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DGUV Regel 109-605

Metals heat treatment sector

January 2021

kommmitmensch
Sicher. Gesund. Miteinander.

kommmitmensch is the national campaign of the German Social Accident Insurance (DGUV). Its purpose is to support companies and educational institutions in developing a culture of prevention in which all action is underpinned by safety and health. Further information at **www.kommmitmensch.de**

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Metals heat treatment sector

DGUV Regel 109-605 January 2021

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1 What is the purpose of this rule?

What is a DGUV Rule?
This DGUV Rule supports you by describing occupational safety and health measures tailored to your sector. For this reason, it is also termed a “sectoral rule”. DGUV Rules are drawn up by experts at the German Social Accident Insurance and further OSH experts. These experts are familiar with the day-to-day conditions in companies within your sector, and know where hazards exist to the safety and health of these companies’ employees.

DGUV Rules assist you in applying German state OSH regulations, DGUV accident prevention regulations, standards and numerous statutory requirements in practice. They also contain a wealth of practical tips and information on implementing occupational safety and health effectively in your company. As an employer, you are at liberty to select alternative solutions; they must however assure at least the same level of safety.

For whom is this DGUV Rule intended?
This DGUV Rule addresses you in the first instance in your capacity as an employer, since you bear responsibility for the safety and health of your employees. Owing to its high practical relevance however, the DGUV Rule is also very useful to all other parties involved in your company in occupational safety and health, such as your staff/works council, OSH professionals, company physicians and safety delegates.

This DGUV Rule provides specific assistance with occupational safety and health measures relating to metals heat treatment. It covers the most important prevention measures by which the statutory safety objectives can be met in your company and for your workforce.

2 Principles of occupational safety and health

2.1 Principles applicable to all sectors

Whether by the provision of supervision through OSH professionals and company physicians, the delivery of instruction and performance of risk assessments, or the assurance of first aid: any employer taking the safety and health of his or her employees into account – systematically, in all processes, and with the employees' participation – creates a sound basis for well organized occupational safety and health.

§ Statutory references

- ArbSchG, German Safety and Health at Work Act
- ASiG, German Occupational Safety Act
- ArbStättV, German Ordinance on Workplaces
- BetrSichV, German Ordinance on industrial Safety and Health
- GefStoffV, German Ordinance on hazardous Substances
- PSA-BV, German Ordinance on the Use of Personal Protective Equipment
- ArbMedVV, Ordinance on Preventive Occupational Health Care

- DGUV Regulation 1, Principles of Prevention
- DGUV Regulation 2, occupational physicians and OSH professionals

- TRBS 1201, Testing of work equipment and equipment requiring supervision
- TRBS 1203 technical rules governing competent persons
- ASR V3 a.2 technical rules for workplaces governing barrier-free design of workplaces
- ASR A1.3 governing safety and health signage
- ASR A2.2 governing fire prevention measures
- ASR A2.3 governing escape routes and emergency exits, escape and rescue plans
- ASR A4.3 governing first-aid areas, equipment and facilities

i Further information

- DGUV Information 204-022 governing first aid in companies
- DGUV Information 205-023 governing fire safety assistants
- DGUV Information 250-010 governing aptitude tests in plant practice

As an employer in Germany, you bear responsibility under the Safety and Healt at Work Act for the safety and health of your company's employees. There are numerous other good reasons however for devoting attention to occupational safety and health in your business. Employees who work in a safe and healthy environment are for example not only less frequently ill, but also work with greater commitment and motivation. Investments in occupational safety and health have also been shown to yield a financial return for companies.

The German Social Accident Insurance supports you in implementing occupational safety and health in your company. The first step is to implement basic prevention measures. These are described on the following pages. They constitute a sound foundation for well-organized occupational safety and health and set the course for further important prevention measures in your company.

Responsibility and assignment of tasks

Responsibility for your employees' safety and health lies with you, the employer. You must therefore organize work in your company in such a way that hazards to life and health are avoided wherever possible and the stress upon your employees does not exceed the limits of their personal performance.

You may assign this task in writing to other reliable and skilled persons within your company; you are however obliged to check regularly that these persons are performing their duties satisfactorily. If necessary, set out measures for improvement. Following an occupational accident or the incidence of an occupational disease, in particular, the causes must be determined and the occupational safety and health measures adapted.

Supervision by occupational physicians and OSH professionals

You are supported in the creation of safe and healthy workplaces by the OSH professionals and occupational physicians, and by your accident insurance institution. DGUV Regulation 2 sets out the scope of supervision by OSH professionals and occupational physicians that you are required to implement.

Safety delegates

Should your company employ over 20 people, you must also appoint safety delegates. Safety delegates are employees of your company who support you in improving occupational safety and health in your company. They volunteer for this task and complete it parallel to their main functions within the company. Their function involves, for example, ensuring that safeguards and protective equipment are in place, and drawing their colleagues' attention to behaviour that is dangerous or presents a health risk. In the process, they provide you with reliable information on how you can improve occupational safety and health.

Skills in occupational safety and health

For occupational safety and health measures to be effective, sound knowledge is required. Ensure therefore that all persons in your company who are entrusted with OSH tasks are adequately skilled. Provide these individuals with the opportunity to attend initial and further training measures. The German Social Accident Insurance Institutions and their umbrella association, the DGUV, provide a wide range of suitable seminars and initial and further training courses.

Assessment and documentation of work conditions (risk assessment)

In order for people to be protected against hazards to safety and health at the workplace, the hazards actually arising must be identified. One of the most important tasks of occupational safety is therefore assessment of the working conditions, or "risk assessment". The purpose of a risk assessment is to determine possible hazards to the safety and health of your employees at each workplace within your company, and to set out measures for eliminating these hazards. At the same time, assess both the physical and mental stresses upon your employees. Observe statutory constraints and prohibitions upon employment, such as those applicable to young people and pregnant and nursing women, particularly with regard to heavy physical work and work involving hazardous substances. Hazards must in the first instance be eliminated or reduced at source. Where this is not (entirely) possible, you must take protective measures in accordance with the T-O-P principle. This means that you must first determine and implement technical (T), then organizational (O), and only then personal (P) measures. By documenting the risk assessment you have performed, you not only meet your statutory obligation to do so, but also create an overview of occupational safety and health measures taken in your company. This enables developments to be understood and the efficacy of measures to be demonstrated.

Occupational medical measures

Occupational medical prevention activity is an indispensable component of occupational safety and health within your company. It includes involving the occupational physician in the risk assessment, general consulting on occupational medicine, and the conducting of preventive occupational medical care including the provision of occupational medical advice to employees on a one-to-one basis. Should preventive medical care reveal a need for specific measures to be taken in the interests of occupational safety and health, you must initiate these measures for the employees concerned.

Instruction

Your employees are able to work safely and without risk to their health only when they are familiar with the hazards at their workplaces, their duties with regard to occupational safety and health, the measures to be taken and the company rules. These rules include company procedures. It is therefore important that your employees receive instruction, ideally directly at their workplaces. You may provide instruction yourself, or assign the task to a reliable and skilled person. Should you employ personnel from temporary employment agencies, you must provide them with the same instruction you provide to your own staff. The occupational physician and/or OSH professional can support you in this task. Instruction must be provided at least once a year, and must be documented. Young people must receive instruction at intervals of six months. You must also ensure that your employees receive instruction:

- before beginning a task,
- when they are assigned to a different task,
- in the event of changes in their area of activity and changes in the working processes.

Dangerous work

Some tasks in your company are particularly dangerous for your employees. Where this is the case, ensure that responsibility for supervision lies with a reliable person who is familiar with the work. Should a person be tasked with performing dangerous work alone, you are obliged to put suitable technical or organizational protective measures in place, such as patrols by a second person, systems for reporting by telephone/radio alarm at agreed times, or personal alarm systems. Your responsible accident insurance institution will be pleased to advise you.

Access to rules and regulations

Make all relevant state rules and regulations and DGUV accident prevention regulations available at a suitable location to all persons in your company. By doing so, you not only ensure that your employees are informed of the necessary prevention measures, but also demonstrate that you take occupational safety and health seriously. Your accident insurance institution is available to answer any questions you may have concerning the rules and regulations.

Personal protective equipment

If hazards to your employees cannot be ruled out by means of technical and organizational measures, you as their employer are obliged to provide them free of charge with personal protective equipment (PPE). Ensure when purchasing the PPE that it bears the CE mark. What forms of PPE are suitable for what particular working conditions and employees is determined by the risk assessment. You are required to consult the employees before making the PPE available.

For the objective of protection to be attained, employees must use the PPE in accordance with the instructions for its use and in observance of the limits to the duration of its wear and use; they must check the proper condition of the PPE regularly; and they must report any observed defects in it immediately. Employees must be instructed in correct use of the PPE. By organizing measures for maintenance, repair and replacement and by correct storage, you ensure that the personal protective equipment remains functional and in a hygienically flawless condition throughout its service life.

Where PPE is used in your company for protection against potentially fatal hazards or risks of permanent harm to health (e.g. PPE against falls from a height, respiratory protection), further measures must be observed. Instruction in correct use of the PPE concerned must for example include practical drills. Further measures may include the planning and proper performance of rescue measures, inspection of the equipment by a skilled person, and the production of special operating procedures.

You can use signs indicating mandatory health and safety measures to inform your employees of the workplaces at which PPE must be used.

Fire safety and emergency measures

You and your employees must be able to act quickly and purposefully in the event of an emergency. Organization of company fire safety and preparation for other emergency measures, such as orderly evacuation of your workplace, therefore also form part of the safety and health of workers at work. For this reason, train as many employees as possible as fire safety assistants.
A recommended figure is at least five percent of your workforce. Appointment of an employee as a fire safety officer is also advisable. This pays off in the event of an emergency. In order for fires to be fought effectively when they arise, you must install suitable fire extinguishing equipment on your premises such as portable fire extinguishers, and familiarize all employees with its use by providing regular instruction.

First aid

Organization of first aid in your company is one of your basic duties. “First aid” covers all measures required in the event of accidents, acute illnesses, poisoning and other emergencies before the arrival of the emergency services or a doctor. Examples of these measures are: safeguarding the accident location, taking accident victims out of acute danger, alerting emergency services, taking immediate lifesaving measures, and providing support for affected individuals. The basic requirement for first-aid materials is covered by the “small” and “large” first-aid boxes to DIN 13157 and DIN 13169 respectively. Hazards specific to the company may necessitate supplementary materials.

Your company must have a sufficient number of first-aiders. The required number depends upon the number of employees in your company. Any employee may assume this task. A requirement is successful completion of further training in first-aid and regular refresher courses every two years. The course fees are paid by the German Social Accident Insurance Institutions. You must also ensure that sufficient first-aiders are also present during shifts and holiday periods.

How many first-aiders?

1. When between 2 and 20 insured individuals are present	One first-aider
2. When over 20 insured individuals are present	
a) In administration and trade businesses	5 %
b) In other businesses	10 %

Regular checks of work equipment

Damaged work equipment may cause accidents. The work equipment used in your company must therefore be inspected regularly, and depending upon the type, also tested. Before an item of work equipment is used, it must be inspected visually and checked, if necessary by a function check, for evident faults that can be determined swiftly in this way. Besides these checks, you must ensure that regular tests are performed at appropriate intervals. How these checks and tests are to be performed, by whom and at what intervals is described in the TRBS 1201 and TRBS 1203 technical rules (refer to the information box, "Statutory references"). In a company working only a single shift, a test interval of one year has proved effective for many items of work equipment. The results of the tests must be retained at least until the following test.

Planning and procurement

Considering the topic of safety and health in all company processes from the outset is a strategy that pays off. Giving consideration to your employees' safety and health even as you are planning workplaces and installations and when procuring work equipment and materials saves you from having to make improvements, which may be expensive, at a later stage.

Accessibility

Design your company's work rooms such that they are accessible to disabled persons. Accessibility benefits not only your employees with disabilities, but the entire workforce. Adequately wide walking areas, sanitary fittings, light switches and handles that are within easy reach, and non-slip floor coverings for example can reduce the risk of accidents and considerably reduce stress and strain.

Workplace health

Health is the most important precondition for your employees to remain fit for and capable of work through to the statutory retirement age. Measures taken at an early stage to reduce work-related physical and mental stresses have a double dividend – for the employees themselves, and for the company. These measures include the design of safe and healthy workplaces, and corporate integration management. The enhancing of health-conscious behaviour among your employees and the creation of working conditions conducive to good health also have a positive impact. Consider that your employees themselves often know best what affects them adversely at work. For this reason, involve them when considering measures for improvement. This also motivates them.

External companies, suppliers, and assignment of your employees to work at the sites of other companies

Do personnel from external companies and suppliers access your company premises? This could also be a source of hazard. Make the necessary arrangements and ensure that these persons are also familiar with and observe your company's workplace safety measures.

Should you or your employees work at the premises of other companies, the same applies in reverse: agree aspects of occupational safety and health with the companies on whose sites your employees are working.

Integration of employees with temporary work contracts

The OSH requirements in your company apply to all employees, including those working there only temporarily, such as temping and work experience personnel. Ensure that these persons are also covered by your workplace safety and health measures.

General information

- Database of regulations, rules, and informative publications of the German Social Accident Insurance:
  ▸ www.dguv.de/publikationen
- DGUV Prevention Competence Network:
  ▸ www.dguv.de (Webcode: e603971)
- Biological and hazardous substances database of the German Social Accident Insurance (GESTIS):
  ▸ dguv.de (Webcode: e20570)
- Safety and Health at Work Ordinances:
  ▸ www.gesetze-im-internet.de
- Technical rules pursuant to the Safety and Health at Work Ordinances:
  ▸ www.baua.de

3 Workplaces and tasks: hazards and measures

3.1 General hazards in heat treatment plants and measures to be taken

3.1.1 Qualification of all parties involved

You are required by law to assign work only to employees who are actually capable of carrying out the work safely. You must therefore ensure that your employees are suitably qualified in consideration of the tasks requirements.

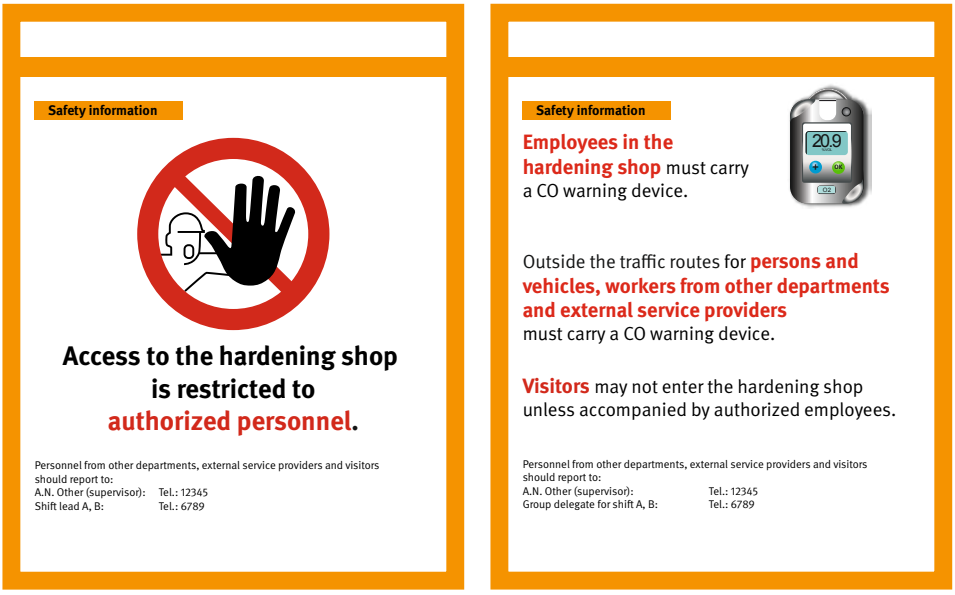


Figure 1
Example of access to the hardening shop with instructions for external parties

Statutory references

- DGUV Regulation 1, Principles of Prevention Section 7, Competence for tasks

Further information

- DGUV Information 215-830 concerning the contracting of external companies for the provision of services
- Heat treatment and materials engineering group (AWT), document concerning modules for the training of workers in the hardening shop (last amended: 11/2014)
  - https://www.awt-online.org > fachausschuesse > Fachausschuss 8 Sicherheit in Wärmebehandlungsbetrieben

Hazards

Heat treatment plants are not machines in the conventional sense (even where they fall within the scope of the Machinery Directive), but process engineering plants. This means that, in contrast to machinery, hazards are primarily caused not by mechanical movements or energy, but by physical phenomena such as temperature and pressure, and by the chemical properties of the substances used, such as (highly/easily) flammable, explosive or acutely toxic substances, or substances capable of causing skin damage.

A machine can usually be brought to a standstill very quickly, as can mechanical movements in process engineering plants. By contrast, a furnace retains its temperature even after the mechanical movements have stopped, and may still contain flammable toxic gases capable of forming a dangerous explosive atmosphere

when mixed with air. Manual intervention may therefore be necessary to rectify the malfunction or shut down the system. Serious accidents continue to happen during such manual interventions.

Manual interventions in a process engineering system require comprehensive knowledge of the process concerned. Unfortunately, the formal training for universal hardeners that imparted this process engineering knowledge in the past no longer exists in Germany. The fundamentals of process engineering are addressed during the training of materials testers specializing in heat treatment technology, but the focus here is on materials science and testing.

The problem is exacerbated by modern control technology, which requires only minor intervention by the operating personnel under normal operating conditions. It is therefore difficult, if not impossible, for operators to become versed in all aspects of the process.

The important task of providing training in process engineering and in dealing with non-routine conditions, such as malfunctions, is an important function of your company.

Measures

Workers are qualified to perform a task in the first instance by:

- Briefing
- Instruction
- Past professional activity
- Professional training
- Seminars

Workers should be familiar with the hazards associated with their tasks, be capable of recognizing dangerous situations independently, and know what measures are to be taken. This applies in particular to malfunctions and unforeseen operating conditions.

In order to determine what qualifications are required for what tasks in heat treatment shops, we recommend creation of a qualification matrix. The qualification required for the individual tasks performed in heat treatment plants is to be determined in this matrix. The qualification matrix must be geared to the company's organizational structure and the plants and processes used. Its scope must include parties who are not part of the heat treatment operation (e. g. external companies, temporary workers, visitors, etc.)

Technical Committee 8 of the Heat treatment and materials engineering working group (AWT), which deals with safety in heat treatment plants, has produced a document describing knowledge requirements for employees in hardening shops. The document provides examples of the range of tasks and the associated requirements profiles for workers in hardening shops.

After creating the qualification matrix, you can use it to decide what further training or other qualification measures for your employees are needed. For example, the German Social Accident Insurance Institutions offer a large number of seminars free of charge. You can also take advantage of the support provided by manufacturers or industry associations for further development of your employees' qualifications.

Access to the heat treatment area

The following measures have proved effective for access to heat treatment areas:

- *Access to the heat treatment area must be regulated. For example, registration of persons from outside the company shows clearly who is present in the area and whether they meet the qualification requirements (briefing on site).*
- *Persons present in the area unaccompanied must first be instructed on specific hazards, first aid, escape routes and rescue concepts.*
- *Where operating personnel and the personnel of external companies may endanger each other, their work must be coordinated.*

Further information can be found in DGUV Information 215-830 concerning the contracting of external companies for the provision of services.

3.1.2 Personal protective equipment

The aim of personal protective equipment is to reduce residual hazards that are not addressed by technical and organizational protective measures. Technical and organizational protective measures take priority over the use of personal protective equipment.

As an employer and/or manager, you have the duty to ensure that employees use the personal protective equipment specified in your risk assessment.

§ Statutory references

- DGUV Regulation 1, Principles of prevention, Part 4: Personal protective equipment
- DGUV Regel 112-189 and 112-989 concerning the use of protective clothing
- DGUV Regel 112-190 concerning the use of breathing apparatus
- DGUV Regel 112-191 and 112-991 concerning the use of foot and knee protectors
- DGUV Regel 112-192 and 112-992 concerning the use of eye and face protectors
- DGUV Regel 112-193 and 112-993 concerning the use of protective headgear
- DGUV Regel 112-194 concerning the use of hearing protection
- DGUV Regel 112-195 and 112-995 concerning the use of protective gloves
- DGUV Regel 112-198 concerning the use of personal protective equipment against falls from a height
- DGUV Regel 112-199 concerning rescue from heights or underground with the use of personal protective equipment against falls from a height

i Further information

- DGUV Information 212-013 concerning heat-resistant protective clothing
- DGUV Information 240-300 containing instructions for preventive occupational medical care in accordance with DGUV Grundsatz G 30 (heat)

Figure 2 Flame-retardant work clothing

Hazards

The use of personal protective equipment is intended to cover residual hazards that still exist once the possible technical and organizational measures have been exhausted. You determine the personal protective equipment required as part of the risk assessment for your company. The physical parameters and properties of the media used in heat treatment processes lead to specific requirements for personal protective equipment.

Selected examples:
- High process temperatures or open flames
- High thermal radiation
- High penetration rate of methanol and therefore short service life of many glove materials
- Caustic properties of ammonia or other substance
- Toxicity of some hardening salts
- Flaking off of scale or parts of workpieces
- Unmarked hot parts in the vicinity

Measures

In general, clothing made of natural fibres, particularly cotton, is recommended in areas in which heat treatment is performed. Clothing made of synthetic fibres melts at higher temperatures and is more flammable than cotton. Clothing made of natural fibres affords better protection against burn injuries.

You must provide your employees with the necessary personal protective equipment free of charge and, if necessary, offer or arrange for preventive occupational medical care.

Where the skin is exposed to hazards despite the use of personal protective equipment, further protective measures (such as establishing a skin protection plan) must be determined in consultation with the occupational physician.

In addition, when personal protective equipment is used, ensure that:
- employees are instructed in the use of the personal protective equipment,
- the personal protective equipment is stored properly at a designated location,
- the personal protective equipment is checked before use and cleaned after use,
- defective personal protective equipment is repaired or replaced before reuse.

Tips for the selection of personal protective equipment for the particular requirements of heat treatment plants:

Tasks performed on or in the vicinity of salt baths:
- Polycarbonate face shields
- Multi-layer protective clothing/clothing for protection against burns caused by liquid salt. The protective clothing should be made of strong cotton fabric, suitable for dry cleaning, with fireproof impregnation. Protective clothing made of synthetic fibres is unsuitable. Underwear should likewise not be made of synthetic fibres.
- Multi-layer easily dropable mittens made of dense cotton fabric with gauntlet, the outer layer of which burns away and drops off upon contact with hot molten material
- Ankle-high safety shoes (foundry boots)
- Work clothing for tasks involving acutely toxic hazardous substances must be stored separately from private clothing.
- Additional or other personal protective equipment, such as that for respiratory protection, may be required during maintenance and servicing tasks.

Figure 3 Aluminized thermal protection overall, shown here in combination with hand and head protection

Protective clothing must be worn during tasks close to high heat or contact with flames. Such clothing is for example:

- Flame-retardant protective clothing in accordance with EN ISO 14116. Ensure that the flame-retardant property of this clothing is not compromised by cleaning.
- Heat-resistant protective clothing made of aluminium-laminated material offers even better protection, for example for work directly at the open furnace door. It is intended for protection of the face and body.
- Heat-resistant safety shoes for work on furnace systems (in particular older systems with poor thermal insulation)

Safety glasses must be worn at workplaces involving very high infrared exposure (caused for example by light-red, yellow and white-hot material). Elevated exposure to infrared radiation over many years can cause cataracts (glassblower's cataracts).

3.1.3 Work-related health hazards – mental stress

Statutory references

- ArbSchG, German Safety and Health at Work Act
- ArbStättV, German Ordinance on Workplaces
- ArbMedVV, Ordinance on Preventive Occupational Health Care
- DGUV Regulation 1, Principles of Prevention
- DGUV Regulation 2, occupational physicians and OSH professionals

Further information

- DGUV Informative publications on mental stresses:
  ▸ www.dguv.de (Webcode: e564593)
- BGHM Informative publications on mental stress and strain:
  ▸ www.bghm.de (Webcode 234)

Activity-based, objective recording of relevant mental stress factors is part of the risk assessment.

Effects of the work content/work task, work organization, work environment and social relationships with a bearing upon mental health must be determined and analysed systematically during the risk assessment.

Numerous aspects of occupational activity may cause mental stress. In their joint declaration on mental health at work in 2013, the German Federal Ministry of Labour and Social Affairs*) and the social partners published key characteristics of work-related mental stress and forms of it which may be critical.

*) Joint declaration by the BMAS and the social partners on mental health in the world of work; BMAS, 2013

Hazards (mental stress)

Table 1 Classes of characteristics and content of the risk assessment for mental stress

1. Class of characteristics: Work content/work task	Possible critical forms
1.1.Comprehensiveness of the task	The task includes: • Preparatory activity only • Performative activity only • Inspection activity only
1.2 Freedom of action	The employee(s) has/have no influence upon the: • Work content • Workload • Working methods/procedures • Sequence of the activities
1.3 Variety	One-sided requirements: • Work items and equipment are similar and few in number • Frequent repetition of similar actions in short cycles
1.4 Information/ presentation of information	• Too much (sensory overload) • Too little (long periods with no new information) • Unfavourable form of presentation • Incomplete (important information missing)
1.5 Responsibility	• Competencies and responsibilities are unclear
1.6 Qualifications	• Tasks do not reflect employees' qualifications (under-qualification/over-qualification) • Inadequate briefing/ familiarization with the task
1.7 Emotional stress, caused by:	• Highly emotional experiences (e.g. dealing with serious illnesses, accidents or deaths of other persons) • Constant addressing of the needs of other people • Continual requirement to display emotions at variance with actual feelings • Threats of violence by other persons

2. Class of characteristics: Work organization	Possible critical forms
2.1 Working hours	• Variable or long working hours • Unfavourably structured shift work, frequent night work • Extensive overtime • Inadequate break times • Work on call
2.2 Working procedures	• Time pressure/ highly intensive work • Frequent disturbances/ interruptions • Rigid working cycles
2.3 Communication/ cooperation	• Isolated single workstation • Little or no support available from superiors or colleagues • No clearly defined areas of responsibility
3. Class of characteristics: Social relationships	**Possible critical forms**
3.1 Colleagues	• Too few/too many social contacts • Frequent disputes and conflict • Nature of conflict: situations associated with social pressure • Lack of social support
3.2 Superiors	• Management personnel not qualified • Lack of feedback, performance not acknowledged • Lack of leadership, lack of support when needed

4. Class of characteristics: Work environment	Examples of negative effects
4.1 Physical and chemical factors	• Noise • Inadequate lighting • Hazardous substances
4.2 Human physical factors	• Poor ergonomic design • Heavy manual work
4.3 Workplace and information design	• Unsuitable workrooms, lack of space • Poor design of signals and information
4.4 Work equipment	• Lack of or unsuitable tools/ work equipment • Unfavourable operation or set-up of machines • Poor software design
5. Class of characteristics: New forms of work	**Examples of negative effects**
These characteristics are not the subject of supervisory activity, but are relevant to the employees' stress situation.	• Geographic mobility • Atypical employment contracts, interrupted career paths • Increasing flexibility of working hours, blurring of working and private life

Source: GDA brochure containing recommendations for implementing risk assessments of mental stress (2nd, extended edition, January 2016)

A wide range of instruments and methods for assessing the risk of mental stress exist which take account of different operational conditions and needs.

