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Technical Rules for Hazardous Substances	Identification and Assessment of the Risks from Activities involving Hazardous Substances: Inhalation Exposure	TRGS 402

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

Committee on Hazardous Substances (AGS)

establishes the rules and adapts them according to the state of development. The TRGS are announced by the Federal Ministry of Labour and Social Affairs (BMAS) in the Joint Ministerial Gazette (GMBl).

Contents

1 Scope

(1) According to Section 7 of the Hazardous Substances Ordinance the employer has the duty to identify and assess extent, type and duration of the inhalation exposure. According to TRGS 400 "Risk assessment for activities involving hazardous substances" the present TRGS is to be applied in the identification and assessment of inhalation exposure if

1. workplace measurements are provided for in the effectiveness check with the application of standardised working procedures (see number 1 (3)) or
2. no standardised working procedures are applied with activities involving hazardous substances.

(2) The present TRGS is not to be applied if activities involving a low risk according to number 6.2 of TRGS 400 are being carried out.

(3) Standardised working procedures and the conditions of their application are listed in number 5.1 of TRGS 400. These include

1. a provided risk assessment,
2. a substance-specific or activity-specific TRGS, in particular process-specific and substance-specific criteria according to TRGS 420 "Process- and substance-specific criteria (VSK) for the risk assessment",
3. concrete measures or procedures for a sector-specific or activity-specific aid,

where these can be transferred directly to the activities being assessed.

(4) The methods and procedures described serve to establish whether the protective measures taken are adequate with respect to inhalation exposure or whether additional measures according to GefStoffV and part 1 of the Annex to the Ordinance on Occupational Health Care must be taken.

2 Definitions

(1) In the present TRGS the terms are used as defined in the "Glossary of terms for the regulations of the Plant Safety Ordinance (BetrSichV), Biological Agents Ordinance (BioStoffV) and the Hazardous Substances Ordinance (GefStoffV)" [1] of ABAS, ABS and AGS. This applies in particular to the terms: working conditions, agent, sector-specific or activity-specific aids, chemical agents, exposure, occupational exposure limit, knowledgeable persons for the performance of the risk assessment, risk, risk assessment, list of hazardous substances, skin contact, provided risk assessment, physicochemical action, protective measures, effectiveness of protective measures.

(2) For reasons of the identification strategy it may be necessary to bring together activities by fixing a working area. The working area is the spatially or organisationally delimited part of a company in which activities involving hazardous substances are carried out by one or more workers and can be brought together in a risk assessment. It may encompass one or more workplaces or working processes.

(3) An inhalation exposure applies when hazardous substances are present in the air in the workers' breathing zone. Their extent is described by their concentration and the duration of their occurrence (in relation to time). To compare the inhalation exposure with occupational exposure limits according to TRGS 900 "Occupational exposure limits" the reference must be related to a period of eight hours. In the case of exposure peaks the time reference is the duration of short-time value phases according to TRGS 900.

(4) A workplace measurement is the identification by measurement of the inhalation exposure of the workers.

(5) A lead component of a substance mixture in the air is a substance which is collected and assessed as representative for all substances or a group of substances. The exposure assessment with reference to a lead component is possible if the concentration ratios of the components in relation to one another in the air have remained constant in the long term. The lead components are fixed within the framework of the identification of the inhalation exposure.

(6) The averaging time is the time span for which the measuring procedures used yield a measured value. It is determined by the time behaviour of the measuring procedure and normally corresponds to the sampling time.

(7) Relevant parameters are the influencing parameters which affect the extent of the inhalation exposure being assessed. They include among others the duration of the exposure, activities, the heaviness of the work, temperature etc. They are obtained from the information concerning the activities involving hazardous substances according to number 4.2[1].

(8) The worst case describes in the present TRGS a situation in which the parameters in the working area being assessed or during the activities being assessed give rise under the worst or realistic operating conditions to an upper limit for the exposure. Parameters which exert an influence on the exposure include, for example, a great workload, a large material consumption, short cycle times, poor ventilation conditions or an unfavourable ergonomic situation.

(9) The finding is the result of the check of the effectiveness of protective measures.

(10) The effectiveness of the protective measures is checked at regular or specially fixed intervals by the establishment of findings. This is done either by measuring technical parameters or by control measurements.

(11) By conducting measurements of technical parameters a check is made within the framework of the establishment of findings after completion of the risk assessment under the conditions and at the intervals laid down in the finding whether the finding is still valid. This preferably includes technical performance criteria which can be checked by measurements using simple means (see also TRGS 500 "Protective measures").

(12) Control measurements are workplace measurements at fixed intervals which may become necessary if measurements according to paragraph 11 are not possible or purposeful.

[1] Relevant parameters correspond to the "Exposure Determinants" in the English specialist literature.

(13) The identification result (as a shift average value) is the result

1. of the non-measuring or
2. the measuring (measured result)

identifications concerning the inhalation exposure. To be able to assess all concentration values determined in the same way, they are prepared in such a way that an identification result is obtained which relates in terms of time to a period of eight hours (examples of the conversion can be found in DIN EN 689) [2]. In the same way short-time values are identified according to TRGS 900 in relation to a period of 15 minutes.

(14) Suitable assessment methods to check the effectiveness of the protective measures taken with activities involving hazardous substances encompass measuring and non-measuring identification methods as well as assessment.

(15) As an alternative to workplace measurements non-measuring identification methods facilitate an effectiveness check with the help of

1. calculations of the hazardous substance concentration (qualified exposure estimation) or measurements which make it possible to conclude the hazardous substance exposure indirectly, e.g. with the help of lead components,
2. technical and organisational test specifications which relate to the measures laid down (see TRGS 500) or
3. the transfer of results for comparable workplaces.

(16) Assessment criteria include:

1. binding occupational exposure limits,
2. concentration values given in a TRGS to trigger measures or limitations of exposure (e.g. state of the art) and
3. other criteria for the assessment of the exposure according to number 5.3.2.

(17) Binding limit values include occupational exposure limits OEL according to TRGS 900 and binding occupational exposure limits of the EU as published by the Federal Ministry of Labour and Social Affairs under GefStoffV.

(18) Ex-company measuring bodies are bodies not internal to companies which act on the instruction of employers to conduct an identification, measurement and assessment of the concentrations of hazardous substances in the air in working areas.

(19) In-company measuring bodies are those which are instructed by their employer to identify, measure and assess in their own company the concentrations of hazardous substances in the air in working areas.

3 Instructions relating to the risk assessment

(1) Activities involving hazardous substances may result in the intake of hazardous substances by inhalation (inhalation exposure to gases, vapours and aerosols), by swallowing (oral intake) and by skin contact (dermal exposure). The required identifications and documentations for the result of risks which may result from this are dealt with in TRGS 400. In the case of dermal exposure and inhalation exposure it may be necessary to conduct additional identifications and assessments, and these are dealt

with in TRGS 401 "Risks resulting from skin contact: identification - assessment – measures" or the present TRGS.

(2) The identification and assessment of inhalation exposure must be conducted for all hazardous substances arising in the workplace air. The occupational exposure limits laid down in TRGS 900 serve as an assessment criterion for a series of hazardous substances. For substances which do not have an occupational exposure limit other suitable assessment criteria or a different assessment procedure must be used.

(3) There are a variety of possibilities available for identifying the inhalation exposure. In many cases exposures can simply be estimated, e.g. from the quantity of substances used and the air volume at the workplace. With small substance quantities and large air throughput in particular it is often not then necessary to conduct any more extensive identifications. More elaborate calculation approaches or the transfer of the identification results for comparable workplaces may also help to reduce the identification effort. If there is still uncertainty concerning the identification result and its evaluation, workplace measurements are necessary. It must be taken into account here, however, that under certain boundary conditions workplace measurements are not possible or meaningful because they will not yield any usable or representative results, for example (see number 4.4 (5) and (6)).

(4) Identifications conducted under worst case conditions can be recommended since they provide a greater certainty that they will be complied with under the usual conditions of the occupational exposure limit or another assessment criterion.

(5) The identifications and assessments relating to inhalation exposure may require special expertise and experience, depending on the nature of the case. They include in particular workplace measurements. The present TRGS gives employers instructions as to when he reaches the limits of his own specialist qualifications and where he can obtain further assistance. By giving the employer ideas for pragmatic solutions an attempt is made, however, to highlight his possibilities for a reasonable limitation of the identification effort.

4 Procedure for the identification of inhalation exposure

4.1 General remarks

(1) To identify the inhalation exposure and the resulting risk the relevant parameters of the activities involving hazardous substances and the concentrations of the hazardous substances in the air at the workplace are determined. A finding is also drawn up which contains statements on the effectiveness of the protective measures in place and stipulations relating to possible further measures, including the check of their effectiveness (Figure 1).

(2) The identification of the inhalation exposure is broken down into the following steps:

1. recording and description of the activities and establishment of the working area for which the assessment of the inhalation exposure is to apply,
2. recording of the hazardous substances and
3. identification of the exposure.

(3) On the basis of the results of the identification of inhalation exposure, an assessment of the effectiveness of the protective measures is conducted within the framework of a finding. To back up the finding regular effectiveness checks of the protective measures are necessary. The nature of the effectiveness checks to be conducted is laid down in the finding.

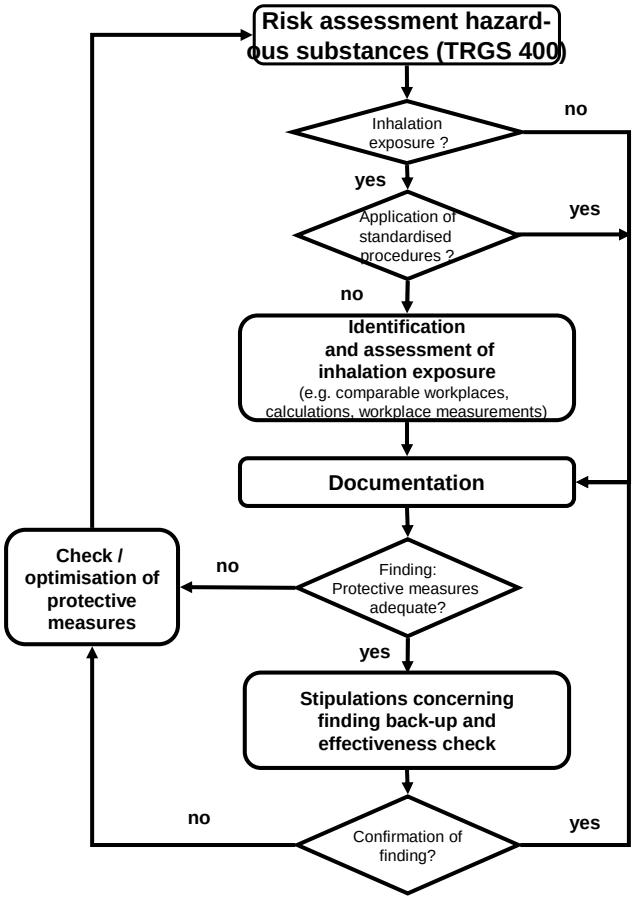

Figure 1: Identification and assessment of the inhalation exposure (diagramatic)

4.2 Recording and description of the activities and establishment of the working area

(1) The recording of the activities and the possible risks is a prerequisite for establishing the working area. The working area can be fixed in terms of locality or organization by indicating, for example,

1. the spatial delimitation,
2. the activities or procedure(s),
3. the type of installation or work equipment.

