

# List of MAK and BAT Values 2022

Permanent Senate Commission  
for the Investigation of Health Hazards  
of Chemical Compounds in the Work Area

Report 58

Deutsche  
Forschungsgemeinschaft

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and BAT Values  
2022**

Permanent Senate Commission  
for the Investigation  
of Health Hazards  
of Chemical Compounds  
in the Work Area

**Report 58**

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# List of MAK and BAT Values 2022

Maximum Concentrations  
and  
Biological Tolerance Values  
at the Workplace

Permanent Senate Commission  
for the Investigation of Health Hazards  
of Chemical Compounds in the Work Area

**Report 58**

Report 58 of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, of 1 July 2022. This report replaces Report 57 of 1 July 2021 and supersedes all previous reports of the Commission.

DEUTSCHE FORSCHUNGSGEMEINSCHAFT

authorized and signed by Professor Dr. Andrea Hartwig

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★ Indicates a change from the 2021 List of MAK and BAT Values

Details of the new threshold values or classifications proposed are listed in the list of MAK values and assessment values in biological material (appendix page I). The Commission has adopted these proposals but puts them up for discussion until 31.12.2022. New data or scientific commentary may be submitted to the Commission’s scientific office (Kommissionssekretariat) until this date. This information will be examined and taken into consideration in the final ratification.





# Maximum Concentrations at the Workplace

## I Significance, use and derivation of MAK values

### Definition

The MAK value (“maximale Arbeitsplatz-Konzentration”: maximum workplace concentration) is defined as the maximum concentration of a chemical substance (as gas, vapour or aerosol) in the workplace air which generally does not have known adverse effects on the health of the employee nor cause unreasonable annoyance (e. g. by a nauseous odour) even when the person is repeatedly exposed during long periods, usually for 8 hours daily but assuming on average a 40-hour working week. As the MAK value is intended for a daily exposure period of 8 hours, the permissible concentration should be reduced if exposure regularly exceeds 8 hours<sup>1</sup>). Certain aspects of occupational hygiene associated with liquid substances, e.g. formation of mist with obscured visibility, dampening of clothing, or condensation on the floor, can not be taken into account in establishing the MAK value. Such effects have a wide range of variation, depending on the industrial process, the procedure, and the physical conditions at the workplace. A suitable instrument for evaluation is not yet available. Regardless of the level of the toxicologically based MAK value, it should be ensured in these cases that safety at the workplace is not placed at risk. This situation is not explicitly mentioned in the documentations because it is not known whether the substance exists as an aerosol at the MAK value. As a rule, the MAK value is given as an average concentration for a period of up to one working day or shift. MAK values are established on the basis of the effects of chemical substances; when possible, practical aspects of the industrial processes and the resulting exposure patterns are also taken into account. Scientific criteria for the prevention of adverse effects on health are decisive, not technical and economic feasibility.

Furthermore,

**the carcinogenicity** (see Section III)

**the sensitizing effects** (see Section IV)

**the contribution to systemic toxicity after percutaneous absorption**  
(see Section VII)

**the risks during pregnancy** (see Section VIII)

**the germ cell mutagenicity** (see Section IX)

of a substance are evaluated and the substance classified or designated accordingly. Descriptions of the procedures used by the Commission in the evaluation of these end points may be found in the appropriate sections of the List of MAK and BAT Values, in the “Toxikologisch-arbeitsmedizinischen Begründungen von MAK-Werten” (available in English translation<sup>2</sup>) and in scientific journals<sup>3</sup> <sup>4</sup> <sup>5</sup> <sup>6</sup> <sup>7</sup>).

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<sup>1</sup>) Hartwig and MAK Commission (2022) Verlängerte Arbeitszeiten und MAK-Werte. MAK Collect Occup Health Saf 7(1):Doc005. [https://doi.org/10.34865/mb0verlarbdgt7\\_1or](https://doi.org/10.34865/mb0verlarbdgt7_1or)

<sup>2</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

In line with the so-called “preferred value approach” also used e.g. in the European Union, MAK values are to be established preferentially as the numerical values 1, 2 or 5 ml/m<sup>3</sup> or, for non-volatile substances, 1, 2 or 5 mg/m<sup>3</sup>, multiplied by powers of ten.

In the use of MAK values, the analytical procedures used for sampling and analysis and the sampling strategy are of great importance.

## **Purpose**

MAK values promote the protection of health at the workplace. They provide a basis for judgement of the toxic potential or safety of the concentrations of substances in the workplace air. However, they do not provide constants from which the presence or absence of a health hazard after longer or shorter periods of exposure can be determined; nor can proven or suspected damage to health be deduced, in an isolated case, from MAK values or from the classification of a substance as carcinogenic. Such deductions can be made only on the basis of medical findings, taking into consideration all the circumstances of the particular case. Therefore, on principle statements in the List of MAK and BAT Values are not to be seen as a priori judgements for individual cases. On principle, observation of MAK values does not eliminate the necessity for regular medical examination of the exposed individuals.

MAK values are not suitable for providing constant conversion factors for deduction of health risks associated with long-term exposure to contaminants in the non-occupational atmosphere, e.g., in the vicinity of industrial plants.

## **Prerequisites**

In principle, the substances are dealt with according to their importance for practical occupational hygiene and the expertise of the members of the Commission. The prerequisite for the establishment of a MAK value is the availability of sufficient data for the substance from the fields of toxicology, occupational medicine or industrial hygiene. Adequate documentation is not always available. The list is revised annually and suggestions for substances to be added and new information on listed substances are welcome<sup>8)</sup>.

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<sup>3)</sup> Adler ID, Andrae U, Kreis P, Neumann HG, Thier R, Wild D (1999) Vorschläge zur Einstufung von Keimzellmutagenen. *Arbeitsmed Sozialmed Umweltmed* 34: 400–403.

<sup>4)</sup> Drexler H (1998) Assignment of skin notation for MAK values and its legal consequences in Germany. *Int Arch Occup Environ Health* 71: 503–505. <https://doi.org/10.1007/s004200050313>

<sup>5)</sup> Hofmann A (1995) Fundamentals and possibilities of classification of occupational substances as developmental toxicants. *Int Arch Occup Environ Health* 67: 139–145. <https://doi.org/10.1007/BF00626344>

<sup>6)</sup> Neumann HG, Thielmann HW, Filser JG, Gelbke HP, Greim H, Kappus H, Norpoth KH, Reuter U, Vamvakas S, Wardenbach P, Wichmann HE (1998) Changes in the classification of carcinogenic chemicals in the work area. (Section III of the German List of MAK and BAT Values). *J Cancer Res Clin Oncol* 124: 661–669. <https://doi.org/10.1007/s004320050229>

<sup>7)</sup> Neumann HG, Vamvakas S, Thielmann HW, Gelbke HP, Filser JG, Reuter U, Greim H, Kappus H, Norpoth KH, Wardenbach P, Wichmann HE (1998) Changes in the classification of carcinogenic chemicals in the work area. Section III of the German List of MAK and BAT Values. *Int Arch Occup Environ Health* 71: 566–574. <https://doi.org/10.1007/s004200050325>

<sup>8)</sup> Please contact the Geschäftsstelle der Deutschen Forschungsgemeinschaft, D-53170 Bonn; or the Sekretariat der Kommission: Karlsruher Institut für Technologie (KIT) – Institut für angewandte Biowissenschaften, Abteilung Lebensmittelchemie und Toxikologie, 76131 Karlsruhe.

## Derivation of MAK values

MAK values are derived by the “Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the DFG” exclusively on the basis of scientific arguments and are published in the List of MAK and BAT Values which is issued annually. For the derivation of MAK values, certain rules of procedure have been developed by the Commission on the basis of established toxicological and occupational medical concepts; answers to at least the more common questions are repeatedly sought in the same way. Therefore, the usual procedures and the general principles for the derivation of MAK values are described below. Essentially, these principles correspond with those published by the European “Scientific Committee on Occupational Exposure Limits, SCOEL”<sup>9)</sup>).

First, the most sensitive parameters described in the available data are to be identified, i. e., those effects which appear first during exposure to increasing concentrations of the substance. To be taken into account in this process are both local effects, that is, the results of effects on surfaces of the organism which are in contact with the environment (e. g. mucous membranes of the respiratory tract and the eyes, skin) and also systemic effects and effects on the lungs, that is, the results of uptake of the substance into the organism. Generally, the concentration-effect relationships for these two kinds of effects are different. The derivation of the MAK value is based on the “no observed adverse effect level” for the most sensitive effect with relevance for health. A NOAEL is not equivalent with a threshold which cannot be scientifically defined. The NOAEL is a concentration determined by experimental conditions at which the given effect is so low that it does not differ from the control value. It must be decided whether or not such effects may be considered to be adverse effects. At present there is no generally accepted definition for an “adverse” effect, at least in part because of the lack of clarity about the still changing definition for the state of being “healthy”<sup>10) 11)</sup>; therefore, this decision must be made anew in every case.

Fundamentally, known effects of a substance in man are given highest priority in the derivation of the MAK value.

In the evaluation of a substance, known effects of structural analogues may also be taken into account.

If no NOAEL may be derived from the available data, a scientifically founded MAK value cannot be established and the substance is listed in Section IIb of the List of MAK and BAT Values.

### a) Selection of substances and collection of data

For the substances being studied, the epidemiological data published in scientific journals, occupational medical reports, toxicological properties and any other potentially useful information is first assembled by carrying out researches in appropriate databanks. The references found in the literature search are checked for their relevance for the assessment

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<sup>9)</sup> European Commission (Ed.) (1999) Methodology for the derivation of occupational exposure limits: Key documentation Cat. No. CE-NA-19253-EN-C, ISBN 92-828-8106-7, EUR 7, Office for Official Publications of the European Communities, L-2985 Luxembourg.

<sup>10)</sup> DFG (Deutsche Forschungsgemeinschaft) (Ed.) (1997) Verhaltenstoxikologie und MAK-Grenzwertfestlegungen. Wissenschaftliche Arbeitspapiere. Wiley-VCH, Weinheim.

<sup>11)</sup> Henschler D (1992) Evaluation of adverse effects in the standard-setting process. Toxicology Letters 64/65: 53–57. [https://doi.org/10.1016/0378-4274\(92\)90172-g](https://doi.org/10.1016/0378-4274(92)90172-g)

of the substance in question and the original publications of the selected literature are examined. When necessary, unpublished internal company data in the form of complete study reports are also included. These are then identified as such in the reference list at the end of the documentation. The validity of the available information and studies is checked. Whether or not a study is relevant for the current assessment is decided on a case to case basis. Whenever possible, evaluation of the studies is based on the guidelines of the OECD or similar bodies.

The unabridged reports are made available to the Commission and are filed at the Commission's scientific central office. Information required by a third party about the company reports cited in the Commission's documentation is supplied in writing by the chair of the Commission at own discretion. Access to company reports is not made available to third parties. Copies, even of parts of reports, are not provided.

### **b) Values based on effects in man**

For many substances encountered at the workplace, irritation or central nervous depression is the critical effect. Valuable information – at least for these acute effects of single exposures – may be obtained from studies of volunteers exposed under controlled conditions which yield data for concentration-effect relationships and also for concentrations without effects (NOAEC). A detailed review of the methods required of such studies and of the usefulness of various parameters for the establishment of threshold concentrations has been published<sup>12)</sup>. Such studies often demonstrate differences in sensitivity between persons who have never been exposed to the test substance and those who have been repeatedly exposed, e. g., at work.

Occupational medical and epidemiological studies provide further information from which the health risks associated with handling particular substances may be evaluated. However, not only the parameters determined in the exposed persons, but also any differences in study design, in the analytical methods and sampling strategies must be considered in evaluating such studies. Various confounders, exposure to mixtures, previous disorders or inadequate exposure records can alter or falsify any detected concentration-effect relationships.

Cross-sectional studies with only single determinations of exposure levels and only single examinations of the exposed persons do not generally permit the association of any observed symptoms with the current exposure situation. This requires information as to past exposure levels.