Mental stress can be determined during the risk assessment; analysis workshops, observational interviews and employee surveys are used for this purpose. Each of these procedures has its own advantages, but also specific requirements and limitations that need to be balanced against each other (refer to the overview of the procedures' strengths and limitations provided in Annex 2 (recommendations and test questions for the selection of instruments/procedures) of the GDA brochure concerning recommendations for the implementation of risk assessments of mental stress (2nd, extended edition, January 2016)).

Measures

The following general measures for work design have proved effective in protecting and enhancing health under circumstances of work-related mental stress:

- Diversity in the requirements imposed by tasks and the information provided
- Avoidance of fatigue by the use of buffers to decouple the cyclical completion of tasks, and the resulting increased autonomy
- Job rotation, i.e. rotation of the work tasks and work locations
- Job enlargement by quantitative expansion of tasks
- Job enrichment by the combining of multiple work tasks to form one larger task
- Where the task presents limited scope for structuring, extension of the options for action in working groups by the use of technical or organizational measures to transfer planning, decision-making and/or supervisory functions; where task requirements are tightly constrained, mechanization or automation of repetitive functions
- Facilitation/support of opportunities for communication between employees

In the interests of good results, it is essential that employees be involved in the process of evaluating mental stress factors and, based upon the results, in defining protective measures.

3.1.4 Work-related health hazards – workplace health

Statutory references

- ArbSchG, German Safety and Health at Work Act
- ArbStättV, German Ordinance on Workplaces
- ArbMedVV, Ordinance on Preventive Occupational Health Care
- DGUV Regulation 1, Principles of Prevention
- DGUV Regulation 2, occupational physicians and OSH professionals

Further information

- DGUV Informative publications: Workplace health Expert committee:
  ▶ www.dguv.de (Webcode: d138325)
- BGHM Informative publications on mental stress and strain:
  ▶ www.bghm.de (Webcode 234)

Hazards

Physical, chemical, biological, human physical and mental effects at work can impair or harm employees' health (more information can be found in other chapters).

Measures

- Your employees often know best what affects them at their workplace or makes them ill. Actively involve your employees in a risk and stress assessment and include them when considering work design measures. This ensures greater acceptance and motivates your employees.
- In individual cases, the statutory health insurance funds support their insured individuals and companies in organizing and delivering measures for the promotion of good health.
- Preventing work-related health hazards by the use of appropriate measures for maintaining and enhancing the health of company employees has proved particularly effective in the following areas (see also DGUV Workplace health Expert committee):
  – Work in the context of demographic change
  – Work organization/health-conscious design of work tasks
  – Corporate integration management
  – Promotion of exercise
  – Promotion of healthy nutrition
  – Health-enhancing leadership behaviour
  – Prevention of violence
  – Inter-cultural aspects of prevention
  – Mental stress and strain
  – Addiction prevention

3.1.5 Competence, qualification, preventive medical care, aptitude

Where particularly dangerous tasks are performed, employers must observe specific rights and duties in order to avoid endangering the safety and health of workers at work. These rights and duties may be set out in acts, subordinate legislation and other regulatory instruments, and in employment contracts, collective agreements or company agreements.

This includes the observance of arrangements and/or agreements concerning competence, qualification, preventive medical care and aptitude which may be based upon a range of statutory instruments, and the observance or non-observance may have a range of legal consequences. In addition, responsibilities arising from management tasks, for example where duties are transferred or delegated and management tasks are performed locally, have a high priority in this context. The active cooperation of employees in this context is also mandatory.

Parties involved at the company level assume their respective responsibilities for the safety and health of employees at work in the four areas of competence, qualification, preventive medical care and aptitude.

A physician specialized in occupational medicine has a special function, as he or she may be in direct contact with the individual employees in the four areas, according to the underlying situation in the company. In order to be able to carry out these tasks, the occupational physician must have personal knowledge of the workplace conditions.

Section 6, ArbMedVV (1) [...] Before performing preventive occupational medical care, he or she must acquire the necessary knowledge of the workplace conditions.

§ Statutory references

- ArbMedVV, Ordinance on Preventive Occupational Health Care
- DGUV Regulation 1, Principles of Prevention

i Further information

- Employment contracts, collective agreements or company agreements

Competence, qualification
Superiors must review an employee's competence for a specific task. In addition to the formal qualifications (training, driving licence, instruction), superiors must also form their own opinion of the employees' physical condition. They usually do so at the start of the work/shift.

Section 7 (1) of DGUV Regulation 1: "When assigning tasks to insured persons, the employer shall consider whether the insured persons are able to comply with the safety and health rules and measures applicable to their specific tasks. The employer shall also take into consideration the required qualifications for specific tasks."

Section 7 (2) of DGUV Regulation 1: "The employer must not assign to insured persons tasks that they are clearly unable to perform without causing risk to themselves or others."

Details of the definition of competence and qualification, their determination, when they are determined and the particular requirements relating to them are set out in DGUV Rule 100-001 concerning principles of prevention.

Superiors can also check the competence of their employees during the regular provision of occupational safety instruction. If necessary, practical exercises can assist here in identifying the level of qualification or any technical or physical deficits which may be present. Drills in the use of personal protective equipment against falls from a height can for example reveal deficits in mental aptitude (fear of heights) and physical fitness.

Preventive occupational medical care
Preventive occupational medical care is among the measures for assuring the safety and health of workers at work and is governed comprehensively in the German Ordinance on preventive occupational medical care (ArbMedVV). Its principal content is summarized below. Preventive occupational medical care must not be a substitute for technical and organizational occupational safety and health measures. In the form of personal occupational medical advice on work-related health hazards, it is however a valuable complement to these measures.

The purpose of preventive occupational medical care is to assess the mutual influences of an individual's work and their physical and mental health. It involves a medical consultation with case history, including work history. This preventive medical care is intended to detect work-related health disorders at an early stage and to determine whether performance of a particular activity is associated with an elevated risk to health.

Before conducting a preventive medical consultation, the occupational medical specialist must familiarize him or herself with the conditions at the workplace.

Mandatory and optional preventive medical consultations must be instigated or offered by employers according to whether tasks involve the hazardous substances, biological agents, physical effects and other tasks listed in the annex of the ArbMedVV. Optional preventive occupational medical consultations must be offered to employees who perform tasks in which harm to their health cannot be ruled out.

As part of the preventive occupational medical consultations, physical and/or clinical examinations are conducted as required when:
- They are required for the advising of individuals
- The physician has informed the subject of the preventive occupational medical care of content of the measure, its purpose and the associated risks
- The subject of the preventive occupational medical care does not refuse to be examined

The certificate of preventive occupational medical care states that a preventive occupational medical consultation was conducted, when and for what reason and also when, in the physician's opinion, the next consultation is required. Identical certificates of the measure are issued to the employer and the person undergoing the consultation.

The physician must record the results and findings of the consultation in writing, provide advice to the individual concerned with reference to the results and findings, and make the results available to the individual at his or her request, if applicable also in writing. The physician is obliged to respect medical confidentiality with respect to third parties, i.e. including to the employer.

Should however the occupational medical consultation reveal that the existing occupational health measures for the employees are inadequate, physicians must inform employers of the fact and propose suitable measures. The employer must then review the risk assessment and take the necessary measures for occupational safety and health.

The annex to the ArbMedVV contains an exhaustive list of tasks for which a mandatory preventive occupational medical consultation must be arranged or an optional consultation offered.

Aptitude examinations
Aptitude (fitness) examinations serve to determine whether, in consideration of the employees' existing and potential physical and mental abilities, they may be considered capable of performing the tasks expected of them in their employment

The key instrument for the avoidance of hazards to safety and health at work is always the risk assessment in the company concerned.

Routine aptitude examinations
Where particularly hazardous tasks are performed, the risk assessment may reveal a possible need for additional routine aptitude examinations. This is the case when the following criteria apply:
- Performance of the task is associated with a hazard to third parties that cannot be ruled out and
- the examination is mandatory owing to specific statutory requirements or requirements deriving from labour law (employment contract, works agreement, collective agreement) and
- the employee has consented to the specific examination.

Aptitude examinations are permissible only where the employer has a legitimate interest in determining the employee's aptitude. This applies in particular to examinations performed in the absence of an evident risk situation. All examinations must respect the principle of proportionality (appropriate, necessary, reasonable).

The examination must first determine the employee's aptitude in the first instance for the specific activity. Should an examination or examination method not enable aptitude to be established, it is not proportionate.

The examination is required when, of the conceivable alternatives available, it constitutes the most benign means of determining aptitude. Should it be possible for aptitude to be established by another, equally effective measure, the examination is not proportionate and therefore inadmissible.

The examination is reasonable when, should the employee not or no longer exhibit aptitude, performance of the task would endanger the life and limb of other persons and the aptitude examination would by comparison present only a minor burden for the employee.

Aptitude examinations conducted owing to clear signs of deficiencies in aptitude
Outside the scope of the routine aptitude examinations, the employer may make continued performance of the task concerned dependent on a medical certificate of aptitude in cases where specific and reasonable doubt exists that employees still exhibit aptitude for continued performance of the task in question (employer's duty of care).

Reasonable doubt may exist when sufficient factual evidence indicates a lack of aptitude. In such scenarios, employees' duty to cooperate may in exceptional cases also derive from the secondary obligation imposed by their employment contracts to take account of the employer's interests (contractual duty of loyalty) in accordance with Section 241 (2) of the German Civil Code (BGB).

Under these circumstances, too, the aptitude examinations must meet the criterion of proportionality.

Requirements to be met by physicians conducting aptitude examinations
Employers may in the first instance appoint a physician of their choice to carry out aptitude examinations. Should the employee assert reasoned concerns, for example with regard to the physician's expertise or impartiality, employers may have an equitable obligation (Section 315 (1) of the BGB) to task a different physician with conducting the examination. This equitable obligation entails balancing the interests of the two parties objectively.

Since knowledge of the job concerned is absolutely essential for assessing aptitude, the physician will normally be a specialist in occupational medicine.

The physician must be personally familiar with the requirements presented by the job concerned. An important aspect of this is the risk assessment of the work areas concerned. The risk assessment is produced by the employer following consultation with the occupational physician and OSH professional.

Result of the aptitude examination
The aptitude examination may reveal that the employee no longer possesses the aptitude to perform individual tasks within his or her area of work. This situation may be temporary or permanent or may lend itself to correction by means of certain work design measures. The primary objective must be for the employee to continue working in the company, with consideration for his or her personal impairments. Should the aptitude examination suggest that the existing occupational safety and health measures are not sufficient, the physician must inform the employer and propose suitable measures.

3.1.6 Fire safety

The process media used in heat treatment plants lead to an elevated fire risk. In order to prevent this hazard from materializing in your plant, implement fire safety measures thoroughly and give consideration to the particular underlying conditions in heat treatment plants.

Statutory references

- ArbStättV, German Ordinance on Workplaces, Section 4, concerning special requirements for the operation of workplaces
- German Safety and Health at Work Act, Section 10, concerning first aid and other emergency measures
- DGUV Regulation 1, Principles of Prevention, Section 22, Measures in the event of an emergency
- A2.2 Technical rules for workplaces concerning measures against fire
- A2.3 Technical rules for workplaces concerning escape routes and emergency exits, escape and rescue plan

Further information

- DGUV Information 205-001 concerning preventive fire safety in the interests of occupational safety
- DGUV Information 205-003 concerning tasks, qualification, training and appointment of fire safety officers
- DGUV Information 205-023 concerning assistant fire safety officers: training and competence
- FBFHB-006 (use of fire blankets; produced by the In-plant fire protection Subcommittee of the DGUV Fire and emergency services, fire prevention and protection Expert committee)
  ▶ www.dguv.de/publikationen Search:12561

Hazards

Should a fire break out, harm to persons is to be expected in addition to damage to property. The harm to persons is caused mainly by the following hazards:

- Inhalation of smoke
- Burns on hot parts and media
- Burns caused by flames

Measures

You must draw up an escape and rescue plan for areas where required by their location, size or form of use (e.g. rooms in which a risk of fire and toxic substances exists).

In order to prevent fires or to minimize their effects, take the following measures in your company:

- Keep the fire load in the proximity of heat treatment plant as low as possible. Essential measures for this purpose include:
  - Removing packing material
  - Regularly emptying oil collecting trays
  - Regularly removing oil deposits on plant and equipment
  - Removing oil binding agents immediately once they have been used to collect oil spills
  - Not storing collected materials contaminated by oil, such as cleaning rags or other waste soiled by oil, in the proximity of furnaces. If this cannot be avoided for operational reasons, use self-closing metal containers.
  - When soiled with nitrite/nitrate salts, organic materials such as wood or rags constitute a fire hazard that is difficult to extinguish. For this reason, remove these materials from the proximity of salt baths.

Figure 4 Increased fire load due to cleaning cloths soaked in oil

- Keep an adequate number of fire extinguishing appliances (such as fire extinguishers) suitable for the fire classes present on the site at easily accessible points. Take the potential fire load into account. Water for example is not a suitable extinguishing agent for oil bath fires or fires in the proximity of salt baths.
  For cyanide or nitrite/nitrate salt baths, fire extinguishers with a basified extinguishing powder must be provided. Should acidic extinguishing agents be used, salts containing cyanide may lead to the formation of hydrocyanic acid, nitrite/nitrate salts may lead to the formation of nitrous gases.
- Equip areas presenting an elevated fire risk with automatic fire alarm systems to enable fires to be detected as soon as they arise.
- Observe the building regulations of the German regional authorities and the local industrial building codes during all structural fire safety measures.
- Should the hazard to the user prevent fire extinguishing apparatus from being used to fight a fire or where hazardous areas are not accessible, the installation of stationary fire extinguishing systems may be advisable (such as sprinkler systems or water spray, water mist, foam, powder or gas extinguishing systems).
- Where CO_2 is used as the extinguishing agent, consideration must be given to the oxygen displacement and the associated danger of suffocation. CO_2 fire extinguishers are unsuitable for small rooms for this reason. An evacuation concept may therefore be required where CO_2 fire extinguishing systems are used.
- Instructing as many plant employees as possible in the use of the fire extinguishing apparatus has proved invaluable. Arrange for regular drills in use of the apparatus. The more proficient your employees are in handling the apparatus, the more reliably fires are extinguished as they arise and before any major damage or harm occurs. At least 5 % of the workforce should be trained as fire protection assistants, and preferably workers in areas presenting an elevated fire risk.
- Appoint a fire safety officer who will advise and support you on plant fire safety issues.
- Draw up an emergency plan covering fires, accidents and incidents requiring evacuation. The following points should be considered in the emergency plan:
  – Reporting chain for emergencies
  – Rescue of injured persons
  – Evacuation concept for the buildings
  – Emergency shut-down concept for media and energy
- An evacuation concept must cover not only rapid evacuation of affected areas, but also the reporting of which areas have been reliably evacuated, in which areas persons are still present, and whether persons are missing. The concept must take account not only of the company's own employees, but also of external parties such as employees of external companies (for example cleaning staff), customers and visitors; see also ⇢ 3.1.1 Access to the heat treatment area.
- Practical experience has shown that a building cannot be evacuated effectively and quickly unless training has been provided in the form of evacuation drills. For this reason, conduct regular evacuation drills with your employees.
- Since oil fires produce thick smoke which rapidly makes orientation in the affected rooms difficult, escape routes must be marked and kept clear. Escape routes can be signed for example by photoluminescent markings on the floor.
- To facilitate fire control and reduce the effects of a fire to a minimum, the supply of energy and media (particularly flammable gases) to a plant or operating unit should be shut off. Check whether the supply of energy and media can be shut off from outside the potential danger zone. If necessary, change the arrangements.
  Provide instruction and training in implementing the shut-off concept. As with other safety devices, regularly check the function of isolating/shut-off devices.
- Unfortunately, it is not uncommon for the fire service to fail to take the appropriate measures immediately upon its arrival. This is due to the fire service being unfamiliar with the particular features of the heat treatment plant and to impaired communication during an emergency. Maintaining regular contact with the responsible fire service through fire safety inspections and joint exercises is therefore strongly recommended.
- For this reason, provide the fire service with a fire service plan (in digital and paper form) in accordance with DIN 14095:2007-05. This plan can form the basis for coordination with the fire service. Its content includes information on:
  – Entrances for persons and vehicles
  – Floor plans of all buildings/plants
  – Fire safety equipment
  – The fire load present (e.g. hardening oil)
  – Unsuitable extinguishing agents (e.g. water in the proximity of salt baths)
  – Other media (e.g. ammonia, propane, methanol, etc.) and the storage of media
  – Other hazardous substances used (e.g. hardening salts)
  – Further hazardous zones (such as electrical control rooms)
  – Individuals responsible, contact details

Figure 5 Use of a portable fire extinguisher

Suitable fire extinguishing procedures should also be agreed with the fire service and specified in the fire service plan. Gas fires for example should not be extinguished by means of extinguishing agents, but by shutting off the gas supply line. It may be necessary for larger quantities of special extinguishing agents to be kept available for use by the fire service.

In addition to these more general aspects of fire safety measures, consider the following particular aspects of heat treatment shops:

- Hydraulic systems, especially hydraulic hoses, constitute a particular source of danger in heat treatment plants. Should a leak from a hydraulic system occur, the high pressures cause the escaping hydraulic oil to be sprayed in the form of fine mist. Should this mist come into contact with a source of ignition (e.g. a hot surface or pilot flame), it ignites immediately. This poses a huge risk to persons in the vicinity. Where a hydraulic system cannot be installed such that it is protected from potential ignition sources, the installation of screen plates is therefore recommended.

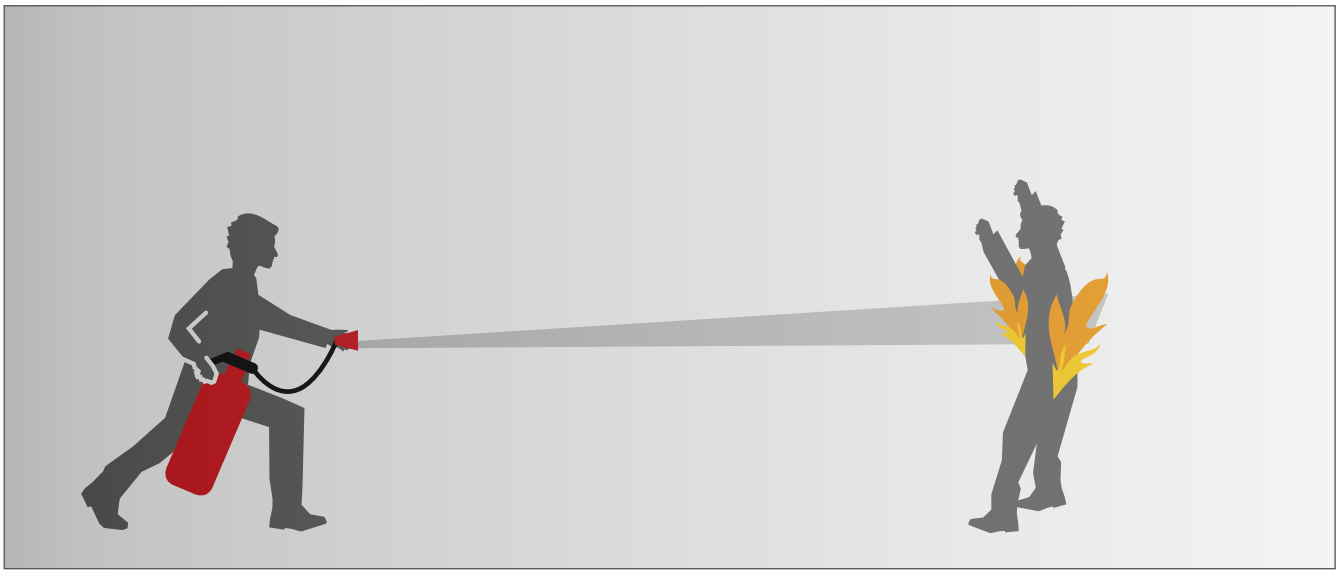


Figure 6 Extinguishing a fire on a person

Fires on persons

Suitable measures for fighting fires on persons must be selected with reference to the risk assessment for the workplace or activity concerned.
Fire blankets are no longer considered a good means of extinguishing fires on persons.

Where present, emergency safety showers can be used immediately to good effect; fire extinguishers should be used in all other cases.
Fire extinguishers enable fires to be fought safely and quickly without presenting an additional risk of injury. A fire extinguisher can be used extremely effectively to put out a fire on a person – irrespective of the type of extinguisher. Even a carbon dioxide (CO_2) extinguisher is suitable, but should be used only if no other extinguisher is available. Contact between CO_2 (approx. –70 °C) and the skin presents a risk of frostbite. Observe the following instructions for the correct use of the fire extinguisher, in order to prevent the person on fire from being exposed to additional risk.

- *Maintain a minimum distance of 2 to 3 m from the person on fire.*
- *If possible, do not direct the extinguishing jet at the face.*
- *Begin by directing the extinguishing jet at the upper body (chest and shoulders): this protects the neck and head from the rising flames.*
- *Then guide the extinguishing jet further down the body and to the sides.*
- *Observe the instructions for use of the fire extinguisher for extinguishing fires on persons.*

If a CO_2 fire extinguisher is used, observe the following additional points:

- *Maintain a minimum distance of at least 1.5 m.*
- *To avoid the risk of frostbite, never direct the extinguishing jet at any part of the body for a longer period of time.*

3.1.7 Temporary storage and manual transport of hardening material

Heat treatment plants usually have a high throughput of workpieces. The workpieces must be delivered and received, temporarily stored, managed, loaded if necessary onto fixtures, and finally packed again for dispatch.

Figure 7 Marking of traffic routes, reception/staging areas and closed areas

Statutory references

- ASR A1.8 concerning circulation routes
- ASR A2.3 concerning escape routes and emergency exits, escape and rescue plan
- DGUV Regel 108-007 concerning storage facilities and equipment

Hazards

A variety of hazards arise during storage (including interim storage, staging at the heat treatment plant) and the manual transport of workpieces. These particularly include:

- Injuries caused by workpieces falling or tipping due to unsuitable means of storage or during interim storage or staging
- Injuries caused by workpieces tipping or falling out of damaged fixtures
- Injuries caused by damaged fixtures
- Injuries occurring during manual handling of workpieces owing to sharp or pointed geometry of the workpieces or fixtures
- Excessive load upon the musculoskeletal system during the manual transport of workpieces due to their weight and frequency of transport
- Injuries caused by material falling during transport by manual pallet truck, and by collisions with persons

Measures

Take the following measures in order to reduce or prevent hazards during storage and manual transport:

Storage areas
- Mark the designated storage areas in order to prevent traffic routes from being obstructed.
- Traffic routes must have the specified dimensions and must not be obstructed or restricted. This particularly applies to escape and rescue routes.

Storage equipment (shelves etc.)
Storage equipment must be suitable for the goods stored in it. Pay particular attention to:
- The intended use and the manufacturer's further information on use
- Stability, and whether vertical or horizontal storage is intended
- The permissible maximum individual and total load for shelves
- Marking of permissible loads
- Securing of stored items to prevent them falling out of or off the shelves
- Protection against collision during loading by means of forklift trucks

Arrange for the storage equipment to be checked regularly. Have any damage impacting safety repaired immediately by a professional.

Pallets and containers
Pallets and containers must be suitable for the goods stored on/in them and be in good condition. Pay particular attention to the following:
- Observe the permissible payloads, superimposed loads and stacking heights.
- Stacks must be vertical with a maximum permissible deviation from the vertical of 2 %.
- Where containers are stacked, the imposed load must decrease towards the top.
- Ladders or other objects must not be leaned against stacks.
- Repair damaged pallets or containers or take them out of use.
- Have pallets or containers checked prior to reuse.
- Protruding or overhanging material presents a risk of injury. If this cannot be avoided, the point concerned must be safeguarded, or at the very least clearly marked.

Figure 8 Hand-guided industrial truck

Manual transport

During manual transport/picking of workpieces, mechanical injuries are caused particularly often by the workpiece geometry (sharp-edged or pointed) and strains on the musculoskeletal system due to the weight.

