laboratory. Unless specified otherwise in the hazard assessment, the quantity of introduced air must reach at least 25 $m^3/(m^2h)$ (related to the main usable floor space, or, as specified in the new standard, usable floor space); given a ceiling height of 3 m, this is approximately equivalent to an eightfold exchange of air. For fume hoods, see also DIN EN 14175 "Fume cupboards" and Section 6.3.1. Regular maintenance and cleaning of the ventilation system prevents the development of hygiene issues through microbial contamination. If it is concluded in the hazard assessment that these measures are sufficient and effective for the designated activities in the long term, the quantity of air exchanged may be reduced, for example, or natural ventilation may be used. However, this is not advisable if changes in use cannot be reliably foreseen (for example in research laboratories).

For further details on ventilation, see also the DGUV Information 213-857 "Laborabzüge – Bauarten und sicherer Betrieb".

Local extraction devices

Local extraction devices are recommended in order to reduce emissions at source. Such devices can stop emissions getting into the laboratory air, but they only work in the immediate vicinity of the locations where emissions enter the air (see Fig. 28).

Such local extraction devices are no replacement for fume hoods, but they can be useful under certain conditions. Fig. 29 shows one example where the outflowing gas is effectively captured and discharged.

Smoke stacks – above atomic absorption spectrometers, for example – must therefore be dimensioned and aligned very accurately to capture as much of the exhaust gas flow directed by thermal convection as possible. Transverse flows in the room must be avoided.

See the DGUV Information 213-855 "Gefährdungsbeurteilung im Labor".

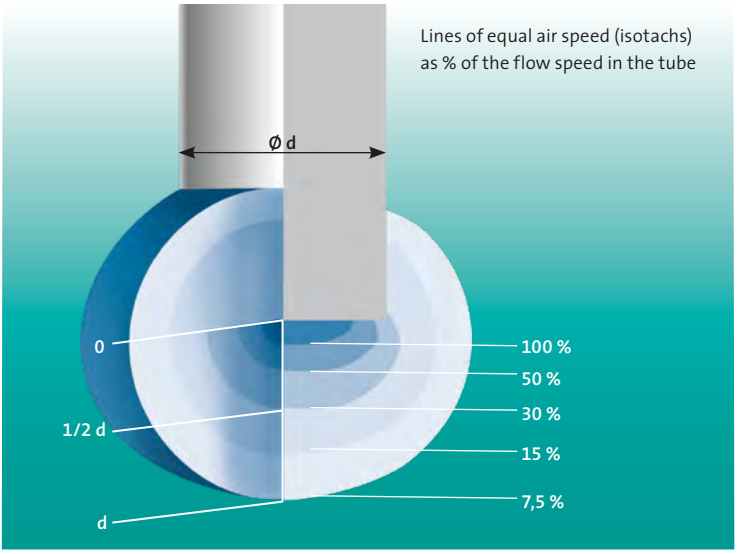


Fig. 28: Isotachs of the inflowing air around the opening of a local extraction device. At a distance equivalent to the diameter d of the tube, the flow speed has already dropped to less than 10 % and can therefore no longer be captured. Effectiveness may be boosted by attaching flanges to the outside of the opening.

Fig. 29: Example of a local extraction device on a gas chromatograph

6.2.5.2 Recirculation of air

Recirculation of air

Recirculation of air is permissible for room ventilation only if no hazardous concentrations of hazardous materials can occur. According to Art. 11 para. 4 of the GefStoffV, exhaust air may only be returned to areas where work involves category 1 or 2 carcinogenic, mutagenic or reprotoxic materials if it is cleaned sufficiently using procedures or equipment that have been approved by the authorities or the Berufsgenossenschaft.

The contents of Art. 11 para. 4 have been incorporated in Art. 10 para. 5 of the GefStoffV 2010.

6.3 Extraction equipment

6.3.1 Fume hoods

6.3.1.1 Protection objectives

Protection objectives, properties and requirements

Fume hoods must be designed in such a way that, when they are operating, their structure and ductwork:

- **prevent gases, vapors and dusts in hazardous concentrations or quantities from entering the laboratory from inside the fume hood**
- **prevent hazardous explosive atmospheres from forming inside the fume hood**
- **protect insured persons from splashing hazardous materials or flying broken glass.**

It must be borne in mind that the containment capacity of fume hoods may change in an unpredictable way in the event of major thermal stresses. Enclosures and workplaces with extraction systems are not fume hoods because they do not achieve some of the above-mentioned protection objectives. For certain work, however, the hazard assessment may indicate that they provide an adequate level of protection.

Variable air volume (VAV) fume hoods and fume hoods with automatic night setback have to be clearly labelled as such for users, for example by means of an adhesive label.

It is advisable to provide a switch on a variable volume flow control fume hoods where the flow rate is regulated so that a higher rate can be set in the event of an accident happening when the sash is lowered.

For further details on fume hoods, see also Section 4.11.1 and DIN EN 14175 “Abzüge”. For details on older fume hoods, see also

DIN 12924-1:1991 “Laboreinrichtungen; Abzüge; Abzüge für allgemeinen Gebrauch, Arten, Hauptmaße, Anforderungen und Prüfungen”, now DIN EN 14175 “Abzüge”. For details on fume hoods for fuming perchloric and sulfuric acid, and for work involving hydrofluoric acid, see DIN EN 14175-7:2013 “Abzüge für hohe thermische und Säurelasten (Abrauchabzüge)”. For details on older fume hoods, see DIN 12924-2:2007 “Laboreinrichtungen – Abzüge – Teil 2: Abrauchabzüge”. Fume hoods that comply with DIN EN 14175-1:2003, DIN EN 14175-2:2003, DIN EN 14175-3:2004, DIN EN 14175-4:2004 and DIN EN 14175-6:2006 “Abzüge” are normally deemed suitable if the criteria relating to containment capacity and ventilation inspections in the DGUV Information 213-857 “Laborabzüge – Bauarten und sicherer Betrieb” are met.

Sample operating instructions are provided in (2).

See also the DGUV Information 213-857 “Laborabzüge – Bauarten und sicherer Betrieb”.

6.3.1.2 Materials

Resistance of fume hoods and ductwork

Fume hoods must be made of materials that withstand the mechanical, chemical and thermal stresses to be expected when they are used as intended. Pipes and ducts of fume hoods must be designed in such a way that they cannot contribute to the spread of a fire. The windows of fume hoods must be equipped with safety glass – preferably laminated – or a suitable plastic.c.

It is particularly important that perchloric acid fume hoods have no gaps and cracks so that no perchloric acid can find its way into oxidizable parts of the structure (chipboard) unnoticed. These fume hoods must allow easy and effective cleaning.

Fire dampers may also be required inside the ductwork to prevent the spread of fire. Corrosion resistance is another factor that needs to be taken into account. With metal ducts in particular, the introduction of corrosive gases, vapors and mists can contribute to corrosion and leaks. Sensors and valves are also damaged. In addition to preventing the introduction of these gases, vapors and mists, washers/scrubbers can also be used to protect the extraction system in justified cases. In perchloric acid fume hoods, efficient rinsing devices are required for the ducts, including after washers/scrubbers. Such ducts should lead out of the building as quickly as possible.

See also Section 4.11.1.

If explosions occur in the fume hood, flying fragments and parts of apparatus can often shatter unsuitable glazing. Side windows and walls should not contain any window glass either, as this easily breaks into sharp fragments and can lead to serious injuries.

6.3.1.3 Pressure relief

Damage limitation through pressure relief

Fume hoods must be equipped with pressure relief devices. These must not put persons at risk.

Suitable pressure relief devices include loose lightweight plates that are fastened down so that they cannot fly away. Fume hoods complying with DIN EN 14175-1 to DIN EN 14175-4 "Abzüge" are normally deemed suitable if they have such a pressure relief device.

6.3.1.4 Sashes

Properties

Fume hood windows that slide vertically, in particular sashes, must be secured to prevent them from falling down. The fume hood must be equipped with access openings and must be closable. A notice saying "Frontschieber geschlossen halten" [Keep sash closed] must be located on the sash in a position where it can be easily seen. An adequate supply of air must be ensured, even if the sash is closed. There may be no risk of injury when closing the sash.

Even if the sash is closed, parts of it that move horizontally or access openings allow work to continue. It is also advisable to have such moving sash parts or access openings in the upper part of the front of the fume hood for setting up and operating tall apparatus. It is an advantage to have an additional locking device half way up the opening.

Access openings or divided sashes are not stipulated for sashes of fume hoods for increased acidic and heat load as specified in DIN 12924-2 "Laboreinrichtungen – Abzüge – Teil 2: Abrauchabzüge" or DIN EN 14175-7 "Abzüge – Teil 7: Abzüge für hohe thermische und Säurelasten (Abrauchabzüge)". This may restrict their use for other purposes.

As regards markings, see also DIN 4844 "Sicherheitskennzeichnung" (now: DIN 4844 "Graphische Symbole – Sicherheitsfarben und Sicherheitszeichen").

If the sash is closed, the flow rate for regulated fume hoods (variable air volume flow – VAV) may be lower, which can increase the explosion hazard due to the lower purging rate. There is then a risk of injury resulting, for example, from crushing.

Fig. 30: Fume hood with divided sash

Information pertaining to the air volume of a fume hoods related to a unit of length, for example related to 30 cm, is to be requested from the manufacturer.

See also DIN EN 294 "Sicherheit von Maschinen; Sicherheitsabstände gegen das Erreichen von Gefahrstellen mit den oberen Gliedmaßen" (now: DIN EN ISO 13857 "Sicherheit von Maschinen – Sicherheitsabstände gegen das Erreichen von Gefährdungsbereichen mit den oberen und unteren Gliedmaßen").

The company Tintschl used a numerical simulation calculation to demonstrate that at least 200 air changes are required to avoid additional fire and explosion hazards in a fume hood (900 mm worktop level) with regard to the volatility of the worst case among the common laboratory solvents, diethylether.

See also company Tintschl presentation of the results in the Standard Committee "Abzüge und Laborlufttechnik" (32).

6.3.1.5 Monitoring the ventilation function

Monitoring and raising the alarm

The perfect ventilation of each fume hood must be monitored by an automatic device. In the event of a fault, an optical and acoustic alarm must go off. The optical signal must be clearly assigned to the various fume hoods and it must not be possible to switch it off. A signal light

indicating the on/off status of the fan motor or the underpressure of the extraction system is not sufficient. The acoustic signal must be audible at all times throughout the laboratory. In the case of centrally controlled fume hoods, it must be ensured that insured persons are familiar with the operating cycle. It must not be possible to tamper with monitoring devices or put them out of action by simple means.

With older fume hoods without automatic monitoring devices, the proper operation of extraction devices must be ensured by organizational measures. In addition, devices indicating the air flow, such as pinwheels, are to be fitted in front of the exhaust air openings and kept in good working order.

It is advisable to use large, obvious lights – preferably flashing – for optical signals so that they are not overlooked.

6.3.1.6 Outlets

Operation and marking

Permanently installed outlets for liquid or gaseous materials in fume hoods must be operated from the outside. It must be clear which handles for the various taps, valves and outlets relate to which media.

The type of material for which the outlet is used must also be clear. See also DIN EN 13792 "Farbige Kennzeichnung von Laborarmaturen". In order to avoid mix-ups, it is advisable to indicate the name of the medium.

