BGAA-Report 1/99e
Existing commercial chemicals – Exposure at the workplace

Contributions to the assessment of the risk of chemical substances at the workplace under the EU programme on existing chemicals

HVBG
Hauptverband der gewerblichen Berufsgenossenschaften

Written by: W. Bock, T.H. Brock, R. Stamm, V. Wittneben

Publisher: Hauptverband der gewerblichen
Berufsgenossenschaften (HVBG)
Alte Heerstraße 111, D–53754 Sankt Augustin
Telephone: +49 (0) 22 41 / 2 31 - 01
Fax: +49 (0) 22 41 / 2 31 - 13 33
Internet: www.hvbg.de
– August 2000 –

Typesetting and layout: HVBG, Public Relations

Printed by: Druckerei Plump OHG, Rheinbreitbach

ISBN 3-88383-573-0

Produced with the help of:

Dipl.-Geogr. Wolfgang Bock Dr. Roger Stamm Margret Stückrath Dipl.-Chem. Rainer Van Gelder	Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA des HVBG, Sankt Augustin
Dr. Giso Schmeißer Dr. Ullrich Welzbacher	Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin
Dr. Dirk Dahmann	Bergbau-Berufsgenossenschaft, Bochum
Dr. Uwe Kern	Steinbruchs-Berufsgenossenschaft, Karlsruhe
Dipl.-Ing. Kurt Kolmsee	Steinbruchs-Berufsgenossenschaft, Hannover
Dipl.-Ing. Olaf Pruski	Berufsgenossenschaft der keramischen und Glas-Industrie, Neuwied
Dr. Joachim Gebert	Hütten- und Walzwerks-Berufsgenossenschaft, Essen
Dipl.-Ing. Günther Sonnenschein	Maschinenbau- und Metall-Berufsgenossenschaft, Düsseldorf
Dipl.-Chem. Michael Rocker	Süddeutsche Metall-Berufsgenossenschaft, Mainz
Dr. Johannes Hüdepohl	Berufsgenossenschaft der Feinmechanik und Elektrotechnik, Köln
Dr. Thomas H. Brock Dr. Werner Ernst Prof. Dr. Harald Frohberg Dr. Volker Wittneben	Berufsgenossenschaft der chemischen Industrie, Heidelberg
Dipl.-Ing. Marnix Poppe	Holz-Berufsgenossenschaft, Köln
Dr. Ehler Cuno Dr. Thomas Hensel	Berufsgenossenschaft Druck und Papierverarbeitung, Wiesbaden
Dr. Siegfried Hoffmann Dr. Lothar Neumeister	Textil- und Bekleidungs-Berufsgenossenschaft, Augsburg
Dr. Uwe Musanke Dr. Reinhold Rühl	Bau-Berufsgenossenschaft Frankfurt am Main, Frankfurt am Main

Produced with the help of:

Dr. Joachim Schwalb	Großhandels- und Lagerei-Berufsgenossenschaft, Mannheim
Dr. Valerie Wilms	Berufsgenossenschaft der Straßen-, U-Bahnen und Eisenbahnen, Hamburg
Dr. Christian Felten	Berufsgenossenschaft für Fahrzeughaltungen, Hamburg

Abstract

This report contains the substance data and exposure descriptions prepared by the Berufsgenossenschaften's* working group on existing commercial chemicals (BGAA) for 44 existing commercial chemicals chosen from the first three EU priority lists and the OECD priority list.

These exposure descriptions focus predominantly on the areas where the substances in question are used and are based on measurements taken at the workplace since 1990 by the Berufsgenossenschaften for the industrial sector and municipal accident insurance associations. The exposure descriptions have already been made available to the competent authorities appointed under the EU programme on existing chemicals. This publication is intended to make them available to a wider professional circle. They can be used for identifying key areas in which preventive measures need to be implemented, for discussing acceptable limits and for assessing risks.

All data analysed for this report are stored in the MEGA database (Messdaten zur Exposition gegenüber Gefahrstoffen am Arbeitsplatz – measurements of exposure to hazardous chemicals at the workplace) at the Berufsgenossenschaften's Institute for Occupational Safety (Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA).

*Institutions for Statutory Accident Insurance and Prevention

Kurzfassung

Als Arbeitsergebnis des Berufsgenossenschaftlichen Arbeitskreises Altstoffe (BGAA) werden Stoffdaten und Expositionsbeschreibungen zu 44 ausgewählten Altstoffen aus den ersten drei Prioritätenlisten der EU und der OECD-Prioritätenliste vorgestellt.

Diese Expositionsbeschreibungen beziehen sich im Wesentlichen auf Verwendungsbereiche der jeweiligen Substanzen und basieren auf betrieblichen Messungen der gewerblichen Berufsgenossenschaften und Gemeindeunfallversicherungsverbände im Zeitraum seit 1990. Die Expositionsbeschreibungen wurden den zuständigen Stellen im EU-Altstoffprogramm zur Verfügung gestellt. Mit dieser Veröffentlichung werden sie der breiteren Fachöffentlichkeit übergeben, sie können z.B. Verwendung finden bei der Identifikation von Präventionsschwerpunkten, im Rahmen der Erörterung von Grenzwerten oder auch zur Risikoabschätzung.

Alle für diesen Report ausgewerteten Daten liegen in der Datenbank MEGA (Messdaten zur Exposition gegenüber Gefahrstoffen am Arbeitsplatz) beim Berufsgenossenschaftlichen Institut für Arbeitssicherheit – BIA vor.

Résumé

Les données des matériaux et les descriptions d'exposition de 44 substances existantes, choisies parmi les trois premières listes de priorités de l'UE et les listes de l'organisation de coopération et de développement économiques (OECD), sont présentées comme résultats du travail effectué par le cercle de travail substances existantes (BGAA) des Berufsgenossenschaften.

Les descriptions d'exposition se réfèrent essentiellement aux secteurs d'utilisation des substances correspondantes et se basent sur des mesurages effectués dans des entreprises membres par les Berufsgenossenschaften et les et des caisses d'assurance accident communales, dans la période depuis 1990.

Ces descriptions d'exposition ont été mises à la disposition des services compétents dans le programme des substances existantes de l'UE. Grâce à cette publication, elles seront transmises à un large public professionnel. Elles pourront être utilisées, par exemple, pour l'identification des priorités de prévention , dans le cadre du débat des valeurs limites et aussi pour l'estimation des risques.

Toutes les données analysées pour ce rapport se trouvent dans la banque de données MEGA (Données de mesurage en ce qui concerne l'exposition aux matières dangereuses sur les lieux de travail) à l'Institut des Berufsgenossenschaften pour la sécurité du travail – BIA.

Resumen

El resultado de las actividades desempeñadas por el grupo de trabajo de las Berufsgenossenschaften sobre Materiales Viejos (BGAA) es una presentación de datos sobre materiales y descripciones de la exposición respecto a 44 materiales viejos que se han seleccionado de las tres primeras listas de prioridad de la UE y de la lista de prioridades de la OECD.

Estas descripciones de exposición se refieren fundamentalmente a los campos de utilización de las respectivas sustancias y se basan en mediciones que las Berufsgenossenschaften de la industria y las asociaciones municipales de seguros de accidente han efectuado en empresas desde 1990. Las descripciones de la exposición se han puesto a disposición de los órganos competentes en el marco del programa de materias viejas de la UE. Con esta publicación se entregan a un público más amplio de expertos. Estos datos pueden utilizarse p.ej. para identificar preferencias de la prevención en el marco de la discusión de valores límite o para realizar una evaluación de riesgos.

Todos los datos evaluados para este informe están disponibles en el banco de datos MEGA (datos de medición respecto a la exposición ante sustancias peligrosas en el puesto de trabajo) del Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA (Instituto de la Berufsgenossenschaften para la seguridad en el trabajo).

Contents

Contents

Page

1 Introduction

1.1 Regulation on the evaluation and control of the risks of existing substances and the EU programme on existing chemicals

Council Regulation (EEC) 793/93 on the "evaluation and control of the risks of existing chemical substances" has been in force in all EU member states since 23 May 1993 [1, 2]. Under this Regulation, "existing chemicals" are chemical substances which were brought onto the market before 18 September 1981. Around 106,000 chemicals, which are listed in the European Inventory of Existing Commercial Chemical Substances (EINECS), fall into this category. The aim of the Regulation is to assess the potential risks posed by these substances to humans and the environment so that decisions can be reached concerning any measures which may need to be implemented. The evaluation will focus on the environment, consumers and employees at the workplace. Initially around 2,500 substances, which have been given priority because of the quantities in which they are produced, are to be assessed.

In preparation for the risk assessments, the Commission of the European Communities has arranged for priority lists to be drawn up; each member state will be responsible for examining one of the substances in question (3, 4, 5). In Germany, the official co-ordinator and reporter ("rapporteur") to the EU Commission is the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin – BAuA), the notification unit appointed under the Chemicals Act (Chemikalien-Gesetz). Major manufacturers will each be responsible for compiling data and drawing up risk assessments for one or more substances.

The EU Regulation on the evaluation and control of the risks of existing substances prescribes that the effect of the substances on humans and the environment be examined. Risks are to be assessed systematically with a view to protecting humans, namely employees and consumers. It is possible to estimate the risk posed by a substance by assessing exposure to the substance and its effect.

The procedure is illustrated in simplified form in the diagram in Figure 1 (see page 14). In addition to physico-chemical data and examinations carried out on human subjects, data from the following toxicological tests are used to determine the toxicological effect of a substance: toxicokinetics and metabolism, acute toxicity, compatibility with skin and mucous membranes, sensitising effect, repeated dose toxicity (subacute, subchronic and chronic toxicity), genetic toxicity, carcinogenicity, toxicity to reproduction, effect on the immune system and neurotoxicity.

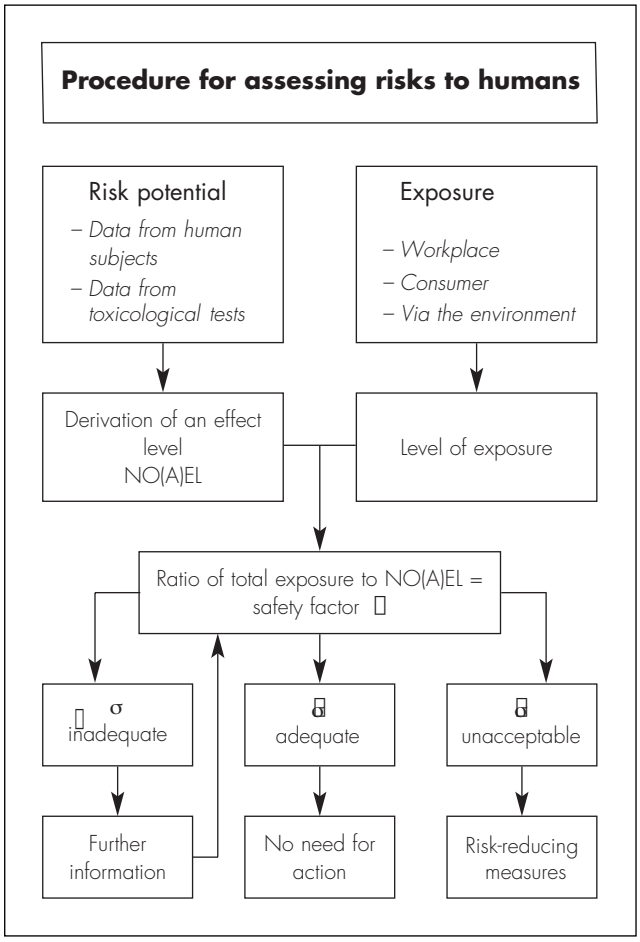


Figure 1:
Procedure for assessing risks to humans

Wherever possible, these factors are used to determine an effect level – the "No Observed (Adverse) Effect Level" (NO[A]EL), below which no harmful effects are observed. The resulting safety factor σ is derived from the ratio of the total exposure to the NO(A)EL. The national assessment units – for occupational safety this is the Federal Institute of

Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin – BAuA), for consumer protection the Federal Institute for Consumer Health Protection and Veterinary Medicine (Bundesinstitut für gesundheitlichen Verbraucherschutz und Veterinärmedizin – BgVV) and for environmental protection the Federal Environmental Agency (Umweltbundesamt – UBA) – and the expert committees, in particular the Society of German Chemists' Advisory Committee for Existing Chemicals (Beratergremium für Altstoffe der GDCh – BUA) and the Berufsgenossenschaften's working group on existing commercial chemicals (Berufsgenossenschaftlicher Arbeitskreis Altstoffe – BGAA), use this safety factor as a basis for deciding whether further action is required.

1.2 Involvement of the Berufsgenossenschaften

The Berufsgenossenschaften are involved in assessing the risks to humans at the workplace. Exposure at the workplace is one of three factors which have to be taken into consideration in order to determine the overall exposure level, the other two factors being exposure as a consumer and exposure via the environment.

Manufacturers and importers of substances, the two main target groups of the Regulation, can generally only determine the exposure levels occurring during the manufacture of the substance in question. In 1994, therefore, the Berufsgenossenschaften offered to assist with the examination of existing chemicals under the Regulation on the evaluation and control of the risks of existing substances by providing the Federal Ministry of Employment and Social Affairs (Bundesministerium für Arbeit und Sozialordnung – BMA) with facts and figures concerning the procedures followed by users of harmful substances in each area of industry. The BMA welcomed the opportunity to involve the Berufsgenossenschaften more closely in the assessment of existing chemicals. To enable the Berufsgenossenschaften to participate in the implementation of the Regulation, the Berufsgenossenschaften's working group on existing commercial chemicals (BGAA), directed by the Berufsgenossenschaft for the chemical industry (Berufsgenossenschaft der chemischen Industrie), was founded by decision of the conference of chief executives in December 1994. The BGAA compiles the measurements from the MEGA database (MEGA = Messdaten zur Exposition von Gefahrstoffen am Arbeitsplatz – measurements of exposure to hazardous substances at the workplace) maintained by the Berufsgenossenschaften's Institute for Occupational Safety (Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA) in Sankt Augustin and uses them as a basis for preparing exposure descrip-

tions [6]. The MEGA database has been used to document extensive measurements taken within the framework of the Berufsgenossenschaften's measurement system for hazardous substances (Berufsgenossenschaftliches Messsystem Gefahrstoffe – BGMG) for 25 years [7].

The BGAA's duties cover the following areas:

1. Investigating and providing advice on how the Berufsgenossenschaften can actively contribute to documenting the risks posed by existing substances.

2. Providing a point of contact between the Berufsgenossenschaften and other bodies involved in the programme on existing chemicals, for example the notification unit and the national assessment unit at the BAuA, the national assessment units of other EU states and major companies participating in the programme.

3. Developing criteria for producing exposure descriptions.

4. Setting priorities for examining substances.

5. Establishing a regulatory framework to ensure that the Berufsgenossenschaften incorporate all available exposure data correctly.

6. Promoting and facilitating the exchange of information between the Berufsgenossenschaften concerning the substances and their areas of application with a view to improving safety at the workplace, including existing chemicals being assessed by other EU member states.

7. Comparing and co-ordinating German data with information from other EU states. The aim is that the criteria applied in determining exposure levels be assessed uniformly.

8. Investigating existing chemicals for which action is currently needed but which are not considered priority substances under the EU Regulation on the evaluation and control of the risks of existing substances. This could possibly result in suggestions for further EU priority lists.

The BGAA is composed of representatives of the Berufsgenossenschaften. It is directed by the Berufsgenossenschaft for the chemical industry and works in close co-operation with the BIA. Correspondence should be addressed to:

Dr Thomas H. Brock
Berufsgenossenschaftlicher Arbeitskreis Altstoffe – BGAA, c/o Berufsgenossenschaft der chemischen Industrie, Postfach 101480, 69004 Heidelberg, Germany

The BGAA has developed a system for drawing up exposure descriptions for the programme on existing chemicals. The "BGAA format" is based on guidelines set down by the national assessment unit (BAuA). The exposure descriptions drawn up by the BGAA are forwarded to the competent body of the German programme on existing chemicals (rapporteur at the BAuA) in this format.

If the requisite measurements are available, the BGAA also prepares exposure descriptions for existing chemicals which other EU members are responsible for investigating. It passes these on to the German rapporteur, who subsequently forwards them to the appropriate rapporteur in the other EU country.

1.3 BGAA Report

The BGAA feels that its exposure descriptions should be made accessible to a wider (professional) circle and has therefore decided to have them published by the German Federation of Institutions for Statutory Accident Insurance and Prevention (Hautverband der gewerblichen Berufsgenossenschaften – HVBG).

The aim is to provide accurate information containing facts of relevance to the issue of risks posed by hazardous substances at the workplace, such as advice on admissible levels, and identifying key areas in which preventive measures need to be implemented. It should be noted that, statistically speaking, some of the measurements contained in the exposure descriptions in this report are presented in a rather generalised form in line with the requirements of the programme on existing chemicals. A more detailed data analysis is often required for the purposes of practical prevention at the workplace and for attributing symptoms of a suspected occupational disease to conditions in which an employee has worked. Nevertheless, the exposure descriptions drawn up by the BGAA provide useful information and guidelines.

This first report contains the BGAA's exposure descriptions for the priority substances appearing on the lists drawn up under the EU Regulation on the evaluation and control of the risks of existing substances and for the substances selected by the OECD (Chapter 5 "Priority Lists"), where the Berufsgenossenschaften have measurements for the exposure situation at the workplace at their disposal. It is not always the case that all work areas of relevance to the substance in question will have been monitored by the Berufsgenossenschaften; for example, large companies often have internal departments which take the measurements for them.

The report therefore focuses on the areas in which the hazardous substances are used and not on their manufacture. As already mentioned, manufacturers usually have their own set of measurements for assessing the risk of hazardous substances at the workplace, so the BGAA's exposure descriptions contain only a few isolated measurements relating to the manufacturing process.

The BGAA has developed its own format for describing exposure levels at the workplace (see Figure 2). The format is explained in more detail in section 2.2.

As well as providing exposure descriptions for assessing the risks of existing substances, the Berufsgenossenschaften have for many years been working on toxicological assessments under the programme for the prevention of damage to health by hazardous substances at the workplace initiated by the Berufsgenossenschaft for the chemical industry [8].

Figure 2:
The BGAA's "Exposure at the workplace" format

Exposure at the workplace	
Identification and limit values of substance	❒ Name ❒ Formula, with molecular weight in g/mol for compounds ❒ Synonyms ❒ CAS number ❒ German limit value ❒ Data collection period ❒ BGAA exposure description no.
Measurement method (EN 689/482)	❒ Sampling method ❒ Analytical method ❒ Analytical reference limit
Exposure description	❒ Shift exposure/Short time exposure values ❒ Statistical parameters – Number of measurements – Number of companies – 50%, 90% and 95% value ❒ If necessary differentiation depending on whether or not local exhaust ventilation is used in the work area concerned ❒ Notes on measurement results and work processes

2 Analysis and presentation of exposure data

2.1 Data base

The measurements used in the following exposure descriptions were collected using the "Berufsgenossenschaften's Measurement System for Hazardous Substances" (BGMG) and stored in the MEGA database [7].

Thanks to the extensive measurement activities which the Berufsgenossenschaften carry out at their member companies, approx. 60,000 air samples are currently analysed at around 4,000 companies every year. The measurements are recorded together with operational, exposure and sampling data in the BIA's MEGA documentation system.

To ensure that the exposure descriptions are as up to date as possible, the analyses incorporate data from the last five years. As the BGAA began its work at the start of 1995, the analyses for the first hazardous substances examined relate to the period from 1990 to 1994; the analyses of all the hazardous substances examined subsequently were based on the following five-year periods.