To prevent the workpiece geometry and weight from being a hazard, pay attention to the following:

- Wearing protective gloves with adequate cut protection is advisable when workpieces of sharp or pointed geometry are handled.
- The key indicator method of the BAuA (German Federal Institute for Occupational Safety and Health) for the assessment of lifting, holding and carrying provides useful guidelines for avoiding excess strain upon the musculoskeletal system.
  ▶ https://www.baua.de Search: LMM

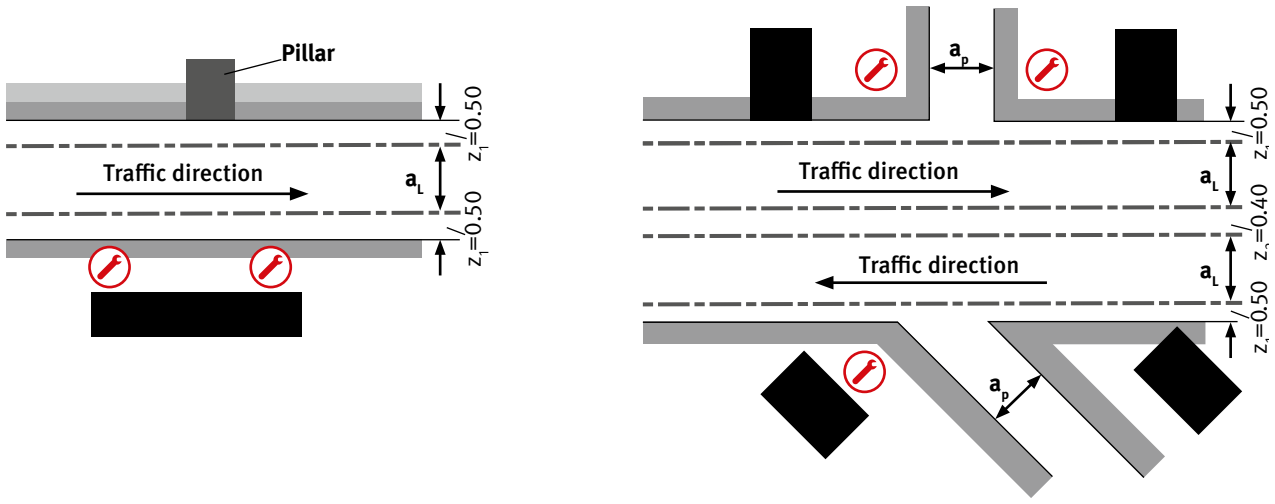
Transport by manual pallet truck or pedestrian-operated industrial truck

Special training as required for operating a forklift truck with driver's seat is not required for operation of this equipment. Thorough briefing and instruction is however required. Note the following in particular:

- When operating pallet trucks, ensure that the load is placed as low as possible, with approx. 5 to 10 cm between the lower edge of the load and the floor.
- Stacked loads tip easily.
- On gradients (such as ramps), the weight must be braked by hand.
- The key indicator method of the BAuA (German Federal Institute for Occupational Safety and Health) for the assessment of pushing and pulling provides useful guidelines for avoiding excess strain upon the musculoskeletal system.
  ▶ https://www.baua.de Search: LMM

Width of circulation routes

The width of the traffic routes is dictated primarily by the width of vehicles and the average number of persons using the routes (see Table 2 on the following page).



a_L Width of traffic vehicle
a_p Footpath width
z_1 Additional edge width
z_2 Additional width between lanes
Workplace
Machine

Figure 9 Width of even traffic routes

Table 2 Width of traffic routes

Type of traffic route	Conditions	Minimum width in m	Remarks
Footpath	Main route	1.25	Dependent upon the number of users
Footpath	Secondary route	0.75	
Roadway for vehicles	One-way: speed < 20 km/h	Vehicle or load width + 1.0 m	The greater of the two widths is decisive; at higher speeds the additional component must be increased.
Roadway for vehicles	Two-way: speed < 20 km/h	Double the vehicle/load width + 1.4 m	The greater of the two widths is decisive; at higher speeds the additional component must be increased.
Combined footpath and roadway	Not permissible close to gates.	Width as for the corresponding roadway + 0.5 m	Safeguard crossings and stairway exits particularly well.

3.1.8 Industrial trucks

Large material flows are a characteristic feature of heat treatment shops. Forklift trucks are most commonly used for this purpose. Heavy hardening material, large material volumes and space constraints that are often tight contribute to the hazard arising during material handling.

Statutory references

- BetrSichV, German Ordinance on industrial Safety and Health
- DGUV Regulations 68 and 69 concerning industrial trucks
  - Section 7 concerning tasking with the operation of industrial trucks
  - Section 37 concerning periodic inspections
  - Section 38 concerning the scope of testing
- ASR A1.8 concerning traffic routes
- TRBS 1201 Technical rules for industrial safety and health, Annex 1 Table 2 concerning established test intervals for periodic tests
- TRBS 2111 Technical rules for industrial safety and health concerning mechanical hazards – general requirements, Points 5.3.1 and 5.3.2
- TRGS 554 Technical rules concerning diesel engine emissions

Further information

- DGUV Information 208-004 concerning fork-lift trucks
- DGUV Grundsatz 308-001 concerning training and assignment of drivers of industrial trucks with driver's seat and driver's cab
- BGHW-SP02 concerning battery charging systems for industrial trucks
- BGHW-SP07 concerning the use of industrial trucks on public roads

Hazards

The following hazards occur during transport with forklift trucks:

- Overloading of the forklift truck
- Crushing and shearing points on the mast
- Collision with persons or objects
- Loads falling onto the drivers and onto persons standing within or adjacent to the radius of action
- Tipping of the forklift truck to the side
- Dismounting from the forklift truck
- Inadequate visibility and constrained traffic routes due to workpieces and material being placed outside storage areas

Figure 10 Restricted visibility during forward travel

Measures

In order to prevent or reduce accidents from occurring during the transport of workpieces and material by forklift truck, take the following measures/observe the following provisions:

- Observe the widths of traffic routes in accordance with ASR A1.8 (refer also to the information box concerning the width of traffic routes in 3.1.5).
- Ensure that training has been provided and proof of competence is available (e.g. training in accordance with DGUV Grundsatz 308-001).
- The forklift truck driver must be assigned in writing to the work.
- The forklift truck driver must be at least 18 years of age (except during training).
- Forklift truck drivers must be suitable for the task concerned. For further details, refer to Chapter 3.1.5, Competence, qualification, preventive medical care, aptitude.
- Briefing on use of the forklift truck
- The capacity stated on the forklift truck's load capacity plate must be observed.
- Use of the restraint system (such as full cab, safety bar systems, lap belt).
- Instruction on correct dismounting (three-point contact).
- The forklift truck must be inspected regularly by a competent person.
- The operator must carry out a daily visual and functional inspection of the forklift truck before using it.
- The forklift truck must be used only for its intended purpose in accordance with the manufacturer's instruction handbook.

The following additional measures have proved effective in practice:

- Use of safety bar systems or a cab door rather than lap belts
- Visual driving path warning system
- Safely reduced speed in areas with increased mixed traffic (foot traffic and forklift trucks)
- Wearing of easily visible clothing (such as a high-visibility vest) in areas with increased mixed traffic (foot traffic and forklift trucks)

Use of diesel-engined forklift trucks in shops:
Soot particles are considered a cause of lung cancer. For this reason, the use of diesel-engined industrial trucks in completely or partially enclosed rooms or shops is considerably restricted under the German Ordinance on hazardous substances (GefStoffV) and the TRGS 554 Technical rules concerning hazardous substances (diesel engine emissions) when the same task can be performed by emission-free drive technologies capable of providing the required engine power or load capacity.

One restriction is that diesel-powered industrial trucks used inside buildings must be equipped with a soot filter. Outdoor use is not subject to restrictions.

Use on public roads
Where forklift trucks are used occasionally on public roads, the following additional measures are required:

- Driving licence in accordance with the German Road traffic act (StVG)
- Type approval certificate of the forklift truck in accordance with the German Vehicle registration ordinance (StVZO)
- Marking with the address of the keeper or an official registration plate, depending on the vehicle type
- Ancillary equipment of the forklift truck in accordance with the information sheet for forklift trucks issued by the German Federal Ministry of Transport

3.1.9 Cranes

Transporting loads can be difficult and arduous. Cranes facilitate this work, since they multiply the human force and are thus able to lift loads without difficulty, and also move them in one or more directions. Cranes are used in heat treatment plants for routine handling of workpieces and material, and also for maintenance and for charging furnaces and quenching baths.

Statutory references

- DGUV Regulations 52 and 53 concerning cranes
- DGUV Regulations 54 and 55 concerning winches, hoists and pulling equipment

Figure 11 Red-hot charge on the crane (before quenching)

Further information

- DGUV Information 209-012 concerning crane drivers
- DGUV Information 209-013 concerning slingers
- DGUV Grundsatz 309-001 concerning the testing of cranes
- DGUV Grundsatz 309-003 concerning the selection, instruction and proof of competence of crane operators
- ISO 4309, Cranes – Wire ropes – Care and maintenance, inspection and discard
- DIN 15400 – DIN 15406, Lifting hooks

Hazards

A wide variety of crane types exist, including trolley cranes, jib cranes, slewing cranes, bridge cranes, gantry cranes, walking cranes, tower cranes, mobile cranes, floating cranes and cable cranes.

Where cranes are used to transport loads, a range of hazards to the life and health of persons, to property and to the environment may arise. These include:

- Load drop caused by component failure
- Collision with or crushing of persons by the load caused by travel movements
- Tipping over, load disengagement and drop
- Vibration caused by uneven craneways and by transport processes such as lifting and depositing of loads

Such hazards exist not only for those working directly with the crane, such as crane operators and slingers, but also for persons employed or present in the operating range of cranes.

Measures

Measures relating to the crane:

- Observance of the load-bearing capacity, hoisting height, outreach, etc. during selection of the crane
- Regular and timely inspections of cranes, lifting gear, load handling attachments and slings; for provisions governing inspection requirements, refer to DGUV Regulations 52 and 53, the German Ordinance on industrial safety and health (BetrSichV) and the instruction handbook. For checklists for crane inspection, see DGUV Grundsatz 309-001; for discard criteria for ropes, see ISO 4309; for discard criteria for hooks, see DIN 15400 – DIN 15406
- Compliance with the maintenance intervals in accordance with the instruction handbook
- Immediate performance or instigation of corrective maintenance and elimination of defects
- Daily operational safety check of the crane including craneway (start of work, shift change, end of work)

Measures to be taken when cranes are used on open oil baths:

- Use of the crane as intended
- Prevention of unauthorized access to/use of cranes
- Tasking of suitable, trained (instructed) persons with operation of the crane
- Instruction of the employees
- Presence of persons on or beneath suspended/ swinging loads is prohibited.

Measures for transport routes:

- Transport routes must be kept clear.
- A clear view must be maintained (particularly near doors, gates, passages, crossings).
- Design of transport routes: as far as possible without overlap, separated from foot traffic, or with dedicated lanes for each direction.
- Marking of transport routes.
- Sufficient lighting.

Measures to be taken when cranes are used on open oil baths:

- The descent rate of the crane must be at least 20 cm/s.
- Should the drive power fail, it must still be possible to lower the load fully into the quenching bath (e.g. by emergency lowering device, emergency power supply).
- Operation of the crane without risk must still be possible when the surface of the bath is on fire (e.g. by means of a remote control, heat shield).
- The crane must be protected against flames, for example by nitrogen flooding of the bath surface.
- Slings must be suitable for the thermal load.
- Equipment for positioning the crane quickly and accurately over the quenching bath has proved effective.

3.1.10 Servicing and maintenance

Approximately one-fifth of fatal occupational accidents occur during maintenance work. The reasons are manifold. The most common accident scenario is the falling of persons from plants or ladders, and entrapment, crushing or collisions by/with parts of plants. The causes are primarily to be found in incorrect organization or behaviour.

Statutory references

- BetrSichV, German Ordinance on industrial Safety and Health, Section 10 concerning maintenance and modification of work equipment
- TRGS 521 Technical rules concerning demolition, renovation and maintenance work involving end-of-life mineral wool
- TRGS 558 Technical rules concerning tasks involving high-temperature wool
- DGUV Regel 113-004, vessels, silos and confined spaces, Part 1: Work in vessels, silos and confined spaces
- DGUV Regel 112-190 concerning the use of breathing apparatus

Figure 12 Furnace chamber in a pusher type furnace

Hazards

Numerous different hazards occur during maintenance and servicing work. The most significant hazards are:

- Falls from plant and ladders
- Crushing, entrapment or collision by/with moving parts
- Crushing, entrapment or collision caused by unexpected start-up
- Electric shock
- Poisoning (in some cases with several years' latency), chemical burns, burns caused by escaping media
- Inadvertent disabling (possibly partial) of the plant's safety concept during maintenance, repairs or conversion work owing to insufficient knowledge of the safeguards

Measures

Should work equipment and plant no longer be in a safe condition, you are obliged as the employer to instigate repair measures immediately. The use of unsafe work equipment and plant is not permitted.

You must also base maintenance measures on the results of a risk assessment and observe the information provided by the manufacturer in the instruction handbook.

Maintenance, repairs and conversions may be performed only by persons in possession of the necessary expertise and capable of assessing the effect of their activities on the safe condition of the plant. This also applies to the selection of service providers. Where you task your own personnel with the work, you must ensure that they are suitably qualified.

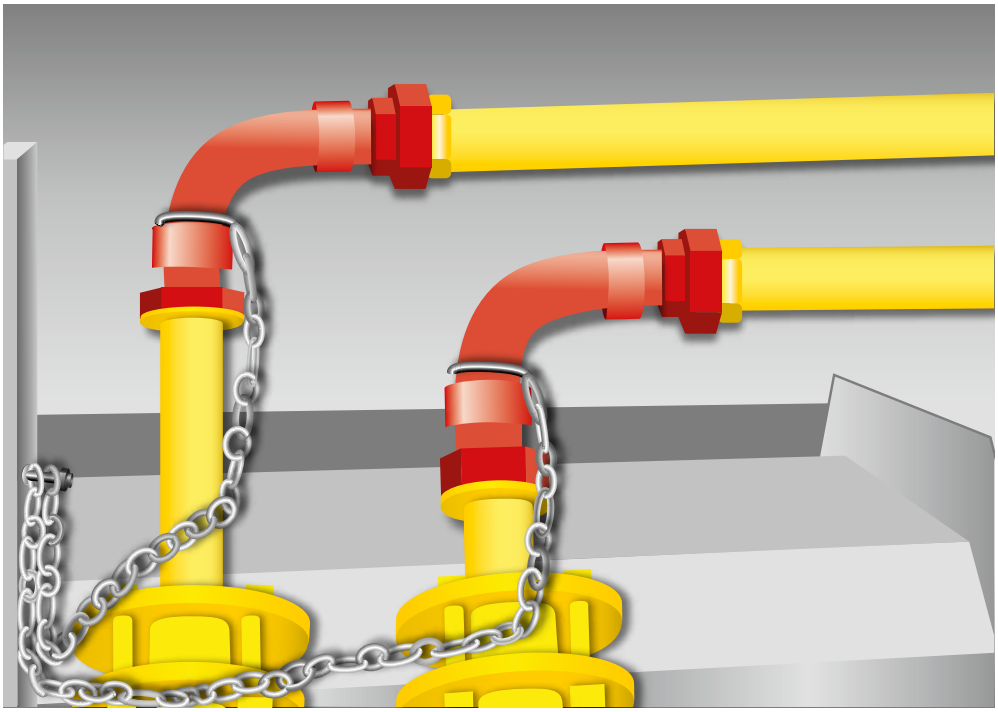


Figure 13
Removable spool pieces for isolation of the gas supply

The following elements are important for the safe performance of maintenance measures:

- It must be set out clearly who is responsible for which safety measure.
- Clear communication between operating and maintenance personnel is required, for example by means of a defined handover procedure.
- Should operation and maintenance be performed simultaneously or several companies work on the plant at the same time, these activities must be coordinated. Where the activities give rise to a mutual hazard, managerial authority must be granted to the coordinating personnel.
- The work area must be safeguarded during the performance of maintenance work; if necessary, access by unauthorized persons must be prevented.
- Safe access must be provided to the maintenance points, particularly during working on installations.
- Raised components/work equipment must be secured or lowered.
- Hazardous stored energy (such as compressed air, spring force) must be released or safeguarded and marked.
- Hazardous media must be removed and safely isolated (e.g. removable spool pieces on gas lines).
  Even when escaping gases are non-toxic and non-flammable, such as nitrogen, they may displace oxygen very quickly in small rooms, leading to danger of suffocation.
- Hazardous forms of energy (such as electricity) must be safely isolated.
- Safe working procedures must be laid down.
- Where the maintenance operations give rise to particular hazards, corresponding warnings and information must be posted.
- Access clearance arrangements must be put in place for certain work (accessing of vessels, confined spaces, furnace chambers).
- During servicing work, stoppages (scheduled or unscheduled) or certain forms of inspection work (pits, on the furnace plant, etc.), the carrying of mobile gas warning devices is recommended. Ensure that the gas warning devices are inspected visually by an instructed person before each working shift.
- A function check must be carried out by qualified personnel and documented every 6 months, a system check by a competent person once a year.

- Before work is begun in places to which access is difficult, the rescue arrangements must be clarified. Where special rescue equipment is required, it must be readily accessible in the vicinity of the work.
- Instruction must be provided on the function of extinguishing systems and extinguishing agents and the hazards presented by them.

Where technical safeguards must be disabled to permit maintenance work or hazardous energy cannot be isolated, you must take other measures to ensure the safety of your employees. It is however imperative that the technical safeguards be put back into operation after the maintenance work. Proper functioning of the technical safeguards must be checked. One problem is that technical safeguards that have been disabled are often not needed for normal operation; should they fail to function properly, this therefore goes unnoticed.

Handover of the furnace plant

Proven good practice is for the instantaneous condition of the plant to be documented in a handover protocol at handover by the operating to the maintenance personnel. Issues such as the following are thus clear and comprehensible even should the persons involved no longer be on the site:

- *Was the plant completely purged of gas?*
- *Is the gas supply shut off and isolated; are energy and media switched off and depressurized?*
- *Is the whole plant once again serviceable, or are certain functions/items of equipment not available?*

Figure 14 Work in a furnace plant

Accessing a furnace plant

A clearance system (access permit) must be employed for authorization of access to a furnace plant. The clearance system sets out what measures are to be carried out before a furnace plant is accessed. The specific measures to be taken depend upon several aspects, such as the design of the plant, the process and the tasks to be performed, and must be determined in advance as part of a risk assessment. Measures typically taken are:

- *Securing/supporting raised doors, elevators*
- *Reliably isolating the electric power*
- *Reliably isolating the process gas supplies (such as endothermic gas, nitrogen, methanol, ammonia, hydrogen) by removal of the removable spool pieces or insertion of blind flanges*
- *Flushing process gases from the furnace chambers*
- *Performing measurements of the furnace chambers for access clearance purposes (critical areas: outgassing of CO from oil baths, poorly flushed zones caused by flow issues)*
- *Carrying portable gas warning devices during access*
- *Determining rescue measures*
- *Briefing the safety persons and all persons involved*
- *Reviewing the safety measures*
- *Determining from what point in time access is permissible*
- *Determining from what point in time access is no longer permissible because the safety measures have been cancelled again*

Handling man-made mineral fibres

Man-made mineral fibres may be released in the course of servicing and maintenance work on furnace plants. The material from which wool used in the furnace is made must therefore be determined before the work is started. Aluminium silicate (ASW), polycrystalline (PCW) and alkaline earth silicate (AES) wools are now commonly used in furnace construction. The TRGS 558 Technical rules concerning tasks involving high-temperature wool set out measures that must be applied for activities involving aluminium silicate wool. Where PCW wools are installed, application of the measures is recommended. Where AES wools are installed, the general safety measures of the German Hazardous substances ordinance (GefStoffV) must be applied.

Measures in accordance with TRGS 558 include:

At fibre concentrations of up to 10,000 fibres per m³ (exposure category 1) (operating and monitoring tasks on industrial furnaces):

- *Low-dust work methods*
- *Use of a class M dust collector for cleaning work*
- *PPE: protective gloves (leather, nitrile) and a particle-filtering FFP2 half mask or half mask with P2 filter should be made available.*

At fibre concentrations between 10,000 and 100,000 fibres per m³ (exposure category 2):

- *Implement all measures in accordance with exposure category 1.*
- *Technical measures in accordance with Annex 1 of the TRGS technical rules for the activity concerned*
- *Fibre dust should be collected as completely as possible.*
- *Workplaces should be isolated, clothing cleaned, separate lockers used.*
- *Respiratory protection (FFP2/P2) must be used during exposure peaks; at other times, respiratory protection must be made available to the workers.*

At fibre concentrations exceeding 100,000 fibres per m³ (exposure category 3):

- *Implement all measures in accordance with exposure category 1 and 2.*
- *FFP3/P3 respiratory protection must be worn (powered respiratory protection is recommended). The limits on the wear duration set out in DGUV Regel 112-190 concerning the use of respiratory protective devices must be observed.*
- *Wear breathable protective overalls (preferably type 5 disposable protective overalls).*

3.1.11 Inspection on heat treatment plants

Safe plants are an important element in occupational safety. Responsibility for the safety of plants lies in the first instance with their manufacturers. Your task as the plant operator is to keep the plant in a safe condition over its entire mission time.

Statutory references

- BetrSichV, German Ordinance on industrial Safety and Health, Section 14 concerning testing of work equipment
- TRBS 1111 Technical rules for industrial safety and health concerning risk assessment
- TRBS 1201 Technical rules for industrial safety and health concerning the testing of work equipment and installations requiring regular inspection
- TRBS 1203 Technical rules for industrial safety and health concerning competent persons

Hazards

Safeguards often go unnoticed during normal and trouble-free operation. A defect in a safeguard is therefore not normally apparent. At the same time, safeguards are relied upon to function and prevent any danger to operating personnel when a demand is made upon them.

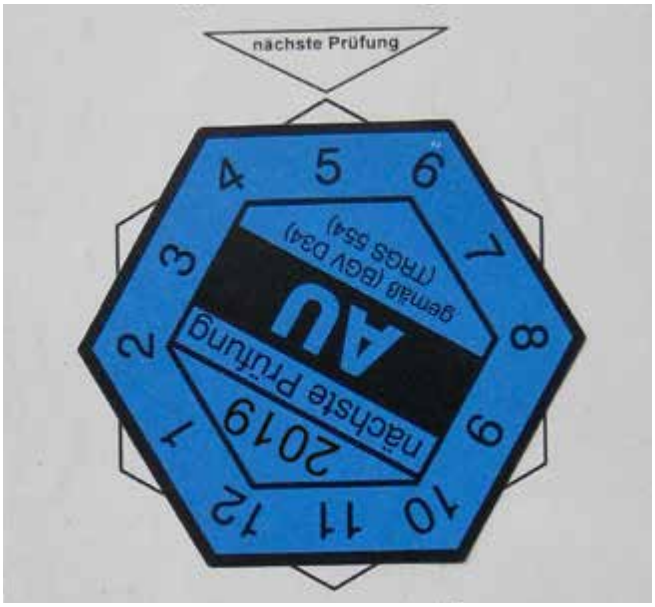


Figure 15 Inspection sticker showing the date of the next inspection

Measures

Whether safeguards are intact can be determined only by inspections. Inspections differ in their interval, the scope of the inspection and the competence of the inspector.

An inspection may be prompted by:
- Expiry of the inspection interval
- An incident, such as malfunction, damage or repair

Simpler inspections can often be carried out by the personnel operating the plant. These inspections are minor in their scope (e.g. visual inspection), have short intervals (once each shift, daily, weekly) and entail little effort (reading off of parameters such as pressure, flow rate, etc.).

More detailed inspections are often carried out as part of annual servicing or during repairs. In this case, disassembly, comparative measurements, functional checks, etc. are carried out in order for information to be obtained with which the instantaneous condition of the safeguard can be assessed and a prognosis made of its serviceability through to the next inspection. The performance of such inspections requires sound technical knowledge and the regular performance of inspection tasks by which, for example, the level of wear and wear reserves can be assessed. The German Ordinance on industrial safety and health (BetrSichV) describes a person competent to carry out an inspection in this context. Should your employees not possess sufficient knowledge, it is more appropriate to have these inspections performed by external service providers.

You must determine what inspections are to be carried out on your plant and work equipment and at what intervals as part of the risk assessment performed in accordance with the BetrSichV. The manufacturer's instruction handbook serves as a good source of orientation.

Instruction handbooks for older furnace plants may not contain information on inspections, or may not even be available. The inspections required for plant safety are

Figure 16 Leak detection by means of a leak detection spray

determined by the plant's safety concept. Inspections must be performed both of any individual component required for functioning of the safety concept, and of the safety system as a whole. The support of third parties (e.g. furnace plant manufacturers) may be advantageous for determining the scope of inspection.

The inspection must be documented and the documentation retained at least until the next inspection is performed. The documentation must include the date, type, scope and result of the inspection. The inspections may also be documented in electronic form.

The following points should also be documented:
- The codes in accordance with which inspection was performed
- The individual inspection points with the respective results
- Evaluation of detected faults and conclusions with respect to continued operation
- The identity of the inspector
- Correction of the detected faults

For assessment of the condition of the plant as-is and predictions of how this will develop, the results and conclusions of previous inspections are useful, as well as those of the most recent inspection.

Useful advice on performing inspections of furnace plants in practice:
- Gather the documents that will ensure a systematic inspection of the plant, such as checklists, tables and manufacturers' information.
- Leaks from systems transporting gas (pipelines and fittings)
  Leak tests must be performed at test pressure and at least at the nominal operating pressure. The leak test comprises two tests:
  – Outward leakage
    Outward leakage usually occurs at unions and on fittings (valves, instrumentation). Leaks can be detected with the use of gas meters and leak detection spray. The use of leak detection spray containing sulfur dioxide (SO_2) has proved effective for detecting ammonia leaks.
  – Internal leakage/leakage from shut-off devices
    The purpose of this test is to determine whether shut-off devices (valves) are leak-tight when closed. The test involves trapping gas under pressure between two closed shut-off devices and observing the drop in pressure.
- Pressure gauges
  Since pressure gauges tend to drift continuously, they must be adjusted.

3.2 Hazards associated with heat treatment in industrial furnaces employing air or process gas atmospheres; corresponding measures

3.2.1 Workrooms and work areas

The media and equipment used also have an impact on work premises and workplaces. Heat treatment plants may pose specific requirements upon the equipment of their workplaces. Ventilation and extraction systems are often required.