Therefore, longitudinal studies with repeated determination of the workplace and systemic exposure levels and repeated examination of the exposed persons play a decisive role in the establishment of thresholds. Valid epidemiological studies of persons exposed for long periods to concentrations which do not produce adverse effects provide a reliable basis for the establishment of threshold levels for the workplace, especially when the study design permits statements as to both local and systemic effects.

The diverse sensitivities of individual employees (as determined by age, constitution, nutrition, climate, etc.) are taken into consideration in the establishment of MAK values. It is currently not possible to take sex-specific differences in toxicokinetics and

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<sup>12)</sup> DFG (Deutsche Forschungsgemeinschaft) (Ed.) (1997) *Verhaltenstoxikologie und MAK-Grenzwertfestlegungen*. Wissenschaftliche Arbeitspapiere. Wiley-VCH, Weinheim.

toxicodynamics into account when establishing MAK and BAT values because of the lack of appropriate scientific data.

When the NOAEL has been determined from the effects of the substance in man observed at the workplace the MAK value is generally established at the level of this NOAEL.

When deriving MAK values for systemic effects and effects on the lungs from studies with volunteers at rest, the results are extrapolated to the increased respiratory minute volume at the workplace. The MAK value is established at half of the concentration used in the volunteer study, which is calculated from the ratio of the respiratory volume of workers to that of persons at rest. Gases and vapours with a blood:air partition coefficient of < 5 represent an exception (see the documentation “Increased respiratory volume at the workplace – Significance for the derivation of the MAK value”<sup>13</sup>). In addition, the results are extrapolated to the longer daily exposure at the workplace, unless there are toxicokinetic data available that show this to be unnecessary.

### c) Values based on effects on animals

Because the effects in man are not known for many substances, MAK values are often derived from results obtained with experimental animals. This is carried out in the clear understanding of the problems associated with extrapolation between species and of the much smaller group sizes than is usual in epidemiological studies. On the other hand, animal studies carried out according to modern principles also offer advantages including precise characterization of exposure levels, the wide range of parameters that can be studied, and the possibility of determining dose-response relationships and NOAELs. The minimum database for the derivation of a MAK value is generally considered to be a NOAEL from a valid 90-day inhalation study with experimental animals. Of the results of studies in which substances were administered to experimental animals by the oral or dermal route, mostly only the systemic effects may be considered to be relevant for persons exposed at the workplace. Therefore, in the documentation of a MAK value such results must be accompanied by information about the local effects of the substance, especially the effects on the respiratory tract.

To extrapolate an oral dose from an animal study to a concentration in the air at the workplace, the Commission uses a procedure which in essence corresponds with that described in the document for determination of “Derived No-Effect Levels” (Guidance on Information Requirements and Chemical Safety Assessment, Chapter R.8, ECHA 2008). The only difference is that the Commission assumes 100% absorption after inhalation and oral administration when there are no substance-specific data. Exceptions to this are the metals and metal compounds, for which 50% absorption is assumed after oral administration if substance-specific data are not available.

Procedure: If substance-specific data are not available, the oral dose is divided by the following correction factor (ECHA 2008), depending on the species:

mouse: 7; rat: 4; rabbit: 2.4; monkey: 2; dog: 1.4.

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<sup>13</sup> see “Increased respiratory volume at the workplace – Significance for the derivation of the MAK value” (2017). <https://doi.org/10.1002/3527600418.mbrespivole6217>

The further assumptions (human body weight: 70 kg, breathing volume: 10 m<sup>3</sup> per 8 hours) still apply. The conversion is calculated with the following formula:

$$\text{Inhaled concentration} = \frac{\text{oral dose (mg/kg body weight and day)} \times \text{oral absorption in the animal (\%)} \times 70 \text{ kg body weight}}{\text{species-specific correction factor} \times \text{inhalation absorption in humans (\%)} \times (10 \text{ m}^3 \text{ per day})}$$

For example, a dose of 1 mg/kg body weight in the rat, a substance-specific oral absorption of 80% and unknown inhalation absorption result in the following concentration:

$$\frac{1 \text{ mg/kg} \times 80\% \times 70 \text{ kg}}{4 \times 100\% \times 10 \text{ m}^3} = 1.4 \text{ mg/m}^3$$

Assuming that the same external concentration in the air leads to the same internal exposure in all species at rest, it must be taken into account when extrapolating data from inhalation studies in animals to humans that in the case of systemic effects and effects in the lungs the body burden (related to kg body weight) of the worker at the workplace, with an assumed respiratory volume of 10 m<sup>3</sup> in 8 hours, is about twice as high as that of the experimental animal in the usual 6-hour experiment. The equivalent external concentration at the workplace is, therefore, half of that used in the experiment. This applies only for gases and vapours with a blood:air distribution coefficient of >5 and for aerosols, provided that the effect is the product of c×t. If it can be shown that the critical effect depends more on the concentration than the product of c×t and that the steady state was reached within the duration of the experiment, the equivalent concentration at the workplace is two thirds of the concentration used in the experiment (1 : 1.5), as then extrapolation of the usual 6-hour exposure in animal experiments to the 8-hour exposure at the workplace is no longer necessary (see the documentation “Increased respiratory volume at the workplace – Significance for the derivation of the MAK value”<sup>14</sup>). If there are valid PBPK models of exposure with the relevant metabolites in humans and animals these are used for extrapolation from the experimental animal to persons at the workplace. If necessary, the dose in the animal experiment is converted if the frequency of exposure differed from that at the workplace. With continuous exposure (for example, feeding studies) the NOAEL from the animal experiment is therefore multiplied by 7/5 to take into consideration the continuous exposure of the animals compared with the intermittent exposure of the usual 5-day working week. With administration of the substance with the diet or drinking water to rats and mice, as a rule the factors used by the EFSA<sup>15</sup>) are used to convert the values into a dose per kg body weight, if there are no measured values.

When the NOAEL is based on results with animals in oral or inhalation studies, the MAK value is generally established at the level of half of the concentration in air extrapolated for workers at the workplace. However, in some cases species differences in sensitivity to the substance must be taken into account and here the toxicokinetic data are particularly important.

<sup>14</sup>) see “Increased respiratory volume at the workplace – Significance for the derivation of the MAK value” (2017). <https://doi.org/10.1002/3527600418.mbrespivole6217>

<sup>15</sup>) EFSA (European Food Safety Authority) (2012) Scientific opinion: Guidance on selected default values to be used by the EFSA Scientific Committee, scientific panels and units in the absence of actual measured data. EFSA J 10: 2579. <https://doi.org/10.2903/j.efsa.2012.2579>

#### d) Exceptional workplaces

The concentrations of inhaled gaseous substances in blood and tissues of persons working under hyperbaric pressure have been shown to correlate positively with the pressure. This dependence of the body burden on the workplace conditions must be taken into account in the application of MAK and BAT values.

#### e) Chemosensory perceptions and effects

Substances present in the workplace air as gas or aerosol are potentially able to induce chemosensory perceptions and thus associated effects relevant to health.

Humans possess very sensitive chemosensory senses which are able to perceive chemicals at the workplace. The sense of smell (*nervus olfactorius*) is particularly sensitive and perceives both *pleasant* and *unpleasant* odours even at very low concentrations, frequently below the MAK value. The so-called “trigeminal chemoreception” (*nervus trigeminus*) perceives *burning* and *biting* sensations, above all at higher concentrations of the substance in the workplace air. Both senses serve primarily the perception of volatile chemicals in the ambient air but can also warn the organism against possible dangers. The sense of smell possesses above all a “psychological” warning function, while trigeminal chemoreception can induce defence mechanisms to avoid damage to tissues.

Nevertheless, the mere perception of the chemical is not a health effect; in addition (a) sensory irritation, (b) considerable odour annoyance or (c) in individual cases “odour-associated” symptoms must occur.

#### *Sensory irritation*

Trigeminal nerve fibres occur in almost all regions of the nose, but also in the mucous membranes of the eyes, the oral cavity and the throat. Various receptors are found on these fibres of the peripheral nervous system, which can be activated by chemicals. They detect changes in temperature and other changes in the milieu (for example, changes in pH) in their immediate environment. The activation of these chemoreceptors forms the physiological basis of sensory irritation. Sensory irritation is understood to be an acute, more or less concentration-dependent effect, which can be regarded as reversible until the activation of the receptors leads to defence reflexes (for example, an increase in blinking frequency, or the release of neurogenic inflammation markers). This sensory defence reaction takes place without signs of inflammation or histopathological changes yet being evident. The sensory NOAEC can be determined in human studies (subjective/objective symptoms) or estimated from suitable studies with animals (mouse,  $RD_{10}$ ). At higher concentrations, however, neurogenic inflammation and adverse histopathological changes of the upper respiratory tract (for example, an inflammatory reaction of the tissue, atrophy/degeneration of the olfactory epithelium) may additionally occur. Such effects have been observed in inhalation studies with rodents. A NOAEC can be derived for this, which can decrease with increasing exposure duration. According to an empirical study,<sup>16)</sup> if there are no studies in humans for sensory irritation, the long-term NOAEC for histopathological effects of the upper respiratory tract of rodents can be used to estimate a NAEC for sensory

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<sup>16)</sup> Brüning T, Bartsch R, Bolt HM, Desel H, Drexler H, Gundert-Remy U, Hartwig A, Jäckh R, Leibold E, Pallapies D, Rettenmeier AW, Schlüter G, Stropp G, Sucker K, Triebig G, Westphal G, van Thriel C (2014) Sensory irritation as a basis for setting occupational exposure limits. Arch Toxicol 88: 1855–1879. <https://doi.org/10.1007/s00204-014-1346-z>



irritation (eyes, nose) in humans. If the target tissue is the olfactory epithelium in rodents, no sensory irritation is to be expected at half the value of the long-term NOAEC; for other target tissues of the upper respiratory tract the same is true at a third of the value of the corresponding NOAEC. If there is only a short or medium-term study available, its NOAEC is divided by 6 or 2, respectively, to extrapolate a long-term NAEC<sup>16</sup>), unless the data for the substance or a better-investigated analogous substance suggest that the increasing exposure duration does not lead to an increase in the effects or leads to an increase of different magnitude. If no NOAEC was obtained, with a suitable database the lower confidence interval of a benchmark dose (BMDL<sub>05</sub> or BMDL<sub>SD</sub>) can be calculated or the NAEC can be estimated by dividing the LOAEC by 2 or 3 depending on the severity of the effects and the gradient of the concentration–effect relationship.

### **Considerable odour annoyance**

The receptors of the sense of smell (*nervus olfactorius*) are activated even at low concentrations of a chemical and induce action potentials in the olfactory nerve. Initially, this leads to the perception of an odour (perception threshold). The basis for this perception is the characteristic activation pattern of the around 350 different odour receptors in humans, which, however, can change very rapidly depending on the duration and concentration of the exposure. These dynamic processes ultimately lead to the recognition of an odour. For the brain to recognise a particular odour (identification threshold), in some cases the concentrations need to be 10 times as high as those necessary for the perception threshold. The primary criterion by which humans judge unknown odours is their hedonic quality; whether they are *pleasant* or *unpleasant*. These judgements are very subjective and individual as they are learnt during the course of life and are connected with the person's experiences with certain odours.

Chemicals at the workplace often have an *unpleasant* smell. Persistent intensive or nauseous odours may lead to *excessive annoyance*. As a rule, this not only involves the perception of the odour, but also *trigeminal* sensations (biting, burning) and the otherwise very pronounced adaptation/habituation to chemosensory irritation does not take place. From an objective physiological point of view, it is almost impossible to say when *excessive annoyance* has been reached. Indirect indicators are reduced cognitive performance resulting from the diversion caused by the substance when the annoying chemosensory perception can no longer be ignored and hinders the actual task being performed. In controlled studies in humans, such behavioural effects can be determined using standardized neuropsychological test procedures.