(2) On the basis of the company-specific information the activities including the technical and organisational details which may be relevant to the exposure (relevant parameters) must be described. Normally it is useful to take over the identification results according to number 4 of TRGS 400 and to extend them to include the conditions which influence the inhalation exposure.

(3) The relevant parameters may include:

1. the task and aim of the activities (e.g. articles, products, service),
2. the work equipment (e.g. welding burners, paintbrushes, forklifts),
3. the procedure (e.g. open, closed, under dust development),
4. the working capacity (e.g. throughput, area capacity),
5. the work organisation (e.g. dwell time/exposure duration, parallel exposures, position of the workers in relation to the substance source),
6. type and quantity of the substances and products used (e.g. designation, physical state, dusty, aerosol-forming, concentrations of the substances),
7. emission locations,
8. technical protective equipment (e.g. type and capacity of the extraction system, housing),
9. corporate fire and explosion safety measures,
10. spatial conditions (e.g. base area, room height, spatial breakdown, degree of room space utilisation),
11. the ventilation conditions (e.g. type of ventilation, ventilation equipment, air guidance, ventilation intensity) and
12. personal protective measures.

4.3 Recording of the hazardous substances

On the basis of the list of hazardous substances (see number 4.7 of TRGS 400) the substances relevant to the inhalation exposure must be selected. The major information for the assessment of the inhalation exposure with respect to the substances in the input substances, intermediate products, end products, reaction products and auxiliary substances as well as their pollutants must be determined. Where not already in the list of hazardous substances, escaping hazardous substances must also be recorded (e.g. diesel engine emissions, welding fumes and dusts). It must be considered that in the analytical evaluation of samples additional substances may be identified which are relevant to inhalation exposure. For the hazardous substances the binding occupational exposure limits (see number 5.2) must be given with the related short-time values and the classification. Furthermore it is appropriate to give information on the release capability of the substances (e.g. formation of dust deposits, volatility). If there are no limit values available, other criteria must be given for the risk assessment (see number 5.3.2).

4.4 Identification of the inhalation exposure

(1) The employer must identify the type, extent and duration of the inhalation exposure.

(2) Where the identification results according to TRGS 400 indicate that for process-related and/or substance-related reasons only minor or negligible exposures are to be expected, no further identifications are needed according to this TRGS. This may be the

case, taking account of the toxicological substance properties, if

1. the release capability is low because of the working conditions and the substance properties (e.g. low vapour pressure, high boiling point with low processing temperature, low dust-forming behaviour),
2. the procedure cannot give rise to the formation of aerosols,
3. only small quantities are used or
4. only low emissions are possible, for example because of small source surfaces or short activity duration (< 15 min), or
5. the release of substances into the air at the workplace is not possible (e.g. chloride determination according to Mohr in chemical laboratories).

(3) There are many different possibilities to identify inhalation exposure and they are to be applied in accordance with the different requirements and practical conditions. Preferably non-measuring identification methods should be applied, such as the transfer of results from comparable workplaces or calculations (Annex 2). Where there are residual uncertainties concerning the level of exposure and in the case of activities involving CMR substances, measuring-based identification methods (Annex 3) must be used, taking account of paragraphs 5 and 6. Instructions concerning identification can be found, for example in DIN EN 689 [2].

(4) Measuring-based and non-measuring identification methods may be used to complement one another. For example, the results of calculations can be used to make a controlled use of workplace measurements ("Calculations as the basis for measurement planning"). Non-measuring identification methods can also be based on measurements, e.g. transfer of results from comparable workplaces. Annex 5 specifies possible uses for suitable identification methods with reference to examples.

(5) Under certain boundary conditions the performance of workplace measurements is not possible or fails to yield any usable or representative results. These include

1. excessively brief exposure periods,
2. there is no suitable measuring procedure (cross-sensitivity),
3. unfavourable climatic conditions (e.g. high wind speeds or temperatures, wet workplaces (use of high-pressure cleaners)),
4. certain jobs in the open.

(6) Measuring procedures for the performance of workplace measurements are suitable if they satisfy the performance requirements of DIN EN 482 [3].

4.5 Requirements for persons or bodies performing identifications and assessments of inhalation exposure according to GefStoffV

(1) For the identification and assessment of inhalation exposure, the employer may only delegate knowledgeable persons and bodies under GefStoffV. The knowledge required goes beyond the general requirements according to TRGS 400 and, depending on the scope and complexity of the task it encompasses knowledge relating to hazardous substances and identification methods.

(2) Employers who do not have access within their company to the necessary knowledge and the essential prerequisites must delegate knowledgeable external bodies to identify and assess the inhalation exposure. Knowledgeable bodies include in particular accredited measuring bodies. It is recommended to the employer that he delegate bodies who conduct safety consulting in addition.

(3) If the inhalation exposure for a particular activity is identified using measuring identification methods, the measuring body must satisfy the requirements specified in Annex 1. If the employer delegates a measuring body that is accredited for workplace measurements, he may assume that the measuring body satisfies the requirements according to Annex 1 and that the knowledge facts determined by this body are relevant[2] If measurements are to be conducted by a measuring body not accredited for workplace measurements, the employer must check whether the measuring body satisfies the requirements specified in Annex 1.

(4) If the inhalation exposure for a particular activity is to be identified using non-measuring identification methods according to Annex 2, it is appropriate to refer to the requirements regarding knowledge and reporting according to Annex 1.

(5) The requirements according to paragraph 2 may be restricted for in-house measuring bodies and may be adapted to the identifications and assessments actually to be performed in the company context. This provision may be applied, for example, if identification of inhalation exposure using simple measuring methods is possible for a particular activity as a function of the company's specific circumstances. In such cases it must be laid down within the framework of the risk assessment what requirements must be satisfied. The quality of the identifications and assessments must be ensured for all individual cases, however.

4.6 Identifications of the exposure to carcinogenic, mutagenic and fertility-toxic hazardous substances according to GefStoffV

(1) In the case of carcinogenic, mutagenic and fertility-toxic substances it is necessary to determine within the framework of the risk assessment exposures according to the requirements of the present TRGS, although in consideration of TRGS 400 number 3.2 (3) it is also possible to transfer results obtained with working conditions of an identical kind.

(2) In view of the special significance of exposure to these substances, under GefStoffV the exposures due to an unforeseen event (see Annex 5 No. 9) of an accident must be determined in addition. This may involve, for example, the measurement of technical parameters or measurements within the framework of continuous monitoring.

[2] List of accredited measuring bodies: http://www.bua-verband.de/gefahrstoffmessstellen.html

5 Assessment of the exposure and the effectiveness of the protective measures

5.1 General remarks

(1) The exposure identified according to number 4.4 must be assessed with respect to a risk to workers and the effectiveness of the protective measures. The result of the assessment is the finding. The finding must be justified and documented. The finding also includes stipulations for the establishment of findings according to number 6.

(2) The finding may be:

1. Protective measures adequate,
2. Protective measures not adequate.

(3) For substances with a binding occupational exposure limit the finding can be justified expertly according to number 5.2.2 (3) or, if this is not possible established with the help of the formal procedure described in number 5.2.2 (4). For substances with no binding occupational exposure limit the assessment criteria given in number 5.3 can be applied.

(4) If a number of substances contribute simultaneously or successively to the exposure in a working area during a shift, an assessment of the mixed exposure must be performed. For substances with an occupational exposure limit the procedure according to number 5.2.1 must be applied. Where binding occupational exposure limits or assessment criteria are given in number 5.3 for defined substance mixtures, number 5.2 must be applied as appropriate.

(5) For substance mixtures with substances without an occupational exposure limit the criteria according to number 5.3 must be applied.

(6) The monitoring of substance mixtures by measurement may be conducted where relevant with the help of lead components. The lead components and an assessment criterion must be laid down within the framework of the identification and assessment of the inhalation exposure. Criteria for the selection of lead components and the applicability of the procedures include:

1. the toxicity of the individual substances, their concentration fractions in the air and the possibility of recording them analytically,
2. constant concentration ratios of the components in relation to one another in the air and
3. the assessment criterion ensures that at least the evaluation index according to number 5.2.1 is complied with.

(7) For substances which fall within the scope of the general dust limit value, the provisions of TRGS 900 must be applied in the assessment of dusts.

(8) If the measuring procedure is not specific, the cumulative reading must be referred to for the assessment. If a number of occupational exposure limits can be considered in this case for the assessment, the lowest limit value in each case must be taken as the basis (e.g. for occupational exposure limits for different species such as tin(II) and tin(IV)).

(9) The assessment criteria given in number 5.2 and number 5.3.1 (2) are specified as shift average values. The short-time values must be complied with in addition to limit the exposure peaks.

5.2 Substances with a binding occupational exposure limit

(1) Occupational exposure limits according to GefStoffV are given in TRGS 900.

(2) In addition to occupational exposure limits, binding occupational exposure limits (BOELs) of the EU must be complied with. These have been implemented in terms of national law by announcements of the BMAS under GefStoffV, where the BMAS has not announced any other assessment criteria (e.g. in a TRGS).

5.2.1 Substance and evaluation index

(1) To ensure the comparability of identification results, the substance index I is obtained from the result (shift average value) of the individual substances by dividing by the relevant binding limit value according to number 5.2:

$$I = \frac{C}{GW}$$

C is the shift average value and GW the limit value for the substance according to number 5.2. As a limit value for the individual substance, the substance index I = 1 applies.

(2) Where a number of substances contribute to the exposure in the working area simultaneously or successively during a shift, the evaluation index BI is calculated for the substance with an OEL from the substance indices of the individual substances by addition:

$$BI_{AGW} = \sum \mathrm{I_i} = \frac{C_1}{AGW_1} + \frac{C_2}{AGW_2} + ... \frac{C_n}{AGW_n}$$

As a limit value the evaluation index BI = 1 applies. It is possible to deviate from this evaluation procedure in an individual case if this is justified by occupational medical or toxicological reasons. For short-time values no evaluation index is determined.

(3) If, in addition to substances with an OEL, other substances are present for which the employer has referred to other assessment criteria or laid down other assessment criteria, the evaluation index (for substances with OEL) and in addition the other assessment criteria according to number 5.3 must be referred to for the assessment.

5.2.2 Establishment of a finding

(1) For substances with a binding occupational exposure limit, the substance and evaluation indices are referred to in order to establish the finding.

(2) The finding "Protective measures not adequate" applies when the limit value is not adhered to, the evaluation index BI is greater than 1 or the short-time requirements are not met (limit value exceeded). In such a case exposure-reducing measures must be taken without delay and then a new identification of the inhalation exposure must be

performed.

(3) If the substance or evaluation indices are smaller than or equal to 1 and the short-time requirements are met (limit value adhered to), it is nevertheless not possible to justify the finding "Protective measures adequate" with this alone on account of the chronological and spatial fluctuations of the inhalation exposure for activities involving hazardous substances. Rather it is necessary to justify why in future the conditions for the finding "Protective measures adequate" is expected. Justifications include for example

1. Identifications for the worst case

   The identifications were conducted for unfavourable conditions in such a way that lower exposures can be expected in a normal case.