With the co-operation of experts from the industries in question, the data were grouped into similar work areas and work processes [9] on the basis of key inventories of company types (area of industry) and work areas. The term "work area" indicates a physically and organisationally separate part of a company, which may incorporate one or more workplaces.

The measurements in the BGMG system were taken for a variety of reasons, the most common being:

- Measurements taken **as part of a supervisory duty** for various reasons. These also include measurements which were taken because of suspected exposure during a work process but which revealed no or only negligible exposure. This obviously results in a very wide spread of measurements in accordance with the variety of work areas examined and the various conditions affecting the measurements in each case.

- Measurements taken on the grounds of a **suspected occupational disease.** These measurements are often taken in "worst-case" conditions. Because of the variety of exposure situations examined, the spread of the measurements is similar to that for the measurements taken as part of a supervisory duty.

2.2 Selection criteria

Only personal exposure levels measured in the air at the workplace which met the following conditions were taken into consideration in the analysis:

- The measurement method meets the measurement strategy requirements of (DIN) EN 689 [10] / TRGS 402 and the measurement method requirements of (DIN) EN 382 [11]. This also includes measurements taken using respiratory protective devices. Not included, however, are measurements obtained from the area behind the gas mask.

- The measurements were taken using the sampling systems (sampling methods/ sampling media) specified by the BGMG at the time the measurements were taken [12].

- The analyses were carried out in accordance with the analysis procedures specified by the BGMG at the time of analysis [12]. Please note: *The analytical reference limit of an analytical procedure refers to the smallest quantity of a substance considered to be of statistical relevance which can be proven to be present with a certainty of 95%. In other words, quantitative concentration data are only listed if the result of the analysis is the same or higher than the analytical reference limit. Concentration data with a "low analytical reference limit" indicate the relative reference limit, which is not constant but depends on analytical and sampling conditions.*

- The process prescribed in ZH 1/120 (now BGI 505) was applied for carcinogenic substances [13].

The measurements were analysed separately wherever possible:

- Average exposure levels per shift: measurements taken for an exposure time of $t_E \geq 1$ hour, which were converted to average levels per shift in accordance with the specified exposure time (8-hour exposure) where appropriate. However, the measurements generally related to an 8-hour exposure time and therefore did not need to be converted. The conversion of the few measurements relating to an exposure time of less than 8 hours has no significant influence on the distribution parameters of the data set as a whole.

- Activity-related measurements taken for an exposure time of $t_E < 1$ hour: the measurements relating to exposure times of < 1 hour are activity-related concentration measurements. For shorter exposure

times the measurements can be used as average exposure levels per shift in "worst case" estimates.

In the BGMG both stationary sampling systems and personal (worn) sampling devices are used for measuring personal related exposure at the workplace. As both systems provide personal related measurements and are therefore both equally suitable for determining exposure levels, evaluations were not categorised according to the sampling system used.

To produce a specific evaluation, work areas and work processes occurring in more than one industry have been grouped together wherever possible. Explanations of individual exposure levels are only given if further process-specific data are available.

Measurement activities were distributed more or less equally among companies of different sizes – size being evaluated in terms of the number of employees [7]. In most of the evaluations no distinction is made between small, medium-sized and large companies because experience has shown that it is usually the processes and substances in question which are of relevance to the exposure situation rather than the size of the company.

As far as possible, separate evaluations were carried out for work areas which did and did not use technical protection measures to reduce exposure (local exhaust ventilation). The following should be noted in this connection:

Technical measures are usually implemented in cases where the specific workplace situation leads to higher emissions of gas, vapour, mist or dust. This can be the case, for example, if large quantities of a substance are handled in an open environment, if a substance evaporates after being applied to large areas or if it is processed at high temperatures. In contrast, emissions are comparatively low if the same substance is used in small quantities, if the substance is applied over small areas or if it is processed at or below room temperature. The result of using technical measures is usually that the exposure level in workplaces with high emissions is brought roughly into line with the level in workplaces with low emissions and no technical measures. Hence the apparent paradox of workplaces with local exhaust ventilation often having the same or even higher exposure levels than those without local exhaust ventilation.

The total number of measurements taken with and without local exhaust ventilation may be lower than the number of measurements taken for the company type/work area in question as the measurement data do not always contain any information about local

exhaust ventilation. The following exposure descriptions indicate only whether or not local exhaust ventilation is used.

2.3 Parameters applied in statistical evaluation

The evaluation was carried out in accordance with an agreement concluded between the Berufsgenossenschaften and the HVBG concerning the use of DOK-MEGA: *To ensure that evaluations are as accurate as possible, data sets shall only be created and subjected to statistical evaluation if more than nine measurements from at least five companies and two Berufsgenossenschaften are available.*

50%, 90% and 95% values were used for the exposure data in the tables, irrespective of the categorisation criteria applied for the set of measurements in question. These figures mean that 50%, 90% or 95% of all available exposure measurements are below the prescribed limit, while the remaining 50%, 10% or 5% are above this limit [14].

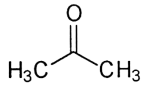
Unlike other statistical parameters, these values enable various data sets to be compared directly so that different exposure conditions can be examined.

3 Exposure descriptions

3.1 Acetone

Identification and limit values

Formula



C_3H_6O

Molecular weight in g/mol	58.08
CAS No.	67-64-1
Synonyms	dimethyl ketone, propanone, propan-2-one, 2-oxopropane
German limit value	1,200 mg/m^3, 500 ml/m^3 (MAK)*
Data collection period	1992 to 1996
BGAA exposure description	No. 35

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3.

Notes on the results

General

The analysis was based on 4,256 measurements taken from around 1,300 companies.

Average exposure levels per shift

The analysis of the average exposure levels per shift measured in the various work areas and company types is presented in Table 1.

*Maximale Arbeitsplatzkonzentration – MAK (maximum admissible concentration)

Manufacture of pharmaceutical/chemical products: the data were collected on dissolvers, bead mills and decanting equipment. Levels in the region of 90% were measured for the preparation and dispensing of paints.

Cleaning, degreasing: the data were collected predominantly in the metalworking, electrical, woodworking and chemical industries. Levels in the region of 90% were measured for the manual cleaning of containers (e.g. paint manufacture) and machine parts (removal of plastic and adhesive residues).

Glueing (plastics, metalworking, electrical, woodworking, furniture industries): levels in the region of 90% were measured for the glueing over large areas.

Glueing (leather/shoe industries): levels in the region of 90% were measured for the manual and mechanical glueing in rooms with unfavourable conditions.

Glueing, floor laying (wood, textiles, plastics): levels in the region of 90% were measured for the application of parquet adhesives and fillers in rooms without ventilation.

Brushing, painting, rolling (plastics, metalworking, electrical, woodworking, furniture, glass and ceramics industries): levels in the region of 90% were measured for manual painting without local exhaust ventilation.

Brushing, painting, rolling (construction industry): the data were collected during the painting of walls, windows and domestic installations. Levels in the region of 90% were measured for the application of primers.

Spray painting (plastics, metalworking, electrical, upholstered furniture, glass and ceramics industries): the data were collected predominantly on dry-type and waterwash spray-booths. Levels in the region of 90% were measured for the spraying of coatings (for example polyurethanes).

Spraying (woodworking industry): the data were collected predominantly on dry-type and waterwash spraybooths.

Spraying (construction industry): the data were collected predominantly during anti-corrosion work. Levels in the region of 90% were measured for the spraying of coatings and primers.

Mechanical surface coating (plastics, furniture, woodworking, metalworking, electrical, ceramics, glass and printing industries): the data were collected on coating machines (dip-coating, cast-coating, enamelling, spreading, laminating). Levels in the region of 90% were measured for cast-coating and spreading and for cleaning work in laminating areas.

Table 1:
Acetone – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manufacture of pharmaceutical/ chemical products	311	120	17	216	413
– Without local exhaust ventilation	152	69	18	171	357
– With local exhaust ventilation	148	66	13	275	417
Cleaning, degreasing	257	143	15	296	619
– Without local exhaust ventilation	127	76	14	398	612
– With local exhaust ventilation	114	64	13	165	596
Glueing (plastics, metalworking, electrical, woodworking and furniture industries)	587	213	13	249	514
– Without local exhaust ventilation	318	120	12	170	309
– With local exhaust ventilation	244	101	13	363	811
Glueing (leatherwork/shoe industry)	425	83	31	510	806
– Without local exhaust ventilation	158	40	5	442	820
– With local exhaust ventilation	262	50	66	538	779
Glueing (floor laying) – All measurements without local exhaust ventilation	128	58	57	343	578

Table 1
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Brushing, painting, rolling (plastics, metalworking, electrical, wood working, furniture, glass and ceramics industries)	97	48	9	78	176
– Without local exhaust ventilation	65	34	10	130	227
– With local exhaust ventilation	19	11	5	11	16
Brushing, painting (construction industry)					
– All measurements without local exhaust ventilation	25	9	1	11	31
Spray painting (plastics, metal-working, electrical, upholstered furnishings, glass and ceramics industries)	397	223	6	66	139
– Without local exhaust ventilation	47	30	5	35	90
– With local exhaust ventilation	329	189	7	77	184
Spraying (woodworking industry)	668	261	4	32	60
– Without local exhaust ventilation	14	10	3	13	67
– With local exhaust ventilation	649	253	4	33	60
Spraying (construction industry)	50	18	8	50	201
– Without local exhaust ventilation	33	11	11	84	504
– With local exhaust ventilation	16	9	4	43	68
Mechanical surface coating (plastics, furniture, woodworking, metalworking, electrical, ceramics, glass and printing industries)	1117	420	9	102	199
– Without local exhaust ventilation	468	183	13	114	200
– With local exhaust ventilation	624	251	8	86	200

Measurements for a reduced exposure time of < 1 hour

The analysis of the average exposure levels per shift measured in the respective work areas and company types is presented in Table 2.

Glueing (floor laying): the data were collected during the laying of wooden (parquet) and textile/plastic flooring. Levels in the region of 90% were measured for the application of parquet adhesives and fillers.

Cleaning: the data were collected during the manual and mechanical cleaning of machines and components. Levels in the region of 90% were measured for the removal of residual adhesive from machines and containers.

Coating (glueing, painting, rolling, spraying): levels in the region of 90% were measured for spraying.

Production and storage of preparations: levels in the region of 90% were measured for decanting.

Table 2:
Acetone – Measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg /m^3
Glueing (floor laying) – All measurements without local exhaust ventilation	114	42	11	738	3018
Cleaning	28	22	34	1438	2628
Coating (glueing, painting, rolling, spraying)	38	29	19	279	793
Production and storage of preparations	14	7	31	197	285

3.2 Acetonitrile

Identification and limit values

Formula	$H_3C—CN$ C_2H_3N
Molecular weight in g/mol	41.05
CAS No.	75-05-8
Synonyms	methyl cyanide, cyanomethane
German limit value	70 mg/m^3, 40 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 9

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with acetone, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

The measurements come from the chemical industry (plastics and pharmaceuticals industries and research laboratories).

Average exposure levels per shift

Table 3 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below. Levels in the region of 90% were measured in laboratories where acetonitrile is used as a mobile phase for chromatographical processes.

Table 3:
Acetonitrile – Average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	15	10	1	8	12.3

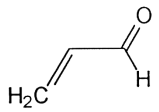
Measurements for a reduced exposure time of < 1 hour

Only one measurement was obtained from the chemical industry. A value of 17 mg/m^3 was measured for the decanting of waste acetonitrile from bottles into waste solvent containers (local exhaust ventilation used).

3.3 Acrylaldehyde

Identification and limit values

Formula



C_3H_4O

Molecular weight in g/mol	56.06
CAS No.	107-02-8
Synonyms	acrolein, 2-propenal
German limit value	0.25 mg/m^3, 0.1 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 14

Measurement method

A defined volume of air is sucked through an impregnated glass fibre filter using a sampling pump with a chemisorber. After extraction with acetonitrile, quantitative analysis is carried out by means of gas chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.01 mg/m^3.

Notes on the results

General

A total of 352 measurements from 172 companies in the chemical, plastics, rubber, ceramics, glass, metalworking, mechanical engineering, electronics, precision mechanics, woodworking and construction industries and other branches of industry were analysed.

As all the measurements taken for surface coating, mechanical machining processes and in offices were below the analytically detectable concentration, no statistical analysis was carried out for these work processes and areas.

Average exposure levels per shift

Table 4 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Table 4:
Acrylaldehyde – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Thermal processing of plastics	94	43	*)	*)	0.02
– Without local exhaust ventilation	59	32	*)	0.015	0.03
– With local exhaust ventilation	35	13	*)	*)	*)
Drying, sintering, calcining, melting	34	23	*)	0.02	0.02
– Without local exhaust ventilation	15	12	*)	0.015	0.045
– With local exhaust ventilation	19	11	*)	*)	0.02
Smokehouses	13	7	0.08	0.25	0.31
Thermal machining processes	175	94	*)	*)	*)
Glueing	52	25	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3).

Thermal processing of plastics (extrusion, hot pressing): 90% of the measurements were below the analytically detectable concentration. Levels above the analytically detectable concentration were measured for the hot pressing of plastic coatings in the furniture industry.

Smokehouses: in smokehouses no-one stays for longer than four hours in the areas in question.

Thermal machining operations (welding, soldering, flame cutting): more than 95% of the measurements were below the analytically detectable concentration. Levels above the analytically detectable concentrationt occurred in individual cases for the welding of plastic bags and the soldering of printed circuit boards.

Glueing: 95% of the measurements were below the analytically detectable concentration. Levels above the analytically detectable concentration occurred in individual cases for the processing of hot-melt adhesives.

Measurements for reduced exposure time of < 1 hour

The measurements are taken from all the aforementioned industries. Table 5 shows the measurements for a reduced exposure time (t < 1 h). Levels above the analytically detectable concentration were measured on reaction vessels.

Table 5:
Acrylaldehyde – measurements for a reduced exposure time of < 1 hour

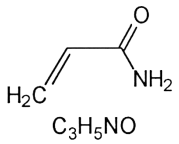
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	18	13	*)	*)	0.2

*) Value < analytically detectable concentration (see also 2.2 and 2.3)

3.4 Acrylamide

Identification and limit values

Formula



Molecular weight in g/mol	71.01
CAS No	79-06-1
Synonyms	propenamide
German limit value	0.06 mg/m^3 (TRK* for the use of solid acrylamide, otherwise a TRK of 0.03 mg/m^3 applies)
Data collection period	1990 to 1995
BGAA exposure description	No. 12

Measurement method

A defined volume of air is sucked through a GGP sampling system. The system contains a glass fibre filter for particle separation and is filled with an activated charcoal tube in a glass cartridge for the adsorption of gaseous acrylamide. After one hour of desorption with dichloromethane/methanol (9 : 1), quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.005 mg/m^3 (see also [15]).

Notes on the results

General

28 measurements from 11 companies were analysed. The measurements come from the chemical industry and flat glass industry. Table 6 shows the average exposure levels per shift.

*Technische Richtkonzentration – TRK (technical reference concentration)

3 Exposure descriptions

The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Chemical industry: levels in the region of 90% were measured for the preparation and filling of reaction vessels with acrylamide (in solid form or as an aqueous solution). Air-lock systems are used when handling solid acrylamide. Respiratory protective devices are obligatory.

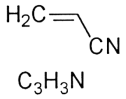
Safety glass manufacture, fireproof glass: levels in the region of 90% were measured for decanting during the manufacture of safety glass.

Table 6:
Acrylamide – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Chemical industry	13	7	0.07	0.15	0.16
Fireproof glass, manufacture and processing	15	4	0.04	0.10	0.11

3.5 Acrylonitrile

Identification and limit values

Formula	 C_3H_3N
Molecular weight in g/mol	53.06
CAS No.	107-13-1
Synonyms	vinyl cyanide, cyanoethene, ethylene cyanide
German limit value	7.0 mg/m^3, 3.0 ml/m^3 (TRK)
Data collection period	1991 to 1995
BGAA exposure description	No. 7

Measurement method

A defined volume of air is sucked through a silica gel tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.05 mg/m^3.

Notes on the results

General

112 measurements from 63 companies were analysed. 35% of the measurements come from the plastics manufacturing industry, 13% from the chemical industry, 9% from the electrical engineering industry and 7% from the paper and card manufacturing industry.

Average exposure levels per shift

Table 7 shows the average exposure levels per shift. 91% of all measurements were below the analytically detectable concentration. Levels above the analytically detectable concentration occurred in individual cases during the manufacture of plastic (reaction vessels, mixers, extruders) in work areas without local exhaust ventilation. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Extruders for plastics, injection moulds: 95% of the levels measured on extruders were below the analytically detectable concentration.

Surface coating: no levels above the analytically detectable concentration were measured.

Paper and card manufacture: no levels above the analytically detectable concentration were measured.

Table 7:
Acrylonitrile – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Extruders for plastics, injection moulds – Without local exhaust ventilation – With local exhaust ventilation	69 53 14	43 34 10	*) *) *)	*) *) *)	*) *) *)
Surface coating (spraying, brushing, rolling, filling, glueing)	20	16	*)	*)	*)
Paper and card manufacture	16	6	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

The data set was too small for a statistical analysis to be carried out (Table 8). The maximum value was 46 mg/m^3, which was measured for the manufacture of coatings, adhesives, fillers and grouts without local exhaust ventilation but using respiratory protective devices.

Table 8:
Acrylonitrile – measurements for a reduced exposure time

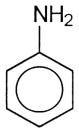
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	7	6	*)	*)	*)

*) There were not enough measurements for a statistical analysis (see also section 2.3)

3.6 Aniline

Identification and limit values

Formula



C_6H_7N

Molecular weight in g/mol	93.12
CAS-No.	62-53-3
Synonyms	aminobenzene, phenyl amine
German limit value	8.0 mg/m^3, 2.0 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 34

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with methanol with 2% KOH, quantitative analysis is carried out by means of gaschromatography using a nitrogen-selective detector. The detectable concentration for two hours of sampling is 0.05 mg/m^3.

Notes on the results

General

The measurements come from all areas of industry and work areas (for example plastics manufacture, glueing, waste disposal). 85% of the measurements are below the analytically detectable concentration.

Table 9:
Aniline – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	28	22	*)	0.06	0.10

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.7 Benzene

Identification and limit values

Formula	 C_6H_6
Molecular weight in g/mol	78.11
CAS-No.	71-43-2
Synonyms	–
German limit value	8.0 mg/m^3, 2.5 ml/m^3 (TRK) for coke oven plants (crude tar separators, condensers, gas exhauster), tank farms in the mineral oil industry and the repair and maintenance of petrol- or benzene-carrying components, otherwise 3.2 mg/m^3, 1.0 ml/m^3 (TRK)
Data collection period	1991 to 1995
BGAA exposure description	No. 13

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling was 1.0 mg/m^3 until 1992 and since then has been 0.1 mg/m^3 [12] (see also [16]).

Notes on the results

General

940 measurements were analysed from around 370 companies in the chemical, plastics, rubber, ceramics, glass, metalworking, mechanical engineering, electronics, precision

mechanics, construction, wholesale and transport industries, vehicle repair shops, foundries and other areas.

In most areas of the mineral oil industry, the chemical industry and coke-oven plants, measurements are generally taken by corporate and external bodies. These results are not included in the MEGA documentation. Measurements from these sectors are given in BIA Report 3/93 "Arbeitsumweltdossier Benzol" (report on benzene in the working environment) [17].

Average exposure levels per shift

Table 10 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Cold/hot processing of plastics (kneading, pressing, extrusion): the measurements come from the plastics processing and electrical engineering sectors. All measurements were below the analytically detectable concentration.