Figure 17 Extraction at a multi-purpose chamber furnace

§ Statutory references

- ArbStättV, German Ordinance on Workplaces, Section 3 and Annex 3.6 Ventilation
- GefStoffV, German Ordinance on hazardous Substances, Section 6 concerning the obtaining of information and risk assessment
- GefStoffV, German Ordinance on hazardous Substances, Section 7 concerning basic obligations
- DGUV Regulation 1, Principles of Prevention Section 9 concerning prohibition of access
- ASR A3.5 concerning room temperature
- ASR A3.6 concerning ventilation
- TRGS 401 Technical rules concerning hazards presented by skin contact
- TRGS 402 Technical rules concerning determination and assessment of the hazards presented by activities involving hazardous substances: inhalative exposure
- DGUV Regel 109-002 concerning workplace ventilation

i Further information

- DGUV Information 209-073 concerning workplace ventilation and assistance with decision-making in industry
- AWT safety recommendations for the operation of industrial furnaces employing process gas atmospheres
  ▸ https://www.awt-online.org > fachausschuesse > Fachausschuss 8 Sicherheit in Wärmebehandlungsbetrieben
- T021, issued by the BG RCI, concerning gas detectors for toxic gases/vapours and oxygenI

Hazards

In heat treatment plants, the type of the plant, the process media used and the tasks to be performed give rise to the following aspects to which particular attention should be paid, over and above the general requirements for workplaces.

- Elevated thermal load, caused for example by residual heat from hardening material, flares, pilot flames, heat radiation from the plant, especially on older, poorly insulated plants
- Health hazards presented by occupational exposure limits not being continuously observed. The primary cause in this case are leaks from the furnace plant of process atmosphere containing acutely toxic gas components. Carbon monoxide (CO), which is present in many process atmospheres, is a particularly critical gas.
- Danger of falling when work is performed on the furnace plant

Measures

The following general measures have proved effective in heat treatment shops.

Shop ventilation system:
The shop ventilation system has the purpose of collecting leaks from the furnace plants that are not captured by the exhaust collection system, other atmospheric pollutants, and the thermal load from the heat treatment operation, and discharging them from the shop. Aspects relevant to the design of a shop ventilation system include the following:

- Maximum thermal input from the outside, for example due to solar radiation
- Emissions of thermal radiation from the plant
- Fluctuations due to seasonal influences (e.g. seasonal variation in weather, capacity utilization)

The exhausted air volume, for example at leakage points, must be balanced by a corresponding supply of fresh air. Ancillary rooms, such as break rooms and similar areas, must also be taken into account in a shop ventilation concept.

A major problem relating to the operation of shop ventilation systems is irregular maintenance of the systems or its complete absence. The performance of ventilation systems deteriorates considerably when they are not maintained regularly. Causes include soiled filters, clogged pipes and broken fan blades. Ensure therefore that your ventilation systems are regularly maintained.

Extraction at leakage points
(see also: Discharge of waste gases):
In order to reduce to a minimum the danger presented by acutely toxic gas components in leaking process atmospheres, ensure that gas from more major leakage points is exhausted as completely as possible. An extraction system is recommended at the following points:

- Above furnace doors
- Pilot flames on flares
- Above gas burners
- Furnace doors, especially when they are opened
- Pressure relief valves
- Intake and discharge points on conveyors and similar systems
- Flame curtains

Observance of the occupational exposure limits:
Determine whether the existing shop ventilation and extraction systems are adequate for compliance with the occupational exposure limits. This can be determined by workplace measurements. Workplace measurements can be taken by permanently installed measuring equipment or regular discrete measurements (for example by mobile instruments or portable gas warning devices). The instruments must be maintained, inspected and calibrated in accordance with the manufacturer's instructions.

Should compliance with the occupational exposure limit values not be possible, further measures are necessary, such as:

- Checking of existing equipment (shop ventilation and extraction systems)
- Searches for unknown leakage points
- Reduction of the leakage rate at the leakage points
- Improvement of the shop ventilation and extraction systems

Access to workplaces
Around a fifth of occupational accidents in plants are caused by falling, slipping and tripping hazards. The effects of these accidents should not be underestimated. Safe routes to the place of work are therefore of great importance. In heat treatment shops, access to workplaces on older plant, for example for maintenance work, is often unsafe.

Access points to workplaces:

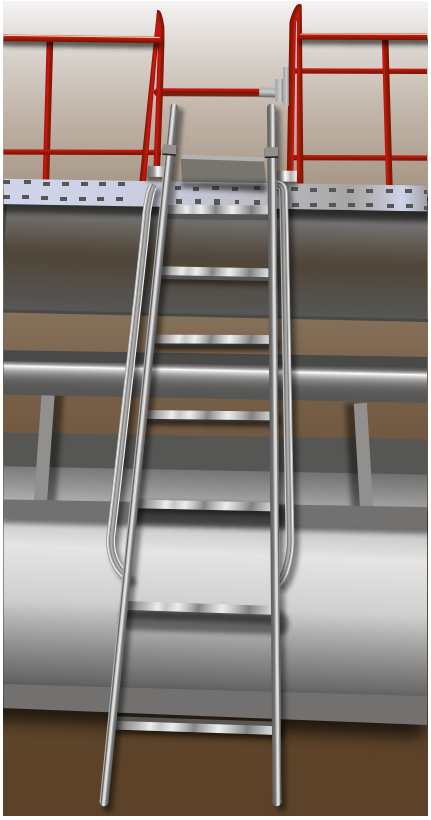


Figure 18
Retrofitted facility for access to a furnace roof

Figure 19 Stair for access to the furnace roof

Define traffic routes on the furnace plant and safeguard them, for example by means of fixed barriers to protect against falls. Should this not be possible, you must specify or create attachment points for PPE against falls from a height.

Carbon monoxide

Carbon monoxide is a colourless, odourless and flammable gas. Its toxic effect arises from its disruption of oxygen transport by the blood. Carbon monoxide's capacity to bind to red blood cells is approximately 300 times that of oxygen. As a result, many red blood cells form a bond with carbon monoxide molecules even at very low concentrations of carbon monoxide in the breathing air. This bond is very difficult to break. Symptoms of carbon monoxide poisoning are headaches, reddening of the skin, dizziness, impaired vision, unconsciousness and in the worst case respiratory arrest. The use of respiratory protection filters is not recommended, as penetration of the filter cannot be detected by the wearer.

Since the usual furnace atmospheres with a carbon monoxide component are lighter than air, the highest concentrations are found above furnace systems or close to the shop ceiling. Increased caution is required when accessing a furnace system, since the lining and the oil bath can store the furnace atmosphere.

Occupational exposure limit: 30 ppm
Explosion limits 12.5 – 74 % by volume (in air)

Further information on this hazardous substance can be found in the DGUV's GESTIS database of substances.

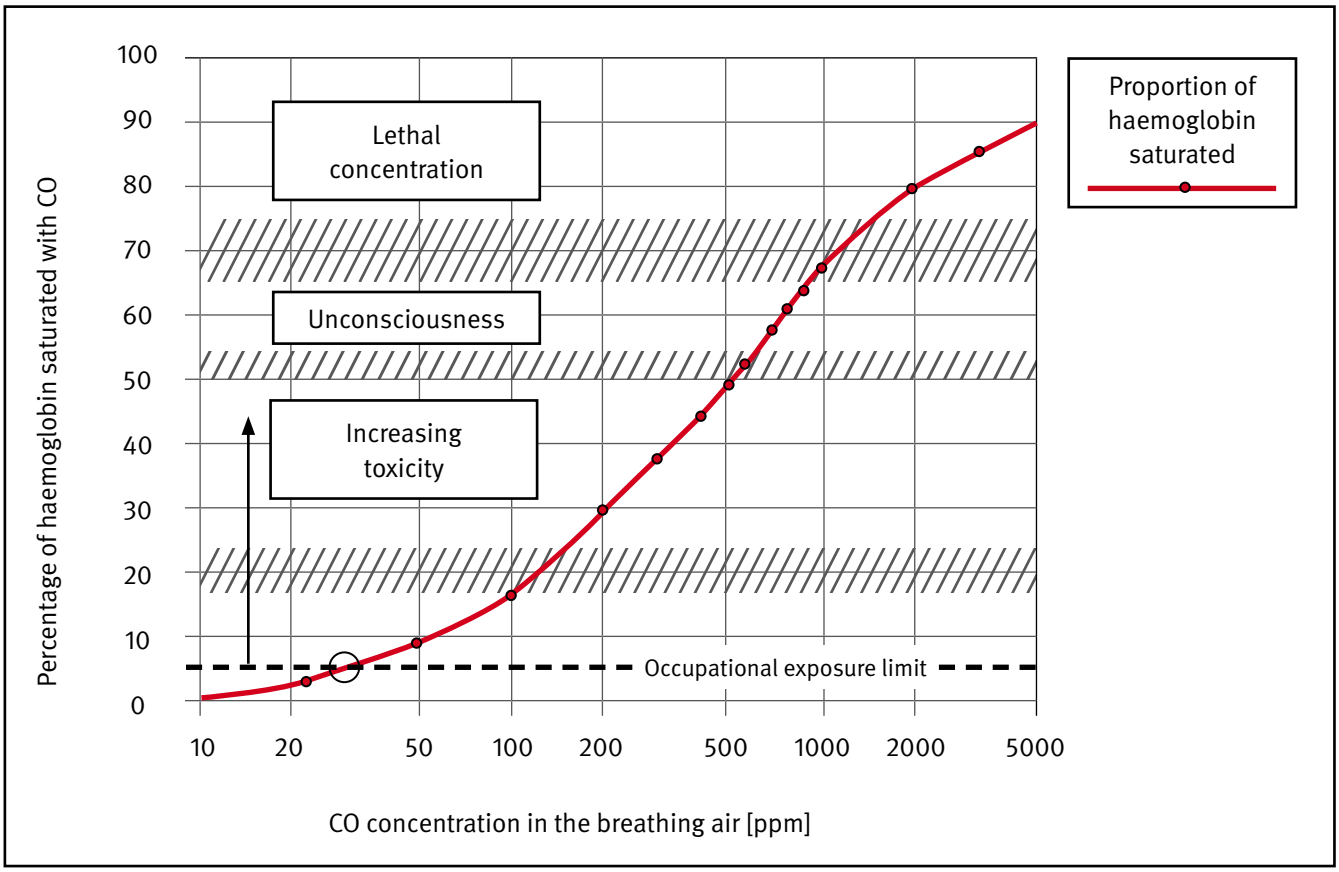


Figure 20 Effect of carbon monoxide

3.2.2 Supply of energy and media

Heat treatment cannot be performed without energy and media. Measures are required to ensure that the provision of energy and media does not give rise to a hazard.

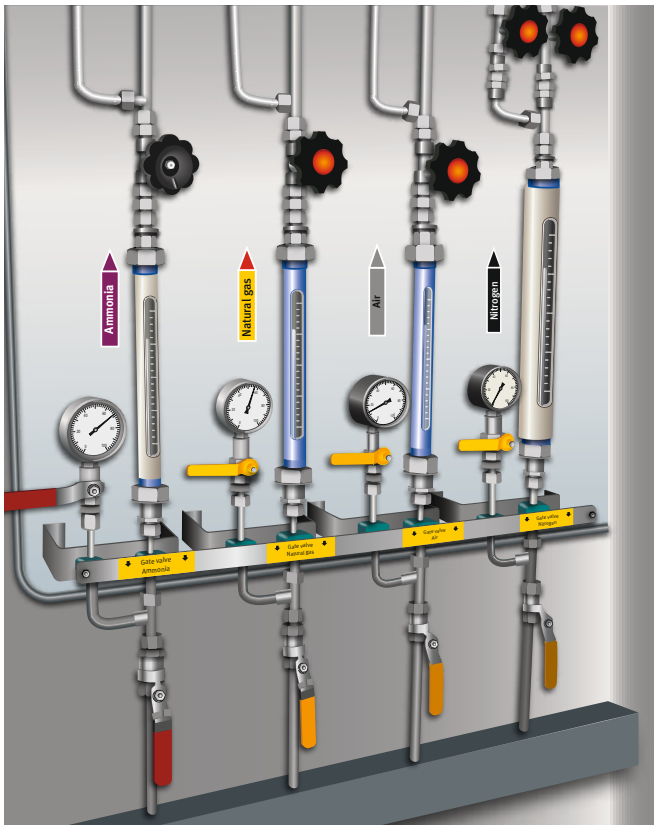


Figure 21 Marking of pipelines and fittings

Statutory references

Marking of pipelines and containers:

- ArbStättV, German Ordinance on Workplaces, Annex 1, 1.3 concerning safety and health signage
- ASR A1.3 concerning safety and health signage
- TRGS 201 Technical rules concerning classification and signage for activities involving hazardous substances

Hazards

Hazards presented by the supply of energy and media may arise in particular as a result of:

- Confusion of media lines due to inadequate marking, resulting in shut-off, isolation or opening of the wrong medium
- The location of the shut-off device is such that critical media (such as the natural gas supply) cannot be isolated without hazard in the event of an accident.
- Damage to media lines (for example due to collision with an industrial truck)
- In the event of an accident, important media are not available, as a result of which it is not possible to place the furnace plants in a safe operating state without risk.
- Formation of dangerous explosive atmospheres owing to leaks on shut-off devices in media lines
- Violation of the occupational exposure limit (OEL) owing to leaks from media lines

Measures

You must therefore implement the following measures for the energy and media supply:

- Mark pipelines and containers with the name of the substance and its hazardous substance symbol or pictogram. On pipelines, the direction of flow of the substance must also be marked. On shut-off or control devices, indication of the use or final appliance is also recommended. This reduces the likelihood of operating errors.
- Protect media lines against being damaged by external hazards, such as collisions with industrial trucks. This can be attained by routing away from traffic and transport routes. If this is not possible, media lines can also be protected by mechanical obstacles, such as collision guards. Also consider the issue of corrosion and, where media lines are routed outdoors, weather conditions.
- Provide facilities by means of which, in the event of a hazard incident (such as fire), critical media such as flammable gases or liquids can be isolated safely from the equipment.

- Conduct regular drills with your employees of how to respond in the event of substances being released from the storage facility, a fire breaking out or any other emergency occurring, and of how to escape to safety.
- Should nitrogen be required for safe operation of the furnace system (for example for purging), ensure that the required nitrogen supply is permanently available, including in the event of a power failure. This can be attained by the use of normally open solenoid valves in lines supplying nitrogen for safety purposes, and manual valves with safeguards to prevent incorrect operation. In addition, the minimum quantity of nitrogen required for safe shutdown (emergency purging) of all supplied appliances in combination must be available at all times. Level monitoring systems that automatically request and initiate supply have proved very effective.
- To avoid operator errors, marking of the normal display range on instruments and the normal operating position of valves is recommended.
- Filters should preferably be installed in gas and fluid supply lines in order to prevent mechanical contamination. This measure maintains the shut-off capacity of valves for longer and prevents it from gradually deteriorating. Where gases are heavily contaminated, the installation of parallel interchangeable filters may be necessary: these allow the filter media to be changed with the system running.
- Check what equipment is still required to function in the event of a power failure in order to prevent danger to persons in the production area. This equipment must be connected to an emergency power supply. Extraction and gas detection systems and the cooling water supply must often be connected to a standby power supply.
- Should an accident involving persons and hazardous substances (such as ammonia) occur, the fire service must also be alerted in order for the area to be safeguarded and cleared for access by the ambulance service.

To keep leakage in the pipeline system as low as possible, you must observe at least the following minimum measures:

- The materials and components used must be suitable for the pressure stage and temperature and for the medium.
- The components and connections used must be technically leakproof.
- Check the technical leakproofing after installation and at regular intervals. (Refer to Table 3 for the inspection intervals.) This is particularly important for components carrying acutely toxic or flammable gases.
  In addition to the outward leak-tightness of pipelines, the internal leak-tightness of shut-off devices (solenoid valves, gate valves, etc.) is also important for plant safety.

To ensure that safety equipment intended to prevent the release of gases and formation of dangerous explosive atmospheres functions reliably, you must ensure that it is maintained and checked.

Piping system – leak testing

	Reason	Source	Comment
Gas distribution up to the first shut-off valve in the system	6 years after completion; thereafter at shorter intervals as appropriate	DVGW rules for natural gas	
Removal/installation of elements (valves, pressure gauges, isolators, etc.)	On restoration to service		
Gas distribution in the furnace plant	Annually	Recommendation	Determined by the operator; local circumstances (stationary monitoring, air exchange, confined spaces) must be taken into account
Distribution of gas from gas generator (e.g. endothermic gas generator, ammonia evaporator) to furnace plant	Annually	Recommendation	Determined by the operator; local circumstances (stationary monitoring, air exchange, confined spaces) must be taken into account

Note:
The leak-tightness of pipelines can be tested only on lines under operating pressure (or higher pressures). Note therefore when testing that not all pipe sections are under pressure in every operating state. The tests must be performed by competent persons in accordance with the German Ordinance on industrial safety and health (BetrSichV).

Table 3 Leak-tightness of piping systems

3.2.3 Methanol tank

Methanol is used in heat treatment mainly for the production of process gases. In this process, methanol is injected into the furnace plants, either directly or following evaporation or cracking in separate plants. Methanol is usually stored in tanks located outside buildings.

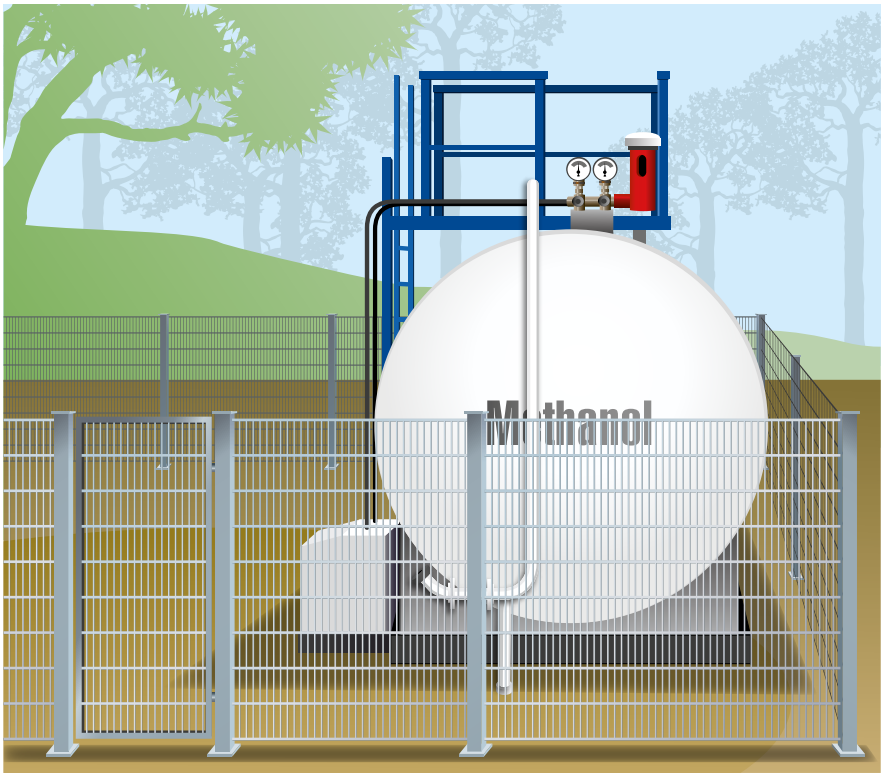


Figure 22
Methanol tank

Statutory references

- TRGS 407 Technical rules concerning activities involving gases – risk assessment
- TRGS 509 Technical rules concerning the storage of liquid and solid hazardous substances in stationary containers and filling and emptying points for transportable containers

Hazards

The following hazards in particular may arise during operation of a methanol tank:

- Leakage of methanol
  Leaks must be anticipated on the tank, the supply lines to the plants, and the pump set, and also during the refuelling process.
  Leaking methanol gives rise to the following hazards for employees and the environment:
  – Formation of a dangerous explosive atmosphere
  – Combustion of leaked methanol
  – Contamination of groundwater and soil
  – Poisoning of workers through inhalation and skin absorption when present in the area affected by the leak, and during maintenance work
- Bursting of the tank
- Accidents, such as damage to the tank caused by vehicles

Measures

For the safe erection and operation of a methanol tank, take at least the following measures:

Erection:

- Prior to erection and commissioning, contact an approved inspection body and the local authority regarding approval and operation of the plant.
- As a general rule, notification is mandatory in Germany by way of a simplified approval procedure in accordance with the 4th Ordinance governing implementation of the German federal pollution control act (14th BImSchV) where the total stored quantity exceeds 3,000 kg of combustible gas and liquid. Notification in the case of methanol is mandatory at 5,000 litres and over in some of the German regions and at 10,000 litres and over in others.
- A site inspection by an approved inspection body is required at commissioning.
- The base/foundation must guarantee stability and be made of non-combustible material.
- Lightning protection and potential equalization must be assured.
- Methanol tanks must be protected against fire loads, such as flammable substances (petrol, fats, oils), wooden sheds, wood stacks. This is usually achieved by a clearance of at least 5 metres or for example by a protecting wall.
- The filling line and safety valves must be at least 5 metres clear of shafts, ducts and windows.
- Adequate circulation of air around the methanol tank must be assured. The tank must be accessible for operation, service and maintenance. This is generally assured by a clearance of at least 1 m from buildings, walls etc.
- Collision protection for the tank and the pipes is required.
- Access by unauthorized persons must be prevented by fencing or an enclosure.
- The base of the discharge area must be protected against penetration by methanol. Facility must be provided on the discharge area for rainwater shafts to be closed off.
- The tank must be equipped with overfill protection.
- A dehydration filter must be fitted to prevent atmospheric humidity from arising in the plant.
- A detonation flame arrestor with venting to a safe area must be provided.
- Underground tanks and underground supply lines must be double-walled and monitored for leaks.
- Fire safety must be ensured by alarm and extinguishing equipment if necessary.
- Installation of a leak monitor in the pump cabinet is recommended.
- The following areas must normally be of explosion-proof design:
  - For above-ground methanol tanks, a zone of 5 metres around the tank
  - For underground methanol tanks, a zone of 0.5 metres around the manhole shaft and a zone of one metre around the vent opening

Operation:

- Organizational arrangements are required in order to ensure that only authorized persons have access to the installation.
- If necessary, rainwater shafts must be closed off during refuelling.
- During filling of the methanol tank, a nitrogen-inerted recovery line is used to displace the atmospheric oxygen in the filling line and tank system and to transport the methanol from the tanker vehicle into the storage tank; a vent line for excess pressure must be provided.
- Should skin contact with methanol be possible, gloves resistant to methanol must be worn (see separate methanol information box).
- The tank must be serviced annually.
- The system must be inspected every three years by an approved inspection body.
- Tanks must be inspected every 10 years (in accordance with the German Water resources act, WHG) by an inspection body or specialist company.

Marking of chemical protective gloves

A glove is deemed resistant to chemicals when a protection index of at least class 2 is achieved for three test chemicals (from the specified list of 12 chemicals).

Protection index table

Breakthrough time	Protection index
> 10 min	Class 1
> 30 min	Class 2
> 60 min	Class 3
> 120 min	Class 4
> 240 min	Class 5
> 480 min	Class 6

List of test chemicals

Code	Test chemical
A	Methanol
B	Acetone
C	Acetonitrile
D	Dichloromethane
E	Carbon disulfide
F	Toluene
G	Diethylamine
H	Tetrahydrofuran
I	Ethyl acetate
J	n-Heptane
K	Sodium hydroxide 40 %
L	Sulfuric acid 96 %

Example: **A F L**

- Methanol
- Toluene
- Sulfuric acid 96 %

In this example the glove has attained a protection index of at least class 2 for these 3 chemicals (A, F, L).

This pictogram indicates liquid-tight gloves which do not achieve the results described above in the test procedure..
These gloves are described **as low chemical resistant or waterproof gloves**.

Figure 23 Marking of chemical protective gloves

Methanol

Methanol is a colourless, highly flammable liquid with a pleasant to pungent odour. It is acutely toxic if swallowed or inhaled or in the event of skin contact. Complaints such as dizziness, headaches, nausea or impaired vision may arise only hours or days later.

Methanol has a high permeation ability; gloves of common materials such as latex, nitrile rubber or polyvinyl chloride are penetrated in less than an hour. The most suitable glove materials are butyl rubber, FKM and neoprene.

Occupational exposure limit:	*200 ppm*
Explosive range (vapours)	*6 – 50 % by volume (in air)*
Boiling temperature	*64.5°C*

Further information on the hazardous substance can be found at:

- *http://www.gischem.de*

3.2.4 Supply of ammonia

Ammonia is used in heat treatment processes primarily for the extraction of process gases. In nitriding processes for example, it serves as a source of atomic nitrogen. The ammonia used is usually stored in separate containers. The containers house the compressed gas tanks and the discharge equipment, including heating and gas monitoring.

Statutory references

- TRGS 407 Technical rules concerning activities involving gases – risk assessment
- TRGS 510 Technical rules concerning the storage of hazardous substances in transportable containers
- TRGS 746/TRBS 3146 Technical rules concerning stationary pressure systems for gases
- ADR, European Agreement concerning the International Carriage of Dangerous Goods by Road, 4.1

Figure 24 Ammonia tank

Hazards

The following hazards in particular may arise during operation of an ammonia supply system:

- The pressurized gas tanks contain liquid ammonia. The pressure is highly dependent on the temperature; excessive heating can be caused for example by direct sunlight or fire. This may lead to the permissible operating pressure being exceeded, resulting in gas escaping or the tank bursting.
- Where materials are used that are not resistant to ammonia, corrosion may result in the escape of gas.
- During maintenance work or exchange of the compressed gas tanks, the release of ammonia constitutes an elevated risk potential.

The following relevant properties give rise to hazards when ammonia is released:

Ammonia is:

- Acutely toxic when inhaled, and causes severe skin burns and serious eye damage.
- Classified as a flammable gas, and together with air is capable of forming an explosive mixture, especially in enclosed spaces.
- Classified as hazardous to water in German water hazard class 2.