2. Relevant boundary conditions are stable in the long term

   It is ensured that the relevant boundary conditions change only to a minor degree in the long term and so comparatively small fluctuations in exposure can be expected. This can be demonstrated, for example, by results from control measurements from previous years.

3. Continuous monitoring

   By means of continuous monitoring suitable protective measures are triggered where a specified concentration is exceeded (see Annex 4).

4. Continuous effectiveness check

   By a constant or regular check of the effectiveness of the protective measures it is ensured that suitable protective measures are triggered as a function of specified criteria.

5. Experience of comparable workplaces

   Experience with comparable workplaces has shown that in the long term fulfilment of the conditions for the finding "Protective measures adequate" can be expected.

(4) If a justification according to paragraph 3 is not possible, a statistically justified formal procedure can be applied as an alternative: Where the short-time requirements are complied with the finding "Protective measures adequate" can be established according to DIN EN 689 (Annex D) [2] provided that

1. the evaluation index BI or substance indices in a shift are smaller than or equal to 0.1 or
2. identification results are available for at least three different shifts and all evaluation indices or substance indices are smaller than or equal to 0.25.

With the application of the formal procedure it must be ensured that the results available reflect representatively the circumstances at the workplace.

5.3 Substance without a binding occupational exposure limit (BOEL)

5.3.1 General remarks

(1) For substances with no BOEL, other assessment criteria must be referred to for the evaluation of the exposure. These can take account of possible acute and chronic

damage to health or they can yield information on the state of the art. Such assessment criteria are not occupational exposure limits within the meaning of Article 3 (6) of the Hazardous Substances Ordinance.

(2) Where for substances other criteria for the assessment of chemical exposures at the workplace are available, which are described by the Committee on Hazardous Substances (AGS) in the current TRGS (e.g. exposure levels and durations linked to the state of the art), they must be adhered to. For carcinogenic substances in particular there may still be a cancer risk even though the values are adhered to. More extensive measures to minimise the exposure must therefore be aimed at.

(3) For substances with no binding limit values it will not be possible to give a generally valid assessment scheme within the meaning of number 5.2.1. The employer must therefore lay down on his own responsibility or in accordance with the existing substance- or activity-specific TRGS the criteria (see number 5.3.2) for the assessment of the inhalation exposure. Where the assessment criteria referred to by the employer are limit values, it is recommended that number 5.2.1 and number 5.2.2 be applied accordingly.

5.3.2 Aids for the establishment of the finding

(1) Annex 5 gives examples and aids for the risk assessment for different activities and procedures.

(2) Even for activities involving hazardous substances for which there is no OEL the employer must perform protective measures whose effectiveness must be checked. For this purpose the employer can conduct measurements of suitable technical parameters to verify the effectiveness of the protective measures taken (see number 7(5) of TRGS 400). Examples include the measurement of the flow rate at an extraction facility, a check of the pressure conditions using automatic pressure display instruments in fresh air ventilated cabins or verification of the effectiveness of a ventilation system using flow sensors. Workplace measurements can also be used in such cases to check the effectiveness (lowering of the exposure level by the protective measure taken: "before-after measurement").

(3) As an aid for the assessment as to whether the protective measures taken are adequate, the following information from the extended safety data sheet according to REACH can be used for hazardous substances without binding occupational exposure limits or assessment criteria according to number 5.3.1 (2):

1. Implementation of risk management measures which are described in the exposure scenario of the extended safety data sheet for uses mentioned there where they meet the requirements relating to a provided risk assessment (TRGS 400 number 5.2 (3)).
2. If the employer deviates from the risk management measures described in the exposure scenario or the requirements for a provided risk assessment according to TRGS 400 are not met, the exposure can be assessed with reference to the DNEL given in the extended safety data sheet, where suitable measuring or non-measuring identification methods are available.

(4) Furthermore the following assessment criteria, among others, can be referred to after a correspondingly knowledgeable evaluation:

1. Limit value proposals of the DFG (German Research Foundation) Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area ("MAK Commission").
2. Indicative Occupational Exposure Limit Values according to directive 98/24/EC, where they have not yet been implemented in TRGS 900.
3. Limit value proposals for chemical exposures at the workplace from other scientific expert commissions (e.g. foreign limit values). A compilation of international limit values is given in the database "GESTIS International limit values for chemical agents" of the IFA [4].
4. Provisional target values which the employer himself lays down within the framework of his risk assessment (e.g. according to the concept for the formation of provisional occupational exposure limits according to TRGS 901 “Begründungen und Erläuterungen zu Grenzwerten in der Luft am Arbeitsplatz" *(Justifications and explanations concerning the limit values in the air at the workplace "*).

(5) For substances with no limit value or substance-specific TRGS in particular the following aids are useful, for example:

1. State of the art, e.g. described in Factsheets of the public accident insurance institutions, positive lists of equipment (BG test cert.: *http://www.dguv.de/bg-pruefzert/de/index.html#)*
2. Criteria for the assessment of chemical exposures at the workplace from sector-related or activity-specific aids (e.g. descriptions of exposure, EGU recommendations (recommendations for the risk identification of the accident insurance institutions), sectoral regulations, practical instructions for good working practice, "Easy-to-use Workplace Control Scheme for Hazardous substances [EMKG]" of the BAuA)

6 Establishment of findings

(1) At regular intervals or for special reasons a check should be made to establish whether the finding of "Protective measures adequate" arrived at is still valid. The intervals for the check must be laid down in the finding depending on the operating conditions; an annual interval is recommended, although as far as possible seasonal influences on the level of exposure should also be considered. Specific reasons for the check may include

1. a change in relevant boundary conditions,
2. a change in the relevant status of the identification procedures (measuring procedure, calculation model, …),
3. a change in the assessment criteria according to number 5, e.g. limit value changes or
4. other factors which were of importance for the establishment of the finding.

If the changes are of importance for the inhalation exposure, the finding must be updated.

(2) The methods, point in time and frequency of the effectiveness check are laid down within the framework of the identification and assessment of the inhalation exposure. It is left here to the knowledgeable user to fix the effectiveness check required in each case. Preferably simple technical methods must be stipulated for the effectiveness check, such as

1. the performance test of the ventilation system or
2. the testing of the response behaviour of warning and control devices (sensors).

(3) If there are no simple methods available for the effectiveness check or those available are not adequate, the checks must be conducted by means of regular control measurements according to a measuring procedure laid down within the framework of the identification and assessment of the inhalation exposure. As a rule it is useful to make the control measurements dependent on the level of the last measuring result obtained in the respective case. Instructions for the conduct of and dispensing with control measurements can be found in DIN EN 689 [2].

(4) Effectiveness checks can also be conducted with permanently installed measuring instruments (continuous monitoring, see Annex 4) if the measuring instruments are designed in such a way that they facilitate an exposure assessment and that the measuring results are recorded. The suitability of the measuring instruments must be checked within the framework of the identification and assessment of the inhalation exposure. Compliance with the short-time value requirements must also be adhered to here. Use of continuous monitoring is especially appropriate when acute risks or particularly high fluctuations in exposure cannot be discounted and measures to protect workers that are triggered by an alarm.

(5) Further control measurements can also be dispensed with if it is demonstrated by an adequate number of measuring results that the protective measures are adequate because of the level and spread of the substance and evaluation indices and of the level and duration of the exposure peaks. This may be the case, for example, if

1. all the preceding measuring results according to this TRGS were lower than the detection limit of the measuring procedure. If the detection limit of the procedure can be lowered because of an extended sampling time during the activity being assessed, this possibility should be used before further measurements are dispensed with.
2. the results of the workplace measurements are on a comparable level to the identification results (e.g. own measurements, information from environmental measuring networks) for the background exposure[3].

It must be ensured that the conditions will in future remain constant or changes will be recognised.

[3] The background exposure should be understood as the air concentration which would be present at the location of the activities involving hazardous substances if these activities were not being carried out.

7 Documentation

(1) The results of the inhalation exposure identified and assessed must be documented. The documentation must be such that all decision-making routes up to a finding can be traced. The documentation is of crucial importance for the evaluation of the results from exposure identifications. Without a complete documentation the exposure documentation is not complete.

(2) The documentation must contain at least information on the following items:

1. reasons and scope of the task,
2. establishment of the working area including its spatial and organisational description,
3. description of the activities involving hazardous substances,
4. type and quantity of the hazardous substances,
5. relevant boundary conditions (number 4.2.(3)),
6. identification method of the exposure,
7. identification results,
8. finding and
9. specifications for the establishment of findings

Furthermore the documentation can also contain instructions and suggestions for measures to be taken. Annex 1 contains requirements for the reporting. These requirements must be referred to for measuring identifications and assessments and appropriately for non-measuring identifications and assessments.

(3) The employer must establish provisions for the retention of the documentation. It is recommended that the documentation of the risk assessment be retained in the long term, especially for activities with carcinogenic, mutagenic or fertility-toxic hazardous substances of category 1 or 2.

8 Literature

[1] Glossary of terms: *www.baua.de/nn_57220/de/Themen-von-A-Z/Gefahrstoffe/Glossar/Begriffsglossar.pdf*

[2] DIN EN 689: Workplace atmospheres - Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy, April 1995

[3] DIN EN 482: Workplace atmospheres - General requirements for the performance of procedures for the measurement of chemical agents, October 2006

[4] Institute for Occupational Safety and Health of the DGUV - IFA: GESTIS – International limit values for chemical agents: *http://www.dguv.de/ifa/de/gestis/limit_values/index.jsp*

Annex 1 to TRGS 402

Requirements for measuring bodies which perform identifications and assessments of exposure, including requirements for reporting

1 General remarks

(1) For the identification and assessment of exposure the employer must make sure that measuring bodies working on his behalf have the requisite knowledge and the necessary equipment in order to be able to fulfil the relevant requirements of the present TRGS within the framework of his instructions. The employer must provide to the measuring bodies becoming active for him all the necessary documents and information according to TRGS 400, and in particular the list of hazardous substances.

(2) The employer must check the result of the identification and assessment of exposure to establish whether the requisite identifications have been carried out and whether they reflect the operational conditions.

(3) If measurements are conducted within the framework of the identification and assessment exposure, the measuring body must have the requisite knowledge and necessary equipment according to GefStoffV and must take appropriate quality assurance measures. The requirements for measuring bodies are specified more concretely in this Annex.

(4) If measures are to be conducted by a measuring body not accredited for workplace measurements, the employer must check whether the measuring body fulfils the requirements of the present TRGS.

(5) According to number 4.5 (5) of the present TRGS for measuring bodies the personnel and technical requirements of this Annex may be adapted as a function of the identifications actually performed in the corporate context. With respect to the knowledge and personnel requirements at least number 2.1 of this Annex must be fulfilled.

(6) The measuring bodies working on behalf of the employer must be independent in technical and organisational terms of the directions of the employer. In the case of in-house measuring bodies the independence of directions may be restricted to the tasks under this TRGS.