See also Section 6.5.2.

6.3.2 Ductless filtering fume enclosures

Properties and limits of use

Ductless filtering fume enclosures must be designed and operated in such a way that no hazards occur. These devices are normally only intended for working with small quantities and are not suitable for work with highly toxic, carcinogenic, mutagenic or reprotoxic materials or with materials that have low boiling points (≤ 65 °C). In order to ensure the retention capacity of the filters, they require very careful maintenance and specialist knowledge on the part of the user.

See also Section 6.3.1 for hazards.

Ducteess filtering fume enclosures (also: recirculating air extraction system with filters, circulating air extractors) cannot generally replace driven-air fume hoods systems as per DIN EN 14175. They are to be

equipped with suitable filter systems. Since the exhaust air is vented into the laboratory, particular attention must be paid to securing adequate cleaning of the ambient air to ensure occupational safety. In this vein, reference is made to the operator's obligation to determine levels and comply with defined limits, also when using extraction boxes with air return. The operator must also demonstrate the suitability of the facilities used within the scope of a risk assessment. Reliable manufacturer statements regarding substances tested with extraction boxes that employ air return can be incorporated in the risk assessment when evaluating suitability. If permanent compliance with the limit values cannot be reliably determined using the characteristics assured by the manufacturer, compliance must be demonstrated separately in application of the Technical Rules for Hazardous Substances (TRGS) 402. Irrespective of manufacturer certificates, the operator is responsible for maintaining a safe working environment, in particular complying the Occupational Health and Safety Act (ArbSchG), Operational Safety Ordinance (BetrSichV) and Ordinance on Hazardous Substances (GefStoffV). All prohibitions relating to recirculation of exhaust air containing CMR substances as per § 10 (5) of the Ordinance on Hazardous Substances (GefStoffV) must be observed.

Special expertise is required on the part of users, in particular to avoid filter overloading.

Within the scope of the risk assessment, particular attention must be paid to determine whether reliable measures are in place to handle the following hazards and potential incidents:

- Potential additional fire loads due to charged or uncharged filter materials, such as activated carbon
- Risks of fire and explosion when handling flammable liquids
- Ignition of explosive atmospheres in the air circulation system
- Spontaneous combustion of filter materials due to load
- Exposure by inhalation to toxic substances and substances that are sensitising to the respiratory system
- Exposure to new, unknown or not adequately tested substances
- Effect of continuous reactions
- Effects of failing substance containers in the event of pressure reactions
- Effects of implosions in the event of a vacuum
- Effects of fragments and splashes.

In addition to this, the following must be secured:

- Compliance with the occupational exposure limit and acceptance/tolerance concentrations in the ambient air
- The retention capacity of the filter is appropriate for the hazardous substances and intended application, and any breakage is both reliably detected and indicated via an alarm

- The hazardous substances already adsorbed cannot be desorbed again as a result of interactions with other substances, e.g. solvents with low boiling point or water vapor
- Hazardous substances already adsorbed cannot be desorbed again as a result of an impermissible rise in temperature
- Safety devices such as sensors are operational and their function is reliably maintained
- Inspection, maintenance and regular tests are performed (type, interval and scope, qualified person) to secure the safety of the equipment
- Filters can be changed reliably and safely without any contamination or exposure.

Since the absorption capacity of the filters is limited, only sufficiently small amounts of substances may be handled to ensure complete absorption of the substances released at all times, also in the event of damage.

Even in the event of damage, fragment and splash protection must remain intact and it must be possible to perform inner rinsing safety to prevent risks of explosion. When bombarded with a different material, substances adsorbed by the filters can potentially be desorbed and released again within a short space of time, depending on their quantity and also the strength of the interaction occurring. Regular maintenance and scheduled filter changes are indispensable. Additional hazards can occur during filter changes and when fires occur in filters.

See DIN 12927 "Laboreinrichtungen – Absaugboxen mit Luftrückführung – Anforderungen, Prüfungen".

For information on the requirements when using safety cabinets with air return for work with carcinogenic or mutagenic cytostatic agents, please refer to the approach recognised by the respective authorities in Germany as per § 10 (5) of the Ordinance on Hazardous Substances (GefStoffV) in Merkblatt M 620 "Sichere Handhabung von Zytostatika" published by the German Social Accident Insurance Institution for the Health and Welfare Services/DGUV Information 207-007 "Zytostatika im Gesundheitsdienst – Informationen zur sicheren Handhabung von Zytostatika", as well as DIN 12980 "Laboreinrichtungen – Sicherheitswerkbänke und Isolatoren für Zytostatika und sonstige CMR-Arzneimittel".

6.4 Workbenches and their storage spaces

6.4.1 Workbenches

Properties, splash protection

The material and design of workbenches must withstand the intended workloads. In particular, work surfaces of laboratory benches and fume hoods must have a liquid-tight covering and a raised edge. In the case of work surfaces located opposite one another, protection against splashing is required up to a height of at least 175 cm.

Bench surfaces for chemical applications are normally equipped with large ceramic tiles and less frequently with acid-proof tiles. A range of other surface materials are available for other purposes.

See also DIN EN 13150 "Arbeitstische für Laboratorien – Maße, Sicherheitsanforderungen und Prüfverfahren".

6.4.2 Storage spaces for hazardous material waste

Properties, ventilation and grounding

Storage spaces for collection containers for hazardous material waste must be connected to an exhaust air device of adequate dimensions that remains effective at all times, even when the collection containers are being filled. The interior of these storage spaces must, at the very least, be lined with material that does not burn easily. In the case of hazardous liquid waste, an adequately dimensioned collection pan must be located below the collection containers.

One possibility is keeping such waste in safety cabinets that comply with DIN EN 14470-1 "Feuerwiderstandsfähige Lagerschränke – Teil 1: Sicherheitsschränke für brennbare Flüssigkeiten".

It is advisable to provide grounding to dissipate electrostatic charges (see also Section 4.12.2). The exhaust air device should be able to capture the vapors forced out of the container when the liquid is poured in.

The dimensioning and technical equipment of the exhaust air device and the low-flammability lining depend on the result of the hazard assessment for the disposal of hazardous materials.

6.5 Supply lines and fittings

6.5.1 Supply lines

Properties and marking

Stationary, tightness-tested lines must be available for the continuous supply of liquid and gaseous materials to the laboratory benches and fume hoods. Stationary supply lines must be marked clearly and permanently.

These lines must remain technically tight at all times. The corrosion and vibration requirements must be borne in mind.

For drinking water lines, see DIN 1988-100 "Technische Regeln für Trinkwasser-Installationen (TRWI) – Teil 100: Schutz des Trinkwassers, Erhaltung der Trinkwassergüte; Technische Regel des DVGW" and DIN 18381 "VOB Vergabe- und Vertragsordnung für Bauleistungen – Teil C: Allgemeine Technische Vertragsbedingungen für Bauleistungen (ATV) – Gas-, Wasser- und Entwässerungsanlagen innerhalb von Gebäuden".

Clear and permanent marking of supply lines is normally achieved using paint, an inscription or plates as specified in DIN 2403 "Kennzeichnung von Rohrleitungen nach dem Durchflussstoff" (see Table 2).

See also Section 5.1 of DVGW-Arbeitsblatt G 621 "Gasinstallationen in Laborräumen und naturwissenschaftlichen Unterrichtsräumen – Planung, Erstellung, Änderung, Instandhaltung und Betrieb".

Green	Water
Red	Steam
Gray	Air
Yellow or yellow plus red	Flammable gases
Yellow or yellow plus black	Non-flammable gases
Orange	Acids
Purple	Alkalis
Blue	Oxygen
Brown or brown plus red	Flammable liquids
Brown or brown plus black	Non-flammable liquids

Table 2: Color coding for marking supply lines

6.5.2 Shutoff devices

Shutoff devices for fuel gases and other media

It must be possible for every fuel gas line that leads to one or more adjacent outlets to be closed separately. The shutoff device must be easy to reach and accessible at all times. Furthermore, another shutoff device must be available at a safe location. The components controlling this shutoff device must be located outside of the laboratory, close to it, within easy reach, clearly marked and accessible at all times. Only devices that are secured from being opened accidentally may be used as outlets for fuel gases. Components controlling laboratory shutoff devices must be marked according to the medium flowing through them.

It is advisable to provide master shutoff devices for all media. With large laboratories, it may be necessary to be able to perform the emergency shutoff from several different locations. If there is a risk of getting intermediate shutoff devices mixed up, they are to be marked by color coding (paint) or lettering, for instance. The component controlling the master shutoff device may, for example, be a switch for remote operation.

See DIN 3537-1 "Gasabsperrarmaturen bis PN 4; Anforderungen und Anerkennungsprüfung" (now: DIN 3537-1 "Gasabsperrarmaturen bis 5 bar für die Gas-Hausinstallation"), DVGW-Arbeitsblatt G 621 "Gasinstallationen in Laborräumen und naturwissenschaftlichen Unterrichtsräumen – Planung, Erstellung, Änderung, Instandhaltung und Betrieb", DIN 18381 "VOB Vergabe- und Vertragsordnung für Bauleistungen – Teil C: Allgemeine Technische Vertragsbedingungen für Bauleistungen (ATV) – Gas-, Wasser- und Entwässerungsanlagen innerhalb von Gebäuden" and DIN 12918-2 "Laboreinrichtungen – Laborarmaturen – Teil 2: Entnahmestellefür Brenngase".

Marking

The end face of the component controlling the device is divided into three zones to characterize the medium (see Fig. 31).

Fig. 31: Colored zones of the component controlling the shutoff device

The color of the control component's outermost zone – often the color of the entire component, except for its end faces – essentially determines the type of medium (see Table 3). Two additional colors or a code (abbreviation or molecular formula) on the end faces can be used to provide precise details on the medium. For example, the color code "green-white-green" with the formula C_2H_2 or "black-red-yellow" with the formula H_2S.

	Green	Water
	Yellow	Flammable gaseous hydrocarbons
	Red	Other flammable gases
	Blue	Non-flammable (including combustion-promoting) gases
	Black	Toxic gases
	Gray	Vacuum
	White	Other media

Table 3: Color coding (outermost zone of control components) of laboratory shutoff devices

The color codes for laboratory shutoff devices are not the same as those for pipes and compressed-gas cylinders.

See DIN EN 13792 "Farbige Kennzeichnung von Laborarmaturen".

6.5.3 Drainage lines

Trap seals

Drainage lines in laboratories must be equipped with trap seals and easily accessible openings for cleaning.

Drying out of trap seals has to be avoided. Odors from the drains may mask warning odors from the laboratory.

See DIN 19541 "Geruchverschlüsse für besondere Verwendungszwecke – Anforderungen und Prüfverfahren".

6.6 Emergency showers

6.6.1 Emergency (overhead) showers

6.6.1.1 Water flow rate and location

Water flow rate and location

An emergency shower supplied with water, if possible of drinking water quality, must be installed at the exit of laboratories. It should be capable of immediately drenching the entire body with adequate quantities of water. At least 30 l of water per minute are required for this purpose.

Drinking water may also be used to supply emergency showers after passing via a backflow preventer or air gap (see DIN EN 1717 "Schutz des Trinkwassers vor Verunreinigungen in Trinkwasser-Installationen und allgemeine Anforderungen an Sicherheitseinrichtungen zur Verhütung von Trinkwasserverunreinigungen durch Rückfließen"). Emergency showers in laboratories need to be supplied with at least 30 l of water per minute for adequate and sufficiently quick decontamination and to extinguish fire on burning people.