### **“Odour-associated” symptoms**

Certain chemical substances can induce immediate “odour-associated” symptoms such as nausea or headaches in some people. As a rule, nothing is known in the scientific literature about the physiological mechanisms behind these symptoms, but it is above all very odour-intensive substances that cause such reactions in certain individuals. Substances which can cause “odour-associated” symptoms even at concentrations below the MAK value are given the footnote “*Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases.*”. A substance is designated with this footnote according to the following criteria: (a) a low, psycho-physically determined odour threshold, (b) a very unpleasant odour even in the range of the perception threshold or (c)

case reports or observations which describe the increased occurrence of “odour-associated” symptoms<sup>17)</sup>).

### **Habituation**

When only the odour is perceived, constant exposure to certain substances (for example, hydrogen sulfide, 2-methyl-2-propanethiol) can lead to habituation and thus also to impairment or the complete loss of the olfactory perception of this substance. Also for this reason, odour perception is not a suitable “warning” against hazardous exposure to such chemicals. At present there is not enough substance-specific knowledge about the underlying mechanisms of very pronounced habituation processes (for example, changes to the odour receptors) and the concentration–effect relationships involved. In the case of such substances, attention must be drawn to the phenomenon of olfactory perception.

### **Documentation**

A detailed scientific documentation of each decision is published in the series Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten, also available in English translation<sup>18)</sup>. Annual supplements are planned. These documents present, clearly and in detail, the scientific data and the reasons for the establishment of a MAK value. Because of this system, it is sufficient to establish only general principles for the derivation of MAK values. The assessment of individual substances on the basis of all the available toxicological and occupational medical data yields a more differentiated and specific evaluation than would the observance of stringently formulated rules.

The published data for the toxicity and effects of a substance in man and animals and all other relevant information are organized according to the kind of effect and presented in the form of a review. This review of the toxicological and epidemiological data for a substance serves initially as a basis for the discussion within the Commission for the derivation of a MAK value and for detailed evaluation of the physicochemical properties, percutaneous absorption, sensitizing effects, carcinogenic effects, prenatal toxicity and germ cell mutagenicity of the substance. When new data become available, the MAK value, classification and designation of the substance are reassessed and, when necessary, altered.

### **Publication**

Prospective changes and new entries are announced one year in advance in the List of MAK and BAT Values, usually on 1st July. In addition, the new entries are published on the homepage of the Commission at the DFG ([https://www.dfg.de/download/pdf/dfg\\_im\\_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf](https://www.dfg.de/download/pdf/dfg_im_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf)). If necessary, in addition to the regular updates each year in July, further announcements of prospective changes and new entries can be made there at any time. Following ratification of the annual List, the organizations listed below are officially informed of the planned changes: “Länderausschuß

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<sup>17)</sup> van Thriel C, Monsé C, Rettenmeier A, Sucker K, Werner S, Leibold E, Brüning T, Arand M, Käßlerlein H, Bartsch R, Kreis P, Hartwig A, MAK-Kommission (2023) Geruchsintensive Stoffe: Grundlagen, Bewertung und Markierung. MAK Collect Occup Health Saf 8: in preparation

<sup>18)</sup> available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

für Arbeitsschutz und Sicherheitstechnik (LASI)” (Federal Committee for Occupational Safety and Technical Security), the “Bundesverband der deutschen Industrie” (Federation of German Industries), the “Deutsche Gesetzliche Unfallversicherung” (German Statutory Accident Insurance) and the “Deutsche Gewerkschaftsbund” (the German Trade Union Federation). The purpose of this measure is to give these organizations enough time to send to the Commission any available scientific documentation relevant to the planned changes and additions to the List of MAK and BAT Values.

## **Mixtures of substances**

In general, the MAK value is only valid for exposure to a single, pure substance. It cannot be applied unconditionally to one component of a mixture in the workplace air or to a technical product which might contain more toxic impurities. Simultaneous or successive exposure to several substances may be much more or, in isolated cases, even less dangerous than the exposure to one of the substances on its own. A MAK value for a mixture of substances cannot be satisfactorily determined by simple calculation because the components of the mixture generally have very different kinds of effect; MAK values can presently be established for such mixtures only after specific toxicological examination or studies of the particular mixture of substances. Given the inadequacy of the currently available data, the Commission decidedly refrains from calculating MAK values for mixtures, particularly for liquid solvent mixtures. However, it is willing, on the basis of its own investigations, to provide values for defined vapour mixtures of practical relevance.

## **Analytical controls**

The compliance with MAK and BAT values (that is, keeping the exposure levels below these values) is intended to protect the health of persons exposed to hazardous substances at work. This objective can be ensured only by regular analytical determination of the concentration of the hazardous substances in the workplace air or of the concentration of the substances, their metabolites or other parameters of intermediary metabolism in the body fluids of exposed persons. For this purpose, it is necessary to use analytical methods which have been tested regarding the analytical reliability and practicability.

The Commission’s analytical working groups for air analyses and for analyses in biological materials have developed such methods and published them in the series *Luftanalysen* and *Analysen in biologischem Material*<sup>19)</sup>. These collections of methods are

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<sup>19)</sup> “Analytische Methoden zur Prüfung gesundheitsschädlicher Arbeitsstoffe”, drawn up by the working groups “Luftanalysen” (Analyses of Hazardous Substances in Air) and “Analysen in biologischem Material” (Analyses of Hazardous Substances in Biological Materials).

Available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019).

The Commission welcomes suggestions for inclusion of new chemical compounds as well as analytical methods. Analytical methods for carcinogenic workplace substances are published in cooperation with the analytical chemistry group from the German statutory accident insurance, ‘Arbeitsgruppe Analytik im Sachgebiet “Gefahrstoffe” des Fachbereichs “Rohstoffe und chemische Industrie” der Deutschen Gesetzlichen Unfallversicherung’ (“Von den Unfallversicherungsträgern anerkannte Analysenverfahren zur Feststellung der Konzentrationen krebserzeugender, erbgutverändernder oder fortpflanzungsgefährdender Stoffe in der Luft in Arbeitsbereichen” (DGUV Informationen 213–5xx), DGUV, D-81359 München:

<https://www.bgrci.de/fachwissen-portal/themenspektrum/ Gefahrstoffe/ Gefahrstoffanalytik/inhalte/dguv-informationen-213-5xx/>

supplemented regularly and are published in both German and English. The methods are conceived as so-called standard operating procedures (SOP) which are intended to ensure comparability of the analytical results from laboratory to laboratory and with the corresponding limit values. Thus they contribute to the quality control of the results. In addition, they provide a good basis for the health protection which is the objective of the limit values.

In the development of these analytical methods, the accuracy and reliability of the results is the most important factor. The methods are updated regularly if new scientific and instrumental findings indicate changes. In this respect the methods always reflect the current state of technology and are well-suited for monitoring limit values.

The methods for analyses in biological materials are, whenever possible, designed so that their measurement range includes the background concentration range. In this way it is possible to differentiate between occupational and environmental exposure and to correctly evaluate the analytical results.

### **Substances that can occur simultaneously as vapour and aerosol**

Substances in the air at the workplace usually occur either as a gas/vapour mixture or in the condensed phase in the form of droplets or particles (dust). There are, however, also substances that do not follow this pattern. These are substances with a low vapour pressure at room temperature, which can therefore occur in relevant amounts as both vapour and aerosol. They can be both liquids and sublimating solids.

When determining the inhalation exposure to substances it must always be considered whether vapour and aerosol mixtures can be formed as a result of the work process. This must be taken into account during the determination and evaluation. In particular, such mixtures occur above all when aerosols are formed during the work process, for example as a result of mechanical processes such as the processing of metals or ceramics, during dipping processes in electroplating or during spraying processes. In addition, there are manufacturing processes in which non-volatile substances evaporate at higher temperatures and then condense again, for example, during the hot processing of bitumen or laser welding, and thus occur in the workplace air simultaneously as a vapour and an aerosol. According to DIN EN 13936<sup>20)</sup>, for substances with a vapour pressure at room temperature of less than 100 Pa and more than 0.001 Pa sampling procedures should always be selected which determine vapour and aerosols simultaneously in one sampling system. Liquids with boiling points between around 180 °C and 350 °C usually fall into this category. The mass transfer between the vapour and condensed phase is a dynamic process which is continually changing as a result of influences such as temperature or air currents. The exact distribution of a substance in the workplace air between the vapour phase and condensed phase is very difficult to determine, and therefore not possible in practice. Systems with which aerosols and vapour can be determined together (the aerosol is determined as the inhalable fraction) are suitable for sampling such substances.

For substances with the physical properties described and for which there is a MAK value for the respirable fraction of the particle phase, at workplaces it is not possible, for analytical reasons, to determine only the respirable aerosol fraction. Also for these substances it is recommended that the inhalable fraction is determined to cover the “worst-

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<sup>20)</sup> DIN EN 13936 (2014) Workplace exposure – Procedures for measuring a chemical agent present as a mixture of airborne particles and vapour – Requirements and test methods. Beuth Verlag, Berlin

case” scenario<sup>21</sup>). As a result of the dynamic behaviour of these substances, only the sum of the vapour and particle fractions can be determined reliably as long as the particle fraction is determined in its entirety as the inhalable fraction.

Substances in the list in Section II which can occur simultaneously as a vapour and an aerosol are marked with the following note: “*The substance can occur simultaneously as vapour and aerosol*”.

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<sup>21</sup>) Breuer D, Dragan GC, Hebisch R, Bartsch R, Giesen Y, Krämer W, Nitschke L, Nitz G, Pannwitz K-H, Tschickardt M, Hartwig A, MAK Commission (2018). Probenahme und Analyse von Stoffen und Stoffgemischen, die gleichzeitig als Dampf und Partikel vorkommen können [Air Monitoring Methods in German language, 2018], Volume 3, Issue 1, 319–355. The MAK-Collection for Occupational Health and Safety. <https://doi.org/10.1002/3527600418.amsampmixd0019>

## II List of Substances

In the following list, maximum concentrations in the workplace air (MAK values) of gases, vapours and aerosols are expressed in ml/m<sup>3</sup> (millilitre (ml) of the substance per cubic metre (m<sup>3</sup>) of air, ppm), a unit which is unaffected by temperature and barometric pressure, as well as in mg/m<sup>3</sup> (milligram (mg) of the substance per cubic metre (m<sup>3</sup>) of air)<sup>22)</sup>, a unit which is temperature and pressure dependent and has therefore been adjusted to a temperature of 20 °C and barometric pressure of 1013 hPa<sup>23)</sup>; the MAK values for non-volatile aerosols (dust, smoke, mist) are given in mg/m<sup>3</sup> air. Non-volatile aerosols are substances which have such a low vapour pressure that at normal temperatures a dangerously high concentration cannot occur in the gaseous phase.

Since the health hazards associated with handling a substance can be affected by its volatility, the vapour pressure of a series of highly volatile compounds has been listed for 20 °C, unless otherwise stated. Knowledge of the vapour pressure makes it possible to estimate whether hazardous concentrations of the substance can accumulate by evaporation under the conditions prevailing at the particular workplace. The listed vapour pressure values are taken from the literature, mainly from the US National Library of Medicine, the ECHA, the SRC-Physprop or the GESTIS database, and have been rounded for practical purposes.