2 Personnel requirements

2.1 Knowledge and personnel

(1) The nature and scope of the knowledge needed for the identification and assessment of exposure by means of measurements are geared in particular to

1. the company-specific circumstances such as the type of company,
2. the substances arising, and
3. the identifications to be conducted.

(2) Depending on the scope and complexity of the task, the knowledge encompasses knowledge related to hazardous substances and the identification method, normally in connection with the an academic degree in a relevant field or graduation in a relevant occupational training and adequate occupational experience in the respective sector of the company.

(3) The specific knowledge related to hazardous substances and identification method for the application of the present TRGS may be acquired by attendance at relevant courses.

(4) A measuring body must have the necessary personnel. This basically assumes the following as a minimum:

1. a person as head of the measuring body who meets the requirements specified under 2.2, who exhibits reliability regarding the proper performance of their tasks, and who bears the main responsibility in professional terms for the assessment of workplace measurements, and
2. a person who fulfils the requirements for samplers specified in 2.3. The function of sampler and head of the measuring body may reside in one person.

(5) A measuring body must, in addition to paragraph 4, have a suitable person to perform the quality assurance of the measuring body. This person must be familiar with the work of the measuring body; he/she should not be actively involved, however, in the performance of the tasks whose quality assurance he/she is checking.

2.2 Head of a measuring body

(1) The head of a measuring body must:

1. have successfully completed a scientific or technical course of higher education,
2. subsequently have practised an activity lasting at least two years, which imparts the knowledge and practical experience in the field of the identification, measurement and assessment of hazardous substances at the workplace and
3. during this period have repeatedly undertaken hazardous substance measurements at the workplace himself and their evaluation according to the Technical Rules for Hazardous Substances.

(2) In addition knowledge concerning the physicochemical properties and the health hazards during activities involving hazardous substances is essential as is knowledge concerning the acts, ordinances, accident prevention regulations, technical rules, standards, and process and safety engineering.

(3) Suitability can also be demonstrated by an equivalent qualification acquired through corresponding training and experience.

2.3 Workers of a measuring body

(1) The workers employed in a measuring body must have acquired scientific or technical training and must be able to demonstrate knowledge and experience in sampling (sampler) and analysis (testing personnel) of hazardous substances in the air at workplaces.

(2) The workers employed at a measuring body must have adequate knowledge and experience for each of the substance groups according to number 7 for which they perform identifications by measurement at the workplace.

(3) It must be ensured by internal or external further training courses that the whole personnel of a measuring body is trained regularly in current developments in hazardous substance law and in the current state of sampling technology and analysis.

3 Requirements concerning equipment

3.1 General remarks

(1) Whoever conducts the identification and assessment by measurement of the inhalation of hazardous substances exposure at the workplace must have the necessary technical and organizational prerequisites. This includes

1. the equipment for the performance of workplace measurements (see number 3.2 of this Annex) and
2. relevant literature (e.g. TRGS, sector- or activity-specific aids, IFA work folder "Measurement of hazardous substances", publications of the BAuA).

(2) A measuring body must be capable of handling and documenting in a proper fashion the following tasks which are part of the identification and assessment:

1. Identification of the relevant boundary conditions
2. Recording of the hazardous substances
3. Sampling
4. Transport and storage of the samples,
5. Analysis (can also be performed by subcontract)
6. Identification of the measured values
7. Acquisition of measuring results and the finding (assessment)
8. Archiving of crude data and reports.

(3) For the tasks mentioned in paragraph 2 arrangements must be made and the responsibilities clearly specified.

(4) More detailed requirements regarding the organisation and infrastructure of a measuring body are described in number 3.3 of this Annex.

(5) The measuring body must perform and document quality assurance measures for the measuring steps of the identification of hazardous substance concentrations in the air in working areas. The requirements are given in number 4 of this Annex.

(6) For measurements underground the special requirements according to number 5 of this Annex must be fulfilled.

(7) A report must be drawn up on the identifications and assessments of hazardous substances in the air in working areas. The specifications regarding reporting are given in number 6 of this Annex.

3.2 Technical equipment

(1) The technical equipment must be in accordance with the state of the art and must be suitable for the relevant application. The basis for the technical equipment is provided by the specifications described in the relevant standards, e.g. DIN EN 482. Special features of the sampling – e.g. measurements in areas with explosive atmosphere or complex measuring tasks – may require special technical equipment.

(2) The technical equipment must be regularly serviced. The requirements of DIN EN ISO/IEC 17025 in the current version must be complied with.

(3) Paragraph 4 of the present TRGS mentions minimum requirements for external measuring bodies. For in-house and official measuring bodies these requirements may be restricted – depending on the measuring programme to be applied in the company context.

(4) A measuring body must possess the following minimum equipment:

1. two sampling pumps which can be carried on the person (personal air samplers), where relevant explosion-proof,
2. equipment for storing and transporting samples,
3. tripods, fixtures, carrying straps,
4. calibration instruments for adjusting the volume of the sampling pumps,
5. time measuring devices,
6. instruments for measuring climate (normally thermometers, barometers and hygrometers),
7. instruments for determining air flows (smoke tubes and anemometers),
8. computer system for data processing and storage,
9. the collecting devices needed for the substance group or sub-areas according to number 7.1 of this Annex including sample carriers with fixtures and
10. for substance group 1 an set of analytical scales, with a reading accuracy of at least 0.01 mg.

3.3 Organisation and infrastructure

3.3.1 Organisation

(1) The requirements of DIN EN ISO/IEC 17025 in the current version must be complied with.

(2) A measuring body must be organised in such a way that every worker is familiar both with the scope and the limits of his area of responsibility.

(3) The areas of sampling and analysis must consult with one another on the measuring procedure (including, among other things, sample volume, air throughput, storability of the samples).

(4) Samplings and reporting with establishment of finding may basically not be separated in terms of personnel.

3.3.2 Additional organisational requirements for the involvement of laboratories which are not part of the measuring body

(1) Laboratories which are not part of a measuring body are within the meaning of the present TRGS laboratories which belong to another organisational unit of the company or which do not belong to the company.

(2) A measuring body may delegate the analytical determination to an in-house or external laboratory by subcontract if this laboratory meets the requirements of the present TRGS for the analysis of hazardous substances in the air at workplaces. Any further subcontracting by this laboratory is not permitted.

(3) The collaboration between the measuring body and laboratory must be regulated in written form in a binding and comprehensive fashion. The parameters subcontracted, the recognised or validated analytical procedures applied and the designation of the work instructions must be given. The measuring body and laboratory are obliged to provide reciprocal information and to exchange experience. The measuring body and laboratory must ensure the quality assurance of the analytical results and document them.

(4) Furthermore the following conditions must be met:

1. The measuring body and laboratory must each present a description of the current, complete measuring and analytical procedure.
2. The measuring body must satisfy itself as to the suitability of the analytical procedure.
3. Information on the course and special features of the sampling which may influence the analytical result must be made available in writing to the laboratory by the measuring body (e.g. in a sampling record or sample transmission form).
4. The laboratory must notify the measuring body, in addition to the reading obtained, of special features arising in the analytical determination, and in particular unanticipated readings and deviations from analytical procedures or cross-sensitivities established.
5. The measuring body or the laboratory must draw up and update working instructions for the handling of the samples during transport and storage.

3.3.3 Infrastructure

The physical location, the structural and spatial prerequisites and the building-related and laboratory equipment must ensure the secure and trouble-free preparation of measurements and analysis and must be in accordance with the statutory occupational and safety provisions.

4 Quality assurance measures for identifications by measurement

4.1 General requirements

(1) A measuring body must operate a quality management system according to DIN EN ISO/IEC 17025 which is appropriate for its area of operations. The nature, significance and scope of the jobs to be performed must be taken into account.

4.2 Minimum scope of the quality assurance measures

4.2.1 Planning of measurements

(1) The principles of the planning of measurements and the measuring strategy must be laid down in a work instruction. Statements concerning the measuring strategy and representative nature of the measurements must be given with reasons in the measuring report. The measuring procedure must supply representative measuring results for an assessment of exposure of the workers.

(2) Clear, written work instructions must also be drawn up and updated on the basis of applicable regulations for all sampling, analytical and measuring procedures. Recognised testing procedures should be given preference. If such procedures are not available, other validated measuring procedures (sampling and analysis) must be used. To plan identifications and measurements the rules laid down in this TRGS must be referred to in particular. All deviations from the work instructions must be justified and documented accordingly.

(3) A measuring body must lay down measuring procedures suitable for the relevant task.

4.2.2 Preparation of sampling/measurement

The preparation of measurements must be performed and documented for the whole procedure and includes the check of the serviceability (e.g. maintenance and calibration of the measuring systems) and the usability of the measuring system as a whole.

4.2.3 Sampling

For every sampling operation a sampling record must be kept which documents all the parameters during the sampling which are relevant to the result of the measurement. The serviceability of the sampling or measuring device must be checked and documented according to the stipulation in the work instruction before and after sampling. Where there are any deviations from the required specifications of the work instruction, the measures laid down in it must be taken.

4.2.4 Parallel testing of field blanks

In order to determine blank values a sufficient number of field blanks must be tested in parallel as laid down in the work instructions. Field blanks must be treated as "genuine" specimens, with the exception of a sampling. With fibre measurements it is sufficient only to count the field blank(s) as well in cases where fibres are counted for genuine specimens.

4.2.5 Sample labelling

All samples including the field blanks must be clearly and unmistakably labelled at all times. Appropriate provisions must be drawn up for this purpose.

4.2.6 Sample transport/storage

To transport and store samples, suitable containers and devices must be used taking due account of the storability of the samples. These containers and devices must be clean when sample carriers come into contact with them and must be kept in an uncontaminated condition.

4.2.7 Analytical determination

(1) As procedural characteristics the detection limit and determination limit according to DIN 32645 and the measuring uncertainty according to DIN EN 482 in the currently valid version must be determined and documented at the first application and at fixed intervals.

(2) For the analysis quality assurance measures must be taken, e.g. by keeping suitable control cards (blank value, average value and retrieval control cards).

4.2.8 Evaluation of results

(1) The procedure for evaluating and indicating the results must be described in the corresponding work instructions of the measuring body.

(2) The results for the field blanks must be evaluated in accordance with stipulation in the respective work instruction. The causes of a contamination and its effects on the result of the sampling/measurement must be established and documented, and where relevant suitable measures must be taken. It must be ensured that results for the related samples can be clearly assigned.

(3) Any malfunctions and anomalies arising must be documented for all steps of the procedure and must be taken into account in the evaluation.

4.3 Round-robin tests

For a series of substances round-robin tests are available; participation is recommended as a quality assurance measure.

5 Requirements for measurements underground

5.1 General remarks

As an addition to the general minimum requirements for measuring bodies described in this Annex and the general requirements for the expert knowledge of measuring bodies, the personnel and the technical equipment, as well as the reporting, the following supplementary requirements must be met by measuring bodies which conduct measurements underground.

5.2 Personnel requirements

(1) Regarding number 2.2 of this Annex:

1 A degree in mining engineering or comparable qualification is deemed to be equivalent to the qualifications/courses of study described.