Decanting: 85% of the measurements were taken in the chemical industry and the wholesale sector. Levels in the region of 90% occurred, for example, for decanting fuels or other mixtures with a high benzene content when no technical protective measures had been implemented.

Repair/Maintenance/Test rigs: the measurements were taken in the metalworking/mechanical engineering industries and at vehicle repair shops. Levels in the region of 90% were measured on engine test rigs and during petrol pumps and engine repairs (particularly carburettors, fuel filters and fuel lines).

Thermal machining processes (welding, laser cutting, electrical cavity sinking): more than 80% of the measurements were taken for electrical cavity sinking operations in the metalworking and electrical engineering industries and for laser cutting in the plastics processing industry. The measurements were below the analytically detectable concentration.

Mechanical machining processes: the analysis focused on the metalworking and mechanical engineering industries. No levels above the analytically detectable concentration were measured.

Glueing: the measurements were taken primarily in the plastics, rubber and shoe manufacturing industries. 90% of the levels measured were in the region of the analytically detectable concentration.

Surface coating (spray painting, brush/roller application, screen printing): the measurements were taken in all sectors of the processing industry. No levels above the analytically detectable concentration were measured.

Dryers, box/smelting and hardening furnaces: the measurements come predominantly from the metalworking industry (surface finishing). In all cases the measurements were below the analytically detectable concentration.

Cleaning machine components: the measurements were taken in the chemical industry and in printing works. No levels above the analytically detectable concentration were measured.

Cleaning tanks: the measurements were taken during the manual cleaning of tanks and on tank cleaning machines. Measurements for the cleaning of fuel oil and diesel tanks were below the 50% value, while levels above 50% were measured for the cleaning of crude benzene tankers. Local exhaust ventilation was either not used or had little effect.

Casting (foundries): levels in the region of 90% were measured for casting in resin-bonded moulds (furan and phenolic resins).

Table 10:
Benzene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Cold/hot processing	60	34	*)	*)	*)
Decanting – Without local exhaust ventilation – With local exhaust ventilation	47 38 9	25 21 4	0.2 0.2 *)	2.0 4.7 *)	11.8 12.6 *)
Repair/Maintenance/Test rigs – Without local exhaust ventilation – With local exhaust ventilation	335 109 187	95 43 53	0.2 0.7 0.2	2.8 3.2 1.0	5.9 5.2 4.3
Thermal machining processes	147	72	*)	*)	*)
Mechanical machining processes	62	31	*)	*)	*)
Glueing – Without local exhaust ventilation – With local exhaust ventilation	28 22 5	14 10 4	*) *) *)	*) *) *)	0.8 1.0 *)
Surface coating	116	54	*)	*)	*)
Dryers, box/smelting and hardening furnaces	38	24	*)	*)	*)
Cleaning machine components	12	8	*)	*)	*)
Cleaning tanks	19	9	14.4	66.0	67.7
Casting (foundries) – Without local exhaust ventilation – With local exhaust ventilation	69 52 11	36 29 7	*) 0.5 *)	3.1 4.0 1.0	5.0 5.4 1.6

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3).

Measurements for a reduced exposure time of < 1 hour

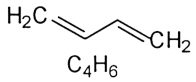
The measurements are taken from all the aforementioned industries. Levels in the region of 90% were measured for the repair and maintenance of gasoline engines.

Table 11:
Benzene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/work areas (no local exhaust ventilation in most cases)	45	31	1.5	7.8	12.7

3.8 1,3-Butadiene

Identification and limit values

Formula	
Molecular weight in g/mol	54.09
CAS No.	106-99-0
Synonyms	buta-1,3-diene, butadiene-1,3
German limit value	11 mg/m^3, 5 ml/m^3 (34 mg/m^3, 5 ml/m^3 for processing after polymerisation and for transportation (TRK)
Data collection period	1990 to 1955
BGAA exposure description	No. 6

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3 (see also [18]).

Notes on the results

General

195 measurements from 104 companies were analysed. The processing of monomeric 1,3-butadiene occurs almost exclusively in the chemical industry.

Average exposure levels per shift

Table 12 shows the average exposure levels per shift. As all measurements except one were below the analytically detectable concentration, no distinction was made between levels measured with and without local exhaust ventilation.

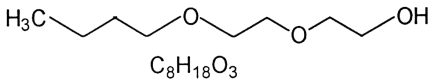
Table 12:
1,3-butadiene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Chemical industry	195	104	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.9 2-(2-Butoxyethoxy)ethanol

Identification and limit values

Formula	 $C_8H_{18}O_3$
Molecular weight in g/mol	162.22
CAS No.	112-34-5
Synonyms	diethylene glycol monobutyl ether, butyl diglycol, butyl carbitol
German limit value	100 mg/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 15

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with dichloromethane/methanol, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 2.0 mg/m^3.

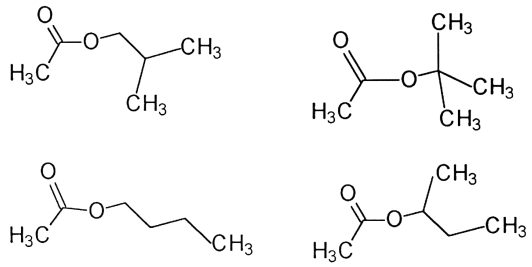
Notes on the results

A total of 16 measurements from 9 companies were available. The measurements come from the chemical industry and the construction industry (sanitation of buildings). No levels above the analytically detectable concentration were measured.

3.10 Butyl acetate

Identification and limit values

Formula



$C_6H_{12}O_2$

Molecular weight in g/mol	116.16
CAS No.	123-86-4 (n-butyl acetate), 105-46-4 (sec-butyl acetate), 540-88-5 (tert-butyl acetate), 110-19-0 (isobutyl acetate)
Synonyms	acetic acid butyl ester, ethanoic acid butyl ester
German limit value	950 mg/m^3, 200 ml/m^3 (MAK) Since January 1992 this limit value has applied for all the isomers together and for each of the four individual isomers of butyl acetate.
Data collection period	1991 to 1994
BGAA exposure description	No. 36

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

Since 1995 the four isomeric butyl acetates have been analysed separately. Until 1994 an overall analysis was performed on the isomeric mix. It was for this reason that the period from 1991 to 1994 was chosen for the evaluation, although there is no reason to assume that the exposure situation changed significantly in the subsequent period. Although the OECD substances list only contains the CAS number for n-butyl acetate, it seems appropriate to examine all the isomers as it has to be assumed that isomeric mixes are used in industrial production.

The present analysis is based on 5,153 measurements from around 1,500 companies.

Average exposure levels per shift

Table 13 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Manufacture of preparations: the data were collected from dissolvers, bead mills and decanting machines. Levels in the region of 90% were measured for preparation and decanting.

Cleaning, degreasing, mechanical: the data were collected predominantly in the metalworking and chemical industries. Levels in the region of 90% were measured on container cleaning machines in paint production plants.

Cleaning, degreasing, manual: the data were collected predominantly in the metalworking and woodworking industries and in paint production plants. Levels in the region of 90% were measured for the cleaning of machines and containers (for example in paint production plants).

Glueing (plastics, metalworking, electrical, woodworking, furniture, leather and shoe industries): levels in the region of 90% were measured for the spraying of adhesives in the furniture industry.

Glueing (floor laying with wood, textiles, plastics): levels in the region of 90% were measured for the spreading of adhesives in rooms without ventilation.

Brushing, rolling, painting (plastics, metalworking, electrical, glass, ceramics and woodworking industries): levels in the region of 90% were measured for painting in areas without local exhaust ventilation.

Brushing, rolling, painting (construction industry): the data were collected during the painting of walls, windows and domestic installations. Levels in the region of 90% were measured for the roller application of primers in rooms without ventilation.

Spray painting (plastics, metalworking, electrical, glass and ceramics industries): the data were collected predominantly on dry-type and waterwash spraybooths.

Spray painting (construction industry): the data were collected predominantly during the painting of metal components.

Spray painting (woodworking): the data were collected predominantly on dry-type and waterwash spraybooths.

Mechanical coating (metalworking, electrical, glass, ceramics and printing industries): the data were collected during dip-coating, casting and spreading (paints) and during laminating. Levels in the region of 90% were measured for paint immersion baths (some open, without local exhaust ventilation).

Mechanical coating (plastics processing, woodworking): the measurements for areas without local exhaust ventilation were taken predominantly on (paint) cast-coating machines, where extractors cannot generally be used for technical reasons (the film of paint starts to come away if there is strong air movement). The measurements for areas with local exhaust ventilation were taken on operators/supervisors of spray robots on enamelling lines. These facilities are generally enclosed.

Table 13:
Butyl acetate – average exposure levels per shift

Company type/Work area	Measure-ments	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manufacture of preparations	522	132	25	125	181
– Without local exhaust ventilation	248	86	29	130	215
– With local exhaust ventilation	247	83	22	94	145
Cleaning, degreasing (mechanical)	58	34	48	389	583
– Without local exhaust ventilation	14	11	77	416	482
– With local exhaust ventilation	44	26	44	296	578
Cleaning, degreasing (manual)	217	133	7	110	194
– Without local exhaust ventilation	118	80	6	81	111
– With local exhaust ventilation	91	54	8	140	205
Glueing (plastics, metalworking, electrical, woodworking, furniture, leather and shoe industries)	297	125	*)	1	15
– Without local exhaust ventilation	133	55	*)	6	15
– With local exhaust ventilation	105	41	*)	5	21
Glueing (floor laying) – All measurements without local exhaust ventilation	76	35	4	76	279
Brushing, rolling, painting (plastics, metal-working, electrical, glass, ceramics and woodworking industries)	121	68	5	62	90
– Without local exhaust ventilation	100	56	5	68	94
– With local exhaust ventilation	14	10	3	46	59
Brushing, painting, rolling (construction industry) – All measurements without local exhaust ventilation	188	37	9	128	488
Spray painting (plastics, metalworking, electrical, glass and ceramics industries)	970	470	9	64	97
– Without local exhaust ventilation	148	82	15	93	130
– With local exhaust ventilation	764	390	9	52	88
Spray painting (woodworking)	1010	390	31	118	163
– Without local exhaust ventilation	65	40	24	143	220
– With local exhaust ventilation	942	364	32	117	159

Table 13
(continued):

Company type/Work area	Measure-ments	Compa-nies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Mechanical coating (metalworking, electrical, glass, ceramics and printing industries) – Without local exhaust ventilation – With local exhaust ventilation	569 275 277	241 128 131	5 6 3	43 60 27	94 115 54
Mechanical coating (plastics processing, woodworking) – Without local exhaust ventilation – With local exhaust ventilation	677 230 443	236 103 155	23 15 25	161 174 145	239 236 243

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3).

Measurements for reduced exposure time of < 1 hour

Parquet laying: levels in the region of 90% were measured for glueing (Table 14)

Table 14:
Butyl acetate – measurements for reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Parquet laying (all measurements without local exhaust ventilation)	100	32	198	740	908

3.11 Cadmium

Identification and limit values

Formula	Cd
CAS No.	7440-43-9
Synonyms	–
German limit value	15 mg/m^3 (0.015 mg/m^3, TRK) for battery manufacture, 30 µg/m^3 (0.03 mg/m^3, TRK) for thermal zinc, lead and copper extraction and the welding of cadmium-containing alloys
Data collection period	1991 to 1996
BGAA exposure description	No. 37

Measurement method

The methods used determine the levels of cadmium together with its compounds in the form of dusts and aerosols.

A defined volume of air is sucked through a glass fibre filter (stationary sampling) or membrane filter (sampling carried out with apparatus worn by a human subject) using a sampling pump. After dissolution, the cadmium contained in the overall volume of dust is measured by means of atomic absorption spectrometry (flame or graphite tube) or X-ray fluorescence spectrometry. Depending on the measurement method used, the analytically detectable concentration for two hours of sampling is 2.0 µg/m^3 or 0.07 µg/m^3 (see also [19]).

Notes on the results

General

1,101 measurements from around 300 companies were analysed in compliance with the Data Protection Act.

The individual cadmium compounds contained in the EU and OECD lists were measured together to give the overall level of cadmium as the active component. Conclusions regarding the presence of specific cadmium compounds can be drawn by referring to the literature.

Average exposure levels per shift

Table 15 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Paint manufacture: the measurements were taken during the preparation (weighing, mixing) of pigments and other colour components. Levels in the region of 90% were measured during screening and emptying processes.

Manufacture of Pb/Cd-containing products: the measurements were taken for preparation, weighing, mixing and smelting during the manufacture of red lead, lead monoxide and lead-containing stabilisers. No local exhaust ventilation was used in the majority of the smelting furnaces.

Manufacture and processing of plastics: weighing/mixing: levels in the region of 90% were measured during the processing of cadmium-containing pigments. Extrusion: levels in the region of 90% were measured during the processing of cadmium-containing stabilisers.

Ceramics and glass industries, screen printing: preparation / moulding / weighing / mixing / melting: levels in the region of 90% were measured for the processing of powdered cadmium-containing pigments to make glazes and printing inks for ceramics. Glazing / spray painting / hand painting / screen printing: processing cadmium-containing pigments in solutions involves lower exposure levels. Levels in the region of 90% were measured for spray painting.

Nonferrous metal and heavy metal smelting works and foundries: the measurements were taken during preparation, smelting (various processes) and casting. Levels in the region of 90% were measured for the smelting of recyclable process material (slag, scrap).

Metalworking, mechanical engineering: mechanical machining processes: the measurements were taken for grinding, turning and planing. Levels in the region of 90% were measured for the machining of nonferrous metal workpieces. Hard/soft soldering: levels in the region of 90% were measured for manual hard-soldering. Surface coating: the measurements were taken during powder coating and galvanising (zinc coating). Levels in the region of 90% were measured for powder coating.

Electrical engineering: the measurements were taken for mechanical/thermal machining and soldering. Levels in the region of 90% were measured during hard-soldering.

Waste incineration: levels in the region of 90% were measured for the maintenance of electrostatic precipitators and for the transportation of filter dust. The majority of work areas have no local exhaust ventilation.

Table 15:
Cadmium – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	µg/m³	µg/m³	µg/m³
Paint manufacture	19	10	*)	1	1
Manufacture of Pb/Cd-containing products	48	11	0.2	11.5	37
– Without local exhaust ventilation	29	5	0.1	2	4
– With local exhaust ventilation	19	7	2	46	282
Manufacture and processing of plastics	110	36	*)	8	23
❒ Weighing/mixing	64	23	1	17	66
– Without local exhaust ventilation	10	6	0.5	2	4
– With local exhaust ventilation	53	20	1.0	22	76
❒ Extrusion	20	8	0.4	1	4
Ceramics and glass industries	401	119	0.1	2.0	9.9
❒ Preparation / moulding / weighing / mixing / melting	83	38	0.3	14.3	30.0
– Without local exhaust ventilation	19	13	0.1	5.1	17.1
– With local exhaust ventilation	59	26	0.3	23.3	30.0

Table 15
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	µg/m^3	µg/m^3	µg/m^3
❒ Glazing / spray painting / hand painting / screen printing	159	68	0.08	0.6	1.0
– Without local exhaust ventilation	41	24	0.2	0.6	0.9
– With local exhaust ventilation	104	45	0.07	0.5	0.8
Nonferrous metal and heavy metal smelting works and foundries	75	17	2	10	20.0
– Without local exhaust ventilation	13	5	0.9	3	3.0
– With local exhaust ventilation	38	13	1	20	21.0
Metalworking / mechanical engineering	164	68	*)	20	102
❒ Mechanical machining processes	49	15	*)	3	4
– Without local exhaust ventilation	28	7	0.5	3	5
– With local exhaust ventilation	19	9	0.3	1	1
❒ Hard /soft soldering	47	28	2	155	280
– Without local exhaust ventilation	11	7	120	290	340
– With local exhaust ventilation	36	22	1	10	30.
❒ Surface coating	32	17	0.2	1	1.4
Electrical engineering	29	20	*)	2	7
Waste incineration	23	11	*)	0.7	1

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

The measurements come from all the aforementioned areas. Levels in the region of 90% were measured for hard-soldering and for the mixing of cadmium-containing colour pigments (Table 16).

Table 16:
Cadmium – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	µg/m^3	µg/m^3	µg/m^3
All company types/work areas	30	20	0.6	60	200

3.12 Chlorine

Identification and limit values

Formula	Cl_2
CAS No.	7782-50-5
Synonyms	-
German limit value	1.5 mg/m^3, 0.5 ml/m^3 (MAK)
Data collection period	1992 to 1997
BGAA exposure description	No. 41

Measurement method

A defined volume of air is sucked through an activated charcoal tube (0.1 M sodium hydroxide solution) using a sampling pump. Quantitative analysis is carried out using a potentiometer. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

55 measurements from 28 companies were analysed in compliance with the Data Protection Act.

Average exposure levels per shift

Table 17 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Treatment of metal and hollow glass (cleaning, pickling, etching): the measurements were taken predominantly in the metalworking industry. 90% of the measurements were below the analytically detectable concentration.

Water treatment (swimming pools, sewage): the measurements were taken predominantly during maintenance work and inspections. 93% of the measurements were below the analytically detectable concentration.

Shoe industry (halogenation during manufacturing process): the measurements were taken during halogenation using chlorine-releasing reagents, including glueing and cutting work. 90% of the measurements were below the analytically detectable concentration.

Table 17:
Chlorine – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Treatment of metal and hollow glass (Cleaning, pickling, etching)	20	9	*)	*)	*)
Water treatment (Swimming pools, sewage)	15	8	*)	*)	0.12
Shoe industry (halogenation during manufacturing process)	20	11	*)	*)	0.12

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

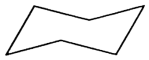
Measurements for a reduced exposure time of < 1 hour

There were not sufficient data to carry out a statistical analysis.

3.13 Cyclohexane

Identification and limit values

Formula



C_6H_{12}

Molecular weight in g/mol	84.16
CAS No.	110-82-7
Synonyms	hexaethylene
German limit value	1050 mg/m^3, 300 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 17

Measurement method

A defined volume of air was sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis was carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

A total of 1,644 measurements from around 50 companies were available.

Average exposure levels per shift

Table 18 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Leather industry / shoe industry: around 75% of the measurements relate to the glueing during cutting, sole production and assembly. Levels in the region of 90% were also measured for these work areas. Levels below 50% were measured for mechanical processing (cutting, stitching, assembly) and for injection moulding machines.

Surface cleaning: the measurements were taken mainly in the woodworking and metalworking industries. Levels in the region of 90% were measured for manual cleaning. The measurements are markedly lower when local exhaust ventilation is used.

Glueing: the measurements come predominantly from the rubber and plastics processing industries and the upholstered furniture manufacturing industry. The effect of local exhaust ventilation on the measurements can be seen clearly. Levels in the region of 90% were measured for the large-scale glueing (in some cases using spray guns).

Floor laying: the measurements were taken during the laying of parquet flooring and carpets. No local exhaust ventilation is used owing to the nature of the processes involved. Levels in the region of 90% were measured for the large-scale application of carpet adhesives in rooms with closed doors/windows.

Surface coating with varnishes/paints: the measurements were taken in the aforementioned areas during the brush, roller and spray application of paints and varnishes. Levels in the region of 90% were measured for brush application.

Printing: the measurements were taken on sheet-fed, web, flexographic and screen printing machines in the metalworking and precision mechanics industries.