See DIN EN 15154-1 "Sicherheitsnotduschen – Teil 1: Körperduschen mit Wasseranschluss für Laboratorien". Laboratories do not fall under the scope of DIN VDE 0100-701 "Errichten von Niederspannungsanlagen – Teil 7-701: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Räume mit Badewanne oder Dusche".

In the case of emergency showers, the component controlling the quick-action valve must be fitted in an easily accessible location with no possibility of a mix-up. The direction of opening must be obvious and, once opened, the valve must not close by itself. Chains may not be used to open valves.

It should be possible to reach an emergency shower from any part of the laboratory in 5 seconds or less. The exact location of the emergency shower depends on the result of the hazard assessment.

It is not appropriate to raise the temperature of the water above the ambient temperature due to the hazard of microbial contamination. During installation it is important to ensure that, as far as possible, water is not left sitting in the supply lines for long periods and that its temperature does not rise above the ambient temperature due to the effects of external heat.

See Section 7.2 for the functional test on emergency showers.

6.6.1.2 Marking

Marking locations

The location of emergency showers must be marked with the emergency sign "Notdusche" [Emergency shower]. Access to showers must be kept free at all times.

Showers must always be quick and easy to reach. For example, it may be helpful to mark the floor underneath the emergency shower so that it stands out (black and yellow stripes) and is not obstructed.

6.6.2 Emergency eye-wash units

6.6.2.1 General requirements

Requirements, stationary and mobile emergency eye-wash units

Laboratories must be equipped with emergency eye-wash units supplied with drinking water, if at all possible in the vicinity of the shower or slop sink. They should be installed so that they can be reached immediately from any workstation and should be capable of rinsing both eyes immediately with adequate quantities of water. The component controlling the valves must be easily accessible, fitted so as to avoid mix-ups and easy to operate. Once opened, valves must not close by themselves. Mobile emergency eye-wash units with automatic shutoff valves on the handle are, however, also permitted. Eye-wash bottles with sterile rinsing liquid are permitted if no running drinking water is available. At least 6 l of water per minute must flow from each outlet of an emergency eye-wash unit.

Drinking water may also be used to supply emergency showers after passing via a backflow preventer.

The water jets must reach a height of at least 10 cm but no more than 30 cm above the outlets.

Eye-wash units must be quick and easy to reach at all times. Eyes should be rinsed with the lids spread wide apart to catch all chemical residue. Rinsing should continue for some time – at least 10 minutes is recommended – and a doctor must check the affected eye(s) immediately.

Mobile emergency eye-wash units with just one rinsing head are permitted.

It is not appropriate to raise the temperature of the water above the ambient temperature due to the hazard of microbial contamination. During installation it should be ensured that, as far as possible, water is not left sitting in the supply lines for long periods and its temperature does not rise above the ambient temperature due to the effects of external heat. DVGW-tested hoses are recommended for flexible lines.

See DIN EN 15154-2 "Sicherheitsnotduschen – Teil 2: Augenduschen mit Wasseranschluss". See Section 7.2 for the functional test on eye-wash units.

6.6.2.2 Location and marking

Marking locations

The location of emergency eye-wash units must be marked with the emergency sign "Augenspüleinrichtung" [Eye-rinsing device]. Access must be kept free at all times.

Emergency eye-wash units must be installed and kept free of obstructions so that they can be reached quickly and used by people of any size. It should be possible to reach an emergency eye-wash unit from any part of the laboratory in 5 seconds or less. Fig. 32 shows a bad example.

Fig. 32: Emergency eye-wash unit with obstructed access representing a bad example. In the event of an injury, valuable seconds would be lost before assistance could be provided to save the affected eye.

6.7 Electrical equipment and appliances

6.7.1 Electrical power supply facilities

Electrical circuits and switching off

Separate electrical circuits must be set up for lighting, ventilation and the general electrical power supply. In addition, laboratory benches and fume hoods should be on separate individual or group circuits.

As far as possible, separate circuits should also be provided for other safety-related equipment. For switching off the power, a master switch is best installed at an easily accessible location, for example at the laboratory exit. If a workplace's electrical consumers have to be disconnected in the event of an accident, it is important to ensure that safety-related devices such as stirrers keep operating.

See also DIN 57789-100; DIN VDE 0789-100; VDE 0789-100 "Unterrichtsräume und Laboratorien; Einrichtungsgegenstände; Sicherheitsbestimmungen für energieversorgte Baueinheiten (VDE-Bestimmung)".

6.7.2 Earthing

6.7.2.1 Contact protection and potential equalization measures

Properties, grounding and RCD

Electrical appliances in laboratory benches and fume hoods must be designed in accordance with the regulations. In particular, they must comply with DIN EN 61010-1:2002 (see also VDE 0411 Teil 1 and/or VDE 0789 Teil 100). If potential equalization is required, electrically conductive bench coverings and other conductive structural parts of the laboratory equipment that can be touched must be interconnected using a potential equalizer. Mobile parts need to be earthed if they are conductive in the event of a fault.

The grounding measures provided for in DIN VDE 0100-540; VDE 0100-540 "Errichten von Niederspannungsanlagen – Teil 5-54: Auswahl und Errichtung elektrischer Betriebsmittel – Erdungsanlagen, Schutzleiter und Schutzpotentialausgleichsleiter" (now: DIN VDE 0100-540; VDE 0100-540 "Auswahl und Errichtung elektrischer Betriebsmittel – Erdungsanlagen und Schutzleiter") are normally sufficient. It is advisable to support the personal protective measures by installing RCDs.

6.7.2.2 Electrostatic discharging

Electrostatic discharging on equipment and containers

Specific tasks may require electrostatic discharging applications. Normally, no such measures are required in laboratories. Depending on the use referred to above, turnkey fume hoods may have a connection point enabling easy connection to the local potential equalizer.

Any earthing cables required to avoid electrostatic ignition sources, for example when transferring flammable liquids, can be connected at this point. Ignition sparks from charged persons can also be avoided. Hasty discharging of charged persons can lead to further hazards.

For the protective conductor test, see DIN 57789-100; DIN VDE 0789-100; VDE 0789-100 "Unterrichtsräume und Laboratorien; Einrichtungsgegenstände; Sicherheitsbestimmungen für energieversorgte Baueinheiten (VDE- Bestimmung)".

6.7.3 Switches and sockets

6.7.3.1 Switches and sockets

Arrangement and switching off

Switches and sockets on laboratorybenches have to be installed above the work surface or, if fitted underneath the benchtop, they have to be set back far enough so as not to represent a hazard in case of escaping or splashing liquids. Fume hood sockets have to be installed outside of these fume hoods. If sockets are required in the fume hood's work area, it must be possible to switch them separately from the outside and there must be no possibility of mix-ups.

Fume hood sockets must have a minimum protection class of IP 44 in accordance with DIN EN 60529; VDE 0470-1 "Schutzarten durch Gehäuse (IP-Code)".

See also DIN EN 14175-2 "Abzüge – Teil 2: Anforderungen an Sicherheit und Leistungsvermögen".

Corroded contacts may lead to unacceptably high resistances in the protective conductor. In addition, the voltage drop at the contact surfaces can heat the socket so much as to cause a fire.

6.7.3.2 Protection against spraying water

Protection against electric shocks

Switches and sockets within the spraying range of emergency showers must be protected from spraying water.

Switches and sockets within the spraying range of emergency showers must be protected from spraying water. Switches and sockets of protection class IP 44 and higher are suitable. As regards degrees of protection, see DIN EN 60529; VDE 0470-1 "Schutzarten durch Gehäuse (IP-Code)". Instructions for determining the form and extent of spraying ranges are provided in DIN VDE 0100-701 "Errichten von Niederspannungsanlagen – Teil 7-701: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Räume mit Badewanne oder Dusche". However, this standard does not cover laboratories. The minimum extent of the spraying range should be the water cone of the emergency shower for the wetted area in accordance with DIN EN 15154-1 "Sicherheitsnotduschen –Teil 1: Körperduschen mit Wasseranschluss für Laboratorien". Local conditions should be taken into account.

7 Inspections

7.1 Inspections

Frequency, type and scope

The Gefahrstoffverordnung requires proprietors to check the performance and effectiveness of technical protective measures regularly, but at least every three years. The proprietor is responsible for defining the type and scope of inspections and the inspection periods based on a hazard assessment, and for documenting these. It is also important to ensure that inspections are only performed by appointed persons with the relevant expertise. They should be documented in an appropriate manner. The stipulations of the Betriebssicherheitsverordnung also apply to appliances used in laboratories. Further inspection obligations from other areas of law over and above those referred to here may apply, in particular regarding the inspection of electrical appliances.

An overview of inspections in laboratories is included as Annex 3. The associated inspection details can be found on the Internet in (3).

7.2 Emergency showers

Inspection at least every month

The proprietor must take care that showers and eye-wash units are checked at least once a month by a person he appoints to ensure they are in good working order.

This inspection includes a check on the flow rate, the water distribution pattern of the shower head and the quality of the water (visual check).

Otherwise, it is not possible to ensure that the actuating valve remains free-moving and the shower head is clear. Changing the water frequently also prevents impurities and microbial contamination in the water pipe.

It is advisable to operate emergency eye-wash units on a frequent basis.

7.3 Fume hoods

Inspection at least once a year

Fume hoods must be serviced at regular intervals and their operation tested and documented. The inspection must be carried out at least once a year by a qualified person. The annual inspection of the ventilation system may be dispensed with if it is possible to ensure by means of self-monitoring of the individual fume hood's operation that any failure to achieve the minimum flow rate is signaled visually and

acoustically. The continuous monitoring device has to be inspected at least every three years.

Expertise and qualification

A person is qualified to perform the inspection referred to in Art. 7 para. 7 of the Gefahrstoffverordnung if, based on his technical training or experience, he possesses sufficient knowledge in the field of fume hood inspections and is sufficiently familiar with the relevant state industrial safety regulations, DGUV regulations, guidelines and generally accepted rules of engineering (for example DIN standards, VDE regulations, equivalents to Technische Regeln of other Member States of the European Union or other states party to the Agreement on the European Economic Area) to assess the condition of fume hoods from an industrial safety viewpoint.

Continuous monitoring requirements

A technical device used for continuous monitoring signals the nonavailability of the monitoring system by means of visual and acoustic error signals. This may be caused by contamination, corrosion, chemical stresses, aging or faults in the electronic system. The equipment currently available on the market does not normally satisfy these requirements.

After modification of the ventilation system (if flow rates are affected, for instance), a new inspection may be necessary.

Scope of inspection

The regular inspection comprises:

- a general visual inspection of the fume hood's condition from a safety viewpoint
- inspection of the sash mechanism for smooth running, jamming and noise; if appropriate, suspension devices and weights must also be inspected for damage, depending on the operating conditions
- inspection of the ventilation function on the basis of the manufacturer's information; for fume hoods commissioned before October 1, 1993, the following alternative definitions apply:
  - benchtop fume hoods (height of work surface 900 mm) require a 400 m3/h air flow rate per meter of front length
  - low-level fume hoods (height of work surface 500 mm) require a 600 m3/h air flow rate per meter of front length
  - walk-in fume hoods (height of work surface 0 mm) require a 700 m3/h air flow rate per meter of front length
  - digestion fume hoods (height of work surface 900 mm) require a 700 m3/h air flow rate per meter of front length.