2 From the minimum of two years' work on the part of the person(s) with principal responsibility, these must also have knowledge and practical experience in the field of the identification, measurement and assessment of underground hazardous substances at the workplace and specific mining experience (underground, possibly in special sectors of mining).

3 The head of the measuring body must be familiar with the particular health hazards in mining, the risks of underground mining and the relevant technical regulations applying to underground mining.

(2) Regarding 2.3 of this Annex:

1. The workers of the measuring body must also be able to present evidence of knowledge and experience of the sampling and analysis of hazardous substances in the air at workplaces underground.

2. With an underground measurements the responsible person assigned from the measuring body must have adequate mining experience and knowledge of mine-specific influences on hazardous substance measurements. The occupational medical conditions which apply to underground workplaces under the Mining Ordinance for Health Protection (GesBergV) and the Ordinance for Mine Ventilation (KlimaBergV) must be fulfilled by the personnel assigned.

3. The further training measures must also take account in particular of mining concerns.

4. Knowledge of and compliance with the general aspects of mine safety (e.g. explosion protection, use of personal protection equipment) must be ensured.

5.3 Technical equipment

Regarding number 3.2 of this Annex:

1. Of the suitable sampling pumps which can be worn on the person at least one pump must meet the requirements of the mining ordinance governing electrical approval (explosion-proof design).
2. For electrical devices intrinsically safe or explosion-proof versions must be used, where necessary.
3. In the explosion-proof area it must be ensured that the devices used do not have any light metal surfaces and cannot be subject to electrostatic charges.
4. At least one device must be available for the ejector sampling.
5. Suitable devices, possibly with a cooling or drying device, must be available for the storage and transport of samples.
6. For stationary sampling fixtures may be necessary in addition to tripods to suspend sampling devices.
7. Systems for the identification of concentration histories must be suitable for measurements underground.

6 Requirements for reporting with measuring and non-measuring identifications

6.1 General requirements for reporting

(1) For every order concerning the identification and assessment of hazardous substances in the air in working areas a report must be drawn up which records the identification in addition to defining the task and contains the result and the assessment of the result according to the relevant technical regulations.

(2) All kinds of identification tasks require complete documentation (see number 7 (1) of the present TRGS).

(3) The results of effectiveness checks can be reported in a simplified form if they relate to detailed reports within the framework of risk assessments.

6.2 Content of the report

The report must be signed by the person responsible from the measuring body and must contain, in addition to the requirements listed in number 6.2.1 to number 6.2.5 of this Annex, a list of the following information:

1. measuring body (name, address),
2. client (name, address),
3. identification task according to Annex 3 No. 2 of the present TRGS,
4. place of the exposure identification (company, address, company location),
5. preliminary meeting (participants, date),

6. person processing the identification task,
7. description of the identification procedure,
8. identification results,
9. assessment of the exposure and the effectiveness of the protective measures (finding) and
10. measures taken to establish findings;

    In the case of measuring identifications also:

11. sampling (processor, date),
12. analysis (laboratory, where relevant processor, date) and
13. report (number, number of pages, date).

6.2.1 Reason for and scope of the task set

(1) The identification task and the reason for the identification must be described. Reference must be made where relevant to old identification results (available reports, risk assessment), modified parameters (new protective measures) etc.

(2) If the identification task only relates to a part of the hazardous substances identified under number 4.3 of the present TRGS, express reference must be made to this.

6.2.2 Documentation of the relevant parameters

The working area/workplace being examined must be described in as detailed a way as possible to grant third parties as well a view of the activity and working sequences of the workers whose inhalation exposure is to be determined. It is recommended to also make sketches and photographs.

6.2.3 Recording and description of the activities and establishment of the working area

The working area must be described according to number 4.2 of the present TRGS with the relevant parameters at the time of the identification. If company information is used, this must be documented.

6.2.4 Recording of the hazardous substances

(1) The hazardous substances must recorded and described by working area/workplace and, where possible, in relation to the activity according to number 4.3 of the present TRGS. (Other) Hazardous substances from adjacent working areas may also be exposure-relevant in the working area under examination.

(2) The following information must be documented:

1. name/description of the preparations/materials/substances used, including intended use/use/occurrence, condition and quantity,
2. the hazardous substances contained therein (possibly with CAS No.),
3. if available, the related limit values, the nature or origin of the limit values, the short-time value criteria and other assessment criteria according to number 5.3 of the present TRGS,
4. the dangerous properties and
5. other relevant regulations.

(3) It must be documented who has performed the recording of the hazardous substances, when and on what basis (list of hazardous substances, SDS etc.).

6.2.5 Identification and assessment of the inhalation exposure

(1) The identification procedure according to Annex 2 and Annex 3 No. 2 and the identification result must be documented so as to be retraceable.

(2) In the identification and assessment of the exposure the following information must be considered in addition, where available:

1. results for earlier exposure measurements,
2. results of other measurements,
3. information on comparable installations or activities,
4. information on relevant standardised working procedures according to TRGS 400 (e.g. procedure- and substance-specific criteria) and
5. results of reliable calculations.

(3) The selection of substances recorded by measurement must be justified. Measuring locations, points in time and measuring durations of the substances must selected in such a way that, in combination with the information already available, the shift average value can be concluded. Exposure peaks must be taken into account according to level, duration and frequency with a view to short-time value requirements.

(4) The identification procedures used must be documented. This includes the following identification procedures involving measurement:

1. the use of a recommended measuring procedure according to Annex 3 No. 3.1 (7),
2. in the case of other measuring procedures
   a) brief description,
   b) reference to the available work instruction and
   c) details of the detection limit/determination limit and cross-sensitivities (where known).

(5) The conditions found in the identification must be documented. They include in particular the following information for the sampling according to Annex 3 No. 4 (2)

1. sampling devices including sampler carriers and collecting media (e.g. sorption agent, filter),
2. volumetric air flow,
3. direct-indication measuring instruments,
4. duration of sampling,
5. climatic data and
6. sample transfer and storage (if necessary)

(6) Special features of the analytical determination must be documented. They include in particular

1. the identification of other exposure-relevant substances in the analytical determination and
2. subcontracting to an external laboratory.

(7) The identification results obtained must be presented in a clear form and comprehensibly for the client. This includes in particular the following information for identification procedures involving measurement

1. date and time of the measurement,
2. sampling location,
3. sample designation and number internal to measuring body,
4. name of substance,
5. readings,
6. measuring results (shift and short-time values),
7. substance indices, where relevant evaluation indices and
8. special occurrences

(8) Assessment of the exposure and the effectiveness of the protective measures, finding, measures taken to establish findings with

1. reference to the task set,
2. finding on the basis of all data available,
3. qualified justification of the finding/assessment,
4. recommendations on/establishment of protective measures, if necessary,
5. measures taken to establish, describe and justify findings,
6. where relevant statement on lead components,
7. where relevant statement on simplified identification procedures involving measurement and
8. short-time value conditions (frequency and duration of the exposure peak, chronological distance between exposure peaks, duration of the total elevated exposure of a shift).

7 Grouping of substances

7.1 Grouping

The requirements for a measuring body are geared to its tasks. A breakdown of the requirements according to the following substance groups has proven useful:

1. Group 1: aerosols (not fibre dusts),
2. Group 2: fibre dusts,
3. Group 3: inorganic gases and vapours,
4. Group 4: organic gases and vapours and
5. Group 5: selected parameters/areas.

7.2 Explanatory notes on the substance groups in identification procedures involving measurement

7.2.1 Group 1: Aerosols (no fibre dusts)

(1) Group 1 encompasses aerosols (dusts, fumes, mist), which are recorded in accordance with DIN EN 481 as an inhalable fraction (I) or as an alveolar fraction (A) and are normally separated off on filters. With regard to the determination of dust constituents group 1 is broken down into sub-divisions:

1. dust mass determination (gravimetry) for the dust fractions according to DIN EN 481,
2. metals and metal compounds,
3. crystalline mineral dusts (e.g. quartz, cristobalite, tridymite or silicates),
4. amorphous silicas (e.g. fused silica, diatomite, diatomaceous silica or quartz material),
5. simple organic constituents (e.g. oxalic acid, phthalic anhydride) and
6. other aerosols.

Organic constituents which impose special measuring requirements (e.g. PAH, nitrosamines) are assigned to group 5.

(2) If substances arise simultaneously in the particulate and vapour phases, a two-phase sampling is necessary; these substances are assigned to group 5.

7.2.2 Group 2: Fibre dusts

(1) Group 2 encompasses fibre dusts which are determined using counting procedures:

1. asbestos fibres and
2. other fibre dusts.

(2) For asbestos fibre measurements it is necessary to use a scanning electron microscope with an X-ray microanalysis system (SEM/ EDX) and plasma asher (BGI 505-46). For exposure measurements in connection with mineral raw materials reference should be made to TRGS 517, Annex 3.

7.2.3 Group 3: Inorganic gases and vapours

(1) Group 3 encompasses for example:

1. halogens,
2. hydrogen halides and other inorganic acids (e.g. hydrogen fluoride, hydrogen chloride, hydrogen sulphide, nitric acid, hydrocyanic acid),
3. other volatile hydrogen compounds such as ammonia, stibine, arsine, diborane, hydrazine or hydrogen phosphide and
4. non-metallic oxides (e.g. nitrogen oxides, sulphur dioxide, carbon dioxides, hydrogen peroxide).

(2) This group includes further single components, such as nickel tetracarbonyl, ozone, phosgene and mercury vapour, which are not broken down into one of the sub-areas mentioned.

7.2.4 Group 4: Organic gases and vapours

Group 4 encompasses, for example:

1. aliphatic and aromatic hydrocarbons,
2. highly volatile halogenated hydrocarbons (HVHC),
3. ketones and ester,
4. alcohols,
5. aldehydes,
6. phenols,
7. glycols and their derivates,
8. amines,
9. expoxides and
10. organic acids.

7.2.5 Group 5: Selected parameters/areas

(1) Selected parameters/areas are assigned to group 5 if the determination requires special experience, special analytical equipment and/or considerable effort (e.g. speciation) with a view to sampling, sample preparation or analysis. This includes for example:

1. simple systems with two-phase sampling with sum parameter determination (e.g. vapour and aerosol phases of cooling lubricants, bitumen, phthalic acid/ester, bisphenol A, diethanolamine, diphenylamine),
2. metal-organic compounds (e.g. organic tin compounds),
3. multi-substance systems (such as lacquer aerosols, PAH, PCB, PCDD/F, nitrosamines or isocyanates),
4. diesel engine emissions (DME) and
5. ultrafine particles.

(2) Group 5 also includes measurements in special working areas (e.g. measurements in mining underground) which impose additional requirements regarding knowledge, personnel and technical equipment.

Annex 2 to TRGS 402

Non-measuring identification methods for exposure

1 General remarks

(1) Non-measuring identification methods include in particular the following:

1. the transfer of results from comparable workplaces and
2. the use of suitable computer models

(2) With the application of non-measuring identification methods the influence of the relevant parameters on the identification result must be assessed and documented. The influence of single or all parameters must be quantified on a case to case basis.

2 Measuring results for workplaces with identical working conditions

(1) Measuring results for workplaces can be transferred to other workplaces where the exposure conditions are comparable. The decision on comparability is taken and documented by the employer in accordance with TRGS 400 number 3.2.