Measures

The following measures are commonly taken for safe erection and operation of an ammonia supply system:

Erection:

- Contact the gas supplier whilst the plant is still at the planning stage. The supplier will advise you on selection of the storage system and on the technical requirements to be met and the necessary permits, as these may differ between the different German regions.
- Rooms in which an ammonia supply system is located must feature fire-retardant separation from adjacent rooms. Should the adjacent rooms be occupied permanently by persons, the form of separation must also be gas-tight and free of apertures. The rooms require adequate natural or forced ventilation.
- Owing to the flammability of ammonia gas, it must be determined whether rooms housing an ammonia supply system are to be classified as potentially explosive atmospheres. In the field, these rooms are often classified as zone 2 potentially explosive atmospheres.
- Erection of ammonia supply systems in break rooms or at permanently manned workplaces is prohibited.
- Pipes carrying ammonia should be welded and detachable unions kept to the minimum necessary.
- All packing materials used must be resistant to ammonia. Non-ferrous metals such as copper or its alloys are not suitable.
- Pressurized gas tanks and valves of approved types must be used.
- The safety concept must include a gas detection system for monitoring the ammonia supply system.
- An emergency stop facility for manual shutdown of the system must be provided outside the potential danger zone. The gas detection system must also be capable of shutting down the system automatically.
- Access by unauthorized persons must be prevented by fencing or an enclosure.
- Spill containment facilities must be designed in accordance with the provisions of the German Water resources act (WHG) and the German Ordinance on facilities for handling substances hazardous to water (AwSV)

Operation:

- Organizational arrangements are required in order to ensure that only authorized persons have access to the installation.
- As part of planning for a disaster scenario involving a large-scale ammonia leak, the means of coordination with emergency services must be determined, and the measures required in order for the surrounding area to be protected and informed (other buildings and the neighbourhood).
- Compressed gas tanks may be connected and disconnected only by employees who have been instructed in the task and specifically assigned to it.
- Exchanging of compressed gas tanks must always be performed by two persons (dual control principle).

Figure 25 Personal protective equipment for activities involving ammonia

Figure 26 Eyewash station

- Personal protective equipment must be worn during connection and disconnection of the compressed gas tanks (at least tightly fitting safety goggles and chemical protective gloves).
- Ensure that facility for a comprehensive eye wash is provided.
- Respiratory masks with a type K gas filter have proved effective for brief repairs of minor accidents (such as closing of valves). At high concentrations, under uncertain conditions or in confined spaces, only self-contained breathing apparatus may be used.
- The ammonia supply system must be maintained regularly in accordance with the manufacturer's instructions.
- The ammonia supply system must be inspected periodically in accordance with the provisions of the German Ordinance on industrial safety and health (BetrSichV) with regard to the risk of explosion and hazards posed by pressure.
- The compressed gas tanks must be inspected every five years (in accordance with the ADR 4.1).
- The requirements to be met at the site deriving from the regional water resources legislation must be observed.

Ammonia

Ammonia is a colourless, flammable and acutely toxic gas. It has a pungent odour and a strong caustic effect on the skin, mucous membranes and respiratory tract, even in strongly diluted form. It is extremely soluble in water and therefore acutely hazardous to water (German water hazard class 2). Owing to its very low odour threshold, it is detectable by smell significantly below the occupational exposure limit.

In the event of skin or eye contact, the affected parts of the body must be washed carefully under running water for at least 10 minutes. Contact with the eyes necessitates immediate further treatment by a specialist following the administration of first aid.

Occupational exposure limit:	*20 ppm*
Explosive range:	*15.4 – 33.6 by volume (in air)*
Boiling temperature	*–33.4 °C*

Further information on the hazardous substance can be found at: ▸ *http://www.gischem.de*

Table 4 Effect of ammonia

NH_3-concentration in ppm	Effect upon the unprotected human organism	Duration of exposure
< 5	Perception by odour	Unlimited
20	Occupational exposure limit Initial exposure gives rise to slight irritation	8-hour working day
At 100	Unpleasant, but no permanent health impairment	Leave the area as swiftly as possible
At 300	Not bearable, irritation of the eyes, nose and respiratory organs	Leave the area as swiftly as possible; no serious long-term injuries
≥ 1700	Asphyxiation, paralysis, acute risk to life	Leave the area immediately, lethal within minutes

3.2.5 Liquefied petroleum gas tank

Liquefied petroleum gas is used in heat treatment processes as a heating fuel gas and as a process gas with a high carbon content. Liquefied petroleum gas includes propane, propene, butane and mixtures containing these substances. It is heavier than air and highly flammable. Liquefied petroleum gas increases considerably in volume (by a factor of 260) when the gas vaporizes.The lower explosion limit is extremely low.

Owing to these properties, liquefied petroleum gas has a high hazard potential.

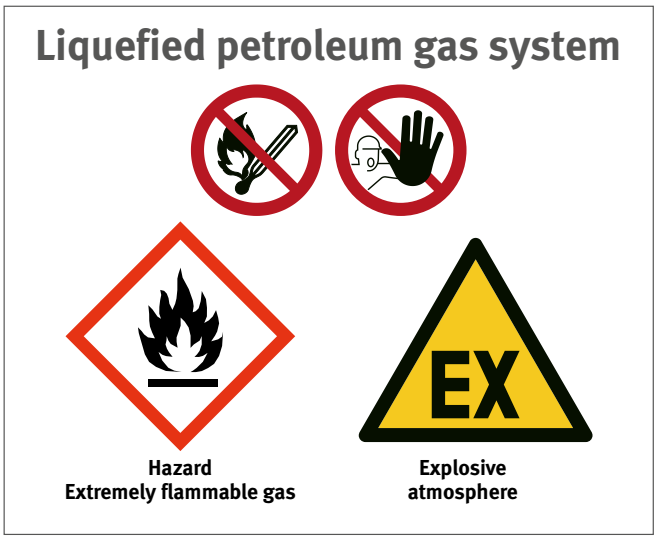


Figure 27 Marking of a liquefied petroleum gas system

Statutory references

- TRGS 407 Technical rules concerning tasks involving gases – Risk assessment
- TRGS 510 Technical rules concerning the storage of hazardous substances in transportable containers
- TRBS 3145/TRGS 745 Technical rules concerning transportable compressed gas tanks: filling, staging, in-plant transport, discharge
- TRBS 3146/TRGS 746 Technical rules concerning stationary pressure systems for gases
- DGUV Regel 113-001 concerning explosion protection rules (EX-RL)

Hazards

Operation of a liquefied petroleum gas tank and the associated distribution system may give rise in particular to the following hazards:

- Leakage and operational escape of liquefied petroleum gas
  Escape must be anticipated on the pressure vessel, on lines supplying the plants, and during the refuelling process.
  Escaping liquefied petroleum gas presents the following hazards for workers:
  – Formation of a dangerous explosive atmosphere
  – Combustion of escaping liquefied petroleum gas
  – Displacement of oxygen
  – Cooling by evaporation
  Note:
  Dispersal in shafts or sewers may result in the hazard arising some distance away from the leakage point.
- Tank burst
- Frostbite caused by contact between the skin and cryogenic liquefied petroleum gas or cryogenic plant components
- Accidents, such as damage to the tank caused by vehicles

Measures

To ensure that liquefied petroleum gas tanks are erected and operated safely, the TRBS 3146/TRGS 746 Technical rules concerning stationary pressure systems for gases must be observed. Measures commonly applied include:

Erection:

- Contact the gas supplier whilst the plant is still at the planning stage. He will advise you on selection of the storage system and on the technical requirements to be met, in particular in accordance with the TRBS 3146/ TRGS 746 technical rules, and on the necessary permits, as these may differ between the different German regions.
- The base/foundation must be stable and made of non-combustible material.

- Liquefied petroleum gas tanks must be protected against fire loads, such as flammable substances (petrol, fats, oils), wood sheds and wood stacks. This is usually achieved by a clearance of at least 5 metres or for example by a protecting wall.
- Air must be able to circulate adequately around the liquefied petroleum gas tank and the tank must be adequately accessible for operation, maintenance and servicing. This is generally assured by a distance of at least 1 m from buildings, walls etc. (50 cm in the case of tank walls without apertures).
- Filling lines and safety valves must be at least 5 metres clear of open ducts, shafts, openings to rooms at a lower level or air intake vents.
- Liquefied petroleum gas tanks and their lines must be protected against mechanical damage. Should the clearance not be sufficient, collision protection may be required, depending upon the situation on site.
- Access to the valves by unauthorized persons must be prevented. This can be achieved for example by means of fencing or an enclosure.
- The base of the discharge area must be protected against penetration by liquefied petroleum gas. Facility must be provided on the discharge area for rainwater shafts to be closed off.
- The tank must be equipped with overfill protection.
- Underground tanks must be protected against corrosion, for example by a particularly effective external coating of epoxy resin.
- Large discharge quantities and underground tanks may necessitate installation of an evaporator.
- Fire safety must be assured; this can be achieved for example by alarm and extinguishing equipment.

Areas at risk of explosion on/around the tanks must be identified as shown in Figures 29 and 30.

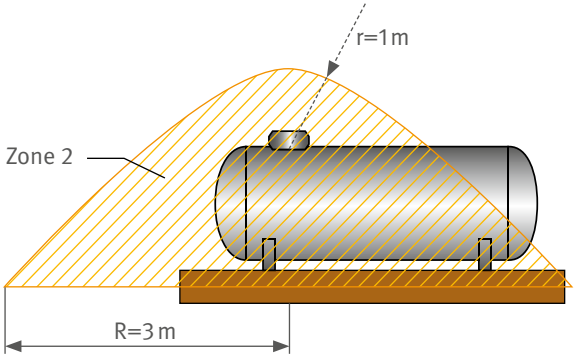


Figure 28 Dimensioning of the area at risk of explosion (zoning) for a liquefied petroleum gas tank installed above ground in the open air

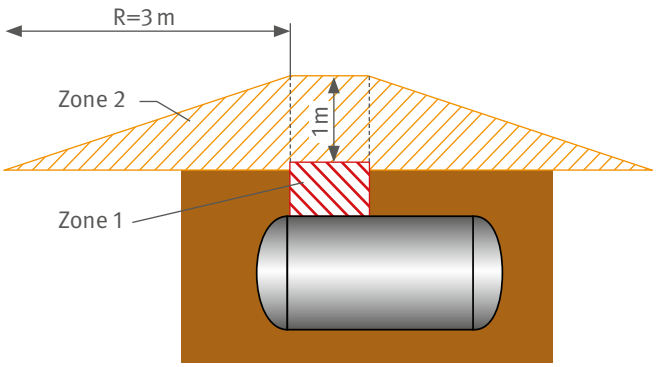


Figure 29 Dimensioning of the area at risk of explosion (zoning) for an underground liquefied petroleum gas tank

Operation:

- Organizational arrangements are required in order to ensure that only authorized persons have access to the installation.
- If necessary, rainwater shafts must be closed off during refuelling.
- The tank and all plant components requiring regular inspection must be inspected in accordance with the German Ordinance on industrial safety and health (BetrSichV), Annex 2. The remaining parts of the plant must be inspected in accordance with Annex 3, Section 2 of the BetrSichV, and maintained in accordance with the specific requirements of the plant. The scope of inspection and the persons responsible for carrying out the inspections prior to commissioning, together with the maximum intervals for periodic inspections, are determined in accordance with Section 4 of the BetrSichV by the size of the tank.

Propane

Propane is an odourless, colourless, highly flammable gas which is heavier than air. An odourant is added to it to enable gas leaks to be detected. The scale of the hazard cannot be inferred from the strength of the odour. The gas is usually stored in liquid form (tank, bottle). The lower explosion limit of propane is among the lowest.

Occupational exposure limit:	*1800 ppm*
Explosive range:	*1.7 – 10.8% by volume (in air)*
Ignition temperature	*470 °C*
Boiling point	*–42 °C*
Density with respect to air	*1.55*

3.2.6 Liquid nitrogen tank

Nitrogen is used in heat treatment processes in particular as a safety gas for purging processes, besides its use as a process gas. Where it is used as a safety gas, pertinent issues include the minimum quantity that must be kept available for safe operation, and whether a safety supply to the plants is still assured in the event of a power failure. Nitrogen is stored in liquid form in tanks outside buildings. The evaporator station is located directly adjacent to the tanks.

Figure 30 Nitrogen tanks with evaporators

§ Statutory references

- TRGS 407 Technical rules concerning activities involving gases – risk assessment
- TRBS 3146/TRGS 746 Technical rules concerning stationary pressure systems for gases

Hazards

The following hazards in particular may occur during operation of a nitrogen tank and the associated plant:

- Leakage of nitrogen
  Leakage must be anticipated both on the tank and the supply lines to the plants, and during refilling.
  Nitrogen leaks give rise to the following hazards for workers:
  – Risk of suffocation due to the displacement of breathing air
  – Cooling by evaporation
- Frostbite caused by skin contact with cryogenic nitrogen or cryogenic plant components
- Tank burst
- Accidents, such as damage to the tank caused by vehicles
- Insufficient supply of nitrogen and thus insufficient safety nitrogen for furnace operation

- Possible causes include:
  – Insufficient evaporator capacity
  – Manual valve shut off
  – Tank level too low
- Bursting of pipes and tanks owing to embrittlement of material caused by non-vaporized cryogenic nitrogen downstream of the evaporator

Measures

For the safe erection and operation of a nitrogen tank, take at least the following measures:

Erection:
- The base/foundation must guarantee stability and be made of non-combustible material.
- Lightning protection and potential equalization must be assured.
- Air must be able to circulate adequately around the nitrogen tank and the tank must be adequately accessible for operation, maintenance and servicing. This is generally assured by a clearance of at least 1 m from buildings, walls etc.
- Collision protection must be provided for the tank and the lines.
- Access by unauthorized persons must be prevented by fencing or an enclosure.
- The tank must be equipped with overfill protection.

Operation:
- Organizational arrangements are required in order to ensure that only authorized persons have access to the installation.
- Inspection must be performed annually by a competent person, and maintenance conducted every six years.
- The pressure vessel must be inspected every 10 years by a specialist company or an approved test body.
- Should nitrogen be required for safe operation of the furnace system (for example for purging), ensure that the required nitrogen supply is permanently available, including in the event of a power failure. This can be attained by the use of normally open solenoid valves in the supply lines carrying nitrogen for safety purposes and manual valves with safeguards to prevent incorrect operation. In addition, the minimum quantity of nitrogen required for safe shutdown (emergency purging) of all supplied appliances in combination must be available at all times. Level monitoring systems that automatically request and initiate supply have proved very effective.
- Elevated concentrations of oxygen may arise in the air in the immediate proximity of cryogenic plant components. This is associated with a significantly increased fire hazard.
- The formation of ice in the vicinity of liquid nitrogen tanks and associated evaporators can increase the risk of slipping. Gritting materials should ideally be kept available throughout the year.

Figure 31
Formation of ice on nitrogen tank pipelines

3.2.7 Storage and refilling of quenching oils

Should hardening oils be stored improperly or an accident occur on the oil bath, for example due to confusion of hardening oils or to operating errors, specific hazards and even fires may occur.
Quenching oils are liquids that are hazardous to water. They are normally assigned to German water hazard class 1, and in the case of emulsified quenching oils to water hazard class 2.

Figure 32 Hardening oil tank

Statutory references

- TRGS 509 Technical rules concerning the storage of liquid and solid hazardous substances in stationary containers and filling and emptying points for transportable containers
- TRGS 510 Technical rules concerning the storage of hazardous substances in transportable containers

Hazards

- Hardening oil released as a result of leaks or accident may give rise to the following hazards:
  - An increased fire load (particularly by contamination of combustible materials such as rags, wood, cardboard, packaging material)
  - A danger to water should it enter the sewerage system or seep into the soil
  - Slipping hazards
- An increased fire hazard caused by confusion of inadequately marked containers or drums (for example containing waste oil contaminated with water)
- Should hardening oil be stored outdoors without being covered by a roof, a risk exists of it being contaminated by water by “breathing” of the containers as a result of large differences in temperature (causing condensation) or the ingress of rainwater.

Measures

Coordination with the emergency services and measures for protection of the surrounding area must be set out as part of disaster planning for the quenching oils present.

- Drums must be stored on their sides in closed rooms, or at least under a roof.
- During transfer by pump, ensure that the equipment used (pump, hoses, etc.) is free of contaminants (such as water, fuels, etc.). Use of a transparent hose enables contamination of the oil being pumped to be detected easily by visual inspection (for example by cloudy, milky discolouration in the event of water contamination).
- Containers or drums used during filling of the oil bath must be clearly marked. Setting containers aside exclusively for use for the temporary storage of quenching oil, for example for repairs, has proved effective. This prevents product contamination/mixing.
- Allowance must be made for the expansion in volume of hardening oil by approx. 4 % (0.00075 %/°C) when it is heated to its operating temperature. The oil bath should not therefore be immediately filled with “cold” oil up to the set filling level.
- Although quenching oils are not classified as hazardous substances under the GefStoffV, they should nevertheless be stored in accordance with the requirements of the TRGS 510 Technical rules concerning the storage of hazardous substances in transportable containers and the TRGS 509 Technical rules concerning the storage of liquid and solid hazardous substances in stationary containers and filling and discharge points for transportable containers. Owing to their flash point of approximately 160 – 310 °C, quenching oils must be assigned to storage class 10 as flammable liquids.
- The local requirements of the German Water resources act (WHG) must be observed.

Figure 33 Oil foam formation on hardening oil contaminated with water (simulated in the laboratory)

3.2.8 Discharge of waste gases

Depending on the process engineering method used and the point of discharge, waste gases are contaminated with different hazardous substances (residues of carbon monoxide, residues of ammonia), oily vapours and pyrolysis products of organic materials occurring in the process. These waste gases must be reliably exhausted from the shop and if necessary purified.

Statutory references

- GefStoffV, German Ordinance on hazardous Substances, Section 7 concerning basic obligations
- Heat treatment and materials engineering group (AWT) Safety recommendations for the operation of industrial furnaces employing process gas atmospheres – Annex 1: Recommendations for the planning and implementation of extraction systems in hardening shops

Hazards

Waste gases are produced in plants wherever combustible materials are intentionally combusted, for example at flame curtains, pilot flames, burn-off on pressure-relief flaps, flares.

Should the waste gases not be discharged in a controlled manner, the following hazards may arise:

- The occupational exposure limit is not reliably observed and the requirement for hazard minimization as set out in the German Ordinance on hazardous substances is not met.
- Deposits of oily vapours present a fire hazard and an elevated fire load.
- The accumulation of unburned flammable gases can give rise to a risk of fire or explosion.

Measures

The discharge of waste gases forms part of the process engineering system and must therefore be integrated into the process. The exhaust system must be planned as part of the process engineering plant.

Where waste gases cannot be discharged through an exhaust line with natural draught, forced exhaust systems must be employed. In the interest of reliable and safe design of the forced exhaust systems, observe the following points:

- Key components such as fans and filters should be of redundant design (this permits maintenance and replacement without interrupting operation).
- Oily and damp waste gases should be discharged separately from “dry” waste gases.
- “Dry” waste gases should be purified by means of dust filters.
- Oily/humid waste gases should be purified by means of wet scrubbers (wet scrubbing generally eliminates any remaining fire hazard in the exhaust system).
- Up to the wet scrubber, extinguishing and cleaning equipment should be integrated into the forced exhaust tracts through which oily waste gases are discharged.
- Wall and ceiling entries must be of fireproof design.
- The control systems of the forced exhaust system and the furnace plant must be coupled. Should the forced exhaust system fail, the furnace plant must automatically assume a defined operating state with low waste gas volumes, or be shut off completely.
- Operation of the forced exhaust system must be guaranteed even in the event of a power failure. This is important in order to maintain discharge of the elevated quantities of hazardous substances from the furnace plant. The arrangement need not be uninterruptible.
- Extraction can be on demand according to the furnace processes; lower demands are placed for example upon extraction at a closed furnace door than that at an open furnace door.

Example of a fail-safe waste gas/waste air forced exhaust system of redundant design

Intended for moist exhaust air containing oil vapour/mist

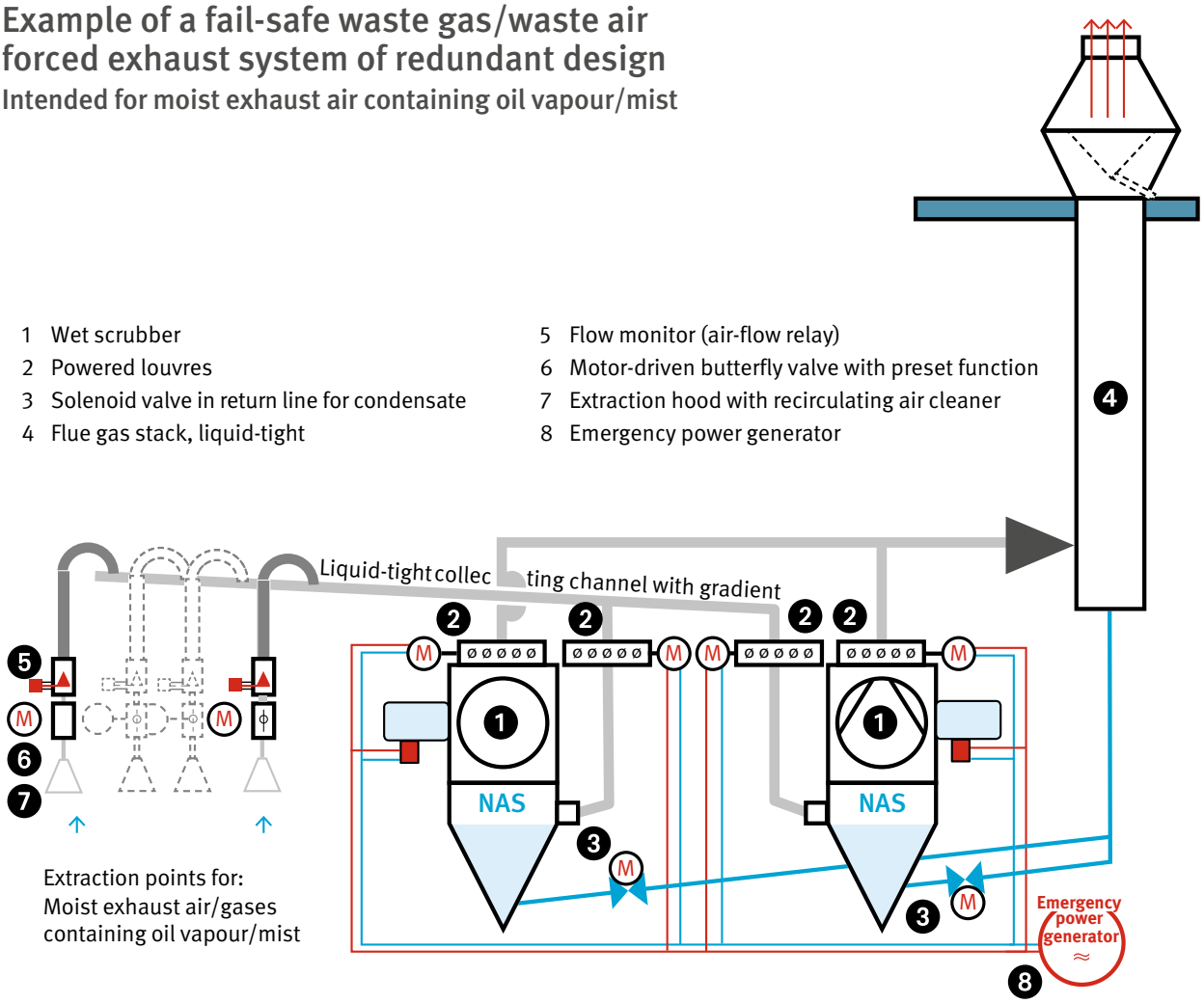


Figure 34 Diagram showing an example of a forced exhaust system

The performance of forced exhaust systems deteriorates considerably if they are not regularly maintained. Causes include fouled filters, clogged pipes and broken fan blades. Ensure therefore that your exhaust systems are checked and maintained regularly in accordance with the German Ordinance on hazardous substances (GefStoffV).

3.2.9 Operation of furnace plants

Modern furnace plants employ highly automated control systems; these do not however cover all eventualities. Take account of the following aspects in order to avoid hazards arising from the combination of the furnace system and the human factor.

Figure 35 Installation comprising tempering furnace, cleaning plant, two hardening furnaces, tempering furnace

Hazards

The following hazards may arise from the combination of the control system and the human factor:

- Where multiple plants are operated: confusion of the operating sequences or the functions of the controls, resulting in plant malfunctions presenting a hazard to persons.
- Incorrect operating procedures when the plants are operated in manual rather than automatic mode, resulting in plant malfunctions presenting a hazard to persons.
- Where plants are coupled within the same process but their control systems are coupled inadequately or not at all, a system does not respond automatically when an incident occurs on the system with which it is coupled. Further faults presenting a hazard to persons may occur.

Intervening in operation without at the same time interrupting automatic mode may result in safety equipment being defeated, particularly on fully automatic, fenced systems. Protection against automatic movements is then no longer assured.

Measures

To prevent the operation or automation of furnace plants from giving rise to hazards, take the following measures:

- Ensure that the safeguards present are used by the employees, are functional, and cannot easily be manipulated or defeated.
- In order to prevent employees who operate multiple furnace plants or carry out maintenance and servicing tasks on multiple plants from inadvertently performing incorrect operations, the operating procedures and control elements of furnace plants should, as far as possible, be of uniform design. This is particularly important with respect to safety equipment. Take this aspect into account when procuring new plants and converting legacy plants. The importance of this is particularly evident in the case of emergency stop controls. It is imperative that dangerous movements be stopped when the emergency stop buttons are pressed. On some installations however, gas supply and heating of the furnace plants are also interrupted.
  Where your installations employ different operating concepts, you must provide employees who operate multiple plants with regular instruction on the differences between them, particularly with regard to the safety elements.

Figure 36
Multi-purpose chamber furnace line comprising tempering furnace, cleaning plant and multi-purpose chamber furnace

- When faults occur on installations, they must often be operated in manual mode in order for the fault to be cleared. This requires sound knowledge of the process as a whole and of the function of the furnace plant. Determine which employee is authorized for this purpose for each furnace plant. Select only sufficiently qualified employees. Ensure during shift planning that qualified personnel are present at all times.
- In order for operating errors to be prevented, marking the normal state of displays and the normal position of controls has been shown to be good practice.
- Ensure that controls and workstations are not located in front of or in the immediate proximity of hazardous areas, such as automatically opening furnace doors.