<b>MAK [ml/m<sup>3</sup>]</b>	MAK value in ml/m <sup>3</sup> (ppm)	value or “–”	see Section I
<b>MAK [mg/m<sup>3</sup>]</b>	MAK value in mg/m <sup>3</sup> measured as the respirable fraction	value or “–”	see Section I
	the inhalable fraction	R	see Section Vd
		I	see Section Vd
<b>Peak lim</b>	peak limitation category (excursion factor)	I/II or “–” (1 to max. 8)	see Section VI
<b>Preg gr</b>	pregnancy risk group	A, B, C, D or “–”	see Section VIII
<b>Perc abs</b>	danger from percutaneous absorption	designated with H	see Section VII
<b>Sens</b>	danger of sensitization	designated with	
	– of the airways	Sa	see Section IV
	– of the skin	Sh	see Section IV
	– of the airways and the skin	Sah	see Section IV
	danger of photocontact sensitization	SP	see Section IV
<b>Carc cat</b>	carcinogen category	1, 2, 3, 4, 5	see Section III
<b>Muta cat</b>	germ cell mutagen category	1, 2, 3 A, 3 B, 5	see Section IX
★ indicates a change from the 2021 List of MAK and BAT Values.			see Section I

<sup>22)</sup> “mg/m<sup>3</sup>” is a measure which means milligram (mg) of the substance per cubic metre (m<sup>3</sup>) of air

<sup>23)</sup> Under the specified atmospheric conditions (20 °C, 1013 hPa) the concentration values can be converted according to the following formula:

$$C(\text{mg/m}^3) = \frac{\text{molar mass in g}}{\text{molar volume in l}} \cdot C(\text{ml/m}^3)$$

The molar volume corresponds to 24.1 l at 20 °C and 1013 hPa (mbar).

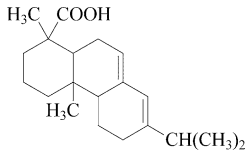
The MAK value is generally established with the units ml/m<sup>3</sup>; the value in mg/m<sup>3</sup> is then calculated with the formula given above. Following a suggestion from users, the calculated values are given correct to two significant figures

## a) Substances with MAK values and substances listed in Sections IIb, IIc and III to XII

MAK values which were established on the condition that the working week exceeds 40 hours have been retained with no change in the toxicological evaluation.

### Abietic acid

[514-10-3]



also includes disproportionation and transposition products  
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh

An immunological genesis of the asthma often seen in persons working with materials containing abietic acid has not been proved.

Acacia melanoxylon → Woods

### Acetaldehyde

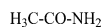
[75-07-0]



MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 91  
see definition of Carcinogen Category 5 and supporting  
documentation  
Peak lim: I(1)  
A momentary value of 100 ml/m<sup>3</sup> (180 mg/m<sup>3</sup>) should not  
be exceeded.  
Preg gr: C  
Carc cat: 5  
Muta cat: 5

### Acetamide

[60-35-5]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

### Acetic acid

[64-19-7]



MAK[ml/m<sup>3</sup>]: 10  
MAK[mg/m<sup>3</sup>]: 25  
Peak lim: I(2)  
Preg gr: C

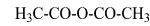
Acetic acid ethyl ester → Ethyl acetate

Acetic acid methyl ester → Methyl acetate

Acetic acid 2-propoxyethyl ester  
→ 2-Propoxyethyl acetate

### Acetic anhydride

[108-24-7]

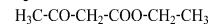


VP[hPa]: 4

MAK[ml/m<sup>3</sup>]: 0.1  
MAK[mg/m<sup>3</sup>]: 0.42  
Peak lim: I(2)  
Preg gr: C

### Acetoacetic acid ethyl ester

[141-97-9]

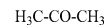


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

### Acetone

[67-64-1]



VP[hPa]: 240

see Section XII

MAK[ml/m<sup>3</sup>]: 500  
MAK[mg/m<sup>3</sup>]: 1200  
Peak lim: I(2)  
Preg gr: B  
prerequisite for Group C see documentation

### Acetonitrile

[75-05-8]



VP[hPa]: 96.6

MAK[ml/m<sup>3</sup>]: 10  
MAK[mg/m<sup>3</sup>]: 17  
Peak lim: II(2)  
Preg gr: C  
Perc abs: H

Acetylacetone → 2,4-Pentanedione

Acetylene black → Carbon black

Acetylene tetrabromide

→ 1,1,2,2-Tetrabromoethane

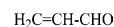
Acetylene tetrachloride

→ 1,1,2,2-Tetrachloroethane

Acetylpropionyl → 2,3-Pentanedione

### Acrolein

[107-02-8]



VP[hPa]: 290

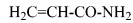
see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

Acrylaldehyde → Acrolein

### Acrylamide

[79-06-1]



see Section XII

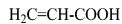
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sh
Carc cat:	2
Muta cat:	2

### Acrylates and methacrylates

see Section IVe

### Acrylic acid

[79-10-7]



MAK[ml/m <sup>3</sup> ]:	10
MAK[mg/m <sup>3</sup> ]:	30
Peak lim:	I(1)
Preg gr:	C

Acrylic acid n-butyl ester → n-Butyl acrylate

Acrylic acid tert-butyl ester → tert-Butyl acrylate

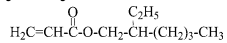
Acrylic acid diester with ethylene glycol  
→ Triethylene glycol diacrylate

Acrylic acid 2-ethoxyethanol diester  
→ Diethylene glycol diacrylate

Acrylic acid ethyl ester → Ethyl acrylate

### Acrylic acid 2-ethylhexyl ester

[103-11-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.132

MAK[ml/m <sup>3</sup> ]:	5
MAK[mg/m <sup>3</sup> ]:	38
Peak lim:	I(1)
Preg gr:	C
Sens:	Sh

### Acrylic acid 2-hydroxyethyl ester

[818-61-1]

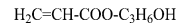


see Section IV

Sens:	Sh
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### Acrylic acid hydroxypropyl ester (all isomers)

[25584-83-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.16 at 25°C (calculated value)

see Section IIb

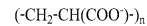
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sh

Acrylic acid isobornyl ester → Isobornyl acrylate

Acrylic acid methyl ester → Methyl acrylate

Acrylic acid pentaerythritol triester  
→ Pentaerythritol triacrylate

### Acrylic acid polymer (neutralized, cross-linked)



MAK[mg/m <sup>3</sup> ]:	0.05 R
Peak lim:	I(1)
Preg gr:	C
Carc cat:	4

– Sodium polyacrylate  
[9003-01-4]

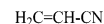
Acrylic acid resin → Acrylic acid polymer (neutralized, cross-linked)

Acrylic acid tetramethylene ester  
→ 1,4-Butanediol diacrylate

Acrylic acid 1,1,1-(trihydroxymethyl)propane triester → Trimethylolpropane triacrylate

### Acrylonitrile

[107-13-1]



VP[hPa]: 116

see Section XII

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sh
Carc cat:	2

Actinolite (fibrous dust) → Asbestos

### Adipic acid

[124-04-9]



see Section Xc

MAK[mg/m <sup>3</sup> ]:	2 I
Peak lim:	I(2)
Preg gr:	C

### Aerosols

see Section V



Afara (*Terminalia superba*) → Woods

### Aflatoxins

[1402-68-2]

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	1
Muta cat:	3A

African blackwood (*Dalbergia melanoxylon*)  
→ Woods

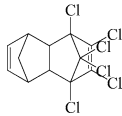
African “cherry” (*Tieghemella heckelii*)  
→ Woods

African ebony (*Diospyros crassiflora*)  
→ Woods

African whitewood (*Triplochiton scleroxylon*)  
→ Woods

### ★ Aldrin

[309-00-2]

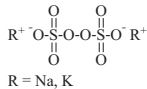


see Section IIc

Alkali chromates → Chromium(VI) compounds

Alkali citrates → Citric acid

### Alkali persulfates



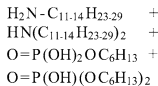
see Section IV

Sens: Sah

Alkali salts of benzoic acid → Benzoic acid  
alkali salts

### Alkyl amines, C11–14-branched, monoethyl and dihexyl phosphates

[80939-62-4]

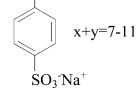
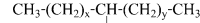


see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

### Alkyl benzenesulfonates C10–C14, linear

[69669-44-9;  
85117-50-6]

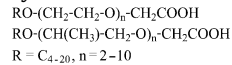


see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

N-Alkyl-N,N-dimethyl-N-benzylammonium-  
chloride → Benzalkonium chloride

### Alkyl ether carboxylic acids



see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

### Allyl alcohol

[107-18-6]

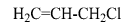


VP[hPa]: 24

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

### Allyl chloride

[107-05-1]



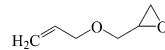
VP[hPa]: 393

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

Allyl 2,3-epoxypropyl ether → Allyl glycidyl  
ether

### Allyl glycidyl ether

[106-92-3]

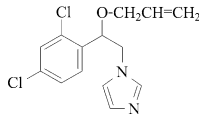


MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sh
Carc cat:	2

4-Allyl-2-methoxyphenol → Eugenol

**1-(2-Allyloxy)-2-(2,4-dichlorophenyl)ethyl)-1H-imidazole**

[35554-44-0]

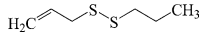


see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**Allyl propyl disulfide**

[2179-59-1]



MAK[m<sup>3</sup>/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 12  
 Peak lim: I(1)

**Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts**

[7429-90-5;

Al

1344-28-1;

1302-74-5;

21645-51-2]

(inhalable fraction)

see Section Vf and g and XII

MAK[mg/m<sup>3</sup>]: 4 I  
 Preg gr: D

**Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts**

[7429-90-5;

Al

1344-28-1;

1302-74-5;

21645-51-2]

(respirable fraction)

see Section Vf and g and XII

MAK[mg/m<sup>3</sup>]: 1.5 R  
 Preg gr: D

**Aluminium oxide**

[1344-28-1]

Al<sub>2</sub>O<sub>3</sub>

(fibrous dust)

see Section III

MAK[m<sup>3</sup>/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**α-Aluminium oxide**

[1302-74-5]

Al<sub>2</sub>O<sub>3</sub>

(corundum)

except for aluminium oxide fibres and ultrafine particles; see Section Vh

see Section Vf

MAK[mg/m<sup>3</sup>]: 0.3 R  
 multiplied with the material density  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 4

**Aluminium silicate fibres**

(RCF)

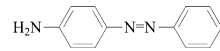
Cristobalite can develop from aluminium silicate fibres used in building materials under thermal load, see documentation.

see Section III

MAK[m<sup>3</sup>/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**p-Aminoazobenzene**

[60-09-3]

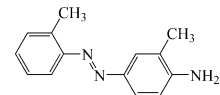


see Section IV

Sens: Sh

**o-Aminoazotoluene**

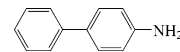
[97-56-3]



MAK[m<sup>3</sup>/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3B

**4-Aminobiphenyl**

[92-67-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.00016 at 25°C (calculated value)

see Section XII

MAK[m<sup>3</sup>/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1  
 Muta cat: 3A

**1-Aminobutane → n-Butylamine****2-Aminobutane → sec-Butylamine****2-Aminobutanol**

[96-20-8]

HOCH<sub>2</sub>-CH(NH<sub>2</sub>)-CH<sub>2</sub>-CH<sub>3</sub>

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.58

see Section Xc

MAK[m<sup>3</sup>/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.7  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

**1-Amino-4-chlorobenzene → p-Chloroaniline**

2-Amino-5-chlorotoluene

→ 4-Chloro-o-toluidine

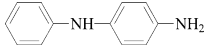
Aminocyclohexane → Cyclohexylamine

1-Amino-3,4-dichlorobenzene

→ 3,4-Dichloroaniline

**4-Aminodiphenylamine**

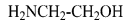
[101-54-2]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 3

**2-Aminoethanol**

[141-43-5]



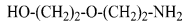
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.3

MAK[ml/m<sup>3</sup>]: 0.2  
 MAK[mg/m<sup>3</sup>]: 0.51  
 Peak lim: I(1)  
 Preg gr: C  
 Sens: Sh

**2-(2-Aminoethoxy)ethanol**

[929-06-6]



The substance can occur simultaneously as vapour and aerosol.