Table 18:
Cyclohexane – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Leather industry / shoe industry	456	98	12	95	144
– Without local exhaust ventilation	209	58	12	87	167
– With local exhaust ventilation	238	50	11	96	143

Table 18
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface cleaning	73	41	5	49	73
– Without local exhaust ventilation	45	26	10	60	145
– With local exhaust ventilation	22	13	3	24	51
Glueing	506	169	17	113	182
– Without local exhaust ventilation	305	103	18	135	214
– With local exhaust ventilation	178	75	14	81	138
Floor laying	149	70	7	89	133
All without local exhaust ventilation					
Surface coating with paints/ varnishes	245	114	3	20	32
– Without local exhaust ventilation	110	46	4	27	39
– With local exhaust ventilation	132	73	3	15	28
Printing	104	37	3	10	13
– Without local exhaust ventilation	58	23	2	9	13
– With local exhaust ventilation	45	17	3	10	12

Measurements for a reduced exposure time of < 1 hour

The measurements were taken predominantly during carpet and parquet laying [Table 19]. These are the areas where levels in the region of 90% were measured.

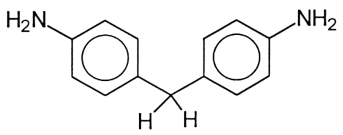
Table 19:
Cyclohexane – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface cleaning – All without local exhaust ventilation	25	6	13	85	93
Surface coating	16	13	37	78	135
Floor laying – All without local exhaust ventilation	70	29	24	847	1190

3.14 4,4′-Diaminodiphenylmethane

Identification and limit values

Formula



$C_{13}H_{14}N_2$

Molecular weight in g/mol	198.26
CAS No.	101-77-9
Synonyms	bis(4-aminophenyl)methane, 4,4′-methylenedianiline, p,p′-methylenedianiline, MDA
Limit value	100 µg/m^3, (0.1 mg/m^3, TRK)
Data collection period	1990 to 1995
BGAA exposure description	No. 45

Measurement method

A defined volume of air is sucked through an absorber (0.05 M sulphuric acid solution) using a sampling pump. Quantitative analysis is carried out by means of gaschromatography using a nitrogen-selective detector. The analytically detectable concentration for two hours of sampling was 20 µg/m^3 until 1992 and has been 1 µg/m^3 since 1993 (see also [20]).

Notes on the results

General

The measurements come from all areas of industry and work areas (for example plastics manufacture, glueing, surface coating, precision casting).

92% of the measurements are below the analytically detectable concentration. In isolated cases levels slightly above the analytically detectable concentration were measured (mixers, extruders).

Table 20:
4,4'-Diaminodiphenylmethane – average exposure levels per shift

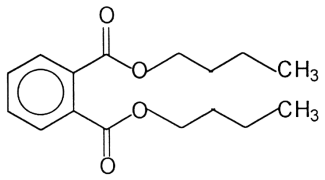
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/work areas	93	51	*)	*)	20

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.15 Dibutyl phthalate

Identification and limit values

Formula



$C_{16}H_{22}O_4$

Molecular weight in g/mol	278.34
CAS No.	84-74-2
Synonyms	phthalic acid dibutyl ester
German limit value	no German limit value
Data collection period	1991 to 1995
BGAA exposure description	No. 4

Measurement method

A defined volume of air is sucked through a membrane filter attached to a silica gel tube using a sampling pump. After elution with methanol, quantitative analysis is carried out by means of high-performance liquid chromatography. The analytically detectable concentration for two hours of sampling is 0.007 mg/m^3.

Notes on the results

General

56 measurements from 31 companies were analysed. 40% of the measurements come from the plastics processing industry.

Average exposure levels per shift

Table 21 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Extrusion, injection moulding, reaction foaming: more than 90% of the measurements were below the analytically detectable concentration.

Welding plastics, hot-air welding: the measurements were taken during the mechanical welding of films in the plastics industry (e.g. manufacture of tarpaulins) and during the manual processing of waterproof sheeting for roofs.

Surface coating: the measurements were taken in the plastics, leather and electrical industries. Levels in the region of 90% were measured for coating (dip-coating) in heated PVC emulsions.

Table 21:
Dibutyl phthalate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Extrusion, injection moulding, reaction foaming	22	14	*)	*)	0.008
Welding plastics, hot-air welding	13	6	0.01	0.03	0.03
Surface coating (spray painting, glueing, flood-coating, dip-coating)	21	11	0.009	0.57	1.01

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.16 1,4-Dichlorobenzene

Identification and limit values

Formula	
Molecular weight in g/mol	147.00
CAS No.	106-46-7
Synonyms	p-dichlorobenzene
German limit value	300 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 16

Measurement method

A defined volume of air is sucked through a silica gel tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3.

Notes on the results

108 measurements from 55 companies were analysed. 20% of the measurements come from the chemical industry; less than 10% of the measurements were taken in areas such as mechanical engineering, electrical engineering, the construction industry and the services sector.

Almost 90% of the measurements were below the analytically detectable concentration (Table 22). Levels above the analytically detectable concentration were measured in isolated cases in the manufacture of air disinfectants (mixing, cold pressing).

Table 22:
1,4-Dichlorobenzene – average exposure levels per shift

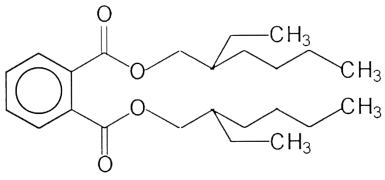
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/work areas	108	55	*)	3.2	6.2

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.17 Di-(2-ethylhexyl) phthalate

Identification and limit values

Formula



$C_{24}H_{38}O_4$

Molecular weight in g/mol	390.56
CAS No.	117-81-7
Synonyms	phthalic acid bis(2-ethylhexyl) ester, dioctyl phthalate, di-sec-octyl phthalate, DEHP, DOP
German limit value	10 mg/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 22

Measurement method

A defined volume of air is sucked through a membrane filter attached to a silica gel tube using a sampling pump. After elution with methanol, quantitative analysis is carried out by means of high-performance liquid chromatography. The analytically detectable concentration for two hours of sampling is 0.025 mg/m^3.

Notes on the results

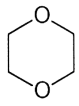
The data (Table 23) come exclusively from the plastics processing industry and were collected during calendering, extrusion, glueing and welding. Levels in the region of 90% were measured for calendering (including use of recycled materials).

Table 23:
Di-(2-ethylhexyl) phthalate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Plastics processing	85	31	0.08	2.45	5.93
– Without local exhaust ventilation	32	14	0.03	0.44	0.57
– With local exhaust ventilation	53	21	0.15	3.65	7.00

3.18 Dioxane

Identification and limit values

Formula	 $C_4H_8O_2$
Molecular weight in g/mol	88.10
CAS No.	123-91-1
Synonyms	p-dioxane, 1,4-dioxane, diethylene dioxide, diethylene oxide, 1,4-dioxacyclohexane
German limit value	180 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA-Expositionsbeschreibung	No. 23

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

40 measurements from 9 companies were analysed. The data were collected predominantly during the processing of plastics (Table 24). 63% of the measurements were below the analytically detectable concentration. Levels in the region of 90% were measured for glueing while using a spray gun.

Table 24:
1,4-Dioxane – average exposure levels per shift

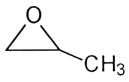
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/ work areas	40	9	*)	35	41

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.19 1,2-Epoxypropane

Identification and limit values

Formula



C_3H_6O

Molecular weight in g/mol	58.08
CAS No.	75-56-9
Synonyms	1,2-propylene oxide, methyl oxirane, 2-methyloxacyclopropane
German limit value	6 mg/m^3, 2.5 ml/m^3 (TRK)
Data collection period	1991 to 1995
BGAA exposure description	No. 25

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3 (see also [21]).

Notes on the results

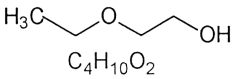
The data come predominantly from the chemical industry. Levels in the region of 90% were measured during the decanting of 1,2-epoxypropane (Table 25).

Table 25:
1,2-Epoxypropane – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/ work areas	25	14	0.5	5.8	7.0

3.20 2-Ethoxyethanol

Identification and limit values

Formula	 $C_4H_{10}O_2$
Molecular weight in g/mol	90.12
CAS No.	110-80-5
Synonyms	ethyl glycol, ethylene glycol monoethyl ether
German limit value	75 mg/m^3, 20 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 28

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3.

Notes on the results

General

548 measurements were analysed from around 210 companies in the paint manufacturing, plastics, rubber, ceramics, glass, metalworking/mechanical engineering, electronical/precision mechanics, printing/paper processing and construction industries and other areas.

Average exposure levels per shift

Table 26 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Paint manufacture: the data were collected predominantly during mixing, stirring, dissolving and decanting. Levels in the region of 90% were measured for decanting and on stirring machines.

Manual coating (excluding spraying): the data come predominantly from the construction industry. No local exhaust ventilation was used. 88% of the measurements were below the analytically detectable concentration. Levels in the region of 90% were measured for manual varnishing and soaking.

Manual coating (spraying): the data were collected in the construction, timber, electrical engineering and metalworking industries. 86% of the measurements were below the analytically detectable concentration.

Mechanical coating, printing: the data were collected in the aforementioned areas. Around 80% of the measurements were below the analytically detectable concentration. Levels in the region of 90% were measured for screen printing.

Cleaning processes: these processes were carried out in all the aforementioned areas. 81% of the measurements were below the analytically detectable concentration. The effect of local exhaust ventilation on exposure levels can be seen clearly. Levels in the region of 90% occurred on container cleaning machines.

Table 26:
2-Ethoxyethanol – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Paint manufacture – Without local exhaust ventilation – With local exhaust ventilation	34 15 18	18 10 9	3 3 3	17 18 14	25 25 22
Manual coating (excluding spraying) – All measurements without local exhaust ventilation	35	15	*)	11	44

Table 26
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m³	mg/m³	mg/m³
Manual coating (spraying)	123	67	*)	9	21
– Without local exhaust ventilation	25	11	*)	8	17
– With local exhaust ventilation	91	54	*)	11	22
Mechanical coating, printing	193	75	*)	15	35
– Without local exhaust ventilation	95	38	*)	14	28
– With local exhaust ventilation	94	44	*)	14	29
Cleaning processes	43	25	*)	5	10
– Without local exhaust ventilation	19	12	*)	6	28
– With local exhaust ventilation	23	14	*)	5	6

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

The data were collected predominantly in the construction industry for manual coating (e.g. roller application).

Table 27:
2-Ethoxyethanol – measurements for a reduced exposure time of < 1 hour

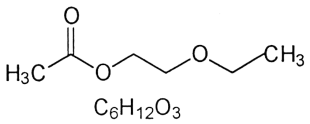
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m³	mg/m³	mg/m³
All company types/work areas	23	9	*)	2	3

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.21 2-Ethoxyethyl acetate

Identification and limit values

Formula



Molecular weight in g/mol	132.15
CAS No.	115-15-9
Synonyms	ethyl glycol acetate, ethylene glycol monoethyl ether acetate, acetic acid (2-ethoxyethyl) ester
German limit value	110 mg/m^3, 20 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 27

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

598 measurements from around 270 companies were analysed.

Average exposure levels per shift

Table 28 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Paint manufacture: the data were collected predominantly during mixing, stirring, dissolving and decanting. Levels in the region of 90% were measured on dissolvers and mills. The effect of local exhaust ventilation on exposure levels can be seen clearly.

Manual coating (excluding spraying): the data come predominantly from the construction and metalworking/mechanical engineering industries. 60% of the measurements were below the analytically detectable concentration. Levels in the region of 90% were measured for manual painting and glazing. The effect of local exhaust ventilation on exposure levels can be seen clearly.

Manual coating (spraying): the data were collected in the construction, woodworking, electrical engineering and metalworking industries. 74% of the measurements were below the analytically detectable concentration.

Mechanical coating, printing: the data were collected in the aforementioned areas. 76% of the measurements were below the analytically detectable concentration. Levels in the region of 90% were measured for screen printing.

Cleaning processes: these processes were mainly carried out in the chemical and metalworking industries. 68% of the measurements were below the analytically detectable concentration. Levels in the region of 90% occurred on container and screen cleaning machines.

Table 28:
2-Ethoxyethyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Paint manufacture	58	17	3	21	38
– Without local exhaust ventilation	32	10	2	33	52
– With local exhaust ventilation	26	12	3	14	24

Table 28
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manual coating (excluding spraying)	62	32	*)	31	83
– Without local exhaust ventilation	41	24	*)	34	99
– With local exhaust ventilation	17	7	*)	24	27
Manual coating (spraying)	201	108	*)	15	33
– Without local exhaust ventilation	21	15	*)	7	7
– With local exhaust ventilation	179	97	*)	15	34
Mechanical coating, printing	221	97	*)	20	36
– Without local exhaust ventilation	105	51	*)	11	36
– With local exhaust ventilation	112	52	*)	22	34
Cleaning processes	38	24	*)	14	18
– Without local exhaust ventilation	16	11	*)	*)	5
– With local exhaust ventilation	22	14	4	17	26

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

The data were collected predominantly in the construction and metalworking industries for manual coating and cleaning (Table 29).

Table 29:
2-Ethoxyethyl acetate – measurements for a reduced exposure time of < 1 hour

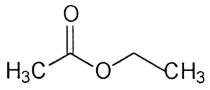
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/work areas	18	12	*)	*)	35

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.22 Ethyl acetate

Identification and limit values

Formula



$C_4H_8O_2$

Molecular weight in g/mol	88.10
CAS No.	141-78-6
Synonyms	acetic acid ethyl ester, acetic ester, ethanoic acid ethyl ester
German limit value	1,400 mg/m^3, 400 ml/m^3 (MAK)
Data collection period	1992 to 1996
BGAA exposure description	No. 38

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.2 mg/m^3.

Notes on the results

General

6,324 measurements from around 1,900 companies were included in the analysis.

Average exposure levels per shift

Table 30 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Manufacture of preparations: the data were collected on dissolvers, bead mills and decanting machines. Levels in the region of 90% were measured for preparation and decanting.

Cleaning, degreasing: the data were collected in the metalworking, woodworking and chemical industries. Levels in the region of 90% were measured for the cleaning of equipment and containers in paint production and solvent recovery plants.

Glueing (plastics, metalworking, electrical, woodworking, furniture, leather and shoe industries): levels in the region of 90% were measured for the spraying of adhesives in the upholstered furniture industry and for manual glueing (brush application, e.g. in the shoe industry).

Glueing (floor laying with wood, textiles, plastics): levels in the region of 90% were measured for the application of parquet adhesives and fillers in rooms without ventilation.

Brushing, painting, rolling (plastics, metalworking, electrical, glass, ceramics and woodworking industries): levels in the region of 90% were measured for brush application over large areas.

Brushing, painting, rolling (construction industry): the data were collected during the painting of walls, windows and domestic installations. Levels in the region of 90% were measured for the roller application of primers in rooms without ventilation.

Spray painting (plastics, metalworking, electrical, furniture, glass and ceramics industries): the data were collected predominantly on dry-type and waterwash spraybooths. Levels in the region of 90% were measured predominantly for large-scale spraying.

Spray painting (construction industry): the data were collected predominantly during the painting of metal components. Levels in the region of 90% were measured for spraying in rooms without ventilation.

Spray painting (woodworking): the data were collected predominantly on dry-type and waterwash spraybooths.

Mechanical coating (plastics, furniture, woodworking, metalworking, electrical, ceramics and printing industries): the measurements for areas without local exhaust ventilation were taken predominantly on (paint) cast-coating machines, where extractors cannot generally be used (the film of paint starts to come away if there is strong air movement). The measurements for areas with local exhaust ventilation were taken on spray robots on painting lines, laminating machines and printing machines. Levels in the region of 90% were measured predominantly for the processing of cast-coating/dip-coating paints and laminating resins.

Table 30:
Ethyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manufacture of preparations	642	176	17	219	368
– Without local exhaust ventilation	292	108	21	180	323
– With local exhaust ventilation	317	112	14	252	384
Cleaning, degreasing	355	196	11	230	403
– Without local exhaust ventilation	165	97	5	126	187
– With local exhaust ventilation	169	93	18	341	599
Glueing (plastics, metalworking, electrical, woodworking, furniture, leather and shoe industries)	1150	346	25	206	344
– Without local exhaust ventilation	542	194	23	216	399
– With local exhaust ventilation	586	170	26	201	287
Glueing (floor laying) – All measurements without local exhaust ventilation	276	96	17	322	543

Table 30
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Brushing, painting, rolling (plastics, metalworking, electrical, glass, ceramics and woodworking industries)	147	84	5	72	137
– Without local exhaust ventilation	102	63	3	68	100
– With local exhaust ventilation	35	19	9	165	183
Brushing, painting, rolling (construction industry) – All measurements without local exhaust ventilation	162	28	2	17	135
Spray painting (plastics, metalworking, electrical, furniture, glass and ceramics industries)	645	333	4	29	52
– Without local exhaust ventilation	81	52	4	27	46
– With local exhaust ventilation	538	277	4	29	50
Spray painting (construction industry)	230	52	7	68	256
– Without local exhaust ventilation	158	24	10	83	316
– With local exhaust ventilation	70	32	3	47	112
Spray painting (woodworking)	1145	434	7	49	83
– Without local exhaust ventilation	31	20	4	44	68
– With local exhaust ventilation	1108	423	7	49	83
Mechanical coating (plastics, furniture, woodworking, metalworking, electrical, ceramics and printing industries)	1447	504	9	172	293
– Without local exhaust ventilation	504	221	7	187	320
– With local exhaust ventilation	904	313	10	173	282

Measurements for a reduced exposure time of < 1 hour

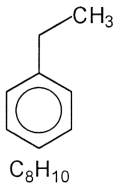
Parquet laying: levels in the region of 90% were measured for the application of parquet adhesives and fillers (Table 31).

Table 31:
Ethyl acetate – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Parquet laying – All measurements without local exhaust ventilation	125	45	32	1577	2044

3.23 Ethylbenzene

Identification and limit values

Formula	
Molecular weight in g/mol	106.16
CAS No.	100-41-4
Synonyms	phenylethane
German limit value	440 mg/m^3, 100 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 18

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After desorption with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3.

Notes on the results

General

6,125 measurements were analysed from around 2,400 companies in the paint manufacturing, plastics, rubber, ceramics, glass, metalworking/mechanical engineering, electronics/precision mechanics, woodworking and construction industries and other areas.

Average exposure levels per shift

Table 32 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Mixers, dissolvers, impeller-type mixers: around 80% of the measurements come from the paint manufacturing industry. Local exhaust ventilation was used in most of the work areas.

Surface cleaning: the measurements were taken in the woodworking, metalworking/ mechanical engineering and precision mechanics industries. Around 50% of the measurements relate to manual cleaning processes. The measurements for work areas with local exhaust ventilation are markedly lower.

Container cleaning: 90% of the measurements were taken in the paint manufacturing industry. Local exhaust ventilation was used in most of the work areas. The measurements for work areas with local exhaust ventilation are markedly lower.

Decanting, weighing: 90% of the measurements were taken in the wholesale and paint manufacturing industries. Levels in the region of 90% occurred mainly in work areas using mills in addition to metering equipment (decanting, weighing).

Laboratories: the measurements were taken in the chemical and paint manufacturing industries. The use of local exhaust ventilation (fume cupboards) has a marked effect on the exposure levels measured.

Glueing, floor laying: the measurements were taken predominantly in the woodworking and plastics processing industries and for floor laying (parquet, carpet). No local exhaust ventilation is generally used in these work areas. Levels in the region of 90% occurred during the laying of parquet flooring.

Surface coating, brush/roller application: the measurements are distributed evenly among the aforementioned areas. Around 80% of the work areas do not have local exhaust ventilation. Levels in the region of 90% occurred during the roller application of coatings to

large areas. In the metalworking industry brush application is used for small parts and repair work.