Ensure in particular when designing fully automatic plants that routine operating interventions are possible without interruption of automatic operation. Where this is not possible on your plants, consult with the manufacturer or your accident insurance institution if necessary in order to determine what modifications are needed. Should technical modifications not be possible or be too complex, determine in consultation with your employees how the operating interventions should be performed. The defeating of safeguards is not permitted under any circumstances.

Emergency stop

Machines must be equipped with an emergency stop device. The emergency-stop device must act upon components of the machine from which an imminent danger may arise and which can be brought to a normal standstill more quickly by the emergency stop device. The imminent danger is usually caused by mechanical movements.

Emergency stop devices must be provided on each control station and at other locations at which initiation of an emergency stop may be necessary. An emergency stop must be reset manually on the emergency stop device which was actuated. It must not be possible for the machine to restart or be restarted before the emergency stop is reset. The emergency stop reset must not be coupled to the machine restart command; restarting of the machine must require a separate action by the operator.

Requirements for shifts with unmanned operation

Owing to their long process times, heat treatment plants are often run overnight or over the weekend. Personnel are often not required for normal operating procedures during these periods. Some plants are therefore operated unmanned in these shifts. Before unmanned operations are introduced, a safety concept must be drawn up based upon a comprehensive risk assessment. The safety concept must specify both technical and organizational measures to assure safety in compensation for the absence of operating personnel. The manufacturer of the plant can provide useful assistance in the development of a safety concept.

The aspects to be considered in the safety concept should include the following:

- *Detection of accidents or faults and measures to be taken*
- *Extended automation of the safety systems (for example: the plant assumes a safe state if a fault is not acknowledged within a defined period of time)*
- *Enhancement of the fire safety concept, for example with:*
  - *Fire alarm system*
  - *Automated fire extinguishing system*
- *Monitoring of the supply of media*
- *Remote monitoring*
- *Relaying of the alarm*
- *Manning during certain plant processes or at specific times*
- *Organization of on-call duty*
- *Etc.*

Lone working

DGUV Regulation 1, Principles of Prevention, Section 8 and DGUV Regel 100-001 concerning principles of prevention

In general, lone working is associated with the normal risk to life and does not require special occupational safety measures. As part of their general duty of care, many employers nevertheless seek to avoid requiring their employees to work alone, keep the duration of lone working as brief as possible, or use organizational or technical means to detect as swiftly as possible when an employee working alone is in an emergency situation.

The situation is different when lone working includes dangerous work. As a rule, dangerous work should not be performed alone. Where it is necessary in exceptional cases, you must implement additional monitoring measures over and above the general protective measures necessitated by the nature of the work itself. Monitoring can take the form of technical measures (such as personal alarm systems) or organizational measures (patrols by a second person, systems for reporting by telephone/radio alarm at agreed times, or permanent camera surveillance).

Dangerous work is work that is associated with increased risk because adequate protective measures cannot be taken. Examples of dangerous work include:

- *Work in silos, vessels or confined spaces*
- *Welding in confined spaces*
- *Work involving heat in areas associated with a fire or explosion hazard, or on closed hollow bodies*
- *Performance of gas pressure and leak tests on containers*
- *Work in areas presenting a gas-related risk*

The risk presented by the work and the necessary protective measures and measures for monitoring lone working are determined as part of the risk assessment.

3.2.10 Handling of hardening material and fixtures

Fixtures are manufactured from heat-resistant (e.g. steel) alloys. They are custom-designed for each furnace plant and can be adapted to different charges or charge structures. Unlike the actual charge itself, the fixtures pass through heat treatment processes multiple times, which is not without consequence. Avoid hazards caused by wear and ageing behaviour of the fixtures.

Hazards

The following particular hazards arise on fixtures due to wear and ageing:

- Dangerous faults caused by the fixture jamming or catching owing to changes in dimensions or geometry during the transport process
- Assembly of the fixtures made more difficult, resulting in a higher risk of crushing, and of flaking/breakage during straightening
- Mechanical failure of fixture elements; falling of parts of the charge off the fixture. The danger is particularly great when fixtures are transported suspended from the crane. This can lead to the entire batch breaking of. Processes involving high carbon contents in the furnace atmosphere present greater risks. When quenching is performed in aqueous polymer solutions, the fixtures may be damaged after only a few heat treatment cycles.

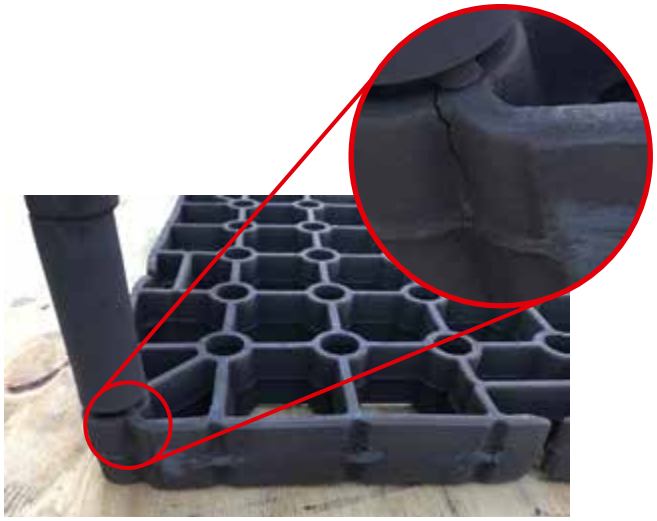


Figure 37 Cracking on a fixture

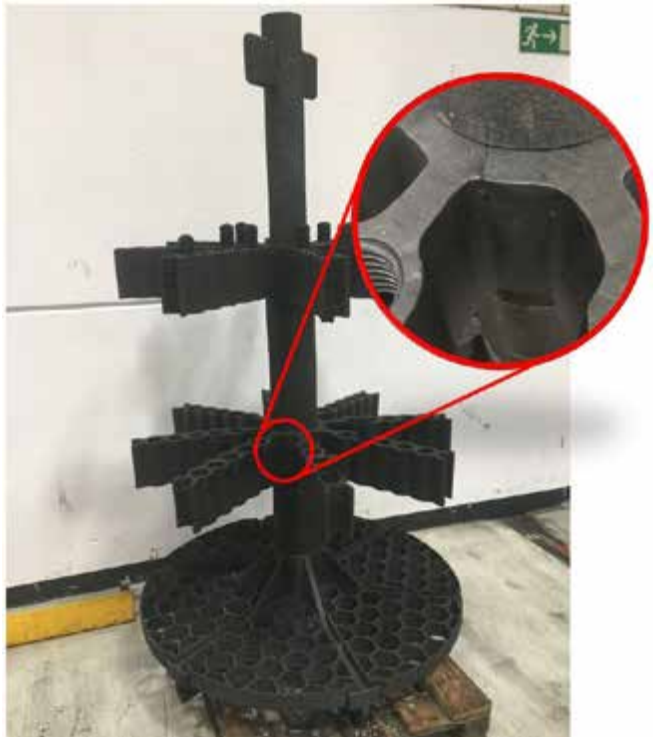


Figure 38 Cracking on a fixture

Measures

Take the following measures to reduce the risk of faults being caused by wear and ageing of fixtures:

- Select a material for the fixture that is suitable for the intended heat treatment process.
- Fixtures that are intended for transport by crane and as an integral part of the load constitute load handling attachments as governed by the 9th Ordinance under the German Product Safety Act (ProdSG). Test these fixtures in the same way as other load handling attachments, and document the test.
  Examples of fixtures that are intended as an integral part of the load are fixtures for use in shaft furnaces. Other charging equipment, such as wire baskets, do not constitute load-handling attachments.
  Like other load handling attachments, fixtures that are deemed to be load handling attachments must be marked by the manufacturer with the CE mark, the manufacturer's details and the maximum load capacity. The accompanying documents include a declaration of conformity and an instruction handbook describing use and testing of the fixtures. The information contained in the manufacturer's instruction handbook must be observed during use and testing of fixtures.
- For fixtures that are pushed or conveyed on rollers, the use of templates or contour patterns has been shown to be an effective means of checking the fixtures. If these checking elements are installed in the transport system upstream of the furnace, damaged fixtures can be detected before they are transported into the furnace plant.
- Check the fixture for wear and ageing and take defective elements out of use.
- To determine when a fixture is due for inspection, proven good practice is to record the number of heat treatment cycles through which the fixture or element has passed.

CFC fixtures for oil quenching:

Where CFC charging equipment is used in oil quenching processes, particular consideration must be given to the possibility of the quenching oil being carried over down the production line. This must be checked for the application under consideration. Owing to its structure, CFC is porous. Treatment of the material by infiltration can reduce porosity, but not eliminate it entirely. In tempering furnaces for example, this additional oil load can lead to increased concentrations in the process chambers and insulation of the heat treatment plant. This in turn gives rise to an increased fire load and risk of explosion. Rinsing of the CFC materials, for example with modified alcohols or hydrocarbons, reduces oil carry-over but does not eliminate it completely. The best results can be attained by thermal cleaning or drying in a vacuum chamber in the cleaning plant.

3.2.11 Formation of explosive atmospheres

Flammable gases, which can form dangerous explosive atmospheres when mixed with air (oxygen), are often used in heat treatment shops. Since explosions can cause considerable injury and damage, measures to prevent the formation of dangerous explosive atmospheres are particularly important.

Figure 39
Gas detector

§ Statutory references

- GefStoffV, German Ordinance on hazardous Substances, Section 6 concerning the obtaining of information and risk assessment
- GefStoffV, German Ordinance on hazardous Substances, Section 11 concerning special measures for protection against physical and chemical effects, particularly against fire and explosion hazards

i Further information

- AWT guidance on risk assessment for hardening shops: hazards caused by the formation of dangerous explosive atmospheres
  ▸ https://www.awt-online.org > fachausschuesse > Fachausschuss 8 Sicherheit in Wärmebehandlungsbetrieben

Hazards

Dangerous explosive atmospheres may form as a result of:
- Leaks on plant or pipelines carrying gas
- Malfunctioning of safety equipment
- Incorrect operating interventions in response to faults on the plant, owing to inadequate training of operating personnel
- Evaporation of hardening oil or other flammable liquids and mixture of the vapours with air
  This occurs for example in tempering furnaces when the hardening oil from the quenching process has not been sufficiently removed in the cleaning plant.

Even where the formation of a dangerous explosive atmosphere is not possible, a hazard to employees cannot be excluded, owing to the toxicity of the gases. Monitoring and observance of compliance with the occupational exposure limit values is therefore absolutely essential.

Measures

As a general rule, the risk assessment must also consider the formation of dangerous explosive atmospheres. You must define the necessary measures and document them in the explosion protection document.

To keep the leakage on pipelines and plant components to a minimum, implement the following measures:
- The materials and components used must be suitable for the pressure stage and temperature and for the medium.
- The components and connections used must be technically leakproof.
- Check the technical leakproofing after installation and at regular intervals.
  In addition to the outward leak-tightness of pipelines, the internal leak-tightness of shut-off devices (solenoid valves, gate valves, etc.) is also important for plant safety.

To ensure that safety equipment intended to prevent the release of gases or formation of dangerous explosive atmospheres functions reliably, you must ensure that it is maintained and checked.

Incorrect operating interventions following malfunctions can be avoided when it is established which employees are authorized to correct malfunctions, and ensured that these employees possess the necessary knowledge and practice.
The necessary knowledge includes detailed knowledge on:
- Functioning of the plant
- The dangers presented by the plant
- The dangers presented by the process media
- The plant's safety concept

Besides these general measures, the following specific measures are recommended:
- Propane has a density 1.5 times that of air. It also has a lower explosion limit of 1.7 % by volume in air. Consequently, propane accumulates in depressions or pits and may form explosive mixtures even at very low concentrations. Static monitoring is therefore recommended of pits, open cellars, outlets, etc. in the vicinity of pipes or unions carrying propene.
- The smaller the room volume, the quicker critical concentrations of flammable gases are reached. Where the equipment installed in a small room presents a possibility of uncontrolled gas leakage, you must therefore implement static measures for monitoring these rooms, or take organizational measures defining the conditions under which the rooms may be entered.

Explosive ranges of gases

Further important parameters for combustible gases are their lower explosion limit (LEL) and upper explosion limit (UEL). Mixtures of gases with air are explosive in the concentration range between the LEL and the UEL.

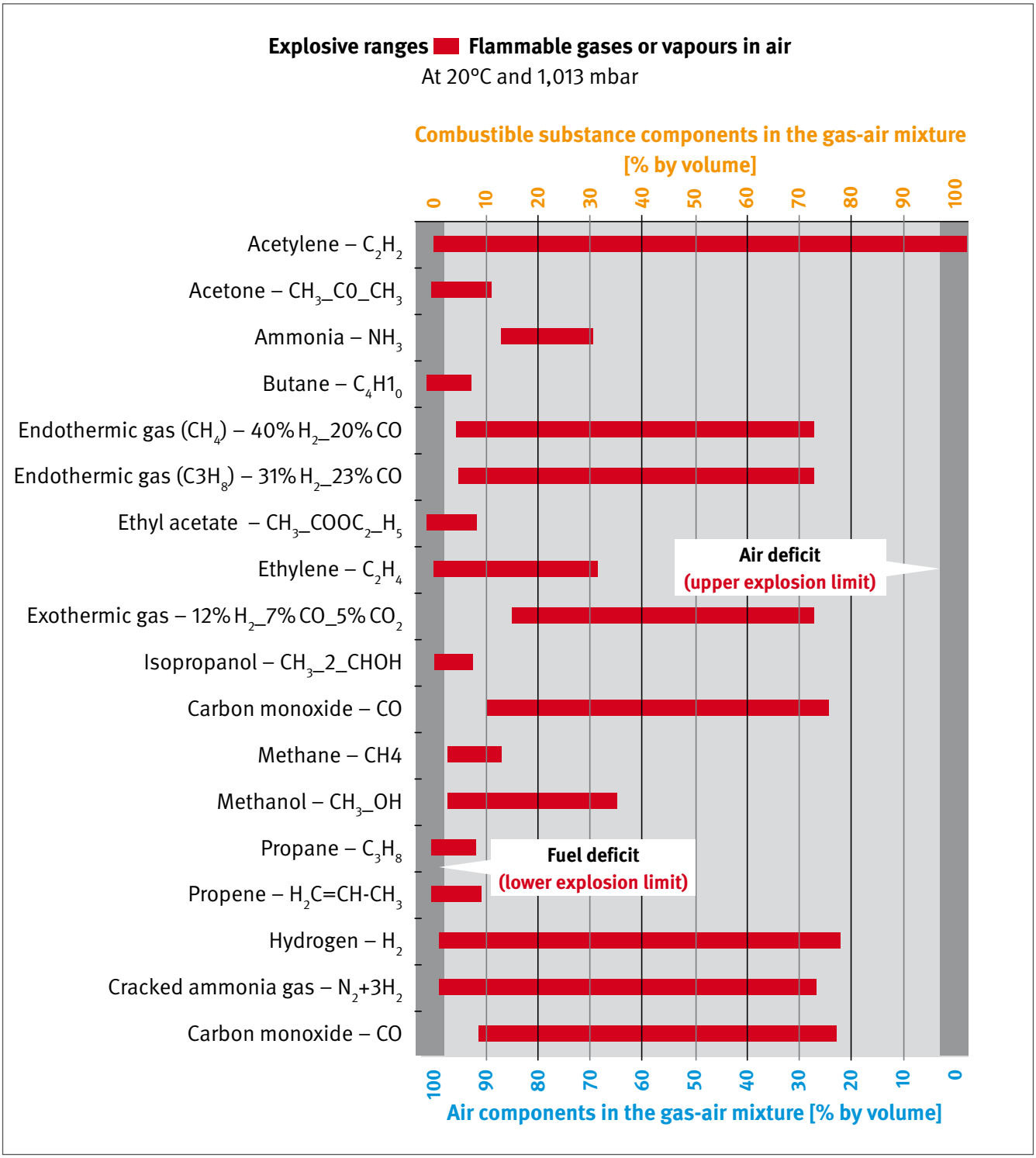


Figure 40 Explosive ranges of flammable gases/vapours in air

3.2.12 Hot surfaces and cryogenic gases

Unprotected contact with hot or cryogenic surfaces and cryogenic liquefied gases can cause major injury to the skin and the underlying tissue. You must take technical or organizational measures to prevent such injuries.

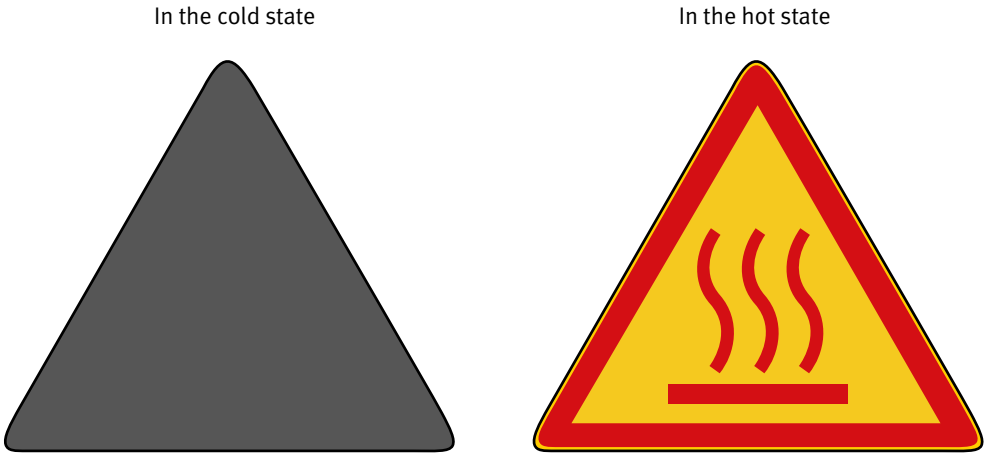


Figure 41 Temperature-sensitive warning sign

Further information

- Safety information sheet issued by Industriegasverband e.V. on the handling of cryogenic liquefied gases
  ▶ https://www.industriegasverband.de/Downloads

Hazards

Hot solids, liquids or gases can cause severe burns or scalding:

- When hot surfaces are touched unintentionally (e.g. pipes, furnaces, containers).
- When hot surfaces are touched intentionally (e.g. handwheels, valves, handles).
- When direct contact is made with hot materials (e.g. liquids, superheated steam, hot air).
- When contact is made with open flames.
- When contact is made with spatter of hot media.

Table 5 Burn thresholds T_0 in the event of contact with hot surfaces of various materials (EN ISO 13732-1)

Material	T_0 (°C) for 1 minute contact duration	T_0 (°C) for 10 minutes contact duration	T_0 (°C) for 8 hours contact duration
Uncoated metals	51	48	43
Coated metals	51	48	43
Ceramic, glass and stone-like materials	56	48	43
Plastics	60	48	43
Wood	60	48	43

Contact with cryogenic surfaces can cause pain, numbness or localized frostbite on exposed areas of skin.

Where contact with cryogenic liquefied gases is possible, the following hazards are particularly relevant:

- Severe frostbite or cold burns caused by direct contact
- Embrittlement of materials (affecting many plastics, structural steel) with resulting loss of strength
- Oxygen deficiency caused by evaporation of liquid nitrogen in small rooms

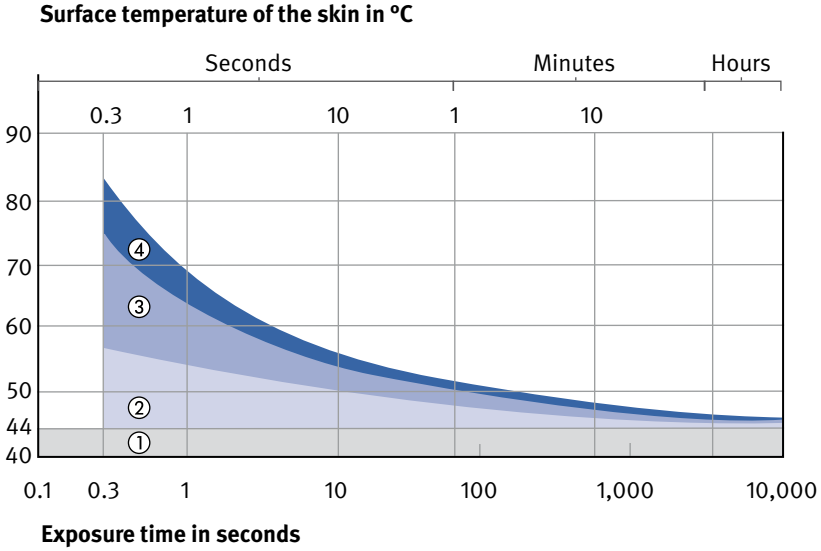
Measures

Hot surfaces on plant:
Where contact with hot plant surfaces is possible, ensure that contact protection is provided in order to prevent burns. Where contact with hot surfaces is not possible even during infrequent work, contact protection is not required. Where technical measures to prevent contact with hot surfaces are not possible, organizational measures (such as marking of the hot surfaces) and personal measures (such as the wearing of insulating, temperature-resistant clothing and personal protective equipment) must be taken.

Hot surfaces on workpieces:
Where sufficient residual heat is still present in workpieces, it can cause major burns. Ensure that whilst these workpieces are cooling down, they are stored in such a way that contact with them is not possible. Where such measures are not possible, take organizational measures (e.g. barrier tape, warning signs). Ensure that employees who have contact with these workpieces wear personal protective equipment, such as insulating protective gloves.

Cryogenic liquefied gases:
Where parts of plant, work equipment and tools come into contact with cryogenic liquefied gases, the temperature of these gases must not cause them to become brittle. Copper, austenitic steels and certain aluminium alloys are suitable materials. Of the plastics, PTFE is suitable under certain conditions.

Protection similar to that for hot surfaces must be provided against contact with cryogenic surfaces on plant.



(1) No change in the tissue
(2) First-degree burns (reddening of the skin, painful swelling)
(3) Transition zone
(4) Second-degree burns (blistering, partial destruction of the skin) and third-degree burns (complete destruction of the skin)

Source: Figure 6.1-1. Severity of burns as a function of skin temperature and exposure duration (SKIBA, 1979)

Figure 42 Severity of burns

Should your employees be at risk of contact with non-insulated cryogenic surfaces or with cryogenic liquefied gases, they must wear personal protective equipment. When cryogenic liquefied gas is transferred to containers at ambient temperature or objects at ambient temperature (or higher) are immersed into cryogenic liquefied gas, spatter – possibly violent – must be anticipated. The likelihood of contact must be considered during selection of personal protective equipment.

Personal protective equipment

Observe the following when selecting personal protective equipment:

- Clothing should be clean, dry and made of natural fibres, and should completely cover the arms and legs.
- Protective gloves must insulate well and be made of material that does not embrittle (e.g. leather).
- Both clothing and protective gloves should fit loosely to allow swift removal in the event of wetting or ingress of cryogenic gas.
- Spectacles do not provide sufficient protection; face protection should therefore be worn.

Ensure that cryogenic liquids cannot escape during transport, for example by using suitable sealable containers that prevent an impermissible build-up of pressure.

Evaporation of one litre of liquid nitrogen results in approximately 700 litres of gaseous nitrogen being formed. Should cryogenic liquefied gases escape in rooms of low volume, the atmospheric oxygen can thus rapidly fall below 17 %, resulting in an oxygen deficiency. You must therefore ensure adequate ventilation, room air monitoring or equivalent measures in rooms of low volume.

3.2.13 Operation of oil baths

Oil fires are among the most frequent causes of damage in hardening shops. What action must you take to keep these and other hazards low when operating oil baths?

Hazards

Hardening oils are flammable liquids. Fires often cause only material damage. Persons are also frequently injured however, for example during fire-fighting or evacuation of the affected rooms. The material damage may cause long disruptions to production or production processes.

Contamination of the oil bath with water is the most frequent cause of oil bath fires. Owing to the very high volumetric expansion of water (1 litre of water produces approximately 1,700 litres of water vapour), very violent reactions may occur during the quenching process. The consequences are the formation of oil foam, overflowing of the oil bath and in extreme cases the ejection of oil from the bath.

Oily deposits in the lines of the waste gas extraction system also give rise to an elevated fire hazard, since with the exception of the ignition source, all conditions for a fire (presence of air, oil vapours from low-boiling substances) are almost always met.

Further possible causes of fires on oil quenching facilities:

- Severe local overheating of the oil bath caused by bulk material charges containing small, thin parts (large surface area in relation to the weight)
- Failure of the oil bath's cooling or circulation systems
- Heating running continuously owing to failure of the control system
- Level in the oil quench bath too high or too low
- Oil bath not rated for the weight of the charge, resulting in the oil bath temperature being too high during quenching
- Incomplete insertion of the charge into the oil bath (malfunction/operator error)

Fires also occur in the tempering furnace area. The most frequent reason is carry-over of oil into the tempering furnace, caused by problems during cleaning of the oily charge after quenching.

A further issue are deposits of burnt hardening oils. Incomplete combustion of quenching oils in the absence of atmospheric oxygen can produce fumes, aldehydes, soot and polycyclic aromatic hydrocarbons (PAHs), the latter being clasified as carcinogenic.

Figure 43 Charge immersed in an open oil bath

Measures

Take the following measures to reduce the risk of oil fires:

- Where waste gases contain oily vapours, the extraction equipment, particularly the pipelines, must be cleaned regularly.
- On water-cooled systems, check the water content of the quenching oil: it must not exceed 0.1% by weight.
- When hardening oil is topped up or refilled, check that the oil to be used is free of water.
- Oil baths must not be filled above the maximum permissible capacity; should the bath be overfilled, the excess oil must be drained off.
  The maximum oil bath level must allow for the oil displacement caused by the charge.
- Where bulk material charges contain small, thin parts, the charge weight must be reduced. Generic recommendations for the magnitude of this reduction are not possible.
- An additional manual check of the oil bath temperature should be performed, for example at each change of shift. The operating temperature of the oil bath should be at least 60 °C below the flash point of the hardening oil.
- An additional manual check of the oil bath level should be performed, for example at each change of shift.
- Proper functioning of the oil bath circulation system and other plant components with a bearing on safety must be ensured, for example by weekly checks of the temperature characteristics in the oil bath.
- Following the cleaning process, the hardening material must be checked for residual oil.
- The installation of stationary extinguishing equipment has proved effective on open oil baths.
- Systems employing water as the operating medium (e.g. cleaning plant) should not be erected in the vicinity of open oil baths.