(2) Comparable exposure conditions at workplaces are present if, with comparable activities involving hazardous substances, a detailed assessment of the influence of the relevant parameters according to number 4.2 (3) of the present TRGS reveals that there is no reason to expect deviations from the identification results to be transferred.

(3) Measuring results for comparable workplaces may come from

1. the same company,
2. other companies (measuring reports),
3. measured databases or
4. exposure descriptions in the specialist literature.

(4) The results of so-called worst-case measurements are particularly suitable for the transfer of measuring results. Numbers 1 and 4 of Annex 5 of the present TRGS include examples of the assessment of exposures with the availability of comparable workplaces.

3 Calculation of exposure

(1) Concentrations can be estimated by calculation if the relevant parameters can be linked by suitable model and they are known for the specific application. This concerns both the short-time (short-time values) and long lasting exposures (shift average values).

(2) Exposure models are normally based on three major elements:

1. the description of the hazardous substances emission,
2. the spatial and chronological spread and distribution of the hazardous substances

and

3. consideration of the work organisation parameters.

(3) The results of model calculations must be plausible. For each application a justification must therefore be given of why the model calculation is suitable in the specific case, and a description must be given of

1. the hazardous substances emission,
2. the spread and distribution of the hazardous substances in space and
3. the work organisation parameters.

(4) By varying the relevant parameters their influence on the level of exposure can be estimated and hence critical parameters can be recognised. For this it is necessary to describe their span at the working place being assessed and possibly determine it more precisely by further identifications.

(5) The calculation procedure must be presented in such a way that the calculations can be comprehended. Results and knowledge which are obtained by varying the parameters must be described.

(6) In certain cases a check of the calculations by exposure measurements can be recommended. If, when comparing measured and calculated exposures,

1. the measured airborne concentration is above the results of the worst-case calculation or
2. the results of the exposure measurements are above the calculated exposure band width,

it is essential to check the calculation model and the measurement.

4 Finding

The calculation ends with a finding. The requirements concerning the assessment of exposure and of the effectiveness von protective measures (number 5 of the present TRGS) and concerning the establishment of findings (number 6 of the present TRGS) are also valid, where applicable, for non-measuring identification methods.

5 Calculation examples

5.1 Offset printing

Owing to comparable operating conditions and repeated operating states offset printing is highly suitable for calculation of the hazardous substances concentration. For application in practice the Berufsgenossenschaft in the printing and paper processing industry developed a simple and graphic procedure for calculating approximately the airborne concentration of the most important printing accessories, and in particular 2-propanol. The reliability of the calculation model was verified by the systematic conduct of comparative measurements and calculations. The results obtained show for 2-propanol a high degree of agreement between the near-practical model and the workplace measurements performed according to the present TRGS. The average

deviation of the calculated results from the measured results is 21 per cent [1].

5.2 Other examples of exposure calculations

Remarks concerning suitable calculation procedures for exposure identification are given in the literature. Table 1 gives examples from the literature where different calculation methods have been used for various workplaces. With regard to the details reference should be made to the points in the literature:

Table 1: Examples of calculation methods and calculation applications for identifying exposures at workplaces

No.	Subject	Source
1	Description of method	1, 2, 3
2	Degreasing of metals	1, 5
3	Anaesthesia workplaces	1
4	Application of sprays	6, 7, 8
5	Consumer exposures	7
6	Xylene exposure in the laboratory	2
7	Application of motor-powered devices in interior spaces	2
8	Disinfection of surfaces	1
9	Exposures in a chemical laboratory (university)	4
10	Comparison of inhalation and dermal exposure (e.g. xylene)	2
11	Estimation of the inhalation exposure in a laboratory (xylene)	2
12	CO_2 exposure in interior spaces	2
13	Hazardous substances in dust	1
14	Diesel engine emissions	1

6 Literature

[1] BIA Report 3/2001: Berechnungsverfahren und Modellbildung in der Arbeitsbereichsanalyse,
http://www.dguv.de/ifa/de/pub/rep/rep01/biar0301/index.jsp

[2] Eickmann, U.; Methoden der Ermittlung und Bewertung chemischer Expositionen an Arbeitsplätzen. ecomed-Verlag, 2008

[3] Keil, C.B.; A tiered approach to deterministic models for indoor air exposures. Applied Occupational and Environmental Hygiene, 15 (2000) 1, 145–151.

[4] Keil, C.B.; Murphy, R.; An application of exposure modeling in exposure assessments for an university teaching laboratory. Journal of Occupational and Environmental Hygiene. Vol. 2006, Issue 3, pp 99–106.

[5] Keil, C.B.; The development and evaluation of an emission factor for a toluene parts-washing process. AIHA Journal 59(1998) January, 14–19.

[6] Eickmann, U.; Eickmann, J.; Tischer, M.; Exposure to Sprays – Comparison of the available exposure models. Gefahrstoffe – Reinhaltung der Luft, 67 (2007) 7/8, pp. 305–318.

[7] Delmaar, J.E.; Park, M.V.D.Z.; van Engelen, J.G.M.: ConsExpo 4.0 – Consumer Exposure and Uptake Models. Program Manual. RIVM Report 320104004/2005 Bilthoven, NL, 2005

[8] Koch, W.; Arbeitsplatzbelastungen bei der Verwendung von Biozid-Produkten – Transformation and Erweiterung eines DV-gestützten Modells zur Abschätzung der inhalativen and dermalen Exposition bei Sprayprozessen. Bundesanstalt für Arbeitsschutz and Arbeitsmedizin (BAuA). Research Report F2022, Dortmund, 2004

Annex 3 to TRGS 402

Measuring identification methods

1 General requirements

(1) Someone who intends to conduct measurements within the framework of the risk assessment according to GefStoffV must plan this with the help of the measuring strategy in accordance with the present TRGS and must have the necessary equipment and knowledge for the measurements arising specifically for the company (see Annex 1).

(2) The measuring strategy for workplace measurements encompasses

1. the establishment of the measuring task,
2. the selection of the measuring procedure and
3. the establishment of the sampling locations and the sampling points in time and duration.

(3) The measuring strategy must be adapted to the conditions at the workplace, in particular the anticipated exposure level, in order to take account of the different exposure situations.

(4) Basically all the relevant substances are taken into account in the planning of measurements relating to the inhalation exposure (see number 3.4 of the present TRGS). It is not always necessary to cover all the relevant substances with the measurements, but this can be restricted to a representative selection or to lead components. Criteria for the selection of the substances to be determined by measurement include in particular the release behaviour, the substance quantities and the toxicity.

2 Measuring tasks

In view of the specific measuring goal or for strategic reasons a distinction is drawn between the following measuring tasks:

1. workplace measurements,
2. measurements of technical parameters to establish findings,
3. control measurements to establish findings,
4. overview measurements,
5. measurements for the worst case,
6. measurements in the proximity of the emission source,
7. continuous monitoring and
8. special measurements.

2.1 Workplace measurements

(1) Workplace measurements supply as a measuring result the average concentration weighted over time of a hazardous substance in the air at the workplace as a shift average value or as a short-time value in accordance with the short-time value concept.

(2) The aim of the workplace measurements is the quantitative identification of exposure to workers for the activities under examination in the working area. Occasionally it may also be necessary to have qualitative identifications of exposure beforehand if, for example, there is a lack of information on the substances arising. The results of workplace measurements must describe the exposure during a shift in a relevant and representative way, namely as a shift average value (measuring result) and as short-time values.

2.2 Measurements of technical parameters to establish findings

Measurements of technical parameters to establish findings are necessary to check whether the finding arrived at retains its validity without change. For this purpose simple parameters such as performance criteria (e.g. exhaust air and extraction volumetric flow) are checked by measurements under the conditions established in the finding.

2.3 Control measurements to establish findings

If measurements to establish findings according to number 2.2 are not possible or not purposeful, control measurements are required. Control measurements are workplace measurements according to number 2.1 under the conditions established in the finding (see number 6 (3) of the present TRGS). Instructions on the conduct of the control measurements are given in DIN EN 689.

2.4 Overview measurements (orientation measurements)

Overview measurements supply relatively rough information on the level of exposure and serve as a basis for decision-making with respect to further steps to be taken. Overview measurements of the chronological or spatial concentration distribution yield information on, among other things:

1. places and times of elevated exposure,
2. duration and frequency of sampling in workplace measurements,
3. emission sources or
4. the effectiveness of ventilation or other technical protective measures.

2.5 Measurements for the worst case

Worst case measurements (see number 3 (8)) are conducted if, as a result of special exposure conditions (e.g. highly dust-producing substances, utilisation at the limit of capacity, special climatic conditions) substantially higher exposures are to be expected.

If under these conditions compliance with the occupational exposure limit can be demonstrated, it can also be assumed that under the usual conditions the occupational exposure limit will be adhered to. In practice such operating conditions are also set specifically.

2.6 Measurements in the proximity of an emission source

Measurements in the proximity of an emission source can supply information on emission rates (source intensities) of sources, which is needed for example in the calculation procedure for the exposure. In individual cases they can also serve as worst-case measurements or give indications as to whether certain substances arise or are released due to the process.

2.7 Continuous monitoring

(1) Continuous monitoring (see Annex 4) can be used when the measuring instruments and the measuring concept are designed in accordance with the measuring task in such a way that they facilitate an exposure assessment and the measuring results are recorded. Suitability must be checked within the framework of the identification and assessment of the inhalation exposure. Compliance with the short-time value requirements must also be observed here.

(2) Continuous monitoring makes sense in particular when, for example, acute risks or particularly great fluctuations in the exposure cannot be discounted, and measures to protect workers are triggered by an alarm.

2.8 Special measurements

In the case of measurements conducted for a special reason, e.g. within the framework of identifications for occupational disease procedures or epidemiological studies, it is recommended that one proceed in accordance with the present TRGS.

3 Measuring procedures

(1) Measuring procedures for workplace measurements encompass

1. measurement planning (see number 1),
2. the sampling procedure,
3. sample transport (if necessary),
4. storage of samples (if necessary),
5. the analytical procedure and
6. the identification by calculation of the measured value from the analysis value and the sampling parameters.

(2) The sampling procedure includes the technical sampling operation or the application of direct-indication measuring procedures on site. The analytical procedure

includes preparation of the sample, the analytical determination and the identification by calculation of the analysis value.

3.1 Requirements regarding measuring procedures

(1) The measuring procedure must be adjusted to the substance being measured, its limit value, the anticipated concentration and the parameters. The procedure must supply the measured value directly or indirectly (e.g. by conversion) in the dimension specified by the limit value.

(2) The measuring procedure must have proven itself under practical conditions and must fulfil the requirements of the practical instructions of the states (Länder) (LV 2.2). The general performance requirements regarding measuring procedures for workplace measurements are laid down in DIN EN 482 [1]. There Table 1 gives the requirements for the extended measuring uncertainty, the minimum measuring range (determination limit) and the averaging duration as a function of the measuring task. These procedure variables must be known when a decision is to be taken as to whether a measuring procedure is suitable for the measuring task to be performed.