The regular inspection of the ventilation function may take place in the form of a differential pressure or velocity measurement in the ventilation nozzle above the fume hood or at the sash opening. The velocity measurement may be performed by determining the mean inflow ve-

locity when the sash is opened to a height of 100 mm. Suitable measuring instruments include thermal or vane anemometers.

The ventilation function of fume hoods installed prior to October 1, 1993 and manufactured in accordance with DIN 12924-1 dated August 1991 or DIN 12924-2 “Laboreinrichtungen; Abzüge; Abzüge für offene Aufschlüsse bei hohen Temperaturen; Hauptmaße, Anforderungen und Prüfungen” dated January 1994 is inspected on the basis of the manufacturer’s specifications.

For inspection details, see the DGUV Information 213-857 “Abzüge – Bauarten und sicherer Betrieb” and (2).

7.4 Safety cabinets for flammable liquids

Inspection at least once a year

Safety cabinets for flammable liquids must be inspected regularly by a qualified person. The inspection focuses in particular on the locking devices for doors and connections, the seals and the air exchange.

It is advisable to carry out inspections at least once a year.

See DIN EN 14470-1 “Feuerwiderstandsfähige Lagerschränke – Teil 1: Sicherheitsschränke für brennbare Flüssigkeiten”.

Great mechanical stress (increase in the permissible load or superstructure) has a negative effect on the flame resistance of a safety cabinet.

Annex 1: Sample escape and rescue plan

http://www.bgrci.de → Prävention → Fachwissen-Portal → Topic List → Laboratories → Work aids → Sample escape and rescue plan (Web code: Page ID #MYNZ)

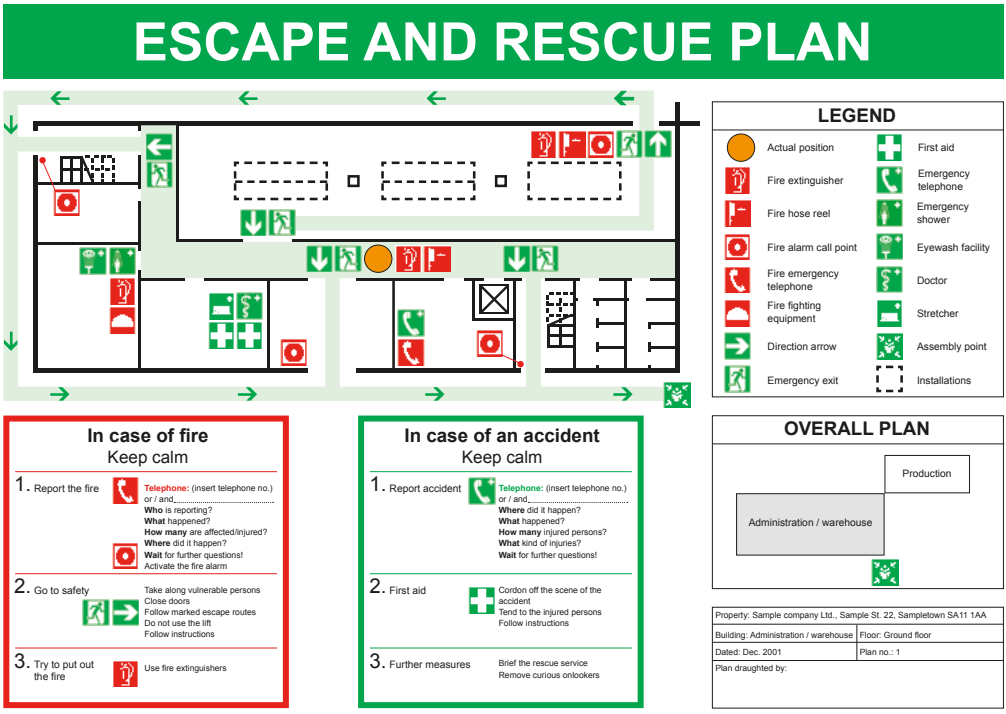


Fig. 33: Sample escape and rescue plan

The sample escape and rescue plan will be updated according to the current rules and will be available in the next issue as well in the online version at http://www.laborrichtlinien.de.

Annex 2: Sample hand and skin protection plan

http://www.bgrci.de → Prävention → Fachwissen-Portal → Topic list → Laboratories → Work aids → Sample hand and skin protection plan (Web code: Page ID #B4R2)

Hand and skin protection plan				
Company:			**Valid from:**	
			Signature	
Hazard › Hazardous substances › Biological agents › Working in humid conditions › Mechanial › Physical				
	Skin protection before starting work	Disinfection	Skin clearer	Skin care after completing work

Table 4: Hand and skin protection plan (sample)

Annex 3: Laboratory inspections

1 General

The person in charge of laboratories is responsible for:

- establishing the devices and equipment subject to compulsory inspection
- appointing the people to perform inspections
- determining the frequency and scope of inspections
- organizing inspections.

To ensure proper inspection, it is necessary to record all appliances and equipment. They may be divided into safety equipment, appliances, structural installations and infrastructure. The frequency and scope of inspections must be defined.

It may also be useful to have the following data and documentation at hand:

- Manufacturer, type designation, year and location of manufacture, operating instructions, other documentation from the manufacturer, and maintenance agreements.
- Documentation on defects and error rates to compile data for the future assessment of how often to perform inspections.

In addition to periodic inspections, it may also be necessary to perform commissioning inspections. In addition to a thorough visual check, the commissioning inspection of a new laboratory should, in particular, include adjusting incoming and outgoing airflows, correctly setting the units controlling laboratory functions, checking the effectiveness of alarm equipment and inspecting the fire protection equipment.

2 Periodic laboratory inspections

The periodic inspections can be split as shown below. They can be assigned to inspectors according to the relevant scope and requirements (Table 5).

Category	Example	Inspector
Daily visual check	Wool yarn on the fume hood, visual display	Users
Functional inspection/inspection with measurements	Measurement of the flow rate at the fume hood, tightness inspection on equipment, more thoroughly technical inspection	Appropriately trained personnel (qualified persons)
Inspection of installations that need to be monitored	Pressure vessels, installations in areas at risk of explosion	ZÜS (authorized inspection agencies), specialists from the TÜV (German association for technical inspection)
Electrical inspection	Mobile electrical equipment	Electrical specialists or persons with electrical engineering training

Table 5: Periodic inspections and typical inspectors

Table 6 shows persons who are normally appropriate for inspecting appliances and installations in laboratories.

		Professional training	Professional experience	Recent professional activities
A	**Trainees, apprentices, students, interns, students about to take diplomas, assistants**	No training completed	None, but some internship experience	None, but some laboratory work and instructed in the use of appliances and equipment
B	**Lab assistants, technicians (lab technicians, chemical/pharmaceutical/medical technical assistants, etc.)**	Completed apprenticeship, training in the relevant discipline with certificate	In the relevant field, lab-specific	Lab-specific, working with the relevant devices and equipment, instructed in the use of appliances and equipment, some knowledge of regulations
C	**Chemists, chemical engineers, laboratory supervisors, research assistants (post-graduate students, persons with a degree in the relevant discipline)**	Completed degree course, practical training during studies	Several years in the relevant field, lab-specific, with devices and equipment	Working with devices and equipment in the laboratory, instructed in the use of appliances and equipment, knowledge of the regulations relating specifically to work with the appliances, mostly supervisory positions; experience of functional equipment inspections
D	**Staff from the engineering department, other employees (technicians, journeymen, foremen)**	Apprenticeship, training in a technical discipline, with certificate	Technical: Maintenance, repair and servicing in general, unspecific for special equipment and laboratories	Technical: Maintenance, servicing and repair, unspecific for equipment
E	**External (customer service, maintenance company, manufacturer's employees)**	Mostly not known, technical, training at the manufacturer's or maintenance company	Technical, specifically with the relevant equipment, handling, inspection and maintenance	Technical, specifically with the relevant equipment, handling, inspection and maintenance
F	**Authorized inspection agencies, experts**	Technical, training at the manufacturer's or maintenance company		Technical, specific inspection experience with the relevant equipment

Table 6: Examples of inspectors in laboratories

A list of established or stipulated inspection frequencies for devices and equipment (3) serves as a starting point for defining the frequency of periodic inspections. Depending on the result of the hazard assessment, the frequency may need to be increased or – if permissible – decreased. The maximum period between inspections of three years, as stipulated in Art. 7 para. 7 of the Gefahrstoffverordnung, is to be complied with for inspecting the effectiveness of technical protective measures.

3 Periodic inspections of laboratory and analytical equipment

For laboratory and analytical equipment not mentioned in the existing rules and regulations a hazard analysis must be performed to determine whether there is an obligation to inspect it. Furthermore the scope and frequency of such inspections must be determined. This excludes the daily visual check by the user for externally visible defects, which must be performed on all appliances such as glassware.

In addition to these inspections, the manufacturer's operating instructions normally include details on maintenance, servicing and calibration. These instructions relate to the correct functioning of the equipment. For example, parts subject to wear and tear such as seals should be replaced, pump oil topped up and conduits cleaned.

The question of when inspections are required in order to ensure the equipment functions reliably and safely can often only be answered by users, because most reliability and safety aspects depend on the relevant conditions of use.

Basically speaking, the questions to be asked during a hazard assessment are as follows:

Is the device installed safely? This involves aspects relating, for example, to accessibility, stability and ergonomics. Related questions include whether all areas where work is performed are easily accessible, whether maintenance work can be performed and whether critical system components (such as connections, plugs and cables) are accessible for regular visual checks.

Is all safety equipment complete and fully operational? This requires appropriate knowledge relating to the operation of safety equipment and goes beyond the normal daily visual check. Questions relating to the manufacturer's documentation are also relevant here: Is this documentation (manuals, circuit diagrams, instructions and similar items) complete and available in a language that is understood? Are the operating instructions adequate and can they be understood by the user? It may be useful to have additional operating instructions for use and maintenance of the equipment if, for example, the manufacturer's manual is very long and only a small number of steps are required for operation, or if there are hazardous operating conditions and the user needs to be made aware of these.

Is a regular functional inspection performed? This can highlight existing problems. For example, a functional test performed with analytical

standards on chromatography equipment will normally indicate if the system is not tight and hazardous materials can escape unnoticed.

Is a regular periodic electrical inspection performed on fixed and mobile electrical equipment? This raises further questions: Is the device fixed or mobile? Are shorter periods required between inspections based on the laboratory conditions (environment, corrosive atmosphere) and type of use (frequent change of location)? Must cables and plug-in connectors be inspected more frequently because of the environmental conditions (humidity, for instance)?

Is the preventive maintenance performed on a regular basis? If parts subject to wear and tear are regularly replaced, there may be fewer malfunctions and thus fewer unsafe operating conditions. For example, the risk of hazardous materials or gases being released during maintenance of seals on gas chromatographs is reduced.

If the answer to one or more of these questions is “No”, further action is required. One possible measure involves increasing the frequency of inspections if specific hazards occur that can be avoided by means of an inspection. Particular factors that influence the frequency and thoroughness of inspections include the corrosiveness of the medium, environmental conditions and the conditions under which experiments are performed. Potential problems that become apparent during operation may lead to shortening the periods between inspections.