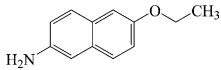
VP[hPa]: 0.002 at 25°C

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.2  
 MAK[mg/m<sup>3</sup>]: 0.87  
 Peak lim: I(1)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

**6-Amino-2-ethoxynaphthalene**

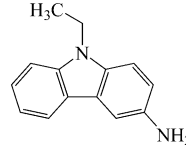
[293733-21-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**3-Amino-9-ethylcarbazole**

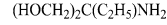
[132-32-1]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**2-Amino-2-ethyl-1,3-propanediol**

[115-70-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 1.6×10<sup>-3</sup>

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

4-Amino-1-hydroxybenzene → p-Aminophenol

2-Aminoisobutanol

→ 2-Amino-2-methyl-1-propanol

1-Amino-2-methoxy-5-methylbenzene

→ 5-Methyl-o-anisidine

3-Amino-4-methoxy-toluene

→ 5-Methyl-o-anisidine

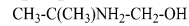
4-Amino-1-methylbenzene → p-Toluidine

1-Amino-2-methylpropane → Isobutylamine

2-Amino-2-methylpropane → tert-Butylamine

**2-Amino-2-methyl-1-propanol**

[124-68-5]



The substance can occur simultaneously as vapour and aerosol.

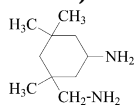
VP[hPa]: 1.3

see Section Xc

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.7  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**3-Aminomethyl-3,5,5-trimethyl-cyclohexylamine (Isophorone diamine)**

[2855-13-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.02

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

Aminonitrofen → 4-(2,4-Dichlorophenoxy)benzenamine

4-Amino-2-nitrophenol  
 → 2-Nitro-4-aminophenol

2-Amino-4-nitrotoluene → 5-Nitro-o-toluidine

**3-Aminophenol**

[591-27-5]



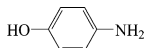
see Section IV

Sens: Sh

4-Aminophenol → p-Aminophenol

**p-Aminophenol**

[123-30-8]



see Section IV

Sens: Sh

p-Aminophenol triglycidylether  
 → Triglycidyl-p-aminophenol

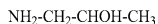
2-[(4-Aminophenyl)-amino]-5-nitrobenzene-sulfonic acid

→ 4-Nitro-4'-aminodiphenylamine-2-sulfonic acid

2-Aminopropane → Isopropylamine

**1-Amino-2-propanol**

[78-96-6]



The substance can occur simultaneously as vapour and aerosol.

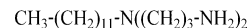
VP[hPa]: 0.6

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**N-(3-Aminopropyl)-N-dodecylpropane-1,3-diamine**

[2372-82-9]



see Section Xc

MAK[mg/m<sup>3</sup>]: 0.05 I  
 Peak lim: II(8)  
 Preg gr: C

**2-Aminopyridine**

[504-29-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.13 at 25°C (calculated value)

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

4-Aminotoluene → p-Toluidine

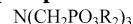
3-Amino-p-toluidine → 2,4-Toluenediamine

5-Amino-o-toluidine → 2,4-Toluenediamine

3-Amino-1,2,4-triazole → Amitrole

**Aminotris(methylenephosphonic acid)**

[6419-19-8]



and its sodium salts

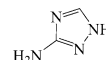
R = H, Na

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Amitrole**

[61-82-5]



MAK[mg/m<sup>3</sup>]: 0.2 I  
 Peak lim: II(8)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

**Ammonia**

[7664-41-7]



VP[hPa]: 8570

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 14  
 Peak lim: I(2)  
 Preg gr: C

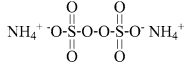
Ammonium molybdate → Molybdenum

Ammonium perfluorooctanoate  
 → Perfluorooctanoic acid (PFOA)

Ammonium peroxydisulfate → Ammonium persulfate

**Ammonium persulfate**

[7727-54-0]

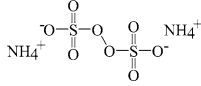


see Section IV

Sens: Sah

**Ammonium sulfate**

[7773-06-0]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Amorphous carbon → Carbon black

Amosite (fibrous dust) → Asbestos

**Amyl acetate (all isomers)**

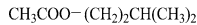
VP[hPa]: &lt;10

MAK[ml/m<sup>3</sup>]: 50MAK[mg/m<sup>3</sup>]: 270

Peak lim: I(1)

## – 3-Methylbutyl acetate

[123-92-2]

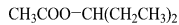


VP[hPa]: 5.3

Preg gr: D

## – 3-Pentyl acetate

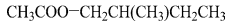
[620-11-1]



Preg gr: D

## – 2-Methylbutyl acetate

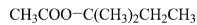
[624-41-9]



Preg gr: C

## – 1,1-Dimethylpropyl acetate

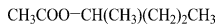
[625-16-1]



Preg gr: D

## – 1-Methylbutyl acetate

[626-38-0]

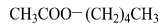


VP[hPa]: 9.3

Preg gr: D

## – 1-Pentyl acetate

[628-63-7]



VP[hPa]: 5.3

Preg gr: C

Amyl alcohol → Pentanol (isomers)

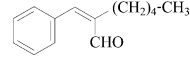
**α-Amylase**

see Section IV

Sens: Sa

**α-Amylcinnamaldehyde**

[122-40-7]



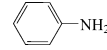
The substance can occur simultaneously as vapour and aerosol.

see Section IV

Sens: Sh

**Aniline**

[62-53-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.68

see Section XII

MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 7.7

Peak lim: II(2)

Preg gr: C

Perc abs: H

Sens: Sh

Carc cat: 4

Aniline yellow → p-Aminoazobenzene

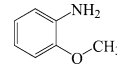
**Animal hair, epithelia and other materials derived from animals**

see Section IV

Sens: Sah

**o-Anisidine**

[90-04-0]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

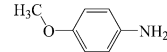
Preg gr: –

Perc abs: H

Carc cat: 2

**p-Anisidine**

[104-94-9]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

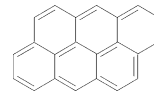
Preg gr: –

Perc abs: H

Carc cat: 3

**Anthanthrene**

[191-26-4]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

Anthophyllite (fibrous dust) → Asbestos

Anthracite dust → Coal mine dust

### Antibiotics

see Section IVe

### Antimony

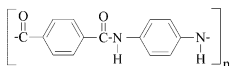
[7440-36-0] Sb  
and its inorganic compounds  
except for stibine  
see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 2  
Muta cat: 3A

ANTU → 1-Naphthylthiourea

### p-Aramid

[26125-61-1]  
(fibrous dust)



see Section III

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

Arborvitae (Thuja spp.) → Woods

Arprocarb → Propoxur

Arsenic → Phenyl arsenic compounds

### Arsenic

[7440-38-2]  
and inorganic arsenic compounds  
see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
with the exception of metallic arsenic and gallium  
arsenide  
Carc cat: 1  
Muta cat: 3A

- **Metallic arsenic**  
[7440-38-2] As
- **Arsenic trioxide**  
[1327-53-3] As<sub>2</sub>O<sub>3</sub>
- **Arsenous acid**  
[13464-58-9] H<sub>3</sub>AsO<sub>3</sub>  
and its salts, e.g.
- **Sodium arsenite**  
[7784-46-5] NaAsO<sub>2</sub>
- **Arsenic pentoxide**  
[1303-28-2] As<sub>2</sub>O<sub>5</sub>
- **Arsenic acid**  
[7778-39-4] H<sub>3</sub>AsO<sub>4</sub>  
and its salts, e.g.
- **Lead arsenate**  
[3687-31-8] Pb<sub>3</sub>(AsO<sub>4</sub>)<sub>2</sub>
- **Calcium arsenate**  
[7778-44-1] Ca<sub>3</sub>(AsO<sub>4</sub>)<sub>2</sub>
- **Gallium arsenide**  
[1303-00-0] GaAs

Arsenic(III) oxide → Arsenic

Arsenic(V) oxide → Arsenic

### Arsine

[7784-42-1] AsH<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Artificial almond oil → Benzaldehyde

### Asbestos

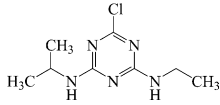
[1332-21-4]  
(fibrous dust)  
Actinolite, Amosite, Anthophyllite, Chrysotile, Crocidolite  
and Tremolite  
see Section III

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 1  
Cigarette smokers bear an increased risk of bronchial  
cancer.

Asphalt → Bitumen (high-temperature processing, vapours and aerosols)

### Atrazine

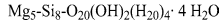
[1912-24-9]



MAK[mg/m<sup>3</sup>]: 1 I  
Peak lim: II(2)  
Preg gr: C

### Attapulgite

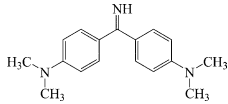
[12174-11-7]  
(fibrous dust)  
see Section III



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 2

### Auramine

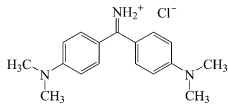
[492-80-8]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2  
Muta cat: 3B

### Auramine hydrochloride

[2465-27-2]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2  
Muta cat: 3B

Australian blackwood (*Acacia melanoxylon*)

→ Woods

Australian silky oak (*Grevillea robusta*)

→ Woods

Ayan (*Distemonanthus benthamianus*)

→ Woods

### Azelaic acid

[123-99-9]

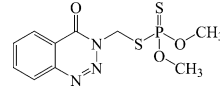


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

### Azinphos-methyl

[86-50-0]



MAK[mg/m<sup>3</sup>]: 1 I  
Peak lim: II(8)  
Preg gr: B  
prerequisite for Group C see documentation  
Perc abs: H  
Sens: Sh

Aziridine → Ethylenimine

Azobiscarbamide → Azodicarbonamide

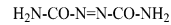
### Azo colourants

see also Pigment Yellow

see Section III

### Azodicarbonamide

[123-77-3]



MAK[mg/m<sup>3</sup>]: 0.02 I  
Peak lim: I(1)  
Preg gr: D

1,1'-Azodiformamide → Azodicarbonamide

Azoimide → Hydrazoic acid

### Barium compounds (soluble)

(as Ba [7440-39-3])

see Section XII

MAK[mg/m<sup>3</sup>]: 0.5 I  
Peak lim: II(8)  
Preg gr: D

### Barium sulfate

[7727-43-7]



(inhalable fraction)  
see Section Vf and g

MAK[mg/m<sup>3</sup>]: 4 I  
Preg gr: C

### Barium sulfate

[7727-43-7]



(respirable fraction)

except for ultrafine particles; see Section Vh  
see Section Vf

MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density  
Peak lim: II(8)  
Preg gr: C  
Carc cat: 4

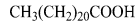
**Beech wood dust**

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 1

Dusts have been shown epidemiologically to be unequivocally carcinogenic. The active carcinogenic principle has not been identified to date.

**Behenic acid**

[112-85-6]

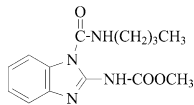


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Benomyl**

[17804-35-2]



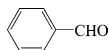
Sens: Sh  
 Muta cat: 3A

Bentonite → Montmorillonite

Benzal chloride → Benzyl dichloride

**Benzaldehyde**

[100-52-7]

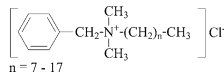


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Benzalkonium chloride**

[8001-54-5]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Benzene**

[71-43-2]



VP[hPa]: 101

see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1  
 Muta cat: 3A

1,2-Benzenedicarboxylic acid → o-Phthalic acid

1,2-Benzenedicarboxylic acid, diisodocylester  
→ Diisodocyl phthalateBenzenedicarboxylic acid dibutyl ester  
→ Di-n-butyl phthalate1,2-Benzenedicarboxylic acid di-2-propenyl ester  
→ Diallyl phthalate

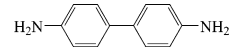
1,3-Benzenediol → Resorcinol

**Benzidine**

[92-87-5]

and its salts

see Section XII

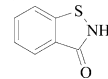


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1

Benzilidene chloride → Benzyl dichloride

1H-Benzimidazole-2-carbamic acid methyl ester  
→ Carbendazim**1,2-Benzisothiazol-3(2H)-one**

[2634-33-5]

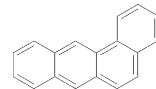


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**Benzo[a]anthracene**

[56-55-3]

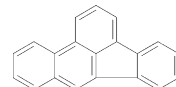


see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3A

**Benzo[b]fluoranthene**

[205-99-2]



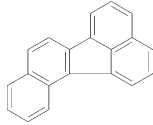
see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B



**Benzo[j]fluoranthene**

[205-82-3]

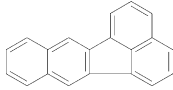


see Section III, "pyrolysis products of organic materials"

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2
Muta cat:	3B

**Benzo[k]fluoranthene**

[207-08-9]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2
Muta cat:	3B

**★ Benzoic acid**

[65-85-0]

(inhalable fraction)

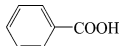
see also Benzoic acid alkali salts

The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995).