Surface coating, spraying: the measurements were taken in the aforementioned areas. In contrast to the manual processes, local exhaust ventilation is used in around 70% of the work areas. The effect of local exhaust ventilation on the exposure levels measured can be seen clearly.

Ethylbenzene is a component – found mainly in conjunction with xylene – of the solvents used in surface coatings. Ethylbenzene is not added to the solvent mixture on its own but as a component of a hydrocarbon mixture.

During the coating process, for example in the construction industry, solvent-containing coatings are applied to a surface using a spray gun. In the metalworking industry spray painting (compressed-air spraying) is the standard process used for coating small, flat structural components, while high-pressure spraying (airless spraying) is used for large structural components. Processes involving local exhaust ventilation are often carried out in booths with from one to three water-washed walls, in front of which the workpieces are sprayed. The resulting mist of paint is extracted through the floor of the booth. Another form of local exhaust ventilation, for example for painting lorries and car parts, involves blowing in cleaned air from above and extracting the contaminated air via holes in the floor.

Extremely large workpieces, which are often treated in the middle of the shop after the end of a shift, are sprayed without local exhaust ventilation.

Surface coating, mechanical: the measurements were taken in the woodworking, metalworking/mechanical engineering and electrical engineering industries. Levels in the region of 90% were measured for dip-coating processes.

Table 32:
Ethylbenzene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Mixers, dissolvers, impeller-type mixers	286	115	9	53	47
– Without local exhaust ventilation	96	47	10	46	62
– With local exhaust ventilation	179	80	9	47	63
Surface cleaning	305	177	2	21	42
– Without local exhaust ventilation	146	95	2	30	51
– With local exhaust ventilation	147	83	2	12	25
Container cleaning	110	45	16	45	79
– Without local exhaust ventilation	17	14	11	91	95
– With local exhaust ventilation	84	31	16	44	67
Decanting, weighing	485	159	10	42	62
– Without local exhaust ventilation	220	104	9	42	60
– With local exhaust ventilation	226	78	10	38	59
Laboratories	44	29	4	16	19
– Without local exhaust ventilation	21	14	4	17	33
– With local exhaust ventilation	18	14	2	11	16
Glueing, floor laying	329	145	4	26	33
– Without local exhaust ventilation	256	115	5	29	38
– With local exhaust ventilation	65	29	*)	12	23
Surface coating, manual (brush/roller application)	829	339	4	31	55
– Without local exhaust ventilation	649	260	3	34	55
– With local exhaust ventilation	113	66	3	19	114
Surface coating, manual (spraying – metalworking, precision mechanics and other)	1091	522	4	25	40
– Without local exhaust ventilation	196	105	7	43	64
– With local exhaust ventilation	819	408	3	19	32
Surface coating, manual (spraying – woodworking industry)	719	306	3	11	16
– Without local exhaust ventilation	22	15	2	13	14
– With local exhaust ventilation	690	299	3	11	16

Table 32
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating, manual (spraying – construction industry)	607	150	9	78	112
– Without local exhaust ventilation	381	63	14	98	125
– With local exhaust ventilation	206	92	4	29	57
Surface coating, mechanical	1099	458	3	20	41
– Without local exhaust ventilation	411	200	2	24	44
– With local exhaust ventilation	663	285	3	19	35

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

The measurements (Table 33) come from all the aforementioned areas. Most of the measurements relate to work areas without local exhaust ventilation.

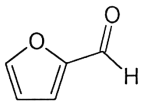
Table 33:
Ethylbenzene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface cleaning, all work areas without local exhaust ventilation	27	16	8	46	70
Glueing, floor laying, all work areas without local exhaust ventilation	115	28	29	95	123
Surface coating, manual (brush, roller application), all work areas without local exhaust ventilation	33	12	33	69	91
Surface coating, manual (spraying)	46	31	10	199	234
– Without local exhaust ventilation	25	15	14	231	523
– With local exhaust ventilation	20	16	7	53	55

3.24 2-Furaldehyde

Identification and limit values

Formula



$C_5H_4O_2$

Molecular weight in g/mol	96.08
CAS No.	98-01-1
Synonyms	furan-2-aldehyde, furanal, furan-2-carboxaldehyde, furfural
German limit value value	20.0 mg/m^3, 5.0 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 32

Measurement method

A defined volume of air is sucked through a silica gel tube using a sampling pump. After extraction with acetone, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

43 measurements from 6 companies were included in the analysis (Table 34).

Ceramics industry (manufacture of abrasive and fireproof products): the data were collected during preparation (mixers), moulding and firing. Levels in the region of 90% were measured for filling and pressing.

Manufacture of acid-proof structures (plastic products and containers): the data were collected during laminating/plating. Levels in the region of 90% were measured during the application of acid-proof fillers, resins and mortars.

Table 34:
2-Furaldehyde – average exposure levels per shift

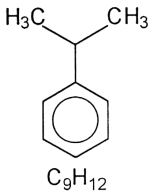
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Ceramics industry – All measurements with local exhaust ventilation	19	6	12.9	37.0	37.7
Manufacture of acid-proof structures (plastic products and containers) – Without local exhaust ventilation – With local exhaust ventilation	24 11 13	6 4 4	*) 2.8 *)	30.0 9.9 98.4	119.0 24.9 147.8

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.25 Isopropylbenzene

Identification and limit values

Formula



Molecular weight in g/mol	120.19
CAS No.	98-82-8
Synonyms	2-phenylpropane, cumene, (2-propyl)benzene
German limit value value	245 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 19

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

789 measurements from around 250 companies were analysed. The measurements come from the construction industry (44%), the paint manufacturing industry (20%) and the metal-working, mechanical engineering and precision mechanics industries (19%). In the work areas examined, isopropylbenzene is used almost exclusively as a component of hydrocarbon solvent mixtures.

Average exposure levels per shift

Table 35 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Paint manufacture: levels in the region of 90% occurred during cleaning work.

Surface coating, brush/roller/spatula application: the measurements come predominantly from the construction industry. The use of local exhaust ventilation reduces exposure levels appreciably. Levels in the region of 90% occurred during roller application.

Surface coating, spraying (airless, air-mix, compressed air): the measurements come predominantly from the construction industry. Levels in the region of 90% were measured for airless spraying.

Surface coating, mechanical: the measurements were taken in the plastics processing, woodworking, electrical engineering and metalworking industries. Levels in the region of 90% were measured for dip-coating and silk screen painting.

Table 35:
Isopropylbenzene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Paint manufacture	125	38	1.4	4.0	5.8
– Without local exhaust ventilation	50	21	1.3	4.0	12.5
– With local exhaust ventilation	61	20	1.4	3.6	5.0
Surface coating, manual (brush/ roller/spatula application)	255	72	3.6	16.9	20.7
– Without local exhaust ventilation	223	55	3.8	18.1	21.7
– With local exhaust ventilation	13	9	1.3	8.2	10.0

Table 35
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating, manual (spraying) – Without local exhaust ventilation – With local exhaust ventilation	300 180 113	92 30 61	1.0 1.3 0.6	5.0 6.0 4.7	8.0 8.0 6.7
Surface coating, mechanical – Without local exhaust ventilation – With local exhaust ventilation	84 39 45	47 23 26	0.5 0.5 0.8	4.0 3.0 4.0	7.4 4.2 8.0

Measurements for a reduced exposure time of < 1 hour

The measurements were taken in all the aforementioned areas during cleaning and surface coating (Table 36).

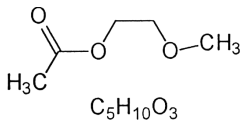
Table 36:
Isopropylbenzene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	25	21	4.5	11.0	11.8

3.26 2-Methoxyethyl acetate

Identification and limit values

Formula



$C_5H_{10}O_3$

Molecular weight in g/mol	118.13
CAS No.	110-49-6
Synonyms	methyl glycol acetate, ethylene glycol monomethyl ether acetate, 3-oxabutyl acetate
German limit value	25.0 mg/m^3, 5.0 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 8

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.5 mg/m^3.

Notes on the results

General

211 measurements from around 10 companies were analysed. 34% of the measurements come from the mechanical engineering/metalworking industries, 26% from the chemical industry and 15% from the electrical industry.

Average exposure levels per shift

Table 37 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Surface coating (spray painting, brush/roller application): 90% of the measurements were below the analytically detectable concentration. Levels above 90% occurred during the application of plastic-containing paints.

Surface coating (flood-coating, dip-coating, soaking): levels above 50% were measured for the application of plastic-containing paints by means of flood-coating/dip-coating/soaking. When local exhaust ventilation was used all measurements were below the analytically detectable concentration.

Cleaning: the measurements were taken during the cleaning of metal, glass and plastic surfaces. The measurements were below the analytically detectable concentration.

Glueing: levels in the region of 90% occurred during glueing of plastic films.

Paper and card manufacture: no levels above the analytically detectable concentration were measured.

Table 37:
2-Methoxyethyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating (spray painting, brush/roller application)	150	80	*)	*)	3.9
– Without local exhaust ventilation	49	27	*)	1.1	3.9
– With local exhaust ventilation	90	54	*)	*)	3.3
Surface coating (flood-coating, dip-coating, soaking)	21	10	1.0	16.1	162.4
– Without local exhaust ventilation	11	6	2.4	154.7	171.4
– With local exhaust ventilation	10	5	*)	*)	*)

Table 37
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Glueing	14	6	*)	8.2	9.3
Cleaning	10	8	*)	*)	*)
Paper and card manufacture	16	3	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

A statistical analysis could not be carried out using the collected data (Table 38). The measurements were between 2 mg/m^3 and 5 mg/m^3.

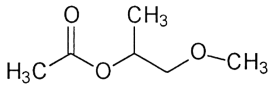
Table 38:
2-Methoxyethyl acetate – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	4	4	*)	*)	*)

*) There were not sufficient data to carry out a statistical analysis (see also sections 2.2 and 2.3)

3.27 2-Methoxy-1-methylethyl acetate

Identification and limit values

Formula	 $C_6H_{12}O_3$
Molecular weight in g/mol	132.15
CAS No.	108-65-6
Synonyms	acetic acid 2-methoxy-1-methylethyl ester, 1-methoxypropyl-2-acetate, 1-methoxy-2-acetoxypropane, propylene glycol monomethylether acetate, (1-methoxy-2-propyl) acetate
German limit value	275 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1992 to 1997

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

1,712 measurements from around 750 companies were analysed.

Average exposure levels per shift

Table 39 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Manufacture of preparations: the measurements were taken predominantly in the paint manufacturing industry during the preparation and processing of raw materials (weighing, grinding) and during decanting. Levels in the region of 90% were measured in the aforementioned areas for the manufacture of synthetic resin and epoxy resin paints.

Cleaning, manual, mechanical: the measurements were taken predominantly in the paint manufacturing and plastics processing industries. Levels in the region of 90% were measured for the removal of plastic-containing residues from containers and machine parts.

Floor laying: the measurements were taken predominantly during the sealing of parquet and industrial floors. Levels in the region of 90% were measured for the application of plastic-containing sealants (PUR, PVC).

Brushing, painting, spreading, rolling: the measurements were taken predominantly in the construction and metalworking industries. Levels in the region of 90% were measured for the application of plastic-containing paints (corrosion protection).

Spraying (compressed air, airless, air-mix): the measurements were taken predominantly in the woodworking and metalworking industries. Levels in the region of 90% were measured for the application of paints containing plastics or synthetic resins.

Printing (screen printing, pad printing): the measurements were taken predominantly for screen printing in the plastics processing and metalworking industries and in the electrical engineering industry. Levels in the region of 90% were measured for manual printing without local exhaust ventilation. In some cases cleaning work was carried out in these areas at the same time.

Table 39:
2-Methoxy-1-methylethyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manufacture of preparations	323	75	5	25	35
– Without local exhaust ventilation	128	47	5	19	28
– With local exhaust ventilation	181	49	5	27	39

Table 39:
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Cleaning, manual, mechanical	115	64	7	28	50
– Without local exhaust ventilation	25	20	11	43	163
– With local exhaust ventilation	82	46	6	27	39
Floor laying All measurements without local exhaust ventilation	43	21	10	74	111
Brushing, painting, spreading, rolling	121	69	3	18	34
– Without local exhaust ventilation	78	45	3	19	45
– With local exhaust ventilation	37	21	3	10	11
Spraying (compressed air, airless, air-mix)	665	345	6	35	56
– Without local exhaust ventilation	81	49	6	56	92
– With local exhaust ventilation	551	289	6	30	48
Printing (screen printing, pad printing)	340	163	3	20	29
– Without local exhaust ventilation	171	88	4	22	36
– With local exhaust ventilation	161	80	3	19	25

Measurements for a reduced exposure time of < 1 hour

The observations regarding the average exposure levels per shift for floor laying and spraying also apply to the named activity-related measurements for a reduced exposure time (Table 40).

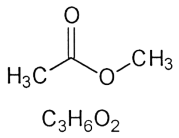
Table 40:
2-Methoxy-1-methylethyl acetate – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Floor laying	49	19	52	102	117
Spraying (compressed air, air-mix, airless)	13	10	18	214	273

3.28 Methyl acetate

Identification and limit values

Formula



$C_3H_6O_2$

Molecular weight in g/mol	74.07
CAS No.	79-20-9
Synonyms	acetic acid methyl ester, ethanoic acid methyl ester
German limit value	610 mg/m^3, 200 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 20

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

1,523 measurements from 563 companies were analysed. The analysis focused on the woodworking industry and floor laying.

Average exposure levels per shift

Table 41 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Mixing, decanting, weighing: 90% of the measurements were taken in the paint manufacturing industry. Around 20% of the measurements were below the analytically detectable concentration. Levels above 95% were measured during the manufacture of parquet adhesives.

Surface cleaning: The measurements come from the metalworking, electrical engineering and woodworking industries. More than 30% of the measurements were in the region of the analytically detectable concentration. Levels above 90% were measured for large-scale cleaning.

Glueing (construction industry: floor laying): more than 50% of the measurements were taken during the laying of floor coverings. In most cases no local exhaust ventilation was used during this work owing to the nature of the processes involved. Exposure levels below 50% were measured for glueing in the woodworking industry. Exposure levels above 90% were measured for the application of parquet adhesives.

Methyl acetate is a component of the solvent mixture used in primers and adhesives for floor coverings. The primers are usually applied to the floor using a roller. Large quantities are applied in a relatively short time. When adhesive is applied to floor coverings (except parquet floors) it is distributed over several square metres using a serrated spatula and the floor covering is subsequently fixed in place. When laying parquet floors, a smaller quantity of adhesive is applied as more care is required when fixing this type of floor covering in position. Primers contain up to 50% methyl acetate, adhesives up to 15% and parquet adhesives up to 25%.

Glueing (plastics / plastic foam processing): levels in the region of 90% were measured for the spraying of adhesives without the use of local exhaust ventilation.

Glueing (woodworking): levels in the region of 90% were measured for the spraying of adhesives without the use of local exhaust ventilation.

Spray painting (metalworking, plastics processing, precision mechanics): no special working conditions were observed for the levels in the region of 90%.

Spray painting (construction industry): methyl acetate is a component of the solvent mixture in some of the paints used for buildings. They are sprayed onto surfaces using a spray gun. No special working conditions were observed for the levels in the region of 90%.

Spray painting (woodworking): in the woodworking industry local exhaust ventilation is generally used during spray painting. The work areas without local exhaust ventilation are airing and drying areas.

Surface coating, mechanical (cast-coating and printing machines): the measurements were taken predominantly in the woodworking and metalworking industries. Levels in the region of 90% were measured on cast-coating machines.

Table 41:
Methyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m³	mg/m³	mg/m³
Mixing, decanting, weighing	81	28	7	192	332
– Without local exhaust ventilation	29	15	7	294	367
– With local exhaust ventilation	43	16	10	175	242
Surface cleaning	81	45	5	83	160
– Without local exhaust ventilation	39	27	1	18	51
– With local exhaust ventilation	36	14	14	137	278
Glueing (construction industry: floor laying)	189	90	49	768	1094
– All measurements without local exhaust ventilation					
Glueing (plastics / plastic foam processing)	38	14	4	24	42
– Without local exhaust ventilation	14	11	1	18	99
– With local exhaust ventilation	22	5	8	30	39
Glueing (woodworking)	33	14	1	19	118
– Without local exhaust ventilation	16	8	1	75	183
– With local exhaust ventilation	17	5	1	18	29
Glueing (shoe manufacture)	48	15	2	22	26
– Without local exhaust ventilation	15	5	11	17	22
– With local exhaust ventilation	33	10	2	23	25
Surface coating: spray painting (metalworking, plastics processing, precision mechanics)	179	89	9	66	86
– Without local exhaust ventilation	32	15	14	81	105
– With local exhaust ventilation	135	74	7	56	81

Table 41
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating: spray painting (construction industry)	31	16	3	30	36
– Without local exhaust ventilation	17	8	3	35	39
– With local exhaust ventilation	11	7	2	21	24
Surface coating: spray painting (woodworking)	173	72	1	10	34
– Without local exhaust ventilation	13	7	1	9	20
– With local exhaust ventilation	160	69	1	10	33
Surface coating, mechanical (cast-coating and printing machines)	217	81	2	63	118
– Without local exhaust ventilation	75	38	5	84	119
– With local exhaust ventilation	140	46	1	46	112

Measurements for a reduced exposure time of < 1 hour

The analysis focused on floor laying work. Levels above 90% were measured during the application of parquet adhesives (Table 42).

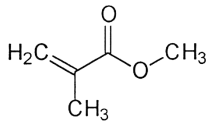
Table 42:
Methyl acetate – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Glueing, filling, laying	74	35	69	2830	3271

3.29 Methyl methacrylate

Identification and limit values

Formula



$C_5H_8O_2$

Molecular weight in g/mol	100.11
CAS No.	80-62-6
Synonyms	methacrylic acid methyl ester, α-methacrylic acid methyl ester, 2-methylpropenoic acid methyl ester
German limit value	210 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 2

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

503 measurements from around 170 companies were analysed. 20% of the measurements relate to interior work in industrial and manufacturing facilities (plastic coatings and special coatings), a further 20% relate to plastics processing. With regard to the selected data

collection period, it should be noted that measurements from the period before 1990 are available for areas other than those featured here, for example for the dental sector. After 1990, however, no further measurements were taken in this area as the exposure levels were so low.

Average exposure levels per shift

Table 43 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Plastics manufacture: the measurements taken on extruders were in the region of the analytically detectable concentration. Levels in the region of 90% were measured on reaction vessels.

Decanting, weighing, mixing: levels below 50% were measured during decanting (for example paint manufacture, wholesale industry). Levels in the region of 90% were measured for manual mixing in the paint manufacturing industry.

Glueing: 40% of the measurements were taken in the plastics processing sector (for example glueing of Plexiglas). In cases where adhesives were applied to smaller surface areas (for example spot glueing in the electrical engineering and shoe manufacturing industries) measurements were below the 50% level. Levels in the region of 90% were measured for the large-scale glueing.

Coating with paints/varnishes/casting resins: measurements focused on the woodworking, glass manufacturing and metalworking sectors. Levels in the region of the analytically detectable concentration (50% level) occurred during the processing of paints and varnishes. Levels in the region of 90% were measured for the application of cast resins (for example in the manufacture of orthopaedic equipment).

Application of floor coatings: measurements focused on interior work in industrial and manufacturing facilities. High exposure levels were measured in all work areas (cast-coating, filling, sealing) in this section. Local exhaust ventilation was rarely used owing to the nature of the processes involved.