4 Documentation

Periodic inspections must be documented. Depending on the device/equipment, a specific documentation is required in the form of inspection logs, inspection records or similar items. Even in cases where no specific periods are indicated for which such documents must be kept, they must be retained at least until the next inspection to provide evidence if required. Marking equipment that has been inspected, for example with inspection stickers, is helpful for the user.

5 Overview of inspections

An overview of typical laboratory inspections and their detailed requirements can be found on the Internet (3).

Annex 4: Simplified labelling of laboratory containers

1 Characteristic of activities with hazardous substances in laboratories

If chemical, physical or physico-chemical methods are applied to carry out preparative, analytical or application- related work in laboratories, a large number of various hazardous substances in small amounts are usually employed. Hundreds or thousands of sometimes extremely small storage bottles are not uncommon. Due to this high number of often changing substances, the effectiveness of a warning message carried by a simplified labelling scheme containing only one or more pictograms alongside the substance designation and possibly a signal word is insufficient for the staff working with the substance. However, a simplified labelling scheme has been successfully used for many years.

The Sachgebiet "Laboratorien" of the Fachbereich "Rohstoffe und chemische Industrie" of the DGUV has therefore developed a simplified system for storage bottles in laboratories, taking into account the new labelling system in line with the CLP regulation.

This system is suitable for compensating for the loss of important and informative hazard designations for users and thereby ensures effective occupational safety. At the same time, this system had to be devised in such a way that it could be feasibly applied in practice. On the one hand, the number of work steps contained in the labelling should be manageable, while on the other the information must be clear and easy to grasp. This would not be the case if a full list of H-statements were provided. The procedure developed was tested in practical application in laboratories.

Applicability must be demonstrated in a hazard assessment and the basic requirements for laboratories in line with the laboratory guidelines and TRGS 526, in particular relating to the qualification and instruction of staff members, must be in place. Furthermore, operating instructions and safety data sheets on the substances must be available to staff so that they are in a position to clarify any uncertainties which could not be resolved by consulting the simplified labelling system.

2 DGUV system for laboratories

Combinations of pictograms and phrases make up the core element of this system. The information content of the H-statements is condensed and conveyed in the form of phrases. One way the system can be applied is in the form of sheets of self-adhesive pictograms bearing the phrases. A selection of commonly and less commonly needed combinations of pictograms and phrases suitable for use in laboratories can be printed on a single sheet and can therefore be easily made available on site. There is only a minor increase in the number of sticker types in comparison to the self-adhesive sticker sheets used with the old labelling system.

In order to create a label, it merely has to be filled out with the substance designation (and, if applicable, additional laboratory-specific information, such as a container number) and generally up to three pictogram/phrase stickers. In a final step, a protective film can also be affixed.

2.1 Condensing information in H-statements through phrases

The information contained within the H-statements was condensed whenever further differentiation does not impact upon the protective measures taken in the laboratory or an excessively detailed explanation would be necessary. In the latter case, the additional information from the safety data sheet is indispensable, and the labelling only serves to initiate the gathering of information from the safety data sheet.

The following condensed terms have been defined:

- The attribute “Explosive” can be used as a collective attribute, as classification under H200 et seq. or H240 does not provide the laboratory with any relevant additional information.
- Differentiation between “Extremely flammable” and “(Highly) flammable” is sufficient for flammability risks in the laboratory, whereby flammability in contact with water is attributable to “Extremely flammable”. Pyrophoric substances are given their own phrase.
- The H statements regarding carcinogenic, germ cell mutagenic and reprotoxic effects are summarised in the two classifications “CMR substance cat. 1” and “CMR substance cat. 2”.
- The H statements regarding specific target organ toxicity (STOT) are reduced to the two statements “Damages organs” for category 1 and “Can damage organs” for category 2. A differentiation of whether this applies after single or repeated exposure is not needed in the laboratory. Category 3 STOT, irritation of the airway, can be covered with the phrase “Irritant”, while substances that have an effect on the central nervous system are given the new phrase “Narcotic”.

- There is not differentiation between a "corrosive/irritant effect" on skin and eyes, as it is mandatory to wear protective goggles at all times in the laboratory.
- Due to the general practice of proper disposal in laboratories, it is generally not necessary to point out a potential aquatic risk. If a corresponding notice is to be used nevertheless, the regular "environment" pictogram (GHS09) can be applied without any additional text phrase.
- The "exclamation mark" pictogram with the text phrase "Hazardous to the ozone layer" is also no longer needed.
- This hazard class only affects a small number of substances, the application of which is strictly regulated. Laboratories that handle these substances are therefore obliged to provide special instruction to staff.

Specification of exposure pathway:
An extra sticker is available on which the relevant exposure pathways (e.g. in the case of "Acute toxicity") can be selected by ticking a box.

In addition to the pictogram-phrase combinations, the following phrases are available for special potential hazards:

- "Contact with water or acids liberates toxic gas" [Note: differentiation of toxicity level is not helpful in laboratory practice]
- "Explosive when dry" [Note: this points out the loss of phlegmatisation for used containers]
- "Reacts violently with water"
- "Can age dangerously" [Note: subject to peroxide formation and other dangerous changes when stored]

2.2 Number of pictograms

As a general rule, up to two pictograms should illustrate the health hazards (acute and chronic effects) and one pictogram should describe the physical-chemical dangers in laboratories.

3 Practical implementation

These pictograms with phrases are available on the internet (http://www.guidelinesforlaboratories.de) and can easily be printed onto your own self-adhesive labels. Ready-printed labels in German language on paper or plastic film are available in various sizes, for example from http://www.jedermann.de.

Overview of the pictogram-phrase combinations


Explosive


Danger to life


CMR substance cat. 1


Corrosive/irritant


Extremely flammable


Toxic


CMR substance cat. 2


Irritant


Highly flammable


Harmful to health

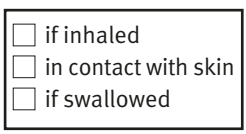

Damages organs


Untested research substance


Flammable


Narcotic

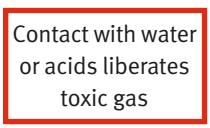

Can damage organs

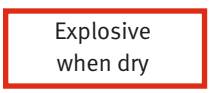



Pyrophoric


Allergenic if inhaled

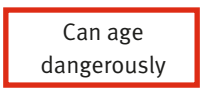

Aspiration dangerous to life

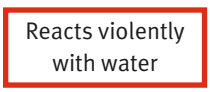





Oxidising agent


Allergenic in contact with skin





Labelling in accordance with CLP regulation for placing n-heptane on the market

Classification:

- Flammable liquids, category 2, H225
- Causes skin corrosion/irritation, category 2, H315
- Specific target organ toxicity (single exposure), category 3 (drowsiness and dizziness), H336
- Aspiration hazard, category 1, H304
- Acute toxicity to aquatic life, category 1, H400
- Chronic toxicity to aquatic life, category 1, H410

Labelling:

Signal word: "Danger"

- Highly flammable liquid and vapor. (H225)
- May be fatal if swallowed and enters airways. (H304)
- Causes skin irritation. (H315)
- May cause drowsiness or dizziness. (H336)
- Very toxic to aquatic life with long lasting effects. (H410)
- Keep away from heat/sparks/open flames/hot surfaces. Do not smoke. (P210)
- Use explosion-proof electrical/ventilating/lighting/.../ equipment. (P241)
- Take precautionary measures against static discharge. (P243)
- Avoid release to the environment. (P273)
- IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician. (P301 + P310)
- Store in a well-ventilated place. Keep container tightly closed. (P403 + P233)

Simplified internal labelling in accordance with the new DGUV system for laboratories

- Name of substance and relevant substances of mixtures
- UUp to 3 pictograms showing the main health and physical hazards with the corresponding phrases
- Optional: signal word

e. g. n-Heptan:

Highly flammable

Aspiration dangerous to life

Narcotic

Example applications of the DGUV system

Annex 5: Criteria for expert laboratory design under consideration of occupational safety and health and environmental protection

Tools for sustainable planning

- Operation and safety plan
  - Purpose and significance for planning and construction
  - Integrated safety planning
  - Anticipation of future operation
  - Life cycle perspective
  - Documented technical safety
  - Purpose and significance for operation
  - Optimal intrinsic safety
  - Operational scenarios for safe operation
  - Documented safety technology
  - Transition from construction to operation
  - Contribution to the sustainability of laboratory buildings
  - Enhanced adaptability if modifications are needed
  - Hazard-dependent and economical structural safety
  - Scope of the operational and safety plan
  - Part of sustainable laboratory building design
  - Necessary prerequisite for sustainable operation
  - Transparent planning decisions for safety
  - Risk minimisation for planners, operators andusers
  - Safety expertise as a professional planningcontract
  - Synchronisation: operational and safety planning
- Continuous improvement process
- Integration into the planning process
- Significance for planning
- Life cycle orientation of the design
- Communication paths of the safety targets
- Integral planning and planning team
- Certification

Basic principles for planning a laboratory building

- Safety and the protection of health as an integral part of sustainability (definitions, terms, compatibility with ecological and economic targets)
- Historical development of requirements for laboratory buildings
- Contents of certification systems and interaction with occupational health and safety
- Fundamental requirements and application of the DGUV Information 213-851 “Working Safely in Laboratories – Basic Principles and Guidelines”, in particular section 6

- For biological laboratories, see also DGUV Information 213-086 “Sichere Biotechnologie – Biologische Laboratorien – Ausstattung und organisatorische Maßnahmen”
- Regulations
  - EU law (EU regulations and directives)
  - German federal rules and regulations (laws, ordinances and technical rules)
  - Rules and regulations of German Social Accident Insurance Institutions (accident prevention regulations (Unfallverhütungsvorschriften), DGUV guidelines, DGUV rules and DGUV information)
  - Standards

  in particular on the topics
  - Occupational safety and health legislation
  - Workplace legislation
  - Hazardous substances legislation
  - Biological agents and genetic engineering legislation
  - Radiation protection legislation
- State of the art
  - Terms and definitions
  - Protection strategies laid out in occupational safety and health legislation (Hazardous Substances Ordinance (GefStoffV), Biological Agents Ordinance (BioStoffV), etc.)
- The laboratory as a work system
- Interface conditions in the laboratory

Building and structural requirements

- Typology and parameters of a building (fields: biology, genetic engineering, chemistry, physics, radiochemistry, ...; building grids, floors ...)
- Functional zoning of spaces
- Flow of people and materials
- Building life cycle
- User requirements

General laboratory profiles

- Intended purpose
- Type of use
- Scientific discipline
- Activities
- Working methods
- Spatial structure
- Special requirements

Use profiles

- Room book
- Compilation criteria
- Ventilation plan
- Plan for access arrangements

- Supply and disposal plans
- Special areas

Hazards and protective measures

- Hazards in the laboratory: involvement of users, points in time, documentation and impact on planning
- "Hard and soft" risk and stress factors
  - Hazardous substances
  - Biological agents
  - Radioactive substances
  - Genetically modified organisms
  - Radiation
  - Ambient climate
  - Temperature and relative humidity
  - Light and lighting
  - Sound and acoustics
  - ...
- Protection targets
- Intrinsic safety concept of the DGUV Information 213-851 "Working Safely in Laboratories – Basic Principles and Guidelines"
- Risk assessment and evaluation during the planning process
- Consideration of planning uncertainties
- Flexibilities of use
- Development of statutory guidelines
- Anticipation of future tolerable risk
- Priorities of protective measures
- Plans for employing people with disabilities
- Transfer of responsibility during the planning process