VP[hPa]:  $9 \times 10^{-4}$  at 25°C

see Section Xc

MAK[ml/m <sup>3</sup> ]:	0.39
MAK[mg/m <sup>3</sup> ]:	2 I
Peak lim:	I(2)
Preg gr:	C
Perc abs:	H

**Benzoic acid**

[65-85-0]

(respirable fraction)

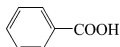
see also Benzoic acid alkali salts

The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995).

VP[hPa]:  $9 \times 10^{-4}$  at 25°C

see Section Xc

MAK[ml/m <sup>3</sup> ]:	0.1
MAK[mg/m <sup>3</sup> ]:	0.5 R
Peak lim:	II(4)
Preg gr:	C
Perc abs:	H

**Benzoic acid alkali salts**

(as benzoate) see also Benzoic acid

Causes pseudoallergic reactions, see

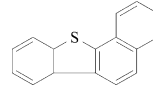
Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995).

MAK[mg/m <sup>3</sup> ]:	10 I
Peak lim:	II(2)
Preg gr:	C
Perc abs:	H

Benzoic aldehyde → Benzaldehyde

**Benzo[b]naphtho[2,1-d]thiophene**

[239-35-0]

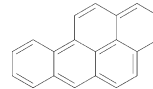


see Section III, "pyrolysis products of organic materials"

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2
Muta cat:	3B

**Benzo[a]pyrene**

[50-32-8]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2
Muta cat:	2

p-Benzoquinone → Quinone

3H-1,3-Benzothiazol-2-thione

→ 2-Mercaptobenzothiazole

**Benztriazole**

[95-14-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $6.89 \times 10^{-2}$  at 25°C

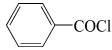
see Section Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

Benzotrichloride → Benzyl trichloride

**Benzoyl chloride**

[98-88-4]

see also  $\alpha$ -Chlorinated toluenes

The substance can occur simultaneously as vapour and aerosol.

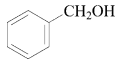
VP[hPa]: 0.5

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	3

Benzoyl peroxide → Dibenzoyl peroxide

**Benzyl alcohol**

[100-51-6]



The substance can occur simultaneously as vapour and aerosol.

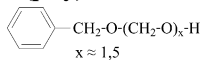
VP[hPa]: 0.13 at 25°C (calculated value)

see Section Xc

MAK[ml/m <sup>3</sup> ]:	5
MAK[mg/m <sup>3</sup> ]:	22
Peak lim:	I(2)
Preg gr:	C
Perc abs:	H

**Benzyl alcohol mono(poly)hemiformal**

[14548-60-8]



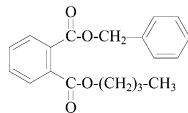
releases formaldehyde

see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sh

**Benzylbutyl phthalate**

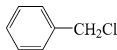
[85-68-7]



MAK[mg/m <sup>3</sup> ]:	20 I
Peak lim:	II(2)
Preg gr:	C

**Benzyl chloride**

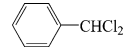
[100-44-7]

see also  $\alpha$ -Chlorinated toluenes

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2

**Benzyl dichloride**

[98-87-3]

see also  $\alpha$ -Chlorinated toluenes

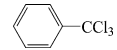
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.5

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2

**Benzyl trichloride**

[98-07-7]

see also  $\alpha$ -Chlorinated toluenes

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.2

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2

**Beryllium**

[7440-41-7]

Be

and its inorganic compounds

see Section XII

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sah
Carc cat:	1

Bété (*Mansonia altissima*) → WoodsBethabara (*Tabebuia serratifolia*) → Woods

BHT → Butylated hydroxytoluene (BHT)

Biacetyl → Diacetyl

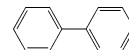
N,N'-Bianiline → Hydrazobenzene

Biformyl → Glyoxal

2,2'-Bioxirane → Diepoxybutane

**Biphenyl**

[92-52-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.012 at 25°C

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

3,3',4,4'-Biphenyltetramine  
→ 3,3'-Diaminobenzidine and its tetrahydrochloride

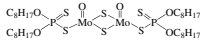
Bis(2-aminoethyl)amine → Diethylenetriamine

N,N'-Bis(2-aminoethyl)-1,2-ethanediamine  
→ Triethylenetetramine

1,3-Bis(aminomethyl)benzene  
→ m-Xylylenediamine

**Bis[O,O-bis(2-ethylhexyl) dithiophosphorato-S,S']dioxodi-μ-thioxodimolybdenum**

[68958-92-9;  
72030-25-2]



VP[hPa]: <1.5×10<sup>-5</sup>  
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

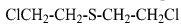
Bis[O,O-bis(2-ethylhexyl)phosphorodithioato-S,S']-zinc → Zinc, O,O'-di-2-ethylhexyl dithiophosphate

Bis(2-chloroethyl)ether → 2,2'-Dichlorodiethyl ether

Bis(2-chloroethyl)sulfide → Bis(β-chloroethyl) sulfide (mustard gas)

**Bis(β-chloroethyl)sulfide (mustard gas)**

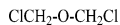
[505-60-2]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 1

**Bischloromethyl ether**

(dichlorodimethyl ether)



[542-88-1]

not to be confused with the asymmetric (Dichloromethyl) methyl ether

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 1

4,4'-Bis(dimethylamino)benzophenone  
→ Michler's ketone

3,5-Bis(1,1-dimethylethyl)-4-hydroxybenzene-propanoic acid octadecyl ester  
→ 3,5-Di-tert-butyl-4-hydroxyphenyl propionic acid octadecyl ester

3,5-Bis(1,1-dimethylethyl)-4-hydroxybenzene-propanoic acid thiodi-2,1-ethanediy ester  
→ 2,2'-Thiodiethylene Bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]

Bis[dimethyltin(isooctylmercaptoacetate)] sulfide → Methyltin compounds

Bis[dimethyltin(2-mercaptoethylolate)]sulfide → Methyltin compounds

1,3-Bis(2,3-epoxypropoxy)benzene  
→ Diglycidyl resorcinol ether

1,4-Bis(2,3-epoxypropoxy)butane  
→ 1,4-Butanediol diglycidyl ether

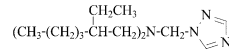
2,2-Bis(4-(2,3-epoxypropoxy)phenyl)propane  
→ Bisphenol A diglycidyl ether

S-1,2-Bis(ethoxycarbonyl)ethyl-O,O-dimethyl thiophosphate → Malathion

Bis(2-ethylhexoxy)-sulfanylidene-sulfido-λ5-phosphane;molybdenum → Bis[O,O-bis(2-ethylhexyl) dithiophosphorato-S,S'] dioxodi-μ-thioxodimolybdenum

**N,N-Bis(2-ethylhexyl)-(1,2,4-triazole-1-yl) methanamine**

[91273-04-0]



The substance can occur simultaneously as vapour and aerosol.

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh

2,2-Bis(p-glycidyloxyphenyl)propane  
→ Bisphenol A diglycidyl ether

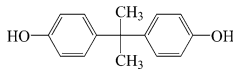
1,2-Bis(2-hydroxyethoxy)ethane → Triethylene glycol

Bis(2-hydroxyethyl)ether → Diethylene glycol

2-[3,5-Bis(2-hydroxyethyl)-1,3,5-triazinan-1-yl]ethanol → N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine

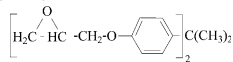
Bis(hydroxymethyl)acetylene → Butynediol

1,3-Bis(hydroxymethyl)-5,5-dimethyl-2,4-imidazolidinedione → 1,3-Dimethylol-5,5-dimethyl hydantoin

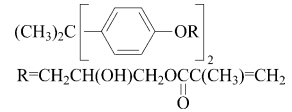
**1,3-Bis(hydroxymethyl)urea**[140-95-4] (HOCH<sub>2</sub>-NH)<sub>2</sub>COreleases formaldehyde  
see Section IIb and XcMAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –2,2-Bis(4-hydroxyphenyl)propane  
→ Bisphenol A1-[3,5-Bis(2-hydroxypropyl)-1,3,5-triazin-1-yl]propan-2-ol → N,N',N''-Tris  
(β-hydroxypropyl)hexahydro-1,3,5-triazineBis(1-hydroxy-2(1H)-pyridinthionato)zinc  
→ Zinc pyriothione1,2-Bis(2-(methacryloyloxy)ethoxy)ethane  
→ Triethylene glycol dimethacrylateBis(2-methoxyethyl)ether → Diethylene glycol  
dimethyl etherBis(2-methoxypropyl)ether → Dipropylene  
glycol monomethyl etherBis[methyltin di(isooctylmercaptoacetate)]  
sulfide → Methyltin compoundsBis[methyltin di(2-mercaptoethylolate)]sulfide  
→ Methyltin compoundsBismorpholino methane  
→ 4,4'-Methylenedimorpholine**Bisphenol A**(4,4'-Isopropylidenediphe-  
nol)[80-05-7]  
see Section XIIMAK[mg/m<sup>3</sup>]: 5 I  
Peak lim: I(1)  
Preg gr: C  
Sens: SP**Bisphenol A diglycidyl ether**

[1675-54-3]

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh**Bisphenol A diglycidyl methacrylate**

[1565-94-2]

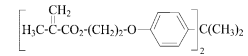


see Section IV

Sens: Sh

**Bisphenol A ethoxylate dimethacrylate**

[24448-20-2]

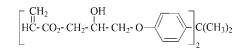


see Section IV

Sens: Sh

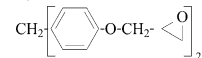
**Bisphenol A glycerolate**

[4687-94-9]



see Section IV

Sens: Sh

**Bisphenol F diglycidyl ether**

see Section IV

Sens: Sh

## – o,o'-Bisphenol F diglycidylether

[54208-63-8]

## – o,p'-Bisphenol F diglycidylether

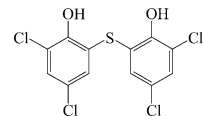
[57469-07-5]

## – p,p'-Bisphenol F diglycidyl ether

[2095-03-6]

1,4-Bis(phenylamino)benzene → N,  
N-Diphenyl-p-phenylenediamineBis(1-piperidylthiocarboxyl) disulfide  
→ Dipentamethylenethiuram disulfide**Bithionol**

[97-18-7]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: SP

**Bitumen (high-temperature processing, vapours and aerosols)**

[8052-42-4; 64741-56-6/64742-93-4]

(straight-run bitumen/air-rectified bitumen)

can occur simultaneously as vapour and aerosol

VP[hPa]: &lt;1

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: 1.5

Sum of vapour and inhalable fraction based on bitumen condensate standard

Peak lim: II(2)

Preg gr: D

Perc abs: H

Carc cat: 3

**Bitumen (high-temperature processing, vapours and aerosols)**

[64742-93-4]

(bitumen, oxidized)

can occur simultaneously as vapour and aerosol

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

Muta cat: 3B

Black coal dust → Coal mine dust

Bombay blackwood (*Dalbergia latifolia*)

→ Woods

Borax → Boric acid

**Boric acid**

[10043-35-3]

and tetraborates

– **Boric acid**

[10043-35-3]

B(OH)<sub>3</sub>

see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I

when boric acid and tetraborates are present together,

the MAK value is 0.75 mg boron/m<sup>3</sup>

Peak lim: I(1)