Should the charge be lowered into an open oil bath by crane, observe the following points:

- Swift lowering with a minimum quenching rate of 20 cm/s must be possible.
- It must be possible for the charge to be lowered even in the event of a power failure; this can be assured for example by means of a brake lifter operating independently of the power supply, or an emergency power supply.
- The cranes should feature facilities by which the crane can be positioned quickly above the oil bath, such as position switches or markings on the craneway.

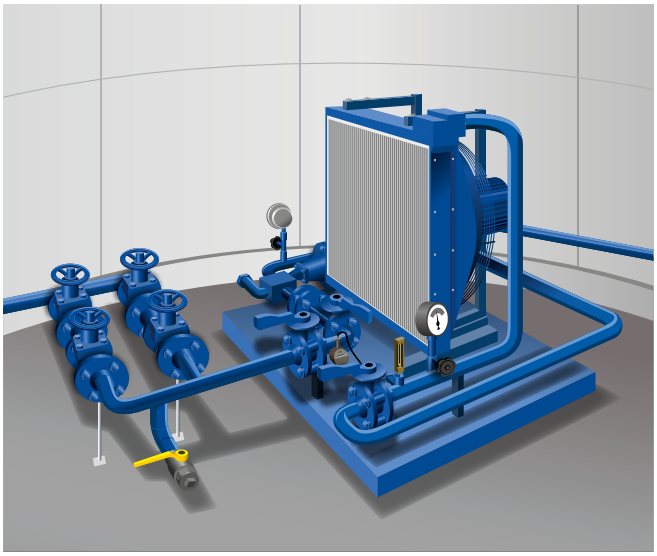


Figure 44 Oil air cooler

- Operation of the crane must be possible without danger to the operator even when the surface of the bath is on fire. This can be achieved by remote control, suitable heat shielding on the controls, and if necessary fire-retardant overalls.

Further problems may be presented by the following situations:

- Malfunction of the oil bath elevator on multi-purpose chamber furnaces during the quenching process
- Jamming of the oily charge in the flame curtain area
- In continuous systems in which the hardening material is dropped into the oil bath via a chute, jamming or back-ups in the chute can cause oil bath fires. Ensure therefore that discharge is continuous.
- Leaks on the suction side of the recirculating pump in the oil cooling circuit, for example on the seals, may enable small quantities of air to enter. The leaks are often so minor that no oil escapes when the pump is at a standstill, and they cannot be detected.
- Should the hardening material not be adequately cleaned in the downstream cleaning plant, hardening oil may be carried over. This then evaporates during tempering.
  Should larger quantities evaporate within a short space of time, a risk exists of a dangerous explosive atmosphere forming. At the very least, the hardening oil is deposited in the insulation of the tempering furnaces and in the exhaust lines, where it forms a potential fire load. Ensure therefore that the cleaning plants are working effectively.

- Unauthorized persons present in the proximity of the oil baths during quenching. The presence of persons below ground level is particularly critical; additional hazards may arise here, for example owing to automatic CO_2 extinguishing systems or overflowing oil baths.

Figure 45 Crackle test

Oil sample

The water content in the oil may vary widely from one part of the oil bath to another. Sampling should be carried out at operating temperature and with circulation activated. Passing a container (with a volume of 1/2 to 1 litre, open at the top) through the chamber furnace together with the charge has proved to be an effective method of obtaining the most representative oil sample possible. As soon as the charge has left the chamber furnace, the container can be removed and its contents transferred to a suitable vessel for further analysis.

Since water is heavier than oil, a sample should be taken from the bottom of open oil baths. For this purpose, the sampling container should be provided with a lid that can be opened when the container is at the bottom of the oil bath. A simpler solution is for a filter with drain cock to be connected, the intake point of which is at the lowest point in the oil bath.

The water content in the hardening oil can be ascertained with relative ease by the crackle test. For this purpose, 4 to 5 cm³ of the hardening oil to be tested is heated in a test tube over a Bunsen burner. The presence of water is revealed by crackling, shocks and strong formation of foam at levels as low as 0.05 % by weight. Larger quantities of water are indicated by the oil assuming a cloudy, coffee-brown appearance.

Personal protective equipment must be worn during performance of the crackle test; the opening of the test tube must be directed away from the body and not towards other persons.

3.3 Hazards associated with salt baths and measures to be taken

3.3.1 Requirements for workrooms and work areas

Owing to the properties and particular characteristics of the salts used in heat treatment shops, further requirements upon the workrooms and work areas may need to be observed.

Statutory references

- ArbStättV, German Ordinance on Workplaces: requirements concerning location and dimensions
- ASR A2.3 concerning escape routes and emergency exits, escape and rescue plan
- DGUV Regel 108-003 concerning floor coverings in workrooms and work areas presenting a risk of slipping

Hazards

The specific hazards posed by salt baths and the heat treatment salts used in them arise primarily owing to the temperature of the molten salts and the properties of the salts. The hazards are primarily:

- Burns caused by hot salt baths, hot workpieces and ancillary materials, and by hot plant components
- Poisoning by the salts

Measures

The protective measures for operation begin with design of the workrooms and work areas. Implement the following measures:

General

- Workrooms and work areas must be located in buildings constructed from non-combustible building materials. Should this not be possible, a heat shield must be installed permanently to prevent combustible parts of the building from being ignited by the molten salt or the heat radiated from it.
- Workrooms and work areas must be capable of withstanding the mechanical, chemical and thermal stresses anticipated during operation of the baths.

Location and dimensions

- Workrooms and work areas in which steel and other heavy metals are heat-treated in baths containing cyanide must not be below ground level on all sides. They must have a minimum floor area of 20 m^2 and a minimum ceiling height of at least 3 m.

Exits

- Workrooms must have at least two exits, if possible in opposing directions. The exits must be located such that the distance to the nearest exit measured as the crow flies does not exceed 20 m from any point in the room.

Floors, floor gratings and platforms

- Floors, floor gratings and platforms must be easy to clean.
- Owing to the risk of fire and formation of gases hazardous to health, floors, floor gratings and platforms in the proximity of salt baths must not be made of organic materials. Organic materials include wood, plastic and rubber.
- Floors must not have any open joints, grooves or other recesses in which salt residues can accumulate. Smoothed concrete floors impermeable to water have proved effective.

- Floor gratings, platforms and their coverings must be installed or erected such that their position cannot change inadvertently.
- Inadvertent changes in position are prevented for example as follows:
  - By sufficient dead weight of the floor gratings and platforms
  - By recessed installation of the floor gratings and platforms
  - By the use of fixing elements such as pins, catches or screws
  - Where pins, catches, screws or similar fixing elements are used to secure floor gratings, platforms and their coverings, they must be of the captive type.
  - Floor drains and collecting chambers must not be connected to the public sewerage system (requirement of the German Water resources act). The liquids collected must be disposed of properly.

Washing facilities, eye showers

- Washing facilities with running water and a facility for thorough eye washing (e.g. eye showers or a sufficient number of eyewash bottles fit for use) must be available in workrooms and work areas or in the immediate vicinity.

Erection of salt baths and associated equipment

- Salt baths and the associated equipment, such as quenching and cleaning equipment, must be erected such that they are easily accessible and can be operated safely.
- Salt bath plants containing salt baths with mutually incompatible molten salts must be erected and operated such that unwanted contact between salts that react dangerously with each other is not to be anticipated.

Extraction equipment

- Where substances hazardous to health are able to escape from the salt baths or associated equipment into the air breathed by the employees, equipment must be in place to collect the hazardous substances at their point of origin or emission, and discharge them. Suitable equipment for collecting hazardous substances at their point of origin or emission from salt baths include peripheral extraction systems (annular hoods, suction walls) and hoods in funnel form.

3.3.2 Areas in the proximity of salt baths

The area in which a plant is located often gives rise to or exacerbates a hazard. In the case of salt baths, the proximity to liquids such as water and inadequate measures to prevent persons falling into the baths are particularly relevant.

Statutory references

- ArbStättV, German Ordinance on Workplaces, Annex 2.1

Hazards

When operating open salt baths you must take additional aspects into account over and above the provisions and requirements of the ArbStättV:

- Owing to the open design of the salt baths, a danger always exists of persons or objects falling into the baths.
- Due to the temperatures and properties of the molten salts, salt spatter presents a risk of thermal and chemical burns.
- The temperatures of the salt baths, which may be very high, present an increased risk of fire.

Measures

Salt baths must be safeguarded to prevent persons from falling into them; this can be achieved for example by the use of sufficiently high bath sides or railings of adequate height.

- Should the rim of the bath be less than 0.9 m above workplace level, additional means of reliably preventing falls into the bath (e.g. railings with a height of 1 m) should be installed.
- In derogation from this requirement, a minimum height of 0.7 m of the bath rim or railing is permissible on the charging side of manually charged baths when:
  - The rim of the bath (outer side of the furnace <-> inner side of the bath) is at least 0.2 m in width
    or
  - the distance between the railing and the inner side of the bath is at least 0.2 m
    or
  - an equivalent measure is taken.

Protection against spatter:

- In order for protection to be provided against salt spatter, the crucibles must be closed with a mechanically lockable cover during the melting process.
- Work or circulation areas in the immediate vicinity of salt baths must be protected against salt spatter.

Charging and ancillary equipment

- The workpieces must be placed safely in the molten salt by means of suitable charging equipment.
- Charging equipment must be placed safely and securely on the salt bath.
- Charging and ancillary equipment such as ladles must be made of solid material and be suitable for the temperature of the salt bath.

Hydraulic fluids and foreign media

- Hydraulic fluids used in conjunction with salt baths must be flame-retardant.
- To prevent molten salt from being ejected from the salt bath, you must ensure that no foreign liquids, such as water condensation, quenching agent, hydraulic fluid, etc., is able to enter the salt bath. This can be achieved by the fitting of collecting channels or protective roofs to supply, control and measuring lines or parts of buildings.

3.3.3 Storage of and activities involving heat treatment salts

The use and storage of heat treatment salts places particular demands on the employees and on the intended storage facility for the salts. This section supplements the German TRGS 510 (Technical rule 510 for hazardous substances), which contains provisions for all hazardous substances.

Statutory references

- German Recycling management act (KrWG)
- German Ordinance on plants for handling substances hazardous to water (AwSV)
- GefStoffV, German Ordinance on hazardous Substances, Section 8 concerning general protective measures
- TRGS 201 Technical rules concerning classification and signage for activities involving hazardous substances
- TRGS 510 Technical rules concerning the storage of hazardous substances in transportable containers
- ASR A1.3 Technical rules for workplaces concerning markings for safety and health
- ADR, European Agreement concerning the International Carriage of Dangerous Goods by Road

Hazards

Heat treatment salts

- Risk of poisoning if swallowed
- Reaction with other substances causing the formation of acutely toxic gases

Measures

Storage rooms and areas

- Heat treatment salts must be packaged such that any undesired leakage of the contents is prevented. Achieve this for example by using packaging that meets the requirements for the transport of dangerous goods.
- The storage rooms and areas used for heat treatment salts must be dry. The storage of hazardous substances within circulation or escape routes is prohibited. Observe appropriate hygiene measures for your employees; in particular, ensure that the store is cleaned regularly.
- Acutely toxic heat treatment salts (including used salts) must be kept under lock and key or stored such that only skilled and reliable persons have access to them.
- Heat treatment salts and other substances capable of reacting dangerously with each other must be stored separately. Examples are cyanide and nitrite/nitrate salts, which may react dangerously with acids. In this context, observe the information on the safety data sheet and the prohibition of combined storage of goods in accordance with TRGS 510.
- Label the individual salts such that confusion is not possible.

Signage

- Areas in which salts are used or stored must be marked with the “No unauthorized entry” sign (D-P006).
- Rooms and areas in which acutely toxic or oxidizing salts are stored must be marked as follows:
  – With the “No unauthorized entry” sign (D-P006)
  – In addition with the “No open flame; fire, open ignition source and smoking prohibited” sign (P003)
- Rooms and areas in which salt baths are operated must be marked as follows:
  – With the “No smoking” sign (P002)
  – With the “No eating or drinking” sign (P022)

- Containers with hazardous contents must be marked clearly and permanently, permitting their unambiguous identification. Should permanent marking not be possible or the permanence be uncertain, you must post a suitable and clearly discernible notice of the hazardous content in the vicinity.

Areas in the proximity of salt baths

- Ensure that salts that react dangerously with each other are not confused with each other or able to come into contact with each other during operation of the bath. Dangerous reactions may occur when nitrite/nitrate and cyanide molten salts come into contact with each other.
- Workplaces must be kept clean, and soiling by salt residues must be eliminated. Larger quantities of spilled or discharged heat treatment salt must be collected and removed immediately.

Activities involving heat treatment salts

- Heat treatment salts must be transported and stored in closed and undamaged packaging or containers.
- Contact with heat treatment salts must be restricted to skilled persons.

Disposal

- Used salts and completely emptied packaging of heat treatment salts must be handled and disposed of in accordance with the German Recycling management act (KrWG). Transport in public areas is governed by the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR).

Recovery of salts

Used heat treatment salts can to some extent be recovered for subsequent reuse. Recovery is primarily employed for nitrite/nitrate salts.

The following safety measures are recommended for operation of a salt recovery plant:

- The general requirements for the handling of heat treatment salts and salt baths apply by analogy.
- The hygiene requirements correspond to those for the operation of salt baths.
- The work area must be kept free of any other substances which react dangerously with the heat treatment salts to be prepared. This includes for example acids used in the preparation of nitrite/nitrate heat treatment salts.
- The fire extinguishing equipment must be suitable for the workplace, the workplace environment, the method of salt preparation and the types of salt to be prepared.
- Waste (residues that can no longer be used and melted down) must be disposed of properly in accordance with the provisions governing solid residues of hardening salts.

3.3.4 Handling of molten salts

When handling salt baths, employees are present in the immediate vicinity of the molten salts. Severe accidents may occur should molten salt spatter. Spattering of molten salt must therefore be prevented under all circumstances.

Hazards

The greatest hazard to your employees is physical contact with the hot molten salt. This immediately causes major skin burns. Contact with the hot molten salts is often caused by spatter.

Measures

To prevent spatter from the hot salt bath, take the following measures:

General handling of the workpieces

- At salt bath temperatures of over 250 °C, the workpieces and the charging and ancillary equipment must be introduced into the bath in the dry state. This can be achieved by adequate preheating. Drilled and blind holes are particularly critical in this context.
- Workpieces should be as free as possible from soiling (e.g. with grease, machining fluids) when they are introduced into the salt baths.
- Workpieces with closed cavities such as hollow bodies or blocked holes must not be placed in salt baths.
- Workpieces may be introduced into and removed from the salt bath only by means of the ancillary equipment intended for this purpose.
- Workpieces must be fastened securely to the charging equipment.
- Ancillary equipment such as ladles must be thoroughly cleaned between use on mutually incompatible molten salts.

Melting and solidification of the salts

Whenever the salt bath is shut down, it is recommended that it first be desludged. Desludging must be performed in compliance with the salt manufacturer's instructions.

- Precautions must be taken to ensure that when salts are remelted, excess pressure does not build up which could lead to the surface of the salt bath breaking up whilst still solid and thus to spatter of the salt already in the liquid phase. Before the salt solidifies, take precautions such as the following to prevent spatter of liquid salt:
  - Reduce the content level in the crucibles below the level up to which heat is applied.
  - Insert a steel wedge or cone; do not remove it again until the salt has fully melted. The cone inserted into the salt serves as a plug which is forced upwards as the salt melts and expands, and thus serves to relieve pressure and prevent spatter of salt.
- Surface layers of the salt bath that have solidified or have not yet melted must not be broken up. This does not apply to surface layers of carbon foam in baths containing cyanide.
- Mechanically lockable covers must be in place on the baths during melting of the salt baths.

Moving of crucibles

- Crucibles may be moved only once the salt has solidified.

Nitrite/nitrate salt baths

- Foreign substances containing carbon must not be allowed to enter nitrite/nitrate salt baths. Such substances particularly include solids such as wood, paper, plastics, gloves and cleaning cloths.

Compatibility of molten salts

- Ensure that when different salts are combined, the manufacturer's information on the compatibility of the salt baths is taken into account.
- Compatibility is assured when for example the cyanide content of the salt carried over into a nitrite/nitrate molten salt bath does not exceed a mass fraction of 13 % KCN or 10 % NaCN.
- Nitrite/nitrate salts must not be introduced into baths containing cyanide.

3.3.5 Draining and cleaning salt baths

Draining and cleaning are among the operations performed on salt baths, but are not a daily occurrence. Precisely for this reason, major accidents repeatedly occur during these activities.

Hazards

The greatest hazard to your employees is physical contact with the hot molten salt. This immediately causes major skin burns. Contact very often occurs by spatter from hot salt baths.

Measures

To prevent egress or spatter from the hot salt bath during draining and cleaning, take the following measures:

Draining the baths

- Only ancillary equipment that is dry, ideally preheated, and not contaminated by foreign salts or other substances may be used for draining of the baths.

Use and operation of salt pumps

- When selecting personal protective equipment, give consideration to the possibility of salt suddenly exiting from the pump system at unanticipated points. Aluminium-laminated heat-resistant protective clothing has proved effective for this purpose. The specified personal protective equipment must be worn during the entire process.
- A procedure must be drawn up for use and operation of the salt pump. Instruction must be provided to the employees based upon this procedure.
- The salt pump must be operated by a person specifically assigned to the task who performs no other tasks during operation of the pump.
- The operator of the salt pump must immediately report any changes on the plant that impact upon safety and must shut the plant down until operational safety is restored. The person responsible must also be informed of any problems, damage or deviation from normal operating conditions.
- Persons not employed by the company and unauthorized persons must be barred from accessing the work area intended for the pumping process. The work area must be kept clear as far as possible of stored goods and in particular of flammable materials. The work area should provide sufficient freedom of movement for the operating process. Escape routes must be created and kept clear.
- Whenever the salt pump is put into operation, it must first be inspected visually together with the delivery line and electrical system.
- The salt pump may be introduced into the salt bath only when dry, preheated and cleaned.

- As the pump is introduced into the salt bath, its outlet must not point in the direction of persons, as steam generated by residual moisture in the pump or the pipe connected to it may otherwise present a hazard.
- The salt pump must be fixed such that it remains in position during start-up and cannot be thrown about.
- The delivery line should preferably be at a gradient so that the lines drain automatically. The line must be fixed, protected against contact and thermally insulated to prevent cooling. Should the delivery line need to be flexible to permit movement of the outlet, metal hose may be used for parts of the line.
- Whenever the delivery lines are put into use, their unions must first be checked for leaks and tightened if necessary. In order for undesired backflow of liquid salt to be prevented, the level of the salt outlet should always lie above that of the molten salt in the salt bath. Should this not be possible, other suitable measures such as pipe ventilation must be taken to prevent the salt from flowing back by itself, and the resulting risk of overfilling.
- The containers into which the molten salt is pumped must be leakproof, dry, temperature-resistant, uncoated and free of contaminants.
- Where the molten salt is filled into drums for disposal, they must comply with the transport regulations.
- During filling, the containers must not stand on combustible surfaces such as wooden pallets or a concrete floor sealed with plastic.
- When the salt pump has been switched off, the outlet of the delivery line must be raised above the salt bath level of the full container.
- Following use, salt pumps must be cleaned with suitable agents in accordance with the manufacturer's instructions, and stored clean.
- Repair and maintenance work may be carried out only on cold, clean salt pumps.

Cleaning the baths

- Salt baths must be desludged regularly according to the workpiece throughput. Where the sludge is heavy, desludging may have to be performed daily. The temperatures of the molten salts during desludging as specified by the manufacturer must be observed.

3.3.6 Maintenance work and tests on salt baths

In the interests of safe working, it is crucial that machinery and plant be intact. Important specific requirements and measures must be observed for the maintenance and testing of salt baths, over and above the general requirements and measures.

Statutory references

- BetrSichV, German Ordinance on industrial Safety and Health, Section 10 concerning maintenance and modification of work equipment
- BetrSichV, German Ordinance on industrial Safety and Health, Section 14 concerning testing of work equipment
- TRBS 1201 Technical rules for industrial safety and health concerning the testing of work equipment and installations requiring regular inspection
- TRBS 1203 Technical rules for industrial safety and health concerning competent persons

Further information

For the testing of power supply, regulation and control equipment, refer to:

- EN 60519-1, Safety in installations for electroheating and electromagnetic processing – General requirements
- EN 60519-2, Safety in installations for electroheating and electromagnetic processing – Particular requirements for resistance heating equipment
- EN 60398, Installations for electroheating and electromagnetic processing – General performance test methods

Hazards

Specific hazards arising during setup and maintenance work and testing on salt baths:

- Skin contact with the molten salts and hot parts of the plant
- Falling into the salt baths

Measures

Setup and maintenance work
In order for the hazard arising during maintenance work on and above salt baths or containers to be reduced, the risk assessment for these activities is of particular importance. You must set out the necessary safety measures in writing and instruct your employees accordingly.

In addition to the general hazards, take account of the particular characteristics of salt baths and also ensure that the health of your employees is not endangered for example by thermal radiation or spatter.

Pay particular attention to the possibility of employees falling into the baths. Irrespective of the height of the fall, this must be prevented by technical measures such as covering of the baths or the use of work cages. In addition, organize maintenance work such that no foreign objects such as tools, workpieces or work materials are able to fall into the salt baths.

Inspections
Inspections performed before initial commissioning and following major modifications and repairs

As the employer, you are obliged to ensure that salt baths are checked by a competent person with respect to their safe condition and reliable operation, and at least for externally visible damage and defects, before they are placed in service for the first time and following any significant modification or repair. This requirement also extends to their components such as temperature control and limiting devices, safeguards, equipment for media and energy supply, charging, extraction and ventilation, and other ancillary equipment.

Examples of significant modifications in this context are modifications to heating and control systems, and structural changes resulting from a change in the composition of the salt bath.

Periodic inspections on salt baths
- You must ensure that temperature limiting devices, unless they are self-monitoring or intrinsically safe, are inspected regularly in order for their serviceability to be ascertained. Inspection of these devices at quarterly intervals is recommended.
- You must instigate inspection of the following by a competent person as required and at least once a year:
  1. Proper condition and serviceability of safeguards and charging, ancillary and ventilation equipment
  2. Serviceable condition and leak-tightness of gas pipes and their fittings

Documentation of results of inspection
Salt baths are not subject to documentation requirements beyond those of other work equipment; as with such equipment, you must ensure that the results of the inspections are recorded. The records must be retained at least until the next inspection.

3.3.7 Process gas furnaces employing salt quenching baths

Operation of process gas furnaces employing salt quenching baths is subject to the general safety rules for process gas furnaces and the general safety rules for salt baths. In combination, the two parts of the plant give rise to new hazards, which are described below.

Hazards

The salts used in martempering and austempering are usually a mixture of nitrite and nitrate salts. These salts have a strong oxidizing effect and can therefore react violently with hydrocarbon compounds (e.g. soot deposits). Should such substances accumulate in salt baths or a larger quantity be introduced suddenly, a considerable risk exists of fire or explosive reactions in which the formation of nitrous gases cannot be ruled out.

Measures

The following measures are recommended in order to prevent soot deposits from giving rise to hazards presented by fire or explosive reactions:

- The general requirements for salt quenching baths apply by analogy.
- The salt quenching bath must feature good circulation. This prevents deposits from forming on the bottom of the bath or crucible, and overheating effects in the heating system. Effective circulation also minimizes local overheating or heat pockets caused by the hardening material (e.g. on small parts with a large surface area). On systems with a drop shaft, an effective barrier curtain of liquid saltis required in the shaft; this supports thermal decoupling of the furnace and quenching bath.
- The salt bath should be covered as completely as possible.
  A cover reduces both the ingress of foreign substances and the release of harmful vapours.
- The process gas furnace must be operated such that the formation of soot deposits in the furnace or on the components is kept as low as possible.
  The following measures may be taken to reduce soot formation:
  - Control of the atmosphere to keep the carbon level below the soot limit
  - Regularly allowing the furnace to burn out
  - The furnace chamber, specifically the transition to the quenching bath, must be inspected regularly for soot deposits and cleaned if necessary.
  - The components should be free of greasy or oily residues.

3.3.8 Particular requirements associated with heat treatment of aluminium or wrought aluminium alloys in nitrite/ nitrate salt baths

A particular application of salt baths is the heat treatment of aluminium or wrought aluminium alloys in nitrate/nitrate salt baths. Exceeding of the permissible salt bath temperature is particularly critical in such salt baths.

Hazards

Nitrite/nitrate salt baths have a high oxygen content. The higher the bath temperatures, the sooner oxygen is released; nitrate salts (nitrate = NO_3) become increasingly unstable at temperatures above around 600 °C. Should the workpieces to be treated contain magnesium, critical reactions between the molten salt and the workpiece can occur at temperatures even lower than this.

Measures

The following aspects are particularly critical when aluminium is treated in nitrate salt baths:

Magnesium content and temperatures of the molten salt

- With consideration for the magnesium content of the wrought aluminium alloy, the following temperatures of the molten salt must not be exceeded:

Table 6: Maximum temperatures of molten salt

Magnesium content	Temperature of the molten salt
Up to 0.5 %	550 °C
Up to 2 %	540 °C
Up to 4 %	490 °C
Up to 5.5 %	435 °C
Up to 10 %	380 °C

The determining of intermediate values for temperatures of the molten salt at other magnesium contents is permissible only between the stages indicated in Table 6.