Table 43:
Methyl methacrylate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Plastics manufacture (reaction vessels, extruders, presses)	43	23	1	56	73
– Without local exhaust ventilation	34	18	1	33	36
– With local exhaust ventilation	9	7	*)	*)	*)
Decanting, weighing, mixing	28	15	15	132	168
– Without local exhaust ventilation	13	8	24	72	120
– With local exhaust ventilation	15	9	9	123	146
Glueing	143	70	7	80	117
– Without local exhaust ventilation	106	57	11	80	132
– With local exhaust ventilation	34	20	3	46	83
Coating with paints, varnishes, casting resins	112	52	1	100	167
– Without local exhaust ventilation	53	21	1	160	187
– With local exhaust ventilation	59	34	1	30	61
Application of floor coatings	127	10	186	771	773
– Without local exhaust ventilation	78	7	241	722	1045
– With local exhaust ventilation	34	2	141	520	625

*) There were not sufficient data to carry out a statistical analysis (see also section 2.3)

Measurements for a reduced exposure time of < 1 hour

The measurements were taken predominantly in the plastics processing sector and during the laying of floors in industrial and manufacturing facilities. Levels below 50% were measured on reaction vessels during the processing of plastic. Levels above 50% were measured for the application of floor sealant resins (Table 44).

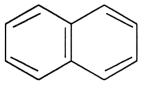
Table 44:
Methyl methacrylate – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types/ work areas	50	14	195	521	683

3.30 Naphthalene

Identification and limit values

Formula



$C_{10}H_8$

Molecular weight in g/mol	128.17
CAS No.	91-20-3
Synonyms	-
German limit value	50 mg/m^3, 10 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 21

Measurement method

A defined volume of air is sucked through a silica gel tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

183 measurements from 94 companies were analysed. 50% of the measurements relate to the woodworking industry, 16% to the construction industry and 12% to the metalworking/ mechanical engineering sectors.

Average exposure levels per shift

Table 45 shows the average exposure levels per shift. Levels above the analytically detectable concentration were measured during the manufacture of repellents and perfumed disinfectants.

Glueing: the measurements were taken predominantly in the woodworking industry. More than 95% of the measurements were below the analytically detectable concentration.

Surface coating: the measurements come from the aforementioned sectors. More than 95% of the measurements were below the analytically detectable concentration.

Table 45:
Naphthalene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Glueing	153	72	*)	*)	*)
Surface coating	30	22	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.31 Nickel

Identification and limit values

Formula	Ni
CAS No.	7440-02-0
Synonyms	–
German limit value	Nickel and its compounds: 0.5 mg/m^3 for Ni as a metal and carbonate (MAK), 0.5 mg/m^3 for NiO, NiS and sulphidic ores (TRK), 0.05 mg/m^3 for Ni compounds in the form of respirable droplets (TRK)
Data collection period	1991 to 1996
BGAA exposure description	No. 43

Measurement method

The methods used determine the levels of nickel together with its compounds in the form of dusts and aerosols. A defined volume of air is sucked through a membrane filter or quartz fibre double filter (measurement in galvanising shops or in workplaces with relative air moisture contents of > 50%) using a sampling pump. After dissolution, the nickel contained in the overall volume of dust is measured by means of atomic absorption spectrometry (graphite tube) or X-ray fluorescence spectrometry. The analytically detectable concentration for two hours of sampling is 10^{-8} g/m^3 (0.00001 mg/m^3) (see also [22]).

Notes on the results

General

2,879 measurements from around 1,050 companies were analysed in compliance with the Data Protection Act.

The individual nickel compounds contained in the EU and OECD lists were measured together to give the overall level of nickel as the active component. Conclusions regarding the presence of specific nickel compounds can be drawn by referring to the literature.

Average exposure levels per shift

Table 46 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Surface finishing / galvanising: the measurements were taken predominantly during the manufacture of nickel coatings (for example using Watts electrolyte).

Foundries (smelting, casting): the measurements were taken predominantly during smelting. Levels in the region of 90% were measured during smelting of nonferrous metal-containing residues.

Grinding / polishing: the measurements were taken predominantly in the mechanical engineering industry. Levels in the region of 90% were measured during the machining of nickel-containing materials (CrNi steels, nickel-plated workpieces).

Manual arc welding: the measurements were taken predominantly in the metalworking industry.

Tungsten inert-gas welding: the measurements were taken predominantly in the metalworking industry. The effect of local exhaust ventilation on exposure levels can be seen clearly.

Inert-gas metal-arc welding: the measurements were taken predominantly in the metalworking industry.

Active-gas metal-arc welding: the measurements were taken predominantly in the metalworking industry. Levels in the region of 90% were measured, inter alia, during welding in confined spaces (for example container manufacture).

Thermal spraying: the measurements were taken in the metalworking and ceramics industries (mould repair). Local exhaust ventilation was used in the majority of cases.

Thermal cutting: the measurements were taken predominantly in the metalworking industry during plasma oxygen cutting and laser cutting. Levels in the region of 90% were measured during the machining of nickel-containing steels.

Surface coating (painting, enamelling, screen printing): the measurements were taken in the metalworking and ceramics industries (porcelain processing). Levels in the region of 90% were measured during the processing of nickel-containing paints.

Nickel-cadmium battery production: the measurements were taken predominantly during compound production (mixing, moulding) and cell production. Levels in the region of 90% were measured for compound mixing and electrode moulding.

Recycling plants: the measurements were taken predominantly during the removal of coatings and casings (television screens, fluorescent tubes).

Table 46:
Nickel – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	µg/m³	µg/m³	µg/m³
Surface finishing / galvanising	581	185	2	10	30
– Without local exhaust ventilation	255	102	2	10	20
– With local exhaust ventilation	309	114	2	20	30
Foundries (smelting, casting)	80	38	1	9	30
– Without local exhaust ventilation	20	13	1	2	2
– With local exhaust ventilation	57	30	1	13	42
Grinding / polishing	716	331	9	260	600
– Without local exhaust ventilation	205	120	9	240	580
– With local exhaust ventilation	474	230	8	220	500

Table 46
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	µg/m³	µg/m³	µg/m³
Manual arc welding	254	122	10	80	230
– Without local exhaust ventilation	33	21	5	47	100
– With local exhaust ventilation	214	104	10	80	230
Tungsten inert-gas welding	219	155	4	40	60
– Without local exhaust ventilation	114	73	6	40	100
– With local exhaust ventilation	83	70	2	20	30
Inert-gas metal-arc welding	120	66	9	140	300
– Without local exhaust ventilation	24	17	9	140	260
– With local exhaust ventilation	91	47	9	140	320
Active-gas metal-arc welding	216	108	9	130	230
– Without local exhaust ventilation	43	32	10	160	290
– With local exhaust ventilation	156	78	8	80	160
Thermal spraying	254	74	20	180	330
– Without local exhaust ventilation	29	9	10	340	470
– With local exhaust ventilation	223	68	30	170	260
Thermal cutting	106	68	9	80	200
– Without local exhaust ventilation	16	12	3	50	70
– With local exhaust ventilation	85	54	9	70	140
Surface coating (painting, enamelling, screen printing)	84	40	0.3	3	6
– Without local exhaust ventilation	22	14	0.2	2	3
– With local exhaust ventilation	53	30	0.3	4	20
Nickel-cadmium battery production	138	12	30	180	320
– Without local exhaust ventilation	23	6	6	54	120
– With local exhaust ventilation	113	11	30	180	320
Recycling plants	20	11	*)	*)	2

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

63 measurements from 39 companies fall into this category. Levels in the region of 90% were measured for plasma oxygen cutting (Table 47)

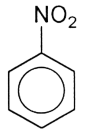
Table 47:
Nickel – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mµg/m^3	µg/m^3	µg/m^3
All company types / work areas	63	39	30	1100	1400

3.32 Nitrobenzene

Identification and limit values

Formula



$C_6H_5NO_2$

Molecular weight in g/mol	123.11
CAS No.	98-95-3
Synonyms	essence of mirbane, oil of mirbane, mononitrobenzene
German limit value	5 mg/m^3, 1 ml/m^3 (MAK)
Data collection period	1992 to 1997
BGAA exposure description	No. 42

Measurement method

A defined volume of air is sucked through a silica gel tube using a sampling pump. After extraction with methanol, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

14 measurements were analysed from 6 companies in the chemical, metalworking, leather, tanker shipping and waste disposal industries in compliance with the Data Protection Act. Table 48 shows the average exposure levels per shift. The examination of the average

exposure levels per shift produced levels below the analytically detectable concentration. There were not sufficient data to carry out a statistical evaluation of the measurements for a reduced exposure time.

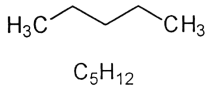
Table 48:
Nitrobenzene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	14	6	*)	*)	*)

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.33 n-Pentane

Identification and limit values

Formula	 C_5H_{12}
Molecular weight in g/mol	72.15
CAS No.	109-66-0
Synonyms	-
German limit value	2,950 mg/m^3, 1,000 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 30

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

102 measurements from 45 companies were included in the analysis (Table 49).

Plastic foam processing: the data were collected during the production and processing of foam. Levels in the region of 90% were measured for frothing and cutting (mainly thermal cutting).

Woodworking: the data were collected during surface coating (glueing, spraying).

Table 49
n-Pentane – average exposure levels per shift

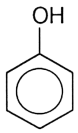
Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Plastic foam processing	75	26	48	242	323
– Without local exhaust ventilation	28	11	39	231	278
– With local exhaust ventilation	41	17	50	192	300
Woodworking	27	19	*)	2	11
– Without local exhaust ventilation	12	8	*)	12	14
– With local exhaust ventilation	15	11	*)	*)	3

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

3.34 Phenol

Identification and limit values

Formula



C_6H_6O

Molecular weight in g/mol	94.11
CAS No.	108-95-2
Synonyms	hydroxybenzene, carbolic acid
German limit value	19 mg/m^3, 5 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 1

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether and subsequent silylation with N,O-bis(trimethylsilyl)trifluoroacetamide, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling was 1.0 mg/m^3 until 1992 and has been 0.5 mg/m^3 since 1993.

Notes on the results

General

1,164 measurements from around 550 companies were analysed. The analysis focused on foundries (17%), the metalworking and mechanical engineering industries (13%), the woodworking industry (12%) and the plastics processing industry (10%).

The measurements for the processing of phenol-formaldehyde foams in the mining industry (for sealing cavities) are below the analytically detectable concentration (up to 2.0 mg/m^3). As such a small number of cases were recorded, the measurements were not subjected to statistical analysis.

Average exposure levels per shift

Table 50 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Processing of phenolic resins in the plastics processing and woodworking industries: the measurements were taken for moulding, kneading, extrusion and injection moulding. More than 90% of the measurements were in the region of the analytically detectable concentration. Levels above the analytically detectable concentration (1.0 mg/m^3) were measured during the moulding of wooden panels and abrasive discs.

Processing of phenolic resins in foundries: around 90% of the measurements were in the region of the analytically detectable concentration. Levels above 90% were measured during the manufacture of cores using phenol-containing resins.

Dryers, box / smelting and hardening furnaces: around half of the measurements were taken during the manufacture of abrasive products. 85% of the measurements were in the region of the analytically detectable concentration.

Mechanical machining processes: the measurements were taken in the metalworking, mechanical engineering, vehicle manufacture and electrical engineering industries. No levels above the analytically detectable concentration were measured.

Glueing: the majority of the measurements came from the metalworking/mechanical engineering, woodworking and plastics processing industries. In more than 95% of cases the measurements were in the region of the analytically detectable concentration.

Surface coating: the majority of the measurements came from the metalworking/mechanical engineering, woodworking and plastics processing industries. In more than 95% of cases the

measurements were in the region of the analytically detectable concentration. Levels above the analytically detectable concentration were measured for the application of phenol-containing materials using compressed-air spray guns and brushes (coatings for the preservation of tanks, drums and floors).

Decanting, weighing, mixing: the majority of the measurements came from the metalworking/mechanical engineering, woodworking and plastics processing industries. 75% of the measurements were in the region of the analytically detectable concentration. Levels above 90% were measured during the mixing of phenol-containing materials (manufacture of abrasive discs, ceramic compounds, phenolic resins).

Table 50:
Phenol – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Processing of phenolic resins in the woodworking and plastics processing industries	329	136	*)	1.0	1.3
– Without local exhaust ventilation	196	91	*)	1.0	2.0
– With local exhaust ventilation	128	56	*)	1.0	1.0
Processing of phenolic resins in foundries	263	98	*)	2.0	2.9
– Without local exhaust ventilation	98	47	*)	2.0	2.0
– With local exhaust ventilation	158	65	*)	1.1	3.0
Dryers, box / smelting and hardening furnaces	93	45	*)	2.0	3.3
– Without local exhaust ventilation	45	22	*)	1.8	4.0
– With local exhaust ventilation	43	23	*)	2.0	2.0
Mechanical machining processes	76	41	*)	1.0	1.0
– Without local exhaust ventilation	36	18	*)	*)	0.6
– With local exhaust ventilation	35	23	*)	0.8	1.0
Glueing	60	42	*)	1.0	2.0
– Without local exhaust ventilation	38	27	*)	1.0	2.0
– With local exhaust ventilation	21	17	*)	*)	3.8

Table 50
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating	234	137	*)	1.5	2.0
– Without local exhaust ventilation	77	49	*)	1.5	2.0
– With local exhaust ventilation	148	89	*)	1.2	2.6
Decanting, weighing, mixing	91	51	*)	5.0	8.5
– Without local exhaust ventilation	33	21	*)	2.6	3.0
– With local exhaust ventilation	50	26	1.0	8.0	12.0

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

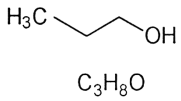
The measurements were not concentrated in any particular industries or work areas. Levels in the region of 90% were measured on hardening furnaces during the manufacture of abrasive products (Table 51).

Table 51:
Phenol – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	18	17	1.2	7.6	12.2

3.35 1-Propanol

Identification and limit values

Formula	 C_3H_8O
Molecular weight in g/mol	60.09
CAS No.	71-23-8
Synonyms	propanol, n-propanol, propan-1-ol, propanol-1, propyl alcohol, n-propyl alcohol, 1-hydroxypropane
German limit value	no limit value
Data collection period	1991 to 1995
BGAA exposure description	No. 26

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

433 measurements from around 170 companies were analysed.

Average exposure levels per shift

Table 52 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Paint manufacture: data were collected predominantly during mixing, dissolving and decanting. Levels in the region of 90% were measured during the processing of raw materials and preparation (e.g. filling end weighing machine).

Manual coating, excluding spraying: the data come predominantly from the construction industry. Levels in the region of 90% were measured for large-scale brush and roller application.

Manual coating, spraying: the data were collected in the construction and metalworking industries. Levels in the region of 90% were measured in the construction sector. The effect of local exhaust ventilation on exposure levels can be seen clearly.

Mechanical coating, printing: the data were collected in the aforementioned areas. Levels in the region of 90% were measured for screen printing.

Cleaning processes: these processes are carried out in all of the aforementioned sectors. The effect of local exhaust ventilation on exposure levels can be seen clearly. Levels in the region of 90% occur on degreasing machines and during manual cleaning without local exhaust ventilation.

Table 52:
1-Propanol – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Paint manufacture – Without local exhaust ventilation – With local exhaust ventilation	70 41 25	21 12 11	2.5 2.8 2.0	16.0 15.5 14.8	21.5 22.0 16.7
Manual coating, excluding spraying – All without local exhaust ventilation	33	14	3.0	493.8	690.8

Table 52
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manual coating, spraying	182	73	4.5	23.2	37.6
– Without local exhaust ventilation	80	11	6.5	33.0	70.0
– With local exhaust ventilation	92	57	2.0	15.6	24.0
Mechanical coating, printing	88	39	5.0	28.3	62.0
– Without local exhaust ventilation	57	27	4.8	17.9	27.6
– With local exhaust ventilation	29	15	3.3	81.7	182.7
Cleaning processes	42	23	6.0	135.4	207.5
– Without local exhaust ventilation	12	8	89.0	446.2	582.0
– With local exhaust ventilation	22	10	4.8	71.6	95.0

Measurements for a reduced exposure time of < 1 hour

The data were collected predominantly in the paint manufacturing and construction industries. Levels in the region of 90% were measured in the construction sector for the roller application of surface coatings. Levels in the region of 50% were measured during the paint manufacturing process.

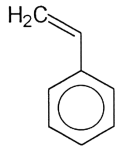
Table 53:
1-Propanol – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	18	10	10	2204	3952

3.36 Styrene

Identification and limit values

Formula



Molecular weight in g/mol	104.15
CAS No.	100-42-5
Synonyms	vinyl benzene, ethenylbenzene, phenylethylene
German limit value	85 mg/m^3, 20 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 10

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with carbon disulphide, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

1,522 measurements from around 460 companies were analysed. The measurements come predominantly from the plastics processing industry (58%) and relate mainly to laminating (20%). Only measurements taken using sampling apparatus worn by human subjects were included in the analysis.

Average exposure levels per shift

Table 54 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Thermal processing of polystyrene: the measurements were taken exclusively during the processing of polymeric styrene (extrusion, injection moulding, deep-drawing). Most of the measurements are therefore in the region of the analytically detectable concentration.

Hot pressing: elevated levels are measured during the hot-pressing of UP resins because of the effect of the heat.

Mixers, stirring machines: levels measured during the production of UP resins (fillers) are above 50%. Levels below 50% occur during paint production.

Filling, smoothing: the measurements were taken in the construction industry and the car body repair business. Levels in the region of 90% occur during manual work carried out without local exhaust ventilation.

Open, large-scale processing in the plastics industry: this category includes laminating, casting, winding and spraying. Levels in the region of 90% were measured for manual processing without local exhaust ventilation.

Open, large-scale processing (construction industry): this category includes laminating, casting, spraying (for lining acid-proof structures) and manufacturing polymer concrete components. Levels in the region of 90% were measured during manual processing without local exhaust ventilation.

Table 54:
Styrene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Thermal processing of polystyrene	35	27	1	5	19
– Without local exhaust ventilation	27	20	*)	*)	*)
– With local exhaust ventilation	4	4	**)	**)	**)

Table 54
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Hot pressing	77	21	73	164	191
– Without local exhaust ventilation	39	14	73	161	210
– With local exhaust ventilation	38	11	61	138	179
Mixers, stirring machines	67	27	46	205	243
– Without local exhaust ventilation	14	8	12	112	123
– With local exhaust ventilation	49	18	59	221	282
Filling, smoothing	67	37	27	159	248
– Without local exhaust ventilation	44	27	31	169	263
– With local exhaust ventilation	21	10	19	135	166
Open, large-scale processing in the plastics industry	1171	345	77	261	316
– Without local exhaust ventilation	495	181	92	283	356
– With local exhaust ventilation	628	215	66	236	284
Open, large-scale processing in the construction industry	128	33	129	332	479
– Without local exhaust ventilation	51	19	116	325	358
– With local exhaust ventilation	69	14	165	399	596

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)
**) There were not sufficient data to carry out a statistical analysis (see also section 2.3)

Measurements for a reduced exposure time of < 1 hour

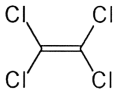
Around half of the measurements were taken during open, large-scale processing. Levels in the region of 90% were measured during manual laminating (for example boat building, production of moulded parts) and canal redevelopment (Table 55).

Table 55:
Styrene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Filling, smoothing	15	4	51	215	228
Open, large-scale processing in the plastics and construction industries	29	20	74	390	659

3.37 Tetrachloroethene

Identification and limit values

Formula	 C_2Cl_4
Molecular weight in g/mol	165.83
CAS No.	127-18-4
Synonyms	1,1,2,2-tetrachloroethylene, tetrachloroethylene, perchloroethylene, "per"
German limit value	345 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 5

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

834 measurements were analysed from around 530 companies in the dry cleaning, metal-working/mechanical engineering and electronics/precision mechanics industries and other areas.