Preg gr: B

– **Sodium tetraborate pentahydrate**

[12179-04-3]

MAK[mg/m<sup>3</sup>]: 5 I

Peak lim: I(1)

Preg gr: C

– **Tetraborates**

as Boron [7440-42-8]

MAK[mg/m<sup>3</sup>]: 0.75 I

Peak lim: I(1)

Preg gr: C

**Boron oxide**

[1303-86-2]

B<sub>2</sub>O<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Boron trifluoride**

[7637-07-2]

BF<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Bowdichia nitida → Woods

Brazilian rosewood (*Dalbergia nigra*) → Woods**Bromelain**

[9001-00-7]

see Section IV

Sens: Sa

**Bromine**

[7726-95-6]

Br<sub>2</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

2-Bromo-2-(bromomethyl)glutaronitrile

→ 1,2-Dibromo-2,4-dicyanobutane

2-Bromo-2-(bromomethyl)pentanedinitrile

→ 1,2-Dibromo-2,4-dicyanobutane

**Bromochloromethane**

[74-97-5]

CH<sub>2</sub>BrCl

VP[hPa]: 147

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 3

2-Bromo-2-chloro-1,1,1-trifluoroethane

→ Halothane

**Bromodichloromethane**

[75-27-4]

CHBrCl<sub>2</sub>

Perc abs: H

Carc cat: 2

Muta cat: 3B

**Bromoethane**

[74-96-4]

H<sub>3</sub>C-CH<sub>2</sub>Br

VP[hPa]: 507

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

Bromoform → Tribromomethane

Bromomethane → Methyl bromide

**2-Bromo-2-nitro-1,3-propanediol**[52-51-7]  $\text{HOCH}_2\text{-CBr(NO}_2\text{)-CH}_2\text{OH}$ 

use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4"

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh

**1-Bromopropane**[106-94-5]  $\text{BrCH}_2\text{-CH}_2\text{-CH}_3$ 

see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Bromotrifluoromethane**[75-63-8]  $\text{BrCF}_3$ 

MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 6200  
 Peak lim: II(8)  
 Preg gr: C

Brown coal tars → Pyrolysis products of organic materials (soft coal tars)

Brucite (fibrous dust) → Nemalite

Brya ebenus → Woods

**1,3-Butadiene**[106-99-0]  $\text{H}_2\text{C=CH-CH=CH}_2$ 

VP[hPa]: 2477  
 see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 1  
 Muta cat: 2

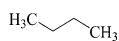
1,3-Butadiene diepoxide → Diepoxybutane

**Butane (both isomers)**

MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 2400  
 Peak lim: II(4)  
 Preg gr: D

**– n-Butane**

[106-97-8]

**– Isobutane**

[75-28-5]



1,4-Butanedicarboxylic acid → Adipic acid

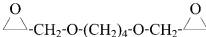
1,4-Butane diglycidyl ether → 1,4-Butanediol diglycidyl ether

Butanedioic acid → Succinic acid

**1,4-Butanediol diacrylate**[1070-70-8]  $\text{H}_2\text{C=CH-CO-(CH}_2\text{)}_4\text{-OC-HC=CH}_2$ 

see Section IV

Sens: Sh

**1,4-Butanediol diglycidyl ether**[2425-79-8] 

see Section IV

Sens: Sh

**1,4-Butanediol dimethacrylate**[2082-81-7]  $\text{CH}_2\text{-CH}_2\text{-O-OC-C(CH}_3\text{)=CH}_2$   
 $\text{CH}_2\text{-CH}_2\text{-O-OC-C(CH}_3\text{)=CH}_2$ 

see Section IV

Sens: Sh

2,3-Butanedione → Diacetyl

**1,4-Butane sultone**

[1633-83-6]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**2,4-Butane sultone**

[1121-03-5]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

Butane sultone → 1,4-Butane sultone

**★ 1-Butanethiol**

[109-79-5]

 $\text{H}_3\text{C-(CH}_2\text{)}_3\text{-CH}_2\text{SH}$ 

VP[hPa]: 40

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.7

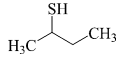
Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

**2-Butanethiol**

[513-53-1]



VP[hPa]: 108 at 25°C

MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 7.5

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: II(2)

Preg gr: D

Perc abs: H

**tert-Butanol**

[75-65-0]



VP[hPa]: 40.8

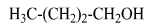
MAK[ml/m<sup>3</sup>]: 20MAK[mg/m<sup>3</sup>]: 62

Peak lim: II(4)

Preg gr: C

**1-Butanol**

[71-36-3]



VP[hPa]: 6.3

see Section XII

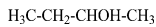
MAK[ml/m<sup>3</sup>]: 100MAK[mg/m<sup>3</sup>]: 310

Peak lim: I(1)

Preg gr: C

**2-Butanol**

[78-92-2]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Butanol-2-amine → 2-Aminobutanol

**2-Butanone**

(Methyl ethyl ketone)

[78-93-3]

VP[hPa]: 105

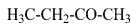
see Section XII

MAK[ml/m<sup>3</sup>]: 200MAK[mg/m<sup>3</sup>]: 600

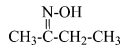
Peak lim: I(1)

Preg gr: C

Perc abs: H

**Butanone oxime**

[96-29-7]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Sens: Sh

Carc cat: 2

2-Butanone peroxide → Methyl ethyl ketone peroxide

 $\delta$ -Butan sultone → 1,4-Butane sultone

2-Butenal (trans-) → Crotonaldehyde

1,2-Butene oxide → 1,2-Butylene oxide

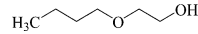
Butoxydiglycol → Diethylene glycol monobutyl ether

1-n-Butoxy-2,3-epoxypropane → n-Butyl glycidyl ether (BGE)

1-tert-Butoxy-2,3-epoxypropane → tert-Butyl glycidyl ether

**2-Butoxyethanol**

[111-76-2]



VP[hPa]: 0.8

see Section XII

MAK[ml/m<sup>3</sup>]: 10MAK[mg/m<sup>3</sup>]: 49

MAK value applies for the sum of the concentrations of 2-butoxyethanol and 2-butoxyethyl acetate in the air.

Peak lim: I(2)

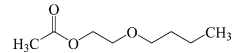
Preg gr: C

Perc abs: H

2-(2-Butoxyethoxy)-ethanol → Diethylene glycol monobutyl ether

**2-Butoxyethyl acetate**

[112-07-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.4

see Section XII

MAK[ml/m<sup>3</sup>]: 10MAK[mg/m<sup>3</sup>]: 66

MAK value applies for the sum of the concentrations of 2-butoxyethanol and 2-butoxyethyl acetate in the air.

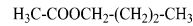
Peak lim: I(2)

Preg gr: C

Perc abs: H

**n-Butyl acetate**

[123-86-4]



VP[hPa]: 13.3

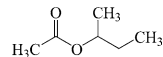
MAK[ml/m<sup>3</sup>]: 100MAK[mg/m<sup>3</sup>]: 480

Peak lim: I(2)

Preg gr: C

**sec-Butyl acetate**

[105-46-4]



see Section IIb

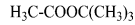
MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**tert-Butyl acetate**

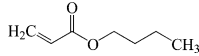
[540-88-5]



MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 96  
 Peak lim: II(2)  
 Preg gr: C

**★ n-Butyl acrylate**

[141-32-2]

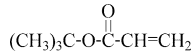


VP[hPa]: 5 at 22.2°C

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

**tert-Butyl acrylate**

[1663-39-4]



see Section IV

Sens: Sh

n-Butyl alcohol → 1-Butanol

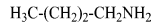
sec-Butyl alcohol → 2-Butanol

tert-Butyl alcohol → tert-Butanol

2-Butylamine → sec-Butylamine

**★ n-Butylamine**

[109-73-9]

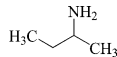


VP[hPa]: 122-128 at 25°C

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 6.1  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C

**★ sec-Butylamine**

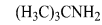
[13952-84-6]



MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 6.1  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D

**★ tert-Butylamine**

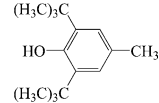
[75-64-9]



MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 6.1  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D

**Butylated hydroxytoluene (BHT)**

[128-37-0]



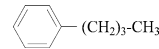
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3.9×10<sup>-3</sup> at 25°C  
see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I  
 Peak lim: II(4)  
 Preg gr: C  
 Carc cat: 4

**n-Butylbenzene**

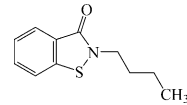
[104-51-8]



MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 56  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

**2-Butyl-1,2-benzisothiazolin-3-one**

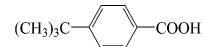
[4299-07-4]

VP[hPa]: 0.00015 at 25°C  
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**p-tert-Butylbenzoic acid**

[98-73-7]



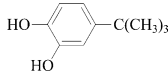
see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

Butylcarbamic acid 3-iodo-2-propynyl ester  
→ 3-Iodo-2-propynyl butylcarbamate

1-(Butylcarbomoyl)-2-benzimidazolecarbamic acid methyl ester → Benomyl



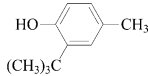
**p-tert-Butylcatechol**[98-29-3;  
27213-78-1]

see Section IV

Sens: Sh

n-Butyl chloroformate → Chloroformic acid  
butyl ester**2-tert-Butyl-p-cresol**

[2409-55-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.02

see Section IIb

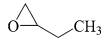
MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Butyldiglycol → Diethylene glycol monobutyl  
ether1,4-Butylene glycol diacrylate  
→ 1,4-Butanediol diacrylate**1,2-Butylene oxide**

[106-88-7]



VP[hPa]: 188

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

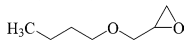
Preg gr: –

Perc abs: H

Carc cat: 2

**n-Butyl glycidyl ether (BGE)**

[2426-08-6]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

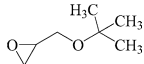
Sens: Sh

Carc cat: 3

Muta cat: 2

**tert-Butyl glycidyl ether**

[7665-72-7]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Sens: Sh

Carc cat: 3

Butyl glycolate → Hydroxyacetic acid butyl  
ester**tert-Butyl hydroperoxide**

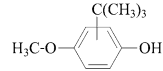
[75-91-2]

(H<sub>3</sub>C)<sub>3</sub>C-OOH

see Section Xa

**tert-Butyl-4-hydroxyanisole (BHA)**

[25013-16-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3.3×10<sup>-3</sup> at 25°C

see Section Xc

MAK[mg/m<sup>3</sup>]: 20 I

Peak lim: II(1)

Preg gr: C

Carc cat: 3

Butyl mercaptan → 1-Butanethiol

**n-Butyl methacrylate**

[97-88-1]

CH<sub>3</sub>-(CH<sub>2</sub>)<sub>3</sub>-O-OC-C(CH<sub>3</sub>)=CH<sub>2</sub>

see Section IV

Sens: Sh

**tert-Butyl methyl ether**

[1634-04-4]

(CH<sub>3</sub>)<sub>3</sub>C-O-CH<sub>3</sub>

VP[hPa]: ~ 300

see Section XII

MAK[ml/m<sup>3</sup>]: 50MAK[mg/m<sup>3</sup>]: 180

Peak lim: I(1.5)

Preg gr: C

Carc cat: 3

**tert-Butyl peracetate**

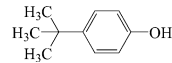
[107-71-1]

H<sub>3</sub>C-CO-OO-C(CH<sub>3</sub>)<sub>3</sub>

see Section Xa

**p-tert-Butylphenol**

[98-54-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.051 at 25°C

see Section XII

MAK[ml/m<sup>3</sup>]: 0.080MAK[mg/m<sup>3</sup>]: 0.5

Peak lim: II(2)

Preg gr: D

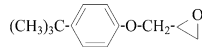
Perc abs: H

Sens: Sh

p-tert-Butylphenol → Formaldehyde  
condensation products with p-tert-butylphenol

**p-tert-Butylphenyl glycidyl ether**

[3101-60-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $2.5 \times 10^{-4}$ 

see Section IV

Sens: Sh

p-tert-Butylphenyl-1-(2,3-epoxy)propyl ether  
→ p-tert-Butylphenyl glycidyl ether

2-tert-Butyl-6-(3-tert-butyl-2-hydroxy-5-methylphenyl)sulfanyl-4-methylphenol  
→ 2,2'-Thiobis(4-methyl-6-tert-butylphenol)

**n-Butyltin compounds**

(as Sn [7440-31-5])

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.004MAK[mg/m<sup>3</sup>]: 0.02

Peak lim: I(1)

Sens: -

For butyltin compounds whose organic ligands were already designated with "Sa" or "Sh", these designations also apply.