Exclusion of certain materials

- Ensure that the nitrate salt baths used for the treatment of aluminium or wrought aluminium alloys are not used for workpieces made of alloys of unknown composition.

Testing of the temperature monitoring devices

- Proven good practice is for proper functioning of the temperature monitoring devices to be checked by a competent person at regular intervals and at least quarterly.

4 Further sources of information

4.1 References

Acts and ordinances

Source:
Retail book trade and the Internet:
e.g. www.gesetze-im-internet.de

- **Arbeitsschutzgesetz (ArbSchG)**
  (German Safety and Health at Work Act)
- **Arbeitssicherheitsgesetz (ASiG)**
  (German Act on Occupational Physicians, Safety Engineers and Other Occupational Safety Specialists)
- **Arbeitsstättenverordnung (ArbStättV)**
  (German Ordinance on Workplaces)
- **Betriebssicherheitsverordnung (BetrSichV)**
  (German Ordinance on industrial Safety and Health)
- **Gefahrstoffverordnung (GefStoffV)**
  (German Ordinance on hazardous Substances)
- **PSA-Benutzungsverordnung (PSA-BV)**
  (German Ordinance on the Use of Personal Protective Equipment)
- **Verordnung zur Arbeitsmedizinischen Vorsorge (ArbMedVV)** (German Ordinance on Preventive Occupational Health Care)
- **Europäisches Übereinkommen über die internationale Beförderung gefährlicher Güter auf der Straße (ADR)**
  (European Agreement concerning the International Carriage of Dangerous Goods by Road)

Technical rules

Source:
Retail book trade and the Internet:
e.g. www.baua.de

Technische Regeln für Betriebssicherheit (TRBS)
(Technical rules for industrial safety and health)

- **TRBS 1111 „Gefährdungsbeurteilung“**
  (risk assessment)
- **TRBS 1201 „Prüfungen von Arbeitsmitteln und überwachungsbedürftigen Anlagen“**
  (testing of work equipment and systems requiring regular inspection)
- **TRBS 1203 „Befähigte Personen“**
  (competent persons)
- **TRBS 2111 „Mechanische Gefährdungen – Allgemeine Anforderungen“**
  (mechanical hazards – general requirements)
- **TRBS 3145/TRGS 745 „Ortsbewegliche Druckgasbehälter – Füllen, Bereithalten, innerbetriebliche Beförderung, Entleeren“**
  (transportable compressed gas tanks: filling, staging, in-plant transport, emptying)
- **TRBS 3146/TRGS 746 „Ortsfeste Druckanlagen für Gase“**
  (stationary pressure systems for gases)

Technische Regeln für Arbeitsstätten (ASR)
(Technical rules for workplaces)

- **ASR A1.3 „Sicherheits- und Gesundheitsschutzkennzeichnung“**
  (safety and health signage)
- **ASR A1.8 „Verkehrswege“**
  (circulation routes)
- **ASR A2.2 „Maßnahmen gegen Brände“**
  (fire prevention measures)
- **ASR A2.3 „Fluchtwege und Notausgänge, Flucht- und Rettungsplan“**
  (escape routes and emergency exits, escape and rescue plan)
- **ASR A4.3 „Erste-Hilfe-Räume, Mittel und Einrichtungen zur Ersten Hilfe“**
  (first-aid areas, equipment and facilities)
- **ASR A3.5 „Raumtemperatur“**
  (room temperature)
- **ASR A3.6 „Lüftung“**
  (ventilation)
- **ASR V3a.2 „Barrierefreie Gestaltung von Arbeitsstätten“**
  (accessible design of workplaces)

Technische Regeln für Gefahrstoffe (TRGS)
(Technical rules for hazardous substances)

- **TRGS 201 „Einstufung und Kennzeichnung bei Tätigkeiten mit Gefahrstoffen“**
  (classification and marking for activities involving hazardous substances)
- **TRGS 401 „Gefährdungen durch Hautkontakt“**
  (hazards presented by skin contact)
- **TRGS 402 „Ermitteln und Beurteilen der Gefährdungen bei Tätigkeiten mit Gefahrstoffen: Inhalative Exposition“**
  (identification and assessment of hazards associated with tasks involving hazardous substances: inhalative exposure)
- **TRGS 407 „Tätigkeiten mit Gasen – Gefährdungsbeurteilung“**
  (activities involving gases – risk assessment)
- **TRGS 509 „Lagern von flüssigen und festen Gefahrstoffen in ortsfesten Behältern sowie Füll- und Entleerstellen für ortsbewegliche Behälter“**
  (storage of liquid and solid hazardous substances in

stationary containers and filling and emptying points for transportable containers)
- **TRGS 510 „Lagern von Gefahrstoffen in ortsbeweglichen Behältern“**
  (storage of hazardous substances in transportable containers)
- **TRGS 521 „Lagern von flüssigen und festen Gefahrstoffen in ortsfesten Behältern sowie Füll- und Entleerstellen für ortsbewegliche Behälter“**
  (demolition, renovation and maintenance work involving end-of-life mineral wool)
- **TRGS 554 „Dieselmotoremissionen (DME)“**
  (diesel engine emissions)
- **TRGS 558 „Tätigkeiten mit Hochtemperaturwolle“**
  (tasks involving high-temperature wool)

DGUV body of regulations governing safety and health at work

Source:
Available from your accident insurance institution and at www.dguv.de/publikationen

Regulations
- **DGUV Vorschrift 1 „Grundsätze der Prävention“**
  (principles of Prevention)
- **DGUV Vorschrift 2 „Betriebsärzte und Fachkräfte für Arbeitssicherheit“**
  (occupational physicians and OSH professionals)
- **DGUV Vorschrift 52 and 53 „Krane“**
  (cranes)
- **DGUV Vorschrift 54 and 55 „Winden, Hub- und Zuggeräte“**
  (winches, hoists and pulling equipment)
- **DGUV Vorschrift 68 and 69 „Flurförderzeuge“**
  (industrial trucks)

Rules
- **DGUV Regel 108-003 „Merkblatt für Fußböden in Arbeitsräumen und Arbeitsbereichen mit Rutschgefahr“**
  (floor coverings in workrooms and work areas where a risk of slipping exists)
- **DGUV Regel 108-007„Lagereinrichtungen und Geräte“**
  (storage facilities and equipment)
- **DGUV Regel 109-002 „Arbeitsplatzlüftung“**
  (workplace ventilation)
- **DGUV Regel 112-189 and 112-989 „Benutzung von Schutzkleidung“**
  (use of protective clothing)
- **DGUV Regel 112-190 „Benutzung von Atemschutzgeräten“**
  (use of respiratory protective devices)
- **DGUV Regel 112-191 and 112-991 „Benutzung von Fuß- und Knieschutz“**
  (use of foot and knee guards)
- **DGUV Regel 112-192 and 112-992 „Benutzung von Augen- und Gesichtsschutz“**
  (use of eye and face protection)
- **DGUV Regel 112-193 and 112-993 „Benutzung von Kopfschutz“**
  (use of protective headgear)
- **DGUV Regel 112-194 „Benutzung von Gehörschutz“**
  (use of hearing protection)
- **DGUV Regel 112-195 and 112-995 „Benutzung von Schutzhandschuhen“**
  (use of protective gloves)
- **DGUV Regel 112-198 „Einsatz von persönlichen Schutzausrüstungen gegen Absturz“**
  (use of personal protective equipment against falls from a height)
- **DGUV Regel 112-199 „Retten aus Höhen und Tiefen mit persönlichen Absturzschutzausrüstungen“**
  (rescue from heights or underground with the use of personal protective equipment against falls from a height)
- **DGUV Regel 113-001 „Explosionsschutz-Regeln (EX-RL)“**
  (explosion protection rules (EX-RL))
- **DGUV Regel 113-004 „Behälter, Silos und enge Räume, Teil 1: Arbeiten in Behältern, Silos und engen Räume“**
  (vessels, silos and confined spaces, Part 1: Work in vessels, silos and confined spaces)

Informative publications
- **DGUV Information 204-022 „Erste Hilfe im Betrieb“**
  (first aid in companies)
- **DGUV Information 205-001 „Arbeitssicherheit durch vorbeugenden Brandschutz“**
  (occupational safety through preventive fire safety)
- **DGUV Information 205-003 „Aufgaben, Qualifikation, Ausbildung und Bestellung von Brandschutzbeauftragten“**
  (tasks, qualification, training and appointment of fire safety officers)
- **DGUV Information 205-023 „Brandschutzhelfer – Ausbildung und Befähigung“**
  (assistant fire safety officers: training and competence)
- **DGUV Information 208-004 „Gabelstapler“**
  (fork-lift trucks)
- **DGUV Information 209-012 „Kranführer“**
  (crane operators)

- **DGUV Information 209-013 „Anschläger“** (slingers)
- **DGUV Information 209-073 „Arbeitsplatzlüftung – Entscheidungshilfe für die betriebliche Praxis“** (workplace ventilation and assistance with decision-making in industry)
- **DGUV Information 212-013 „Hitzeschutzkleidung“** (heat-resistant protective clothing)
- **DGUV Information 215-830 „Einsatz von Fremdfirmen im Rahmen von Werkverträgen“** (contracting of external companies for the provision of services)
- **DGUV Information 240-300 „Handlungsanleitung für die arbeitsmedizinische Vorsorge nach dem Berufsgenossenschaftlichen Grundsatz G 30 „Hitze“** (instructions for preventive occupational medical care in accordance with the DGUV Principles G 30 concerning heat)
- **DGUV Information 250-010 „Eignungsuntersuchungen in der betrieblichen Praxis“** (aptitude tests in plant practice)

Principles

- **DGUV Grundsatz 308-001 „Ausbildung und Beauftragung der Fahrer von Flurförderzeugen mit Fahrersitz und Fahrerstand“** (training and assignment of drivers of industrial trucks with driver’s seat and driver’s cab)
- **DGUV Grundsatz 309-001 „Prüfung von Kranen“** (testing of cranes)
- **DGUV Grundsatz 309-003 „Auswahl, Unterweisung und Befähigungsnachweis von Kranführern“** (selection, instruction and proof of competence of crane operators)

- **DGUV FB AKTUELL FBFHB-006 „Einsatz von Löschdecken“ des Sachgebiets Betrieblicher Brandschutz, Fachbereich „Feuerwehren, Hilfeleistungen, Brandschutz“ FBFHB-006** (use of fire blankets; produced by the In-plant fire protection Subcommittee of the DGUV Fire and emergency services, fire prevention and protection Expert committee)

Standards

Source:
Beuth-Verlag GmbH, Burggrafenstrasse 6, 10787 Berlin, Germany and VDE-Verlag, Bismarckstrasse 33, 10625 Berlin, Germany

- **DIN 13157:2009-11 „Erste-Hilfe-Material – Verbandkasten C“** (First aid material – First aid box C)
- **DIN 13169:2009-11 „Erste-Hilfe-Material – Verbandkasten E“** (First aid material – First aid box E)
- **DIN 14095:2007-05 „Feuerwehrpläne für bauliche Anlagen“** (Ground plans for components for buildings for fire service use)
- **DIN 15400 – DIN 15406 „Lasthaken für Hebezeuge“** (Lifting hooks)
- **EN 60519-1 /VDE 0721 Teil 1: 2017-06 „Sicherheit in Elektrowärmeanlagen und Anlagen für elektromagnetische Bearbeitungsprozesse:2017-06; Allgemeine Anforderungen“** (Safety in installations for electroheating and electromagnetic processing – General requirements)
- **EN 60519-2/VDE 0721 Teil 2: 2007-05 „Sicherheit in Elektrowärmeanlagen; Besondere Anforderungen an Anlagen mit Widerstandserwärmung“** (Safety in installations for electroheating and electromagnetic processing – Particular requirements for resistance heating equipment)
- **EN 60398/VDE 0721 Teil 50:2016-02 „Elektrowärmeanlagen und Anlagen für elektromagnetische Bearbeitungsprozesse – Allgemeine Funktions-Prüfverfahren“** (Installations for electroheating and electromagnetic processing – General performance test methods)
- **DIN ISO 4309:2013-06 „Krane – Drahtseile – Wartung und Instandhaltung, Inspektion und Ablage“** (Cranes – Wire ropes – Care and maintenance, inspection and discard“

Further sources

Arbeitsgemeinschaft Wärmebehandlung und Werkstofftechnik e.V. (AWT)

- **„Bausteine für die Qualifizierung von Mitarbeitern in der Härterei“**
  (modules for the training of workers in the hardening shop; last amended 11/2014)
- **„Handlungshilfe für Härtereien bei der Gefährdungsbeurteilung – Gefährdung durch Bildung von gefährlichen explosionsfähigen Atmosphären“**
  (guide to risk assessment for hardening shops: hazards caused by the formation of dangerous explosive atmospheres)
- **Sicherheitstechnische Empfehlungen für den Betrieb von Industrieöfen mit Prozessgasatmosphären**
  (safety recommendations for the operation of industrial furnaces employing process gas atmospheres)
  https://www.awt-online.org/fachausschuesse/fa_8_sicherheit_in_waermebehandlungsbetrieben.html

- **Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BauA), Leitmerkmalmethode zur Beurteilung von Heben, Halten, Tragen**
  (key indicator method for the assessment of pushing and pulling)

- **Bundesministerium für Verkehr, Merkblatt für Stapler**
  (code of practice for fork-lift trucks)

Berufsgenossenschaft Handel und Warenlogistik (BGHW)

- **SP 02 „Batterieladeanlagen für Flurförderzeuge“**
  (battery charging systems for industrial trucks)
- **SP 07 „Einsatz von Flurförderzeugen im öffentlichen Straßenverkehr“**
  (use of industrial trucks on public roads)

- **Berufsgenossenschaft Rohstoffe und chemische Industrie (BG RCI), T021 „Gaswarneinrichtungen für toxische Gase/Dämpfe und Sauerstoff“**
  (gas detectors for toxic gases/vapours and oxygen)
  http://www.gischem.de

- **Deutsche Gesetzliche Unfallversicherung (DGUV), DGUV FB AKTUELL FBFHB-006 „Einsatz von Löschdecken“ des Sachgebiets Betrieblicher Brandschutz, Fachbereich „Feuerwehren, Hilfeleistungen, Brandschutz“ FBFHB-006**
  (use of fire blankets; produced by the In-plant fire protection Subcommittee of the DGUV Fire and emergency services, fire prevention and protection Expert committee“)

- **Industriegaseverband e.V., Infoblatt SICHERHEITSHINWEISE: „Umgang mit tiefkalt verflüssigten Gasen“**
  (information sheet:“safety instructions: handling of cryogenic liquified gases“)
  http://www.industriegaseverband.de/Downloads

4.2 Annex: Structural requirements set out in DGUV Regel 109-007 (concerning guidelines for the heat treatment of steel and other heavy metals in salt baths; formerly BGR 153)

Knowledge of the requirements to which plants were subject at the time of their placing on the market may be useful for their assessment when in operation. The requirements of BGR 153 (formerly ZH 1/412), April 1990 edition, were binding for a long time for plants employing salt baths for the heat treatment of metals.

Excerpt from BGR 153, containing guidelines for the heat treatment of steel and other heavy metals in salt baths, April 1990 edition, concerning structural requirements:

2. Definitions

2.1 Examples of equipment in this context are equipment for ventilation, temperature control and limitation, charging, extraction, washing and cleaning, ancillary equipment and quenching baths.

2.2 Salt baths in the sense of this rule are furnaces heated electrically or by combustible fuel for the heat treatment of workpieces in molten salt. During normal operation the furnaces are filled with molten salt.

...

2.4 Temperature control devices in the sense of this rule are devices which control the heating power as a function of the measured temperature of the molten salt.

2.5 Temperature limiting devices in the sense of this rule are safety devices which prevent permissible temperatures of the molten salt from being exceeded.

4.5 Temperature control and temperature limiting devices

4.5.1 Salt baths must be equipped with temperature control devices.

4.5.2 Nitrate salt baths must be equipped with temperature limiting devices acting separately from the temperature control devices in such cases where the installed heat output allows the temperature of the molten salt to:

- Exceed 560 °C in furnaces employing steel crucibles
  Or
- Exceed 650 °C in furnaces employing crucibles of heat-resistant and scale-resistant steel.

The temperature limiting devices must switch off the salt bath furnaces automatically when the maximum permissible temperature of the molten salt is exceeded, and must also prevent the furnaces from being switched on again automatically.

Temperature control and temperature limiting devices acting separately must each possess dedicated temperature sensors and switching devices (valves, contactors).

Fuses are examples of temperature limiting devices.

4.5.3 Sensors for temperature control and temperature limiting devices must be situated such that they are not damaged when the salt bath is charged.

4.5.4 The sensors of the temperature limiting devices must be situated at the points in the molten salt at which the highest temperatures are anticipated.

4.5.5 Equipment for measuring, controlling, limiting and indicating the temperature of the molten salt must be situated or covered such that it is protected against direct thermal radiation and salt spatter.

4.6 Disconnection from the power supply

4.6.1 Facility must be provided for salt baths and upstream and downstream equipment for treatment to be disconnected from the power supply.

This is achieved for example by means of fuses, plugs or plug-in couplings or main control devices in accordance with Section 4.6.2.

Isolation from the power supply is necessary for example for the performance of maintenance or repair work.

4.6.2 Salt bath installations must be equipped with a separate main control device for each form of energy.

The following constitute salt bath installations:
- *Salt baths.*
- *Facilities for treatment upstream and downstream of the salt bath.*
  Or
- *Salt baths with facilities for treatment upstream and downstream of the salt bath which are connected to a common power supply.*

Examples of main control devices are main switches and main valves.

With regard to main switches, see DIN VDE 0721-911, Industrial electroheat installations; general safety regulations

4.6.3 Facility must be provided for main control devices to be operated from outside the danger zone.

The danger zone is the area in which persons may be at risk of injury or harm, for example by thermal radiation, spatter of hot molten substance or liquids, open flames, hot workpieces, substances presenting a health risk, and crushing and shearing points.

4.6.4 Main switches shall be able to be secured against inadvertent or unautorized activation in the off-position.

4.6.5 Actuators of main control devices must be easily accessible and be designed, situated and identified such that their assignment, direction of operation and operating state are clearly identifiable.

...

4.11 Water supply to the plant

Water for the water quenching baths must be supplied through pipes with unobstructed inlets.

Where supply pipes are immersed in the quenching water, reverse suction and thus discharge of quenching water is possible.

4.3 Annex: Structural requirements set out in DGUV Vorschrift 59 concerning the heat treatment of aluminium and wrought aluminium alloys in nitrate salt baths (formerly BGV D14)

Knowledge of the requirements to which plants were subject at the time of their placing on the market may be useful for their assessment when in operation. The requirements of BGV D14 concerning the heat treatment of aluminium and wrought aluminium alloys in nitrate salt baths (in the version of 30 March 2007) were for a very long time binding for plants for this purpose.

Excerpt from BGV D14 concerning the heat treatment of aluminium and wrought aluminium alloys in nitrate salt baths (in the version of 30 March 2007) regarding structural requirements:

I. Scope
Section 1 Scope
This accident prevention regulation governs the heat treatment of aluminium or wrought aluminium alloys with a magnesium content of up to 10 % in salt baths of potassium nitrate, sodium nitrate or their mixtures (nitrate salt baths).

Implementation instruction:
Salt baths of this kind generally employ mixtures of potassium nitrate and sodium nitrate salts in ratios of 1 : 4 to 1 : 2. Commercial salt mixtures may also contain nitrite and colour additives for the purposes of identification. For certain materials that must not be treated in salt baths of this kind, refer to Section 11.

II. Definitions
Section 2 Definitions
(1) Aluminium in the sense of this accident prevention regulation is ultra-pure aluminium or pure aluminium.

Implementation instruction:
For the composition of ultra-pure aluminium and pure aluminium, refer to DIN 1712-1, Aluminium; Ingots and DIN 1712-3, Aluminium; Half-finished products.

(2) Wrought aluminium alloys in the sense of this accident prevention regulation refers to aluminium alloys which are processed into semi-finished products in the plastic state (e.g. rolling, extrusion, drawing, forging).

Implementation instruction:
For the composition of wrought aluminium alloys, see DIN 1725-1, Aluminium alloys; Wrought alloys. The maximum magnesium content is governed by Section 1 of this accident prevention regulation.

...

(4) Heat treatment installations in the sense of this accident prevention regulation are the nitrate salt bath (the container and the molten salt within it) and the heating, temperature monitoring and other safety equipment.

(5) Containers in the sense of this accident prevention regulation are baths, crucibles or other vessels for holding the molten salt.

(6) Heating equipment in the sense of this accident prevention regulation is equipment located inside or outside the container with the function of attaining and maintaining the required temperature of the molten salt.

(7) Temperature monitoring devices in the sense of this accident prevention regulation are equipment for measuring and controlling (temperature control equipment) and limiting (temperature limiting equipment) the relevant permissible temperature of the molten salt.

(8) Sludge in the sense of this accident prevention regulation comprises impurities in the molten salt which settle on the bottom of the container, such as scale from the container or residues of lubricants on the treatment material.

III. Construction and equipment
Section 3 Characteristic data
(1) The following information must be marked clearly and permanently on each heat treatment plant:
- Manufacturer or supplier
- Type or model number
- Year of manufacture

(2) In addition to the data stated in Paragraph 1, the following must be applied:

a) On electric heating equipment:
– Rated voltage
– Rated current
– Total electrical output (connected load)
– Type of current
– Frequency

b) On gas heating equipment:
– Gas type
– Maximum permissible gas pressure
– Total fuel output (connected load)

Implementation instruction:
For the designations of heating equipment, refer to DIN 24 201, Industrial furnaces; heating and heat-treating furnaces; concepts

(3) Each container must be marked permanently with the following information:
– Manufacturer or supplier
– Type or model number
– Year of manufacture
– Maximum permissible container temperature

Section 4 Container material
Containers must be made of material resistant to scaling and corrosion.

Implementation instruction:
Examples of materials resistant to scaling and corrosion are Armco or calorized iron.

Section 5 Container covers
Containers must be equipped with covers that prevent persons or objects from falling into them and melt from spattering out.

Section 6 Heating equipment
(1) Heating equipment for nitrate salt baths may employ only electric current or gas for heating purposes.

Implementation instruction:
The most important technical rules for the heating of nitrate salt baths are:
– *DIN 57116/VDE 0116, Electrical equipment of furnaces*
– *VDE 0721 Part 2b, Industrial electroheat installations*
– *DIN 4788-2, Induced and forced draught gas burners*
– *DIN 4788-3, Gas Burners; Flame Monitoring Devices, Flame Monitors, Control Devices and Automatic Firing Units*
– *DVGW-Arbeitsblatt G 610 concerning gas burners on industrial furnaces*

(2) Where the interior of the container is heated electrically, it must be ensured that neither charging equipment nor workpieces are able to rest on the heating pipes.

(3) Heating pipes must be situated such that sludge can settle only below the pipes.

(4) Gas heating systems must be equipped with automatic ignition and low-pressure cut-off devices. Observation of the flame must be possible.

(5) Gas heating equipment must be designed such that the container is not in direct contact with the flames.

(6) Gas heating equipment must be designed such that soot does not form.

Implementation instruction:
The avoidance of soot formation requires not only a suitable design, but also optimum adjustment of the gas burners.

(7) Heating equipment must be situated such as to exclude the possibility of local overheating.

Implementation instruction:
Local overheating may also cause chemical reactions within the bath, leading to explosions.

Local overheating can occur owing to:
– *Uneven heating*
– *Insufficient clearance between heating equipment and container*
– *Sludge deposits on the bottom of the tank*

(8) It must be possible for the heating equipment to be switched off manually from a safe location. The switching position of the switching device for electric heating and the shut-off device for gas heating must be clearly identifiable.

(9) When solidified bath contents are melted, the type of heating equipment and its location must be such that during heating, contents of the bath that are still solid are prevented from being ejected from the container by the pressure of gasses trapped in the salt.

Implementation instruction:
This pressure can be prevented from building up when for example the gas is able to escape through salt that has already melted. On deep baths with internal electric heating, it may be necessary for channels first to be melted into the solidified bath contents by means of a vertical heater arrangement, such has heating bars, before heating proper is initiated.

Should a bottom heating system be required in addition to the side heating system on baths with external heating, the requirement can be met for example when
- *Side and bottom electric heating can be activated separately.*
  Or
- *A gas-heated furnace system is designed such that the side walls are heated first.*

Section 7 Temperature monitoring devices
(1) Nitrate salt baths must be equipped with temperature control devices which is designed to prevent the maximum permissible temperature of the molten salt from being exceeded. The temperature of the molten salt detected by the sensors must be displayed visibly and recorded graphically..

(2) Nitrate salt baths must be equipped with temperature limiters which function separately from the temperature control equipment. The temperature limiters must switch off the heating equipment automatically and at the same time issue a reliably perceptible warning signal when the maximum permissible temperature of the molten salt for the hardening material concerned is exceeded.

Implementation instruction:
The maximum permissible temperature of the molten salt depends on the magnesium content of the hardening material (see also Section 10).

Owing to the requirement for temperature control and limiting devices to act independently of each other, these devices must also have separate temperature sensors.

The warning can be acoustic or visual, depending on the operating conditions.

(3) The temperature monitoring devices must be situated such that it is protected against melt spatter ejected from the container.

(4) The measuring sensors must be situated such that they are not damaged during charging of the bath.

Section 8 Additional safety devices
(1) Nitrate salt baths must be equipped with an additional safety device which switches off the heating equipment safely and triggers a reliably perceptible warning device when the molten salt exceeds a temperature of 560 °C. This safety device must act independently of the temperature limiting devices described in Section 7 (2).

Implementation instruction:
The molten salt temperature of 560 °C is that which must not be exceeded in nitrate baths even when no hardening material is present. This maximum temperature should not be confused with the temperatures stated in Section 10 for heat treatment of the hardening material according to the magnesium content.

(2) Once the supplementary safety device has tripped, it must not be possible for the heating equipment to be restarted until the safety element which is no longer effective has been replaced by a functional element.

Implementation instruction:
Examples of effective safety elements are suitable fuses.

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