Average exposure levels per shift

Table 56 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Decanting, distillation: 95% of the measurements were taken in the chemical industry (including the wholesale trading of chemical products). Levels in the region of 90% were measured for the manual emptying of drums.

Surface coating (laminating, cladding, spraying): the measurements are distributed evenly among the aforementioned industries. Around 90% of the measurements were in the region of the analytically detectable concentration.

Manual surface cleaning: the measurements come from the electrical engineering/precision mechanics and metalworking/mechanical engineering industries. Levels above 50% were measured for the manual cleaning of surfaces without local exhaust ventilation.

Surface cleaning machines: half of the measurements come from the electrical engineering and precision mechanics industries and half from the metalworking and mechanical engineering industries.

Dry cleaning: from 1990 to 1994 measurements were only taken if there were clear signs of elevated exposure levels, for example evidence collected during investigations into occupational diseases.

Exposure levels were also measured in Germany's new federal states. Levels of up to 95% level of the overall data set were recorded during the use of Spezima dry cleaning machines.

Since the last transitional regulations became invalid on 1 January 1995, all dry cleaning machines using tetrachloroethylene as a solvent have had to comply with the requirements of the 2nd Ordinance for the Implementation of the Federal Emissions Control Act (2. Verordnung zur Durchführung des Bundesimmissionsschutzgesetzes [2. BImSchV]) of 10 December 1990. Under these regulations dry cleaning equipment must be monitored continually by means

of integral monitoring systems and external/internal inspections. This is intended to prevent the continued use of systems which are likely to release an increased volume of emissions in the event of malfunction. As a result of these measures being introduced, the measurements for systems which meet the requirements of the 2nd Ordinance for the Implementation of the Federal Emissions Control Act are generally below 35 mg/m^3. The exposure levels measured for activities carried out some distance away from the dry cleaning machines are lower.

Table 56:
Tetrachloroethene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Decanting, distillation	23	10	5	34	45
– Without local exhaust ventilation	5	3	*)	*)	*)
– With local exhaust ventilation	17	9	5	44	48
Surface coating (laminating, cladding, spraying)	81	45	3	13	26
– Without local exhaust ventilation	81	16	3	5	5
– With local exhaust ventilation	39	26	3	28	31
Manual surface cleaning	17	12	19	342	793
– Without local exhaust ventilation	12	8	7	637	803
– With local exhaust ventilation	4	4	*)	*)	*)
Surface cleaning machines	321	154	38	326	541
– Without local exhaust ventilation	31	19	18	322	505
– With local exhaust ventilation	279	135	41	331	544
Dry cleaning (up to 1994, see explanation)	364	312	44	147	215
– Without local exhaust ventilation	147	127	34	111	213
– With local exhaust ventilation	216	186	51	158	206

*) There were not sufficient data to carry out a statistical analysis (see also section 2.3)

Measurements for a reduced exposure time of < 1 hour

The measurements come from all the aforementioned industries. Levels above 50% were measured for manual cleaning and manual screen printing (Table 57).

Table 57:
Tetrachloroethene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	28	22	35	273	319

3.38 Tetrahydrofuran

Identification and limit values

Formula	 C_4H_8O
Molecular weight in g/mol	72.10
CAS No.	199-99-9
Synonyms	tetramethylene oxide, oxolane, diethylene monoxide, THF
German limit value	590 mg/m^3, 200 ml/m^3 (MAK)
Data collection period	1991 to 1996
BGAA exposure description	No. 39

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

357 measurements from approx. 120 companies were included in the analysis.

Average exposure levels per shift

Table 58 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Plastic coating (glueing, printing, laminating, welding): the data were collected during the mechanical and manual (production of flat roofs and industrial floors) processing of plastic. Levels in the region of 90% were measured during the application of large quantities of adhesive (spraying of adhesive, for example to join panels together) and during manual work without local exhaust ventilation (welding plastics during the production of flat roofs and industrial floors).

Manufacture of plastic adhesives: the data were collected during the preparation and decanting of adhesives (PVC adhesives). Levels in the region of 90% were measured during preparation.

Manufacture of plastics / plastic foams: the data were collected during the injection moulding, blow moulding and deep-drawing of plastics. Levels in the region of 90% were measured for the production of plastic foam.

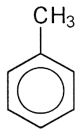
Table 58:
Tetrahydrofuran – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Plastic coating	308	100	13	137	242
– Without local exhaust ventilation	140	55	12	165	290
– With local exhaust ventilation	149	47	13	133	182
Manufacture of plastic adhesives	20	7	40	150	166
Manufacture of plastics and plastic foams	19	13	1	67	89

3.39 Toluene

Identification and limit values

Formula



C_7H_8

Molecular weight in g/mol	92.14
CAS No.	108-88-3
Synonyms	methylbenzene, phenyl methane
German limit value	190 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 40

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After elution with diethyl ether, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.3 mg/m^3.

Notes on the results

General

7,782 measurements from around 2,200 companies were included in the analysis.

Average exposure levels per shift

Table 59 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Manufacture of preparations: the data were collected on dissolvers, bead mills and decanting equipment. Levels in the region of 90% were measured during mixing and decanting.

Cleaning, degreasing (mechanical): the data were collected predominantly in the metalworking and chemical industries. Levels in the region of 90% were measured on container cleaning machines.

Cleaning, degreasing (manual): the data were collected predominantly in the metalworking, woodworking and chemical industries. Levels in the region of 90% were measured during the cleaning of machines (for example in paint manufacturing plants).

Glueing (plastic / rubber processing): levels in the region of 90% were measured during the spraying of adhesives.

Glueing (woodworking): levels in the region of 90% were measured during the large-scale glueing.

Glueing (manufacture of upholstered furniture): levels in the region of 90% were measured during the spraying of adhesives.

Glueing (leatherwork / shoe manufacture): the focus was on workplaces thought to be in need of attention. Levels in the region of 90% and 95% were measured during the manual glueing in slipper factories. The highest levels were measured in a factory where parts which had been coated with adhesive were left to dry in the work area itself (the weather was cold so the doors and windows were closed).

In recent years formulas have changed and the toluene content of most adhesives has been reduced appreciably.

Glueing, floor laying (wood, textiles, plastics): levels in the region of 90% were measured during glueing with spreaders in rooms without ventilation, particularly at the start of the data collection period. An appreciable decrease in exposure levels was recorded towards the end of the data collection period after formulas were changed.

Painting (brush, roller, spreader application) (metalworking, electrical engineering): levels in the region of 90% were measured for painting without local exhaust ventilation.

Painting (brush, roller, spreader application) (construction industry): the data were collected during the painting of walls, windows and domestic installations. Levels in the region of 90% were measured, for example, during the painting of metal.

Hand painting (porcelain manufacture): no local exhaust ventilation was used in the workplaces examined.

Spray painting (metalworking, electrical engineering): the data were collected predominantly on dry-type and waterwash spraybooths.

Spray painting (woodworking): the data were collected predominantly on dry-type and waterwash spraybooths. The measurements for areas where no local exhaust ventilation is used were taken in airing and drying areas of painting facilities.

Spray painting (construction industry): the data were collected during corrosion protection work. Levels in the region of 90% were measured during high-pressure spraying.

Mechanical surface coating (plastics / rubber industries): the measurements were taken on flexographic, pad and screen printing machines. Levels in the region of 90% were measured during the application of rubber coatings (e.g. mats, seals).

Mechanical surface coating (metalworking, electrical engineering): the measurements were taken on flexographic, pad and screen printing machines, cast-coating machines and painting lines. Levels in the region of 90% were measured on pad printing machines.

Mechanical surface coating (woodworking): the measurements for areas without local exhaust ventilation were taken predominantly on (paint) cast-coating machines, where extractors cannot generally be used for technical reasons (the film of paint starts to come away if there is strong air movement). The measurements for areas with local exhaust ventilation were taken on operators/supervisors of spray robots on painting lines. These facilities are generally enclosed.

Screen printing, manual (construction industry): levels in the region of 90% were measured during manual screen printing (for example sign painters).

Screen printing, manual (ceramics, glass and printing industries): levels in the region of 90% were measured during the processing of porcelain.

Gravure illustration printing: the data were collected for monocausal exposure to toluene during gravure illustration printing. Levels in the region of 90% were measured for cleaning work.

The measurements taken in workplaces without local exhaust ventilation are generally lower because they relate to activities which are carried out in areas some distance away from the gravure printing machine, where exposure levels are unlikely to exceed the MAK-value. Therefore, no local exhaust ventilation is generally used in these areas.

The measurements taken in workplaces with local exhaust ventilation are higher because they relate to activities carried out in the immediate vicinity of the gravure printing machine. Gravure printing machines are always used with local exhaust ventilation.

Between 1991 and 1995 considerable technological advances were made at the gravure printing companies which took part in the analysis. In addition, the admissible limit value for toluene was reduced from 100 ml/m^3 (380 mg/m^3) to 50 ml/m^3 (190 mg/m^3) with effect from 27 May 1994. Therefore, the exposure situation at the companies also changed as protective equipment was introduced to ensure that the new requirements were met. In 1995 an appreciable decrease in exposure to toluene was observed in all work areas.

Table 59:
Toluene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Manufacture of preparations	508	130	4	55	98
– Without local exhaust ventilation	211	71	5	59	138
– With local exhaust ventilation	268	85	4	54	82
Cleaning, degreasing (mechanical)	61	39	7	22	44
– Without local exhaust ventilation	13	7	7	24	28
– With local exhaust ventilation	44	24	6	21	65
Cleaning, degreasing (manual)	340	186	3	62	121
– Without local exhaust ventilation	186	111	2	65	130
– With local exhaust ventilation	138	70	5	51	123
Glueing (plastic / rubber processing)	238	88	3	71	183
– Without local exhaust ventilation	128	53	3	158	244
– With local exhaust ventilation	107	42	3	39	66

Table 59
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Glueing (woodworking) – Without local exhaust ventilation – With local exhaust ventilation	137 60 77	63 34 34	1 6 1	104 129 89	196 206 170
Glueing (manufacture of upholstered furniture) – Without local exhaust ventilation – With local exhaust ventilation	96 58 32	28 16 13	1 1 1	17 20 14	40 35 54
Glueing (leatherwork / shoe manufacture) – Without local exhaust ventilation – With local exhaust ventilation	333 184 143	78 47 38	10 18 4	152 147 127	225 221 221
Glueing (floor laying) – All measurements without local exhaust ventilation	877	244	45	335	504
Brush / roller application (metalworking) – Without local exhaust ventilation – With local exhaust ventilation	124 93 22	71 53 18	1 1 1	26 27 8	42 44 16
Brush/roller application (construction industry) – All measurements without local exhaust ventilation	285	78	*)	4	25
Brush application, hand painting (porcelain industry) – All measurements without local exhaust ventilation	94	33	3	26	33
Spray painting (metalworking, electrical engineering) – Without local exhaust ventilation – With local exhaust ventilation	546 101 420	295 61 232	2 1 2	15 11 14	38 17 39
Spray painting (construction industry) – Without local exhaust ventilation – With local exhaust ventilation	406 282 104	82 39 42	3 3 4	32 21 44	50 39 191

Table 59
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Spray painting (woodworking)	1337	510	5	36	54
– Without local exhaust ventilation	80	47	4	35	45
– With local exhaust ventilation	1246	478	5	36	55
Mechanical surface coating (plastics and rubber industries)	240	93	1	98	238
– Without local exhaust ventilation	121	49	3	192	352
– With local exhaust ventilation	117	51	1	39	56
Mechanical surface coating (metal-working, electrical engineering)	148	76	2	21	32
– Without local exhaust ventilation	50	32	1	18	50
– With local exhaust ventilation	92	48	3	23	28
Mechanical surface coating (wood-working)	609	198	8	96	177
– Without local exhaust ventilation	168	71	10	164	218
– With local exhaust ventilation	440	147	7	90	138
Screen printing, manual (construc-tion industry)	43	10	10	227	306
– Without local exhaust ventilation	25	8	15	303	351
– With local exhaust ventilation	18	3	10	36	54
Screen printing, manual (ceramics, glass and printing industries)	66	25	1	18	156
– Without local exhaust ventilation	43	16	2	20	157
– With local exhaust ventilation	19	9	1	1	59
Printing (gravure illustration printing industry)	1430	15	48	198	258
– Without local exhaust ventilation	470	13	17	85	118
– With local exhaust ventilation	849	14	86	232	284

*) Value < analytically detectable concentration (see also sections 2.2 and 2.3)

Measurements for a reduced exposure time of < 1 hour

Table 60 shows the measurements for a reduced exposure time. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Glueing, floor laying (wood, textiles, plastics): levels in the region of 90% were measured during the glueing (using a spreader) of textile/plastic coverings in rooms without ventilation.

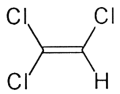
Cleaning, degreasing, general: the measurements were taken predominantly in the metal-working/electrical engineering industry and in the wholesale sector. Levels in the region of 90% were measured for the cleaning of tanks.

Table 60:
Toluene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Glueing (floor laying) – All measurements without local exhaust ventilation	376	99	51	358	489
Cleaning, degreasing – Without local exhaust ventilation – With local exhaust ventilation	48 30 18	23 8 15	18 20 9	67 54 67	113 109 106

3.40 Trichloroethene

Identification and limit values

Formula	 C_2HCl_3
Molecular weight in g/mol	131.38
CAS No.	79-01-6
Synonyms	1,1,2-trichloroethylene, ethylene trichloride, "tri"
German limit value	270 mg/m^3, 50 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 3

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

General

407 measurements were analysed from around 190 companies in the dry cleaning, metal-working/mechanical engineering and electronics/precision mechanics industries and other areas.

Average exposure levels per shift

Table 61 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Decanting, distillation: more than 90% of the measurements come from the chemical industry (including paint manufacture). Levels in the region of 90% were measured for the emptying of drums, even with local exhaust ventilation.

Surface coating: the measurements are distributed evenly among the aforementioned industries. Levels in the region of 90% were measured for the glueing of rubber. This applies both to the glueing on large areas (conveyor belts, conveyor drums) and on small areas (tyre repairs). The measurements taken for the glueing of small metallic components were in the region of the analytically detectable concentration.

Surface cleaning, manual: the measurements come from the aforementioned industries. Levels in the region of 90% were measured for manual cleaning without local exhaust ventilation.

Surface cleaning machines: 90% of the measurements were taken in the metalworking/mechanical engineering and precision mechanics/electrical engineering industries. Extractors were used with most of the machines. Levels in the region of 90% were measured on machines without extractors.

Table 61:
1,1,2-Trichloroethene – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Decanting, distillation in the chemical industry	31	16	11	71	154
– Without local exhaust ventilation	10	8	9	32	36
– With local exhaust ventilation	19	9	11	82	153

Table 61
(continued):

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating (glueing, laminating, cladding, filling)	144	78	10	215	425
– Without local exhaust ventilation	74	44	8	185	399
– With local exhaust ventilation	66	41	11	232	420
Surface cleaning, manual	14	7	41	304	592
Surface cleaning machines	188	90	54	241	403
– Without local exhaust ventilation	23	18	22	282	566
– With local exhaust ventilation	159	74	54	239	364

Measurements for a reduced exposure time of < 1 hour

The measurements were taken predominantly during surface cleaning and decanting (Table 62). Levels in the region of 90% were measured in asphalt laboratories (extraction of binding agents) and for the manual cleaning of metal. No local exhaust ventilation was used.

Table 62:
Trichloroethene – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	30	22	241	711	912

3.41 Trichloromethane

Identification and limit values

Formula	$CHCl_3$
Molecular weight in g/mol	117.38
CAS No.	67-66-3
Synonyms	chloroform
German limit value	50 mg/m^3, 10 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 33

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with carbon disulphide, quantitative analysis is carried out by means of gaschromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 0.1 mg/m^3.

Notes on the results

Laboratories: the data were collected in the chemical industry and in research and analytical institutes (Table 63). Local exhaust ventilation was used in all workplaces. Laboratories are generally fitted with fume cupboards, whose effectiveness (i.e. ability to extract harmful substances from the air) depends mainly on whether there is a sufficiently strong flow of exhaust air, whether work is carried out inside the fume cupboard keeping the sliding front panel closed whenever possible and whether the fume cupboard is used correctly so as to keep it functioning effectively. The measurements depend on the substance being extracted, the size and quantity of the air extraction systems used and the effectiveness of the protective equipment used. Exposure can also be expected when extracts are shaken out and dried. Exposure

levels in the region of 90% occur in the laboratory if no ventilation equipment (general room ventilation equipment, fume cupboards) is used (in laboratories ventilation equipment of this kind is obligatory under the guidelines for laboratories [23]) or if this equipment is not used correctly.

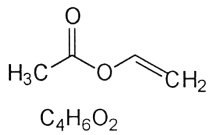
Table 63:
Trichloromethane – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Laboratories	11	7	6.5	39.6	50.1

3.42 Vinyl acetate

Identification and limit values

Formula



$C_4H_6O_2$

Molecular weight in g/mol	86.09
CAS No.	108-05-4
Synonyms	acetic acid vinyl ester
German limit value	35 mg/m^3, 10 ml/m^3 (MAK)
Data collection period	1990 to 1995
BGAA exposure description	No. 11

Measurement method

A defined volume of air is sucked through an activated charcoal tube using a sampling pump. After extraction with diethyl ether, quantitative analysis is carried out by means of gas-chromatography using a flame ionisation detector. The analytically detectable concentration for two hours of sampling is 1.0 mg/m^3.

Notes on the results

General

A total of 200 measurements from around 100 companies were analysed. Around 50% of the measurements come from the woodworking industries, with the focus on glueing.

Average exposure levels per shift

Table 64 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Surface coating: the measurements were taken in the paper, construction and metalworking industries. No levels above the analytically detectable concentration were measured.

Glueing: more than 90% of the measurements were taken in the woodworking industries during the processing of hot-melt adhesives. 95% of the measurements were below the analytically detectable concentration.

Reaction vessels: the measurements come from the technical and production sectors. The reaction vessels examined were used mainly in discontinuous work processes carried out in enclosed systems. Exposure can occur when the vessels are opened and cleaned and when vinyl acetate is added. Ventilation / local exhaust ventilation was used in some cases. It was not possible to categorise the measurements depending on whether or not local exhaust ventilation was available as so few workplaces were fitted with these facilities.

Table 64:
Vinyl acetate – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Surface coating	28	14	1	1	1
– Without local exhaust ventilation	8	6	*)	*)	*)
– With local exhaust ventilation	18	8	1	1	1
Glueing	162	85	1	2	2
– Without local exhaust ventilation	95	57	1	1	1
– With local exhaust ventilation	65	31	1	2	2
Reaction vessels	10	4	6	56	64

*) There were not sufficient data to carry out a statistical analysis (see also section 2.3).

3.43 Hydrogen peroxide

Identification and limit values

Formula	H_2O_2
Molecular weight in g/mol	34.01
CAS No.	7722-81-1
Synonyms	perhydrol, "hydrogen superoxide"
German limit value	1.4 mg/m^3, 1.0 ml/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 31

Measurement method

A defined volume of air is sucked through a tube (liquid matrix saturated with potassium titanium oxalate solution) using a sampling pump. Quantitative analysis is carried out photometrically. The analytically detectable concentration for two hours of sampling is 0.01 mg/m^3.

Notes on the results

General

92 measurements from 12 companies were included in the analysis.

Average exposure levels per shift

Table 65 shows the average exposure levels per shift. The examination of the average exposure levels per shift measured for individual company types and work areas produced the results listed below.