Technical protective measures specific to the building and field

- Procedure
- General conditions for working safely
- Operational and circulation areas
- Technical ventilation
- Electrotechnical safety
- Technical safety referring to media
- Equipping the laboratory with regard to safety
- Safety markings and alarms
- Emergency equipment
- Emergency and escape routes
- Assessment of effectiveness
- Fire and explosion protection
  - Physicochemical fundamentals
  - Hierarchy of explosion protection measures
  - Explosion hazards in the laboratory
  - Significance of suction and air exchange rates

  - Ignition sources in the laboratory
  - Explosion protection zones
  - Equipment categories in Ex-protection zones
  - Documentation
- Containment
- Ventilation safety devices
- Measures dependent on the risk factor

Modification options with minimized potential of malfunction and hazards

- Variability during operation
- Reaction to new scientific requirements
- Reaction to regulatory changes that are ineligible for grandfathering

Bill of quantities and planning for approval

- Contents
- Statutory guidelines and references
- Sustainability criteria
- Normative references

Building process

- Parties involved in the building process
- Coordination of the main process owners
- Service phases according to the Official Scale of Fees for Services by Architects and Engineers (Honorarordnung für Architekten und Ingenieure, HOAI) including those involved in the project
- Reaction to new scientific requirements
- Reaction to statutory changes that are ineligible for grandfathering

Building handover

- Prerequisites for the handover of the building to the owner or operator
- Documentation requirements
- Prerequisites for use and operation
- Delimitation of responsibilities between owner, operator and user
- Legal aspects of as-built documents

Passage of risk to operators and users

- Complete building documentation
- Instructions on maintenance, inspections, operation and care
- Plan documents and calculated inspection and approval status
- User/operator manual and introductory training
- Significance for later statutory responsibilities of operators/users
- Significance for the positions of planners and clients

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TRGS 402: Ermitteln und Beurteilen der Gefährdungen bei Tätigkeiten mit Gefahrstoffen: Inhalative Exposition (Translation TRGS 402: Identification and assessment of the risks from activities involving hazardous substances: inhalation exposure)

Bekanntmachung zu Gefahrstoffen 409: Nutzung der REACH-Informationen für den Arbeitsschutz (BekGS 409, Translation Announcement 409: Using REACH-information for health and safety at work)

TRGS 410: Expositionsverzeichnis bei Gefährdung gegenüber krebserzeugenden oder keimzellmutagenen Gefahrstoffen der Kategorien 1A oder 1B (Exposure register for the exposition to carcinogenic or germ cell mutagenic substances of category 1A or 1B)

TRGS 420: Verfahrens- und stoffspezifische Kriterien (VSK) für die Ermittlung und Beurteilung der inhalativen Exposition (Translation TRGS 420: Process and substance criteria (VSK) for identifying and assessing inhalation exposure)

TRGS 500: Schutzmaßnahmen (Protective measures)

TRGS 510: Lagerung von Gefahrstoffen in ortsbeweglichen Behältern (Translation TRGS 510: Storage of hazardous substances in non-stationary containers)

TRGS 526: Laboratorien (Laboratories)

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TRGS 555: Betriebsanweisung und Information der Beschäftigten (Translation TRGS 555: Working instruction and information for workers)

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Strahlenschutzgesetz (StrlSchG) (Radiation Protection Act)

4 Rules, regulations and information documents relating to health and safety at work

Available from the relevant social accident insurance institution. Contact addresses can be obtained at https://www.dguv.de, download from https://publikationen.dguv.de.

DGUV regulations

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Health and safety rules (DGUV rules)

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DGUV Regeln 112-195/112-995: Benutzung von Schutzhandschuhen (former BGR 195/GUV-R 195) (Use of protective gloves)

DGUV Regel 113-001: Explosionsschutz-Regeln (EX-RL) (former BGR 104/GUV-R 104) (Explosion protection rules)

DGUV Regel 113-017: Tätigkeiten mit Explosivstoffen (former BGR/GUV-R 242) (Aktivities with explosives)

DGUV Regel 113-018: Unterricht in Schulen mit gefährlichen Stoffen (former BG/GUV-SR 2003) (Teaching in schools with hazardous substances)

DGUV Principles

DGUV Grundsatz 313-001: Prüfbuch für Zentrifugen (former BGG 934) (Test book for centrifuges)

DGUV information documents

DGUV Information 204-001: Erste Hilfe (Plakat, DIN A2) (former BGI/GUV-I 510-1) (Poster, DIN A2: First aid)

DGUV Information 204-006: Anleitung zur Ersten Hilfe (former BGI/GUV-I 503) (First aid instructions)

DGUV Information 204-022: Erste Hilfe im Betrieb (former BGI/GUV-I 509) (First aid at the workplace)

DGUV Information 207-007: Zytostatika im Gesundheitsdienst – Informationen zur sicheren Handhabung von Zytostatika (former GUV-I 8533) (Cytostatics in the health service – Information on the safe handling of cytostatics)

DGUV Informationen 208-016/208-017: Handlungsanleitung für den Umgang mit Leitern und Tritten (former BGI 694/GUV-I 694) (Guideline for using ladders and steps)

DGUV Information 212-007: Chemikalienschutzhandschuhe (former BGI/GUV-I 868) (Chemical protective gloves)

DGUV Information 213-012: Gefahrgutbeförderung in PKW und in Kleintransportern (former BGI 744) (Transportation of dangerous substances in cars and vans)

DGUV Information 213-021: Nanomaterialien am Arbeitsplatz (former BGI/GUV-I 5149) (Nano materials on the workplace)

DGUV Information 213-026: Sicherheit im chemischen Hochschulpraktikum – Eine Einführung für Studierende (former BGI/GUV-I 8553) (Safety in university chemistry courses – an introduction for students)

DGUV Information 213-039: Tätigkeiten mit Gefahrstoffen in Hochschulen (former BGI/GUV-I 8666) (Use of hazardous materials at universities)

DGUV Information 213-051: Betriebsanweisungen für Tätigkeiten mit Gefahrstoffen (former BGI 566) (Working instructions for activities with hazardous substances)

DGUV Information 213-052: Beförderung gefährlicher Güter (former BGI 671) (Transporting hazardous goods)

DGUV Information 213-053: Schlauchleitungen – Sicherer Einsatz (former BGI 572) (Hose assemblies – Safe use)

DGUV Information 213-060: Vermeiden von Zündgefahren infolge elektrostatischer Aufladungen (former BGI 5127 coincidentally with TRBS 2153) (Avoiding ignition hazards due to electrostatic charges)

DGUV Information 213-070: Säuren und Laugen (former BGI 595) (Acids and alkalis)

DGUV Information 213-071: Fluorwasserstoff, Flusssäure und anorganische Fluoride (former BGI 576) (Hydrogen fluoride, hydrofluoric acid and inorganic fluorides)

DGUV Information 213-072: Lösemittel (former BGI 621) (Solvents)

DGUV Information 213-079: Tätigkeiten mit Gefahrstoffen (former BGI 564) (Activities with hazardous substances)

DGUV Information 213-080: Arbeitsschutzmaßnahmen bei Tätigkeiten mit Gefahrstoffen (former BGI 660) (Safety measures for activities with hazardous materials)

DGUV Information 213-082: Gefahrstoffe mit GHS-Kennzeichnung – Was ist zu tun? (former BGI 5150) (Dangerous substances with GHS marking – What has to be done?)

DGUV Information 213-086: Sichere Biotechnologie – Biologische Laboratorien – Ausstattung und organisatorische Maßnahmen (former BGI 629) (Safe biotechnology – Biological Laboratories – Equipment and organisational measures)

DGUV Information 213-098: Stoffliste zur DGUV Regel 113-018 "Unterricht in Schulen mit gefährlichen Stoffen" (former BG/GUV-SR 2004) (List of substances of the DGUV rule 113-018 "Teaching in schools with hazardous substances") https://degintu.dguv.de (visited 2019-08-01)

DGUV Information 213-850: Sicheres Arbeiten in Laboratorien – Grundlagen und Handlungshilfen (former BGI/GUV-I 850-0) (Working Safely in Laboratories – Basic Principles and Guidelines)

DGUV Information 213-855: Gefährdungsbeurteilung im Labor (former BGI 850-1, BGI 798) (Hazard assessment in laboratories)

DGUV Information 213-857: Laborabzüge – Bauarten und sicherer Betrieb (former BGI 850-2) (Laboratory fume hoods – construction types and safe operation)

DGUV Information 215-210: Natürliche und künstliche Beleuchtung von Arbeitsstätten (Natural and artificial lighting of workplaces)

DGUV Information 215-211: Tageslicht am Arbeitsplatz – leistungsfördernd und gesund (former BGI/GUV-I 7007) (Daylight in the workplace – powerful and healthy)

DGUV Information 215-410: Bildschirm- und Büroarbeitsplätze – Leitfaden für die Gestaltung (former BGI 650/GUV-I 650) (VDU and office workstations – Design guideline)

BG RCI instruction sheets

Source: Berufsgenossenschaft Rohstoffe und chemische Industrie, Postfach 10 14 80, 69004 Heidelberg (https://medienshop.bgrci.de)

BG RCI Merkblatt A 016: Gefährdungsbeurteilung – Sieben Schritte zum Ziel (former BGI 570) (Translation Merkblatt A 016e: Hazard assessment – Seven steps to the goal)

BG RCI Merkblatt A 017: Gefährdungsbeurteilung – Gefährdungskatalog (former BGI 571) (Translation Merkblatt A 017e: Hazard assessment – Hazard catalog)

BG RCI Merkblatt A 018: Betriebsärzte und Fachkräfte für Arbeitssicherheit – Regelbetreuung in Betrieben mit mehr als 10 Beschäftigten (Occupational physicians and OSH professionals – Standard supervision in enterprises with more than 10 employees)

BG RCI Merkblatt A 023: Hand- und Hautschutz (former BGI 540) (Hand and skin protection)

BG RCI Merkblatt A 026: Unterweisung – Gefährdungsorientierte Handlungshilfe (former BGI 8697) (Instruction – based on the hazard assessment)

BG RCI Merkblatt M 034-4: Druckminderventile für Sauerstoff (former BGI 617-4) (Pressure relief valves for oxygen)

BG RCI Merkblatt M 039: Fruchtschädigende Stoffe – Informationen für Mitarbeiterinnen und betriebliche Führungskräfte (former BGI 537) (Embryotoxic substances – Information for female employees and senior staff)

BG RCI Merkblatt M 040: Chlorkohlenwasserstoffe (Chlorinated hydrocarbons)

BG RCI Merkblatt T 025: Umfüllen von Flüssigkeiten – vom Kleingebinde bis zum Container (former BGI 623) (Transferring liquids – from small to big containers)

BG RCI Merkblatt T 029: Füllen von Druckbehältern mit Gasen (former BGI 618) (Filling pressure vessels with gases)

BG RCI Merkblatt T 032-1: Laborabzüge – Auf einen Blick (former BGI 850-2a) (Laboratory fume hoods at the glance)