(3) In the case of known, non-correctable cross-sensitivities the full measured value must be referred to. It must be ensured that the measured value is not reduced by other components.

(4) The suitability of the measuring procedure must be checked. During the check of measuring procedures the requirements of the relevant standards, and in particular EN 482, must be satisfied. The correct nature of the measuring procedure is to be ensured by means of quality assurance measures, such as comparative tests with reference procedures, standard reference materials, round-robin tests or mixing tests (e.g. test gases).

(5) The technical equipment used must be suitable for the respective application. Special features of the sampling – for example measurements in explosive atmospheres or complex measuring tasks – must be taken into account in the selection. Preference should be given to devices whose compliance with the relevant standards, such as DIN EN 481, 482, 838, 1076, 1231, 1232, 12919, 13890, 15767, 45544, has been verified.

(6) Since the analytical determination is often conducted separately in terms of time from the sampling, it must be ensured that the transport and storage of the sample (type and duration) are such that its physical and chemical state is not changed.

(7) Measuring procedures recommended for workplace measurements are published by the Working Group "Analytical Chemistry" of the Commission of the German Research Foundation (DFG) for the Investigation of Health Hazards of Chemical Compounds in the Work Area (DFG) [2], by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) [3], the Federal Institute for Occupational Safety and Health (BAuA) [4], and by the "Analysis" working group of the expert committee on "Chemistry" of the Berufsgenossenschaften (institutions for statutory accident insurance and prevention) [5].

3.2 Requirements for the measurement of short-time values

(1) The short-time exposures must be identified according to the level, duration and frequency over the course of a shift if relevant concentration fluctuations cannot be discounted.

(2) Basically to ensure a uniform procedure the short-time values must be monitored by determining the 15-minute average value. This also applies to substances without an occupational exposure limit.

(3) In the case of substances for which an instantaneous value has been fixed which may not be exceeded at any time (=x=), the specifications of TRGS 900 lay down that the shortest possible averaging time is selected in accordance with the measuring possibilities. The averaging time must, however, not be less than one minute. Basically it must at the same time be ensured that all quality requirements of the present TRGS are also fulfilled for the shortest possible averaging time.

(4) For substances without a short-time value exposures shorter than one hour may exceed the numerical value of the respective limit value at most by a factor of 8.

(5) For the measuring identification of the short-time values direct-indication instruments have proven themselves in many cases. In particular they permit the recording of chronological exposure profiles, from which then the relevant short-time exposures can be determined using suitable calculation procedures [6].

(6) Furthermore TRGS 900 number 2.3 must be observed.

4 Sampling locations, times and sampling duration

(1) The basis for fixing the sampling locations and times is the result of the establishment of the working area and the activities of the workers involving hazardous substances. In particular the information on the working procedures, working sequences and the working and ambient conditions (relevant parameters according to number 4.2) must be observed. The sampling locations and times selected must be suitable for giving a representative presentation of the major influencing factors acting on the exposure.

(2) For the sampling the following parameters in particular must be fixed:

1. the sampling location or locations,
2. the point in time and the duration of the sampling or measurement,
3. the chronological sequence of the samplings or measurements and the time span between them,
4. further instructions on the conduct of samplings/measurements (e.g. recording of special parameters and the capacity of technical extraction systems) as well as
5. the sampling parameters required for the identification by calculation of the measured values.

The decision on the sampling parameters selected must be documented.

(3) Basically workplace measurements must be conducted on an individual-related basis with the systems worn on the person or carried on a mobile basis in the respiration zone of the workers. As an exception stationary measuring systems can also

be used if the measuring results permit an assessment of the exposure. The sampling must be conducted in the case of stationary measurements on respiration level and in the immediate proximity of the workers. In cases of doubt the location with the higher risk must be chosen as the measuring location. The decisions in favour of stationary measurements must be justified in each individual case.

(4) Averaging by measurement over the total exposure time during a shift is a particularly suitable way of establishing the shift average value. If the averaging time of the measuring procedure is shorter, the minimum number of the necessary measurements distributed over the length of the shift must be based on Table 1. The arithmetic mean of the measured values will be included in the measuring result. If there are different averaging times, the time-weighted arithmetic mean must be formed.

Table 1: Minimum number of samples for identifying the shift average value

Averaging time (sampling time)	*Number of samples*
10 sec.	*≥ 30*
1 min.	*≥20*
5 min.	*≥12*
15 min.	*≥ 4*
30 min.	*≥ 3*
1 hrs.	*≥ 2*
≥2 hrs.	*≥ 1*

5 Results of workplace measurements

(1) In workplace measurements over the whole length of the shift the measured value is the equivalent of the measuring result.

(2) With sampling times which deviate from the shift length special examinations are necessary. In the simplest case with a uniform exposure over the whole shift the measured value obtained during a certain part of the shift according to number 2(6) "Averaging time" is taken as equivalent to the measuring result.

(3) If during a shift a number of mutually distinguishable exposure periods arise, the average concentration levels of the hazardous substances under examination must be identified for each period individually. From these individual values a time-weighted arithmetic mean is calculated in relation to the sum of the individual periods and this mean represents the shift-related measuring result. If one or more of these exposure periods contains no hazardous substances exposure, the concentration "zero" may also be included in the calculation for it or them (shortened exposure).

(4) If in working areas the exposure time for workers may vary (e.g. in the case of flexitime or overtime), the maximum possible exposure time must be taken for the assessment in the spirit of a worst case scenario.

(5) Since assessment criteria are laid down according to number 5.2 and number 5.3.1 (2) for an exposure time of eight hours, an appropriate conversion has to be performed for any deviating exposure times.

6 Finding

Workplace measurements serve to record the finding. The requirements regarding the assessment of exposure and the effectiveness of protective measures (number 5 of the present TRGS) and regarding the establishment of findings (number 6 of the present TRGS) are valid where applicable.

7 Literature

[1] DIN EN 482: Workplace atmospheres. General requirements for the performance of procedures for the measurement of chemical agents, October 2006

[2] Deutsche Forschungsgemeinschaft – Analytische Methoden zur Prüfung gesundheitsschädlicher Arbeitsstoffe, Luftanalysen; Ed.: H. Greim, Wiley-VCH-Verlag, Weinheim, current version

in which: Hebisch, R., Fricke, H.-H., Hahn, J.-U., Lahaniatis, M., Maschmeier, C.-P., Mattenklott, M.: Probenahme and Bestimmung von Aerosolen and deren Inhaltsstoffen (14th delivery (2005) pp. 1–40)

in which: Hebisch, R., Breuer, D., Krämer, W. Maschmeier, C.-P., Tschickardt, M.: Probenahme and analytische Bestimmung von Gasen and Dämpfen (15th delivery (2007) pp. 1–37)

[3] IFA Folder „Messung von Gefahrstoffen", Erich Schmidt Verlag Bielefeld, current version

[4] Hebisch, R. Poppek, U.: Empfohlene Analysenverfahren für Arbeitsplatzmessungen, Dokumentation, 19th edition. Bremerhaven: Wirtschaftsverlag NW Verlag für neue Wissenschaft GmbH 2007. (Publication Series of the Federal Institute for Occupational Safety and Health)

[5] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (BGI 505), Expert Committee "Chemicals" (current version at *http://www.arbeitssicherheit.de/de/html/bgvr-verzeichnis?gruppe=BGI&searchnr=505*)

[6] Dahmann, D., C. Monz „Arbeitsplatzexpositionsprofile (AEP)" „Gefahrstoffe-Reinhaltung der Luft" 60 (2000), 397-401

Annex 4 to TRGS 402

Procedure for the effectiveness check with the help of continuously recording measuring instruments (continuous monitoring and alarm devices)

(1) The TRGS 402 provides for continuous monitoring as a possibility for the effectiveness check of protection measures. In this it is ensured by an alarm and measures thus triggered that no shift average values exceeds the limit values or that the short-time values are complied with.

(2) Continuous monitoring is achieved with normally stationary measuring instruments which record continuously or quasi-continuously the concentration of the hazardous substance in the air in the working area. Frequently the air is extracted at a number of locations in the working area and either mixed or fed successively to the analyser. The exposure in the working area must be identified from the concentration values thus measured. This can proceed by comparative measurements conducted on the person or a suitable selection of the sampling locations. In continuous measurements for the purpose of environmental protection in particular attention must be paid to the positioning of the measuring sensors or the sampling in the breathing air zone if such measurements are to be used at the same time for continuous monitoring within the meaning of the present TRGS.

(3) Alarm devices must as far as possible be worn on the person or positioned directly in the area where workers are present in such a way that a reliable alarm of acute danger is ensured.

(4) The calculation operations required to compare the measured value with the binding limit value, the short-time value or another suitable assessment criterion are laid down in the risk assessment and deposited in the measuring instrument for the purpose of automatic analysis.

(5) The effectiveness of protective measures is checked in continuous monitoring in that the measuring instrument gives a pre-alarm and triggers measures to lower the concentration so early that it is possible to reliably prevent any surpassing of the binding limit value or another assessment criterion. If these measures are not effective, either because the concentration continues to rise or the pre-alarm is given for too long, a main alarm is triggered and the people must leave the working area. If the main alarm has been triggered because the maximum allowable period of excess is exceeded, the working area may no longer be entered by the workers affected during this shift unless they wear respiratory protective equipment to counter the incident.

(6) The switching points for the pre-alarm and main alarm are laid down in the risk assessment. The times where a pre-alarm and main alarm is active must be documented. This documentation must also be referred to within the framework of the regular check of the risk assessment.

Annex 5 to TRGS 402

Workplace examples and further instructions concerning the application of TRGS 402

In this Annex a number of typical workplace situations are described and indications are given as to how this Technical Rule can be applied. This is intended as an aid to the identification and assessment of inhalation exposure at one's own workplaces.

1 Workplaces with constant conditions

(1) What is typical for workplaces with constant conditions is the fact that day after day, month after month the same activities are carried out under recurring conditions. Everything that influences the hazardous substance exposure of the workers changes little over a long period. Work sequences, technologies used, process parameters (e.g. pressure, temperature), type and quantity of the substances used, degree of utilisation of the installation and ambient conditions (ventilation, climate) are repeated in every shift and remain constant for the long term.

(2) Examples of workplaces with constant working conditions include industrial serial production, printshops, dry cleaning, commercial sterilisation, quality controls in routine laboratories or large-scale chemical plants.

(3) It is characteristic for such workplaces that

1. the exposure is typically recorded in the form of the shift average values,
2. the operating states are repeated regularly and
3. the exposure conditions change little in the long term.

(4) At these workplace basically all identification methods can be used depending on the individual case. Since wide-ranging workplaces are involved, the method "transfer of the results from comparable workplaces" is especially suitable. As the example of "offset printshops" in Annex 2 shows, calculations can also lead to results which are amenable to assessment. For workplace measurements there are at best measuring restrictions if, for example, no analytical procedure is available. In terms of measuring strategy both the whole shift and parts of the shift can be converted (see Annex 3, Table 1).

(5) If measuring results are available for which there is no expert reason to indicate that the finding is sustainable, the formal procedure indicated in number 5.2.2 (4) can be referred to in order to provide a statistical back-up to the finding.