Hairdressing profession: 37 out of 39 measurements were taken while hairdressers bleached their customers' hair at one of the BIA's test facilities, which is fitted out like a hairdressing salon. The test facility is equipped with a ventilation system. The product used on customers was prepared prior to treatment by mixing a bleaching agent (powder or granules)

with a 4% to 18% hydrogen peroxide solution. The conditions were different to those in a professional hairdressing salon as only bleaching (no perming or dying) was carried out while the measurements were taken. Therefore the measurements cannot be considered to be typical of a hairdressing salon.

Bleaching of paper, fabric and wood: the data were collected during bleaching (H_2O_2, in some cases with ammonium hydrogen carbonate to activate the bleach). Levels in the region of 90% were measured on bleaching machines.

Table 65:
Hydrogen peroxide – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Hairdressing profession – All measurements without local exhaust ventilation	39	2	0.1	0.9	1.2
Bleaching of paper, wood and fabric	25	9	0.1	1.3	1.7

Measurements for a reduced exposure time of < 1 hour

The measurements were taken exclusively during bleaching in the hairdressing profession. Levels in the region of 90% were measured for work carried out in rooms without ventilation (windows and doors closed) (Table 66).

Table 66:
Hydrogen peroxide – measurements for a reduced exposure time of < 1 hour

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
Hairdressing profession – All measurements without local exhaust ventilation	28	1	0.5	2.2	3.1

3.44 Zinc oxide fumes

Identification and limit values

Formula	ZnO
Molecular weight in g/mol	81.39
CAS No.	1314-13-2
Synonyms	–
German limit value	5 mg/m^3 (MAK)
Data collection period	1991 to 1995
BGAA exposure description	No. 24

Measurement method

A defined volume of air is sucked through a membrane filter using a sampling pump. After dissolution (1 M hydrochloric acid : 1 M nitric acid), quantitative analysis is carried out by means of atomic absorption spectrometry or X-ray fluorescence spectrometry. The analytically detectable concentration for two hours of sampling is 0.001 mg/m^3.

Notes on the results

5,153 measurements from around 1,500 companies were analysed in compliance with the Data Protection Act. The data relate mainly to the metalworking/mechanical engineering industries (61%) and the metal producing industry (20%).

Levels in the region of 90% were measured during the thermal machining (welding, soldering) of zinc-containing materials, for example galvanised metal sheet (Table 67).

Table 67:
Zinc oxide fumes – average exposure levels per shift

Company type/Work area	Measurements	Companies	50% value	90% value	95% value
	Number	Number	mg/m^3	mg/m^3	mg/m^3
All company types / work areas	583	213	0.06	0.8	1.6

4 Abbreviations and Units

BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Occupational Safety and Health)
BGAA	Berufsgenossenschaftlicher Arbeitskreis Altstoffe (Berufsgenossenschaften's working group on existing chemicals)
BGMG	Berufsgenossenschaftliches Messsystem Gefahrstoffe (Berufsgenossenschaften's measurement system for hazardous substances)
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit (Berufsgenossenschaften's Institute for Occupational Safety)
BgVV	Bundesinstitut für gesundheitlichen Verbraucherschutz und Veterinärmedizin (Federal Institute for Consumer Health Protection and Veterinary Medicine)
BImSchV	Verordnung zur Durchführung des Bundesimmissionsschutzgesetzes (Ordinance for the Implementation of the Federal Emissions Control Act)
BMA	Bundesministerium für Arbeit und Sozialordnung (Federal Ministry of Employment and Social Affairs)
BUA	Beratergremium für Altstoffe der Gesellschaft Deutscher Chemiker (The Society of German Chemists' Advisory Committee for Existing Chemicals)
CAS	Chemical Abstract Services
DIN	Deutsches Institut für Normung (German Standards Institute)
EINECS	European Inventory of Existing Commercial Chemical Substances
EN	European standard
FID	flame ionisation detector
GC	gaschromatography
HVBG	Hauptverband der gewerblichen Berufsgenossenschaften (German Federation of Institutions for Statutory Accident Insurance and Prevention)
M	molar

4 Abbreviations and Units

MAK	Maximale Arbeitsplatzkonzentration (maximum admissible concentration)
MEGA	Datenbank zu Messdaten über die Exposition gegenüber Gefahrstoffen am Arbeitsplatz (Database of measurements of exposure to hazardous substances at the workplace)
mg/m^3	concentration in milligrams per cubic metre of air
ml/m^3	concentration in millilitres per cubic metre of air
$\mu g/m^3$	concentration in micrograms per cubic metre of air
NOAEL	No Observed Adverse Effect Level
OECD	Organisation for Economic Cooperation and Development
PVC	polyvinyl chloride
σ	safety factor
SIAM	Substances Initial Assessment Meeting
SIDS	Screening Information Data Set
TRGS	Technische Regel für Gefahrstoffe (Technical Rule for Hazardous Substances)
TRK	Technische Richtkonzentration (technical reference concentration)
UBA	Umweltbundesamt (Federal Environmental Agency)
UP resins	unsaturated polyester resins

5 Appendix – Priority Lists

Table 68:
EU Existing Chemicals – 1st Priority List

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
60-00-4	Edetic acid	–	D
62-53-3	Aniline (aminobenzene, phenylamine)	34	D
64-02-8	Tetrasodium methylenediamine tetraacetate	–	D
71-43-2	Benzene	13	D
75-05-8	Acetonitrile (methyl cyanide)	9	E
79-01-6	1,1,2-Trichloroethene (TRI, ethylene trichloride)	3	UK
79-06-1	Acrylamide	14	UK
79-10-7	Acrylic acid	–	D
79-20-9	Methyl acetate (acetic acid methyl ester)	20	D
79-41-4	Methacrylic acid	–	D
80-62-6	Methyl methacrylate (MMA)	2	D
84-74-2	Dibutyl phthalate (DBP, phthalic acid dibutyl ester)	4	NL
91-20-3	Naphthalene	21	UK
95-76-1	3,4-Dichloroaniline	–	D
95-80-7	4-Methyl-m-phenylene diamine	–	D
98-82-8	Isopropylbenzene (cumene)	19	E
100-41-4	Ethylbenzene	18	D
100-42-5	Styrene (phenyl ethylene, vinyl benzene)	10	UK

Table 68
(continued):

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
101-77-9	4,4'-Diaminodiphenylmethane (4,4'-methylenedianiline)	45	D
103-11-7	2-Ethylhexyl acrylate	–	D
106-46-7	1,4-Dichlorobenzene	16	F
106-99-0	1,3-Butadiene	6	UK
107-02-8	Acrylaldehyde (acrolein, 2-propenal)	14	NL
107-13-1	Acrylonitrile (ethylene cyanide, vinyl cyanide)	7	IRL
107-64-2	Dimethyl dioctadecyl ammonium chloride	–	D
108-05-4	Vinyl acetate (acetic acid vinyl ester)	11	D
108-95-2	Phenol	1	D
110-49-6	2-Methoxyethyl acetate (methyl glycol acetate)	8	NL
110-65-6	2-Buten-1,4-diol	–	D
110-82-7	Cyclohexane	17	F
111-77-3	2-(2-Methoxyethoxy)ethanol	–	NL
112-34-5	2-(2-Butoxyethoxy)ethanol (butyl diglycol)	15	NL
117-84-0	Dioctyl phthalate	–	NL
127-18-4	1,1,2,2-Tetrachloroethene (perchloroethylene, PER)	5	UK
141-97-9	Ethylacetoacetate (EAA, acetoacetic acid ethyl ester)	–	D
1163-19-5	Bis-(pentabromophenyl)ether	–	F/UK

Table 68
(continued):

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
1570-64-5	4-Chloro-o-cresol	–	DK
7664-39-3	Hydrogen fluoride	–	NL
32536-52-0	Diphenyl ether, octabromo derivative	–	F/UK
65996-92-1	Distillates (coal tar)	–	NL
67774-74-7	Benzene, $C_{10–13}$ alkyl derivatives	–	I
85535-84-8	Alkanes, $C_{10–13}$ chlorine	–	UK

5 Appendix – Priority Lists

Table 69:
EU Existing Chemicals – 2nd Priority List

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
67-66-3	Trichloromethane (chloroform)	33	F
71-23-8	1-Propanol	26	D
75-45-6	Chlorodifluoromethane	–	I
75-56-9	1,2-Epoxypropane (1,2-propylene oxide, methyl oxirane)	25	UK
77-78-1	Dimethyl sulphate	34	NL
88-12-0	N-Vinyl-2-pyrrolidone	–	UK
90-04-0	o-Anisidine	–	A
95-33-0	N-Cyclohexyl benzothiazol-2-sulphenamide	–	D
98-01-1	2-Furaldehyde	32	NL
100-97-0	Hexamethylene tetramine (methenamine)	–	D
108-88-3	Toluene	40	DK
109-66-0	n-Pentane	30	N
110-80-5	2-Ethoxyethanol	28	D
111-15-9	2-Ethoxyethyl acetate	27	D
115-96-8	Tris(2-chloroethyl) phosphate	–	D
117-81-7	Di(2-ethylhexyl) phthalate (Bis(2-ethylhexyl) phthalate, DEHP)	22	S
120-82-1	1,2,4-Trichlorobenzene	–	DK
123-91-1	1,4-Dioxane	23	NL
557-05-1	Zinc distearate	–	NL

Table 69:
(continued):

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
1314-13-2	Zinc oxide	24	NL
7440-66-6	Zinc	–	NL
7646-85-7	Zinc chloride	–	NL
7681-52-9	Sodium hypochlorite	–	I
7722-84-1	Hydrogen peroxide	31	FIN
7733-02-0	Zinc sulphate	–	NL
7779-90-0	Trizincbis(orthophosphate)	–	NL
25154-52-3	Nonylphenol	–	UK
25167-70-8	2,4,4-Trimethylpentene	–	D
25637-99-4	Hexabromocyclododecane	–	S
26761-40-0	Diisodecyl phthalate	–	F
28553-12-0	Diisononyl phthalate	–	F
32534-81-9	Diphenyl ether, pentabromo derivative	–	UK
61790-33-8	Tallow alkylamines	–	D
68515-48-0	1,2-Benzenedicarbonic acid, diC_{8-10}-branched alkyl esters, C_9-rich	–	F
68515-49-1	1,2-Benzenedicarbonic acid, diC_{9-11}-branched alkyl esters, C_{10}-rich	–	F
84852-15-3	4-Nonylphenol, branched	–	UK

5 Appendix – Priority Lists

Table 70:
EU Existing Chemicals – 3rd Priority List

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
75-91-2	tert-Butyl hydroperoxide	–	NL
79-11-8	Chloroacetic acid	–	NL
80-05-7	4,4'-Isopropylidenediphenol	–	UK
81-14-1	4'-tert-Butyl-2', 6'-dimethyl-3',5'-dinitroacetophenone	–	NL
81-15-2	5-tert-Butyl-2,4,6-trinitro-m-xylene	–	NL
85-68-7	Benzylbutyl phthlate	–	N
98-95-3	Nitrobenzene	42	D
110-85-0	Piperazine	–	S
120-12-7	Anthracene	–	GR
122-39-4	Diphenylamine	–	D
1306-19-0	Cadmium oxide	–	B
1333-82-0	Chromium trioxide	–	UK
1634-04-4	(tert-Butyl)methyl ether	–	FIN
3033-77-0	2,3-Epoxypropyltrimethyl ammonium chloride (Glycidyltrimethyl ammonium chloride)	–	FIN
3327-22-8	(3-Chloro-2-hydroxypropyl)trimethyl ammonium chloride	–	FIN
5064-31-3	Trisodium nitrilotriacetate	–	D

Table 70
(continued):

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
7440-02-0	Nickel	43	DK
7440-43-9	Cadmium	37	B
7775-11-3	Sodium chromate	–	UK
7778-50-9	Potassium chromate	–	UK
7782-50-5	Chlorine	41	I
7786-81-4	Nickel sulphate	–	DK
7789-09-5	Ammonium dichromate	–	UK
10039-54-0	Bis(hydroxylammonium) sulphate	–	D
10588-01-9	Sodium dichromate	–	UK
11138-47-9	Perboric acid, sodium salt	–	A
13775-53-6	Cryolite	–	D
15096-52-3	Trisodiumhexafluoroaluminate	–	D
26447-40-5	Methylene diphenyl diisocyanate	–	B
30899-19-5	Pentanol (amyl alcohol)	–	D
65996-93-2	Pitch, coal tar, high temperature	–	NL
85535-85-9	Chloro(C_{14-17}) alkanes	–	UK

5 Appendix – Priority Lists

Table 71:
EU Existing Chemicals – OECD Priority List

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
67-64-1	Acetone	35	USA
78-67-1	2,2'-Dimethyl-2,2'-azodipropionitrile	–	J
95-31-8	N-tert-Butylbenzothiazol-2-suphenamide	–	J
99-96-7	4-Hydroxybenzoic acid	–	J
106-91-2	2,3-Epoxypropyl methacrylate	–	J/USA
108-80-5	Cyanuric acid	–	J
109-99-9	Tetrahydrofuran	39	USA
110-63-4	1,4-Butanediol	–	J
115-95-7	Linalyl acetate	–	SW
115-96-8	Tris(2-chloroethyl) phosphate	–	D
121-69-7	N,N-Dimethylaniline	–	USA
123-30-8	4-Aminophenol	–	J
123-42-2	4-Hydroxy-4-methyl-2-pentanone (diacetone alcohol)	–	J
123-86-4	Butyl acetate	36	USA
141-78-6	Ethyl acetate	38	USA
840-65-3	Dimethylnaphthalene-2,6-dicarboxylate	–	J
868-77-9	2-Hydroxyethylmethacrylate	–	J
872-50-4	N-Methylpyrrolidone	–	USA

Table 71
(continued):

CAS Number	Hazardous Substance	BGAA Exposure Description	Country responsible
994-05-8	2-Methoxy-2-methylbutane	–	USA
2439-35-2	2-(Dimethylamino)ethylacrylate	–	J
3048-65-5	3a,4,7,7a-Tetrahydro-1H-indene	–	J
3452-97-9	3,5,5-Trimethyl-1-hexanol	–	J
4457-71-0	3-Methyl-1,5-pentanediol	–	J
11070-44-3	Tetrahydromethylphthalic anhydride	–	J
68515-49-1	1,2-Benzenedicarbonic acid, di-C_{9-11}-branched alkyl esters, C_{10}– rich	–	F

6 Index

6 Index

c

Page

6 Index

6 Index

Page

N

O

P

6 Index

R

S

T

Page

v

w

z

7 References

[1] Chemikaliengesetz, Europäisches Recht: Verordnung (EWG) Nr. 793/93 des Rates zur Bewertung und Kontrolle der Umweltrisiken chemischer Altstoffe, 23. März 1993. Amtsblatt der Europäischen Gemeinschaften L 84, 36. Jahrgang, 5. April 1993

[2] Chemikaliengesetz, Europäisches Recht: Verordnung (EG) Nr. 1488/94 der Kommission zur Festlegung von Grundsätzen für die Bewertung der von Altstoffen ausgehenden Risiken für Mensch und Umwelt gemäß der Verordnung (EWG) Nr. 793/93 des Rates, 28. Juni 1994

[3] Chemikaliengesetz, Europäisches Recht: Verordnung (EG) Nr. 1179/94 der Kommission über die erste Prioritätenliste gemäß der Verordnung (EWG) Nr. 793/93 des Rates, 25. Mai 1994.

[4] Chemikaliengesetz, Europäisches Recht: Verordnung (EG) Nr. 2268/95 der Kommission über die zweite Prioritätenliste gemäß der Verordnung (EWG) Nr. 793/93 des Rates, 27. September 1995

[5] Chemikaliengesetz, Europäisches Recht: Verordnung (EG) Nr. 143/97 der Kommission über die dritte Prioritätenliste gemäß der Verordnung (EWG) Nr. 793/93 des Rates, 27. Januar 1997

[6] *Stamm, R.:* Die BIA-Dokumentation von Meßdaten zur Gefahrstoffexposition am Arbeitsplatz. Staub – Reinhalt. Luft 55 (1995) Nr. 5, S. 193 - 194

[7] Berufsgenossenschaftliches Institut für Arbeitssicherheit des Hauptverbandes der gewerblichen Berufsgenossenschaften e.V. Berufgenossenschaftliches Messsystem Gefahrstoffe der gewerblichen Berufsgenossenschaften BGMG, 4. Auflage. Hauptverband der gewerblichen Berufsgenossenschaften – HVBG, Sankt Augustin 1999

[8] Berufsgenossenschaft der chemischen Industrie (Hrsg.): Programm zur Verhütung von Gesundheitsschädigungen durch Arbeitsstoffe – Toxikologische Bewertungen. Berufsgenossenschaft der chemischen Industrie, Heidelberg

[9] Schlüsselverzeichnisse für die Dokumentation von Meß- und Betriebsdaten. (Kennzahlen 4050–4291). In: BIA-Arbeitsmappe Messung von Gefahrstoffen. Hrsg.: Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA, Sankt Augustin. 15. Lfg. IX/95, Erich Schmidt, Bielefeld 1989 – Loseblatt-Ausg.

[10] EN 689: Anleitung zur Ermittlung der inhalativen Exposition gegenüber chemischen Stoffen zum Vergleich mit Grenzwerten und Meßstrategie (Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for

comparison with limit values and measurement strategy)

[11] EN 482: Arbeitsplatzatmosphäre – Allgemeine Anforderungen an Verfahren für die Messung von chemischen Arbeitsstoffen (Workplace atmosphere – General requirements for the performance of procedures for the measurements of chemical agents)

[12] Stoffe und BIA-Probenahmeverfahren. (Kennzahl 3200, S. 3–77). Meßverfahren für Gefahrstoffe (Kennzahl 6010 ff). In: BIA-Arbeitsmappe Messung von Gefahrstoffen. Hrsg.: Berufsgenossenschaftliches Institut für Arbeitssicherheit – BIA, Sankt Augustin. 15. Lfg. IX/95, Erich Schmidt, Bielefeld 1989 – Loseblatt-Ausg.

[13] Hauptverband der gewerblichen Berufsgenossenschaften (Hrsg.): Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120; jetzt: BGI 505). Carl Heymanns, Köln (12.1983 bis 07.1997)

[14] *Jambu, M.:* Explorative Datenanalyse. Stuttgart: Gustav Fischer Verlag (1992)

[15] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 37: Verfahren zur Bestimmung von Acrylamid (jetzt: BGI 505-37)

[16] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 4: Verfahren zur Bestimmung von Benzol (jetzt: BGI 505-4)

[17] *Pflaumbaum, W., Bock, W., Willert, G., Stückrath, M., Blome, H.:* Arbeitsumweltdossier Benzol. BIA-Report 3/93. Hrsg.: Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin 1993

[18] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 26: Verfahren zur Bestimmung von 1,3-Butadien (jetzt: BGI 505-26)

[19] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 54: Verfahren zur Bestimmung von Cadmium (jetzt: BGI 505-54)

[20] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der

Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 39: Verfahren zur Bestimmung von 4,4'-Diaminodiphenylmethan (jetzt: BGI 505-39)

[21] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 28: Verfahren zur Bestimmung von 1,2-Epoxypropan (jetzt: BGI 505-28)

[22] Von den Berufsgenossenschaften anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender Arbeitsstoffe in der Luft in Arbeitsbereichen (ZH1/120). Nr. 10: Verfahren zur Bestimmung von Nickel (jetzt: BGI 505-10)

[23] Hauptverband der gewerblichen Berufsgenossenschaften: Richtlinien für Laboratorien (ZH1/119; jetzt: BGR 120). Fassung vom 1. Oktober 1993. Carl Heymanns, Köln 1993