BG RCI Merkblatt T 044: Bildschirmarbeitsplätze (VDU workstations)

5 Standards

Source: Beuth Verlag GmbH, Burggrafenstraße 6, 10787 Berlin, https://www.beuth.de

DIN 477-1:1990-05: Gasflaschenventile für Prüfdrücke bis max. 300 bar; Bauformen, Baumaße, Anschlüsse, Gewinde (zurückgezogen, jetzt: DIN 477-1:2012-06: Gasflaschenventile für Flaschenprüfdrücke bis einschließlich 300 bar – Teil 1: Ventileingangs- und Ventilausgangsanschlüsse) (Gas cylinder valves for types, sizes and outlets test pressures up to 300 bar (withdrawn, now DIN 477-1:2012-06: Gas cylinder valves for cylinder test pressures up to 300 bar – Part 1: Valve inlet and outlet connections))

DIN 1946-7:1992-06: Raumlufttechnik; Raumlufttechnische Anlagen in Laboratorien (VDI-Lüftungsregeln) (zurückgezogen, jetzt: DIN 1946-7:2009-07: Raumlufttechnik – Teil 7: Raumlufttechnische Anlagen in Laboratorien) (Heating, ventilation and air conditioning; HVAC systems in laboratories (VDI code of practice) (withdrawn, now DIN 1946-7:2009-07: Ventilation and air conditioning – Part 7: Ventilation systems in laboratories)

DIN 1988-100:2011-08: Technische Regeln für Trinkwasser-Installationen – Teil 100: Schutz des Trinkwassers, Erhaltung der Trinkwassergüte, Technische Regel des DVGW (Codes of practice for drinking water installations – Part 100: Protection of drinking water, drinking water quality control, DVGW code of practice)

DIN 2403:2014-06: Kennzeichnung von Rohrleitungen nach dem Durchflussstoff (zurückgezogen, jetzt: DIN 2403:2018-10) (Identification of pipelines according to the fluid conveyed) (withdrawn, now DIN 2403:2018-10))

DIN 3017-1:1998-05 Schlauchschellen; Teil 1: Schellen mit Schneckentrieb; Form A (Hose clamps; Part 1: Hose clamps with worm gear drive; shape A)

DIN 3537-1:1990-06: Gasabsperrarmaturen bis PN 4; Anforderungen und Anerkennungsprüfung (zurückgezogen, jetzt: DIN 3537-1:2011-09: Gasabsperrarmaturen bis 5 bar für die Gas-Hausinstallation – Anforderungen und Prüfungen) (Gas stop-valves rated for pressures up to 4 bar; requirements and acceptance testing) (withdrawn, now DIN 3537-1:2011-09: Gas stop valves for domestic gas installations up to 5 bar for the gas house installation – Requirements and tests)

DIN 4815-2:1979-06: Schläuche für Flüssiggas; Schlauchleitungen (zurückgezogen, jetzt: DIN 4815-2:2010-12: Gummi- und Kunststoffschläuche für Flüssiggas – Teil 2: Schlauchleitungen) (Hoses for LPG; hose assemblies (withdrawn, now DIN 4815-1:2010-12: Rubber and plastics hoses for liquefied – Part 2: Hose assemblies))

DIN 4844: Sicherheitskennzeichnung (zurückgezogen, jetzt: DIN 4844-1:2012-06: Graphische Symbole – Sicherheitsfarben und Sicherheitszeichen – Teil 1: Erkennungsweiten und farb- und photometrische Anforderungen; DIN 4844-2:2012-12: Graphische Symbole – Sicherheitsfarben und Sicherheitszeichen – Teil 2: Registrierte Sicherheitszeichen; DIN 4844-2/A1:2015-09: Graphische Symbole – Sicherheitsfarben und Sicherheitszeichen – Teil 2: Registrierte Sicherheitszeichen; Änderung A1) (Safety marking (withdrawn, now DIN 4844-1:2012-06: Graphical symbols – Safety colours and safety signs – Part 1: Observation distances and colorimetric and photometric requirements; DIN 4844-2:2012-06: Graphical symbols – Safety colours and safety signs – Part 2: Registered safety signs, DIN 4844-2/A1:2015-09: Graphical symbols – Safety colours and safety signs – Part 2: Registered safety signs; Amendment A1))

DIN 12001-1:1987-12 Sicherheitszeichen im Labor; Warnung vor Gasflaschen (zurückgezogen, jetzt DIN EN ISO 70100:2012-10) (Safety markings in laboratories; pressure cylinders (withdrawn, now DIN EN ISO 7010:2012-10))

DIN 12475:1996-01: Laborgeräte aus Glas; Saugflaschen, zylindrische Form (zurückgezogen, jetzt: DIN EN ISO 6556:2013-02) (Laboratory glassware; filter flasks, cylindrical shape (withdrawn, now DIN EN ISO 6556:2013-02))

DIN 12476:1983-06: Laborgeräte aus Glas; Saugflaschen, konische Form (zurückgezogen, jetzt: DIN EN ISO 6556:2013-02) (Laboratory glassware; filter flasks, conical shape (withdrawn, now DIN EN ISO 6556:2013-02))

DIN 12491:1998-07: Laborgeräte aus Glas; Vakuum-Exsikkatoren (zurückgezogen, jetzt DIN EN ISO 13130:2011-10) (Laboratory glassware; vacuum desiccators (withdrawn, now DIN EN ISO 13130:2011-10))

DIN 12596:1984-01: Laborgeräte aus Glas; Gas-Waschflaschen; Form nach Drechsel (Laboratory glassware; Drechsel gas washing bottle)

DIN 12880:2007-05: Elektrische Laborgeräte – Wärme- und Brutschränke (Electrical laboratory devices – heating ovens and incubators)

DIN 12897:1978-11: Laborgeräte aus Metall; Hebebühnen, Sicherheitstechnische Anforderungen, Prüfung (Metal laboratory ware; supports, scissors jack type, safety requirements and tests)

DIN 12898:1992-04: Laborarmaturen; Schlauchtüllen (zurückgezogen, jetzt DIN 12898:2019-07: Laborarmaturen – Schlauchtüllen) (Laboratory taps; Outlet nozzles (withdrawn, now DIN 12898:2019-07: Laboratory taps – Outlet nozzles))

DIN 12918-2:2009-09: Laboreinrichtungen – Laborarmaturen – Teil 2: Entnahmestellen für Brenngase (Laboratory equipment – Laboratory fittings – Part 2: Valves for fuel gases)

DIN 12924-1:1991-08: Laboreinrichtungen; Abzüge; Abzüge für allgemeinen Gebrauch, Arten, Hauptmaße, Anforderungen und Prüfungen (zurückgezogen, jetzt: DIN EN 14175-1:2003-08, DIN EN 14175-2:2003-08, DIN EN 14175-3:2019-07) (Laboratory furniture; fume cupboards; general purpose fume cupboards; types, main dimensions, requirements and testing (withdrawn, now DIN EN 14175-1:2003-08, DIN EN 14175-2:2003-08, DIN EN 14175-3:2019-07))

DIN 12924-2:2007-04: Laboreinrichtungen; Abzüge – Teil 2: Abrauchabzüge (zurückgezogen, jetzt: DIN EN 14175-7:2012-08) (Laboratory furniture; fume cupboards – Part 2: Fume cupboards for increased acidic and heat load (withdrawn, now DIN EN 14175-7:2012-08))

DIN 12927:1995-10: Laboreinrichtungen – Absaugboxen mit Luftrückführung – Anforderungen, Prüfungen (Laboratory furniture – Ductless filtering fume enclosures – Requirements, tests)

DIN 12980:2016-10: Laboreinrichtungen – Sicherheitswerkbänke und Isolatoren für Zytostatika und sonstige CMR-Arzneimittel (zurückgezogen; jetzt: DIN 12980:2017-05) (Laboratory furniture – Safety cabinets for handling cytostatic substances (withdrawn, now DIN 12980:2017-05))

DIN 18381:2016-09: VOB Vergabe- und Vertragsordnung für Bauleistungen – Teil C: Allgemeine Technische Vertragsbedingungen für Bauleistungen (ATV) – Gas-, Wasser- und Entwässerungsanlagen innerhalb von Gebäuden (German construction contract procedures; Part C: General technical specifications for building works – Gas, water and sewage plumbing works inside of buildings)

DIN 19541:2004-12: Geruchverschlüsse für besondere Verwendungszwecke – Anforderungen und Prüfverfahren (Trap seals for special uses – Requirements and test methods)

DIN 25466:2012-08: Radionuklidabzüge – Regeln für die Auslegung und Prüfung (Fume hoods for radioactive materials – Rules for construction and tests)

DIN 30664-1:1994-12: Schläuche für Gasbrenner für Laboratorien, ohne Ummantelung und Armierung – Teil 1: Sicherheitstechnische Anforderungen und Prüfungen (Hoses for gasfired burners for laboratories, without shroud and armoring – Part 1: Safety requirements and tests)

DIN 30665-1:1982-3: Gasverbrauchseinrichtungen; Gasbrenner für Laboratorien (Laborbrenner); Sicherheitstechnische Anforderungen, Prüfung (Gas appliances; gas burners for laboratory use (laboratory burners); safety requirements and tests)

DIN 31000:2011-05; VDE 1000:2011-05: Allgemeine Leitsätze für das sicherheitsgerechte Gestalten von Produkten (zurückgezogen, jetzt DIN 31000:2017-04; VDE 1000:2017-04) (General principles for the safety design of technical products (withdrawn, now DIN 31000:2017-04; VDE 1000:2017-04))

DIN 32620:1976-08: Schlauchbinder; Spanner und Band (Clamps)

DIN 57789-100:1984-05; DIN VDE 0789-100:1984-05; VDE 0789-100:1984-05: Unterrichtsräume und Laboratorien; Einrichtungsgegenstände; Sicherheitsbestimmungen für energieversorgte Baueinheiten [VDE-Bestimmung] (zurückgezogen) (Classrooms and laboratories; fitments; equipment and furniture safety specification for powered constructional units [VDE regulation] (withdrawn))

DIN EN 2:2005-01: Brandklassen (Classification of fires)

DIN EN 3-7:2007-10: Tragbare Feuerlöscher – Teil 7: Eigenschaften, Leistungsanforderungen und Prüfungen (Portable fire extinguishers – Part 7: Characteristics, performance requirements and test methods)

DIN EN 294:1992-08: Sicherheit von Maschinen; Sicherheitsabstände gegen das Erreichen von Gefahrstellen mit den oberen Gliedmaßen (zurückgezogen, jetzt: DIN EN ISO 13857:2008-06) (Safety of machinery; safety distances to prevent danger zones from being reached by the upper limbs (withdrawn, now DIN EN ISO 13857:2008-06))

DIN EN 560:2008-03: Gasschweißgeräte – Schlauchanschlüsse für Geräte und Anlagen für Schweißen, Schneiden und verwandte Prozesse (zurückgezogen, jetzt DIN EN 560:2018-11) (Gas welding equipment – Hose connections for equipment for welding, cutting and allied processes (withdrawn, now DIN EN 560:2018-11))

DIN EN 1089-3:2011-10: Ortsbewegliche Gasflaschen – Gasflaschen-Kennzeichnung (ausgenommen Flüssiggas (LPG)) – Teil 3: Farbcodierung (Transportable gas cylinders – Gas cylinder identification (excluding LPG) – Part 3: Colour coding)