2 Shortened exposure at workplaces with constant working conditions

(1) Frequently there are workplaces where certain activities involving hazardous substances are performed for only a short time every day. In the remaining time other activities (not involving exposure to hazardous substances) are carried out. This type of occupation is repeated daily and also remains unchanged over a period of months.

(2) Examples of such workplaces are cold sterilisation in hospitals, stationary welding work or sampling operations for a limited time.

(3) Everything that influences the exposure of the workers to hazardous substances in the period which is shorter than the length of the shift changes little overall. The working sequence, the technology used, process parameters (e.g. pressure, temperature), the nature and quantity of the substances used, the degree of utilization and ambient conditions (ventilation, climate) are comparable every time the working sequence is repeated. In every shift it is possible to distinguish clearly between the times during which there is an exposure to hazardous substances and times which there is no exposure to hazardous substances. This includes for example activities in other rooms where there is no exposure, such as office work or preparatory work where no hazardous substances are used. Account must invariably be taken of whether hazardous substances can be entrained into rooms where there is no exposure (on the skin or clothing) and that concentrations of certain substances in the air at the workplace sometimes only break down very slowly.

(4) The working sequences involving exposure to hazardous substances are assessed as in number 1 if the conditions for this are fulfilled. Where the exposure times are only very short, there may be problems with the measurement because the lower determination limit of the analytical procedure is not reached. It may be helpful in such cases to combine a number of operations into one test. In many cases it is sufficient to check whether the short-time value conditions are complied with. On the basis of the duration of the phases with and without exposure to hazardous substances the time-weighted shift average value is calculated.

(5) Even when the occupational exposure limit or other assessment criteria are complied with it may be appropriate to provide for additional protective measures precisely during the short periods. Often workers can reduce their exposure to hazardous substances considerably by a controlled and short-term use of personal protective equipment (PPE). PPE is sometimes the only practicable means of keeping the exposure to certain hazardous substances "under control" if it can be foreseen that this will occur for only a short period (e.g. during the taking of samples).

3 Workplaces involving occasional exposure

(1) If the activities involving exposure to hazardous substances by inhalation at stationary workplaces only arise irregularly or only occasionally, regular workplace measurements are difficult to plan. At such workplaces certain working procedures or activities with a comparable exposure to hazardous substances are repeated irregularly, e.g. every week, every month or even more seldom (occasional batches). In the interim other or comparable activities for which the exposure to hazardous substances is not comparable may arise (changing batches). The technology, working sequence and ambient conditions (ventilation, climate) change little, however. Individual process parameters of the working procedure such as pressure, temperature or the nature and quantity of the materials used may differ.

(2) It is typical of such workplaces, for example, that they may involve changing batches in the chemical industry or maintenance work on permanently installation equipment.

(3) The inhalation exposure is assessed separately for each individual case where there are different activities and working procedures within the framework of the identification and assessment. With changing batches such as are usual in the chemical or pharmaceutical industry, for example, it is recommended to lay down within the framework of the identification and assessment of the inhalation exposure those batches where the most unfavourable exposure conditions apply.

(4) If it is not possible to conduct the necessary workplace measurements for the effectiveness check under the same conditions as for the identification and assessment of the inhalation exposure, the results obtained must be assessed with due consideration of the deviations.

4 Stationary workplaces with irregular exposure

(1) Assessment of the exposure to hazardous substances in working areas where activities and the input of substances are changing constantly is particularly difficult.

(2) This may be the same, for example, in craft companies, for non-specialised maintenance, repair, production and assembly work, in automotive or forklift workshops, for services at filling stations (oil change etc.) or in research laboratories.

(3) At such workplaces certain working procedures or activities with comparable exposure to hazardous substances are repeated irregularly, e.g. every day, every week, every month or even more seldom. In the interim, however, other or comparable activities involving varying exposure to hazardous substances may arise.

(4) Technologies, working procedures and ambient conditions (ventilation, climate) change little with the respective activities. Individual parameters of the working procedure, and in particular the nature and quantity of the materials used, may differ, however.

(5) The identification of the inhalation exposure for the various activities is laborious, especially with respect to the measurements. But since the activities and the materials used within a sector mostly differ only insignificantly from company to company, cross-company surveys and assessments, e.g. in the form of "provided risk assessments", sector-based regulations, IFA recommendations, risk identification by the German accident insurance institutions (EGU), practical instructions relating to good practice or process- and substance-specific criteria, are the method of choice. The employer will not then have to conduct his own identifications, but only ensure that the corresponding specifications are complied with. Employers should therefore urge their suppliers, the industrial associations or other representative organisations that appropriate aids are drawn up for the respective sector.

5 Mobile workplaces with irregular exposure

(1) The procedure described in the present TRGS for the survey of workplace conditions, for the identification and assessment of exposure and for the effectiveness check encounters its limits, however, where work is performed at locations which change a number of times a day. The question as to whether the limit values can be complied with can actually only be answered in retrospect with the aid of workplace measurements. That is why, alongside the conduct of protective measures, functional

checks according to TRGS 500 have priority over identifications relating to the inhalation exposure.

(2) This normally applies with respect to activities performed on construction sites (e.g. painters, floor-layers, bituminous pavers) or non-stationary assembly and maintenance work (e.g. on photocopiers).

(3) The individual working steps normally proceed in such activities following the same sequence, while the number of operations, the procedures and materials applied and the scope of work may vary. In addition the ambient conditions (ventilation, room size, work in the open) vary considerably.

(4) Here the working procedures and the use of materials must be designed from the outset in such a way that risks due to inhalation exposures do not even arise. This can be done by means of appropriate working regulations, by the selection of the materials used (e.g. according to product codes related to occupational safety and health) or the specification of concrete protective measures such as those in process- and substance-specific criteria according to TRGS 420.

(5) All these measures assume that the exposure situation for the respective activity has been identified and assessed beforehand on a sector basis. With the application of the "safe working procedures" described care must be taken to ensure that no additional risks may arise due to the external environment (background exposure etc.). As indicated under number 4 (5), employers should urge their suppliers, the industrial associations or other representative organisations to ensure that appropriate aids are drawn up for the relevant sector.

(6) With the use of non-company personnel, for example for maintenance and repair jobs, the employer (owner of the establishment) must instruct the external company and provide it with the relevant information (concrete identification of exposure is the task of the external company).

6 Workplaces with unpredictable, constantly changing exposure

(1) There are workplaces where everything can change, which will influence the exposure to hazardous substances. For example, with many jobs in contaminated areas (e.g. investigation and remediation of existing contamination, construction work at landfills or any sites contaminated accordingly by industrial or commercial use, and with the demolition of industrial plants) or at special waste collection facilities it is for the most part not reliably known what hazardous substances will occur and in what form.

(2) Normally the assessment to be performed on the basis of the present TRGS turns out in individual cases to be not appropriate and too laborious, especially since it is not possible to obtain any adequately reliable information for future states with respect to such work. Workplace measurements are hardly representative under such conditions and are only of limited informative value.

(3) Prior investigations can only give indications of existing substances and their distribution. The reliability of these indications depends among other things on the correct selection for the specific location of the investigation parameters, the type and density of sampling etc., i.e. the representative nature of the investigations to be assumed for the object of the investigation (subsoil, groundwater, brickwork etc.). At locations such as landfills for household waste the stock of substances actually present

can also hardly be described reliably by means of extensive samplings and corresponding analyses. Furthermore there is no fixed workplace (see number 7). Even if the nature of the work remains constant, highly fluctuating exposures may arise due to the (unforeseen) occurrence of different hazardous substances not recorded in the investigations.

(4) For this reason the hazardous substance exposure of workers can normally only be ascertained in real terms in retrospect (the use of biomonitoring may provide helpful information here, see TRGS 710 "Biomonitoring"). That is why protective measures based on a risk assessment must be fixed for such work, measures which take account of the conceivably worst case. This may mean that the use of personal protective equipment through to a full chemical protection suit with insulating respiratory protective equpment is essential, that construction machines and vehicles have to be used which are fitted with breathing air supply systems to BGI 581 or that, if appropriate measuring technology is available, the protective measures are triggered by an alarm.

(5) Of particular help with such activities are practical instructions concerning suitable working procedures and modes of conduct, such as those developed for asbestos clearance, certain jobs in contaminated areas (remediation of building pollutants and fire damage) and special waste collection facilities. The development of such practical instructions (especially TRGS, BG information sheets) assumes sector-wide activities (see number 4 (5)).

7 Workplaces in the open

(1) In the case of work conducted outside the identification and assessment of exposure by measurement according to the specifications of the present TRGS is only possible to a limited extent. This includes, for example, activities in stone quarries, agriculture and forestry, horticulture, road-building, at coking plants and open-air facilities in the chemical industry, during the loading and emptying of tankers, during roofing work or when coating facades. Even if constant activities are performed at these workplaces and the working steps, procedures and materials hardly change, major fluctuations in inhalation exposure will arise due to the influence of wind and weather. Workplace measurements are hardly representative under these conditions and only informative to a limited extent.

(2) Since wind direction and wind strength will change constantly in the open, workplace measurements according to the present TRGS and control measurements for the assessment of the exposure situation only make sense in a few cases. An indication of the worst case exposure can be obtained by measurements conducted in the proximity of the emission source. During activities in the open workers do not always manage to work with their backs to the wind. Protective measures must therefore also be determined with a view to the worst possible conditions.

(3) For workplaces in the open employers should urge their suppliers, industrial association and other representative organisations to draw up aids for the relevant sector.

8 Workplaces underground

(1) At workplaces underground, for exampling load work in potassium or salt mining, work at the face and in the roadways of coal mines, drilling work, road heading, maintenance and repair work and work on mine supports, identical or similar kinds of work is carried out under changing ambient conditions which are nevertheless always precisely known (ventilation). Dangerous and other hazardous substances are subject to a general authorisation procedure by the mining authorities under the Mining Ordinance for Health Protection. Hazardous substances which are released will under certain circumstances also pollute mine areas which are downstream in ventilation terms.

(2) Measurements conducted within the framework of the identification and assessment of inhalation exposure and control measurements are normally not appropriate here. It is frequently possible to conduct reliable calculations of the concentrations on the basis of substance-specific and process-specific data (e.g. emission rates, ventilation data) and the parameters of the authorisation procedure.

(3) The sustainable guarantee of the effectiveness of the protective measures must be ensured by means of technical (e.g. ventilation) or organisational (e.g. quantity limitation) measures.

9 Unforeseen occurrences

To ensure the early detection of elevated exposure levels due to unforeseen occurrences, preference can be given to the use of continuous monitoring procedures (see Annex 4). Where such procedures are not available, other measuring procedures can also be used which are subject to the following requirements in addition to the general quality requirements:

1. The measuring personnel may not be put at risk by the measurement. The measuring assignment must be taken into account in accordance with the contingency plans, taking account especially of the potential use of measuring technology under the special conditions mentioned.
2. The results must be available promptly to facilitate an appropriate reaction to the occurrence.
3. The result of the measurements must supply relevant information which is beyond doubt. This means it must be ensured that the occurrences mentioned can be clearly identified when they have arisen. Special requirements regarding the potential case of use must therefore be set for the specificity, verification strength and sensitivity of the procedures.