DIN EN 1717:2011-08: Schutz des Trinkwassers vor Verunreinigungen in Trinkwasser-Installationen und allgemeine Anforderungen an Sicherheitseinrichtungen zur Verhütung von Trinkwasserverunreinigungen durch Rückfließen; Deutsche Fassung EN 1717:2000: Technische Regel des DVGW (Protection against pollution of potable water installations and general requirements of devices to prevent pollution by backflow, German version EN 1717:2000; Technical rule of DVGW)

DIN EN 1838:2013-10: Angewandte Lichttechnik – Notbeleuchtung (Lighting applications – Emergency lighting)

DIN EN 12128:1998-05: Biotechnik – Laboratorien für Forschung, Entwicklung und Analyse – Sicherheitsstufen mikrobiologischer Laboratorien, Gefahrenbereich, Räumlichkeiten und technische Sicherheitsanforderungen (Biotechnology – Laboratories for research, development and analysis – Containment levels of microbiology laboratories, areas of risk, localities and physical safety requirements)

DIN EN 12464-1:2011-08: Licht und Beleuchtung – Beleuchtung von Arbeitsstätten – Teil 1: Arbeitsstätten in Innenräumen (Light and lighting – Lighting of work places; Part 1: Indoor work places)

DIN EN 13150:2001-12: Arbeitstische für Laboratorien – Maße, Sicherheitsanforderungen und Prüfverfahren (Workbenches for laboratories – Safety requirements and test methods)

DIN EN 13792:2002-12: Farbige Kennzeichnung von Laborarmaturen (Colour coding of taps and valves for use in laboratories)

DIN EN 14056:2003-07: Laboreinrichtungen – Empfehlungen für Anordnung und Montage (Laboratory furniture – Recommendations for design and installation)

DIN EN 14175-1:2003-08: Abzüge – Teil 1: Begriffe (Fume cupboards – Part 1: Vocabulary)

DIN EN 14175-2:2003-08: Abzüge – Teil 2: Anforderungen an Sicherheit und Leistungsvermögen (Fume cupboards – Part 2: Safety and performance requirements)

DIN EN 14175-3:2019-07: Abzüge – Teil 3: Baumusterprüfverfahren (Fume cupboards – Part 3: Type test methods)

DIN EN 14175-4:2004-12: Abzüge – Teil 4: Vor-Ort-Prüfverfahren (Fume cupboards – Part 4: On-site test methods)

DIN EN 14175-6:2006-08: Abzüge – Teil 6: Abzüge mit variablem Luftstrom (Fume cupboards – Part 6: Variable air volume fume cupboards)

DIN EN 14175-7:2012-08: Abzüge – Teil 7: Abzüge für hohe thermische und Säurelasten (Abrauchabzüge) (Fume cupboards – Part 7: Fume cupboards for high heat and acidic load)

DIN EN 14470-1:2004-07: Feuerwiderstandsfähige Lagerschränke – Teil 1: Sicherheitsschränke für brennbare Flüssigkeiten (Fire safety storage cabinets – Part 1: Safety storage cabinets for flammable liquids)

DIN EN 14470-2:2006-11: Feuerwiderstandsfähige Lagerschränke – Teil 2: Sicherheitsschränke für Druckgasflaschen (Fire safety storage cabinets – Part 2: Safety cabinets for pressurized gas cylinders)

DIN EN 15154-1:2006-12: Sicherheitsnotduschen – Teil 1: Körperduschen mit Wasseranschluss für Laboratorien (Emergency safety showers – Part 1: Plumbed-in body showers for laboratories)

DIN EN 15154-2:2006-12: Sicherheitsnotduschen – Teil 2: Augenduschen mit Wasseranschluss (Emergency safety showers – Part 2: Plumbed-in eye wash units)

DIN EN 15251:2012-12 Eingangsparameter für das Raumklima zur Auslegung und Bewertung der Energieeffizienz von Gebäuden – Raumluftqualität, Temperatur, Licht und Akustik (Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics)

DIN EN 60529:2014-09; VDE 0470-1:2014-09: Schutzarten durch Gehäuse (IP-Code) (Degrees of protection provided by enclosures (IP code))

DIN EN 61010-1:2011-07; VDE 0411-1:2011-07: Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Corr.:2011) (Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements (IEC 61010-1:2010 + Corr.:2011))

DIN EN 61010-2-010:2015-05; VDE 0411-2-010:2015-05: Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 2-010: Besondere Anforderungen an Laborgeräte für das Erhitzen von Stoffen (IEC 61010-2-010:2014) (Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-010: Particular requirements for laboratory equipment for the heating of materials (IEC 61010-2-010:2014))

DIN EN 61010-2-020:2007-03; VDE 0411-2-020:2007-03: Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 2-020: Besondere Anforderungen an Laborzentrifugen (IEC 61010-2-020:2006) (zurückgezogen, jetzt DIN EN 611010-2-020:2017-12; VDE 0411-2-020:2017-12) (Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-020: Particular requirements for laboratory centrifuges) (IEC 61010-2-020:2006)) (withdrawn, now DIN EN 611010-2-020:2017-12; VDE 0411-2-020:2017-12)

DIN EN 61010-2-081:2015-11; VDE 0411-2-081:2015-11: Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel-und Laborgeräte – Teil 2-081: Besondere Anforderungen an automatische und semiautomatische Laborgeräte für Analysen und andere Zwecke (IEC 61010-2-081:2015) (Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-081: Particular requirements for automatic and semiautomatic laboratory equipment for analysis and other purposes) (IEC 61010-2-081:2015))

DIN EN ISO 6556:2013-02: Laborgeräte aus Glas – Saugflaschen (Laboratory glassware – Filter flasks)

DIN EN ISO 7010:2012-10: Graphische Symbole – Sicherheitsfarben und Sicherheitszeichen – Registrierte Sicherheitszeichen (Graphical symbols – Safety colours and safety signs – Registered safety signs)

DIN EN ISO 7730:2006-05: Ergonomie der thermischen Umgebung – Analytische Bestimmung und Interpretation der thermischen Behaglichkeit durch Berechnung des PMV- und des PPD-Indexes und Kriterien der lokalen thermischen Behaglichkeit (Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria)

DIN EN ISO 13130:2011-10: Laborgeräte aus Glas – Exsikkatoren (Laboratory glassware – Desiccators)

DIN EN ISO 13857:2008-06: Sicherheit von Maschinen – Sicherheitsabstände gegen das Erreichen von Gefährdungsbereichen mit den oberen und unteren Gliedmaßen (Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs)

DIN EN ISO/IEC 17025:2005-08: Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien (zurückgezogen, jetzt DIN EN ISO/IEC 17025:2018-03) (General requirements for the competence of testing and calibration laboratories) (withdrawn, now DIN EN ISO/IEC 17025:2018-03)

DIN-Fachbericht CEN/TR 14739:2005-04: Schema für die Durchführung einer Risikobewertung für brennbare Kältemittel bei Haushalts-Kühl- und Gefriergeräten (Scheme of carrying out a risk assessment for flammable refrigerants in case of household refrigerators and freezers)

DIN ISO 3585:1999-10: Borosilicatglas 3.3 – Eigenschaften (Borosilicate glass 3.3 – Properties)

DIN VDE 0100-540:2007-06: Errichten von Niederspannungsanlagen – Teil 5-54: Auswahl und Errichtung elektrischer Betriebsmittel – Erdungsanlagen, Schutzleiter und Schutzpotentialausgleichsleiter (zurückgezogen, jetzt: DIN VDE 0100-540:2012-06; VDE 0100-540:2012-06: Errichten von Niederspannungsanlagen – Teil 5-54: Auswahl und Errichtung elektrischer Betriebsmittel – Erdungsanlagen und Schutzleiter (IEC 60364-5-54:2011)) (Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors (withdrawn, now Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors (IEC 60364-5-54:2011))

DIN VDE 0100-701:2008-10; VDE 0100-701:2008-10: Errichten von Niederspannungsanlagen – Teil 7-701: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Räume mit Badewanne oder Dusche (Low-voltage electrical installations – Part 7-701: Requirements for special installations or locations – Locations containing a bath or shower)

DVGW Arbeitsblatt G 621:2009-11 Gasinstallationen in Laborräumen und naturwissenschaftlichen Unterrichtsräumen – Planung, Erstellung, Änderung, Instandhaltung und Betrieb (Gas installations in laboratories and science lecture rooms – Design, construction, modification, maintanance and operation)

6 Media and books

Source: Jedermann-Verlag GmbH, Postfach 10 31 40, 69021 Heidelberg, http://www.jedermann.de

DVD "Kompendium Arbeitsschutz": Vorschriften und Regelwerk, Symbolbibliothek, Programm für die Durchführung und Dokumentation der Gefährdungsbeurteilung (GefDok und GefDok Light), Vorschriften und Regelwerk sowie die Symbolbibliothek können auch online abgefragt werden (kostenpflichtig) (Compendium on industrial health and safety: Rules and regulations, library of symbols, programs for performing and documenting hazard assessments (GefDok and GefDok Light), the rules and regulations and library of symbols can also be accessed online (against fee))

Praxishilfe: Arbeitsschutz mit System (Health and safety guide), BG RCI

Source: Bookshops and Libraries

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Occupational Safety and Health): Kleine ergonomische Datensammlung (Small collection of ergonomic data), TÜV Media, 16th ed., 2017

E. Dittrich (ed.): The Sustainable Laboratory Handbook, Wiley-VCH Verlag, Weinheim 2015

P. Eisenbarth, D. Kleuser, H. Bender: Expositionssituation in Laboratorien der chemischen Industrie, Gefahrstoffe – Reinhaltung der Luft, Vol. 58, No. 10, 381 – 385, 1998

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Tiered Approach to an Exposure Measurement and Assessment of Nanoscale Aerosols Released from Engineered Nanomaterials in Workplace Operations
http://www.bgrci.de → Prävention → Fachwissen-Portal → Topic list → Hazardous Substances → Current Items → Nanomaterials at the workplace (Webcode: Page-ID #V2TR) (visited 2019-08-01)

BG RCI's online aid for converting labelling elements to the GHS system: https://www.ghs-konverter.de (visited 2019-08-01)

GESTIS hazardous material database: https://www.dguv.de → Institut für Arbeitsschutz der DGUV (IFA) → Gefahrstoffdatenbanken → GESTIS-Stoffdatenbank or directly at: https://www.dguv.de/ifa/gestis-database (visited 2019-08-01)

GisChem hazardous material database by BG RCI and BGHM: https://www.bgrci.de → Prävention → Fachwissen-Portal → Gefahrstoffe → GisChem (Web code: Page ID #MYYN) or directly at: https://www.gischem.de (visited 2019-08-01)

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"Working Safely in Laboratories" incorporates the February 2008 edition of Technical Rules for Hazardous Materials "Laboratorien" (TRGS 526), prepared by the former Fachausschuss Chemie within the framework of the cooperation model. These technical rules for hazardous materials are supplemented and explained by further details. The document is aimed at proprietors and is intended to help them meet their obligations and to indicate ways of avoiding industrial accidents, occupational illnesses and work-related health risks.

"Working Safely in Laboratories" therefore represents a consensus of expert opinion and describes the generally accepted state of the art.

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