Carc cat: 4

**- Mono-n-butyltin compounds**

Preg gr: C

**- Di-n-butyltin compounds**

Preg gr: B

**- Tri-n-butyltin compounds**

Preg gr: B

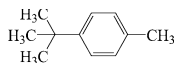
**- Tetra-n-butyltin**

[1461-25-2]

Preg gr: C

**p-tert-Butyl toluene**

[98-51-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.87

see Section IIb

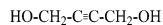
MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**Butynediol**

[110-65-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.7 \times 10^{-3}$ MAK[ml/m<sup>3</sup>]: 0.1MAK[mg/m<sup>3</sup>]: 0.36

Peak lim: I(1)

Preg gr: C

Perc abs: H

Sens: Sh

**γ-Butyrolactone**

[96-48-0]



see Section IIb

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Perc abs: H

**Cadmium**

[7440-43-9]

Cd

and its inorganic compounds  
(inhalable fraction)

see Section XII

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

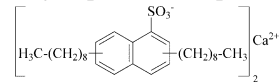
Perc abs: H

Carc cat: 1

Muta cat: 3A

**Calcium bis(dinonylnaphthalenesulphonate)**

[57855-77-3]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**Calcium hydroxide**

[1305-62-0]

Ca(OH)<sub>2</sub>

see Section Xc

MAK[mg/m<sup>3</sup>]: 1 I

Peak lim: I(2)

Preg gr: C

Calcium arsenate → Arsenic

Calcium carbimide → Calcium cyanamide

Calcium chromate → Chromium(VI) compounds

**Calcium cyanamide**

[156-62-7]

CaCN<sub>2</sub>MAK[mg/m<sup>3</sup>]: 1 I

Peak lim: II(2)

Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

Perc abs: H

Calcium molybdate → Molybdenum

**Calcium oxide**

[1305-78-8]

CaO

MAK[mg/m<sup>3</sup>]: 1 I

Peak lim: I(2)

Preg gr: C

Calcium petroleum sulfonates → Petroleum sulfonates, calcium salts (technical mixture in mineral oil)

### Calcium sodium metaphosphate

[23209-59-8]  $x \text{CaO} \cdot x \text{Na}_2\text{O} \cdot \text{P}_2\text{O}_5$   
(fibrous dust)  
see Section III

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

### Calcium sulfate

(inhalable fraction)  $\text{CaSO}_4$   
Anhydrite [7778-18-9]  
Hemihydrate [10034-76-1]  
Dihydrate [10101-41-4]  
Gypsum [13397-24-5]  
see Section Vf and g

MAK[mg/m<sup>3</sup>]: 4 I  
Preg gr: C

### ★ Calcium sulfate

(respirable fraction)  $\text{CaSO}_4$   
Anhydrite [7778-18-9]  
Hemihydrate [10034-76-1]  
Dihydrate [10101-41-4]  
Gypsum [13397-24-5]  
see Section IIb

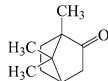
MAK[mg/m<sup>3</sup>]: –  
Preg gr: –

Calocedrus decurrens → Woods

CAM → Chloroacetamide-N-methylol (CAM)

### Camphor

[76-22-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.027  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

### ε-Caprolactam

[105-60-2]  
(vapour and dust)



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.4 \times 10^{-3}$

MAK[mg/m<sup>3</sup>]: 5 I  
Peak lim: I(2)  
Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

### Carbamic acid ethyl ester

[51-79-6]  $\text{H}_2\text{N-CO-O-CH}_2\text{-CH}_3$

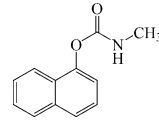
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 13 at 78°C

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2  
Muta cat: 3A

### ★ Carbaryl (1-Naphthyl methylcarbamate)

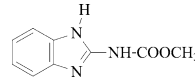
[63-25-2]



see Section IIc

### Carbendazim

[10605-21-7]



MAK[mg/m<sup>3</sup>]: 10 I  
Peak lim: II(4)  
Preg gr: B  
Muta cat: 5

Carbodicyclohexylimide

→ Dicyclohexylcarbodiimide

### Carbon black

(inhalable fraction)

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

### Carbon dioxide

[124-38-9]

$\text{CO}_2$

MAK[ml/m<sup>3</sup>]: 5000  
MAK[mg/m<sup>3</sup>]: 9100  
Peak lim: II(2)

### Carbon disulfide

[75-15-0]

$\text{CS}_2$

VP[hPa]: 400

see Section XII

MAK[ml/m<sup>3</sup>]: 5  
MAK[mg/m<sup>3</sup>]: 16  
Peak lim: II(2)  
Preg gr: B  
Perc abs: H

**Carbon monoxide**

[630-08-0] CO

see Section XII

MAK[ml/m<sup>3</sup>]: 30  
 MAK[mg/m<sup>3</sup>]: 35  
 Peak lim: II(2)  
 Preg gr: B

Carbon silicide → Silicon carbide

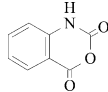
Carbon tetrachloride → Tetrachloromethane

Carbonyl chloride → Phosgene

Carborundum → Silicon carbide

**N-Carboxyanthranilic anhydride**

[118-48-9]

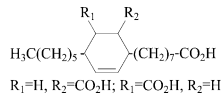


see Section IV

Sens: Sh

**5(or 6)-Carboxy-4-hexylcyclohex-2-ene-1-octanoic acid**

[53980-88-4]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Cedar (Thuja spp., Calocedrus spp.) → Woods

**Cellulases**

see Section IV

Sens: Sa

Cement → Portland cement dust

Ceramic fibres → Aluminium silicate fibres

**Cereal flour dusts**

Rye, Wheat

see Section IV

Sens: Sa

Ceylon ebony (Diospyros ebenum) → Woods

Cherry mahogany (Tieghemella heckelii)

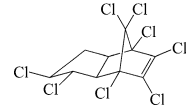
→ Woods

1-(3-Chlorallyl)-3,5,7-triaza-1-azoniaadamantane chloride → Methenamine 3-chloroallylchloride

Chloramine → N-Methyl-bis(2-chloroethyl)amine (nitrogen mustard)

**★ Chlordane**

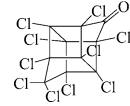
[57-74-9]



see Section IIc

**Chlordecone**

[143-50-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

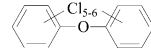
2-Chloro-2-(difluoromethoxy)-1,1,1-trifluoroethane → Isoflurane

**Chlorinated biphenyl oxides**

several CAS

Nos, e.g.

[55720-99-5]



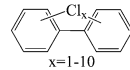
Chlorinated biphenyl oxides form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated biphenyl oxides with low chlorine content can occur as a particle-vapour mixture, whereas chlorinated biphenyl oxides with a large quantity of chlorine occur only as particles.

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Chlorinated biphenyls**

[53469-21-9]



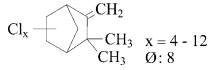
Chlorinated biphenyls form a group of compounds with different degrees and positions of chlorine substitution; often, more than one of these substances occur simultaneously at the workplace. Chlorinated biphenyls with low chlorine content (up to 5 chlorine atoms) can occur as a particle-vapour mixture, whereas chlorinated biphenyls with a large quantity of chlorine occur only as particles.

see Section XII

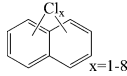
MAK[mg/m<sup>3</sup>]: 0.003 I  
 (PCB 28 + PCB 52 + PCB 101 + PCB 138 + PCB 153 + PCB 180) x 5  
 Peak lim: II(8)  
 Preg gr: B  
 Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum; see also Section XII  
 Perc abs: H  
 Carc cat: 4  
 Muta cat: 5

**Chlorinated camphene**

[8001-35-2]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Chlorinated naphthalenes**

Chlorinated naphthalenes form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated naphthalenes with low chlorine content can occur as a particle-vapour mixture, whereas chlorinated naphthalenes with a large quantity of chlorine occur only as particles.

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Chlorinated paraffins**

unbranched  $C_{10}H_{22-n}Cl_n$  –  $C_{30}H_{62-n}Cl_n$   
 chains, several  $n = 1 - 28$   
 CAS Nos, e.g. 20–70% Cl  
 [63449-39-8]

Chlorinated paraffins form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated paraffins with low chlorine content and short chain length can occur as a particle-vapour mixture, whereas chlorinated paraffins with a large quantity of chlorine or with long alkyl chains occur only as particles.

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

 **$\alpha$ -Chlorinated toluenes:****mixture of Benzoyl chloride [98-88-4],****Benzyl chloride [100-44-7],****Benzyl dichloride [98-87-3],****Benzyl trichloride [98-07-7]**

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1

**Chlorine**

[7782-50-5]

Cl<sub>2</sub>

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 1.5  
 Peak lim: I(1)  
 Preg gr: C

**Chlorine dioxide**

[10049-04-4]

ClO<sub>2</sub>

MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.28  
 Peak lim: I(1)  
 Preg gr: D

**Chlorine trifluoride**

[7790-91-2]

ClF<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Chlorite → Talc****Chloroacetaldehyde**

[107-20-0]

ClCH<sub>2</sub>-CHO

VP[hPa]: 133

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**2-Chloroacetamide**

[79-07-2]

Cl-CH<sub>2</sub>-CO-NH<sub>2</sub>

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh

**Chloroacetamide-N-methylol (CAM)**

[2832-19-1]

H<sub>2</sub>CCl-CO-NH-CH<sub>2</sub>OH

releases formaldehyde

see Section Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh  
 Carc cat: 3

**Chloroacetic acid → Monochloroacetic acid****Chloroacetic acid methyl ester**

[96-34-4]

Cl-CH<sub>2</sub>-CO-OCH<sub>3</sub>

VP[hPa]: ~7

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 4.5  
 Peak lim: I(1)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
 Perc abs: H  
 Sens: Sh

**Chloroacetyl chloride**

[79-04-9]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**2-Chloroacrylonitrile**

[920-37-6]



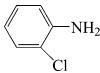
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

γ-Chloroallyl chloride → 1,3-Dichloropropene

4-Chloroaniline → p-Chloroaniline

**o-Chloroaniline**

[95-51-2]



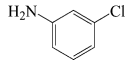
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.13  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**m-Chloroaniline**

[108-42-9]



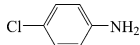
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.031  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh

**p-Chloroaniline**

[106-47-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.036 at 26°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2

**Chlorobenzene**

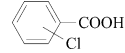
[108-90-7]



VP[hPa]: 12

see Section XII

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 23  
 Peak lim: II(2)  
 Preg gr: C

**Chlorobenzoic acid (all isomers)**

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.0031 at 25°C (calculated value)

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

– **o-Chlorobenzoic acid**  
 [118-91-2]

– **m-Chlorobenzoic acid**  
 [535-80-8]

– **p-Chlorobenzoic acid**  
 [74-11-3]

**p-Chlorobenzotrichloride**

[5216-25-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.2

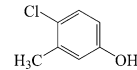
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Chlorobromomethane → Bromochloromethane

2-Chloro-1,3-butadiene → Chloroprene

**p-Chloro-m-cresol**

[59-50-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.067

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**1-Chloro-1,1-difluoroethane (FC-142b)**

[75-68-3]

ClF<sub>2</sub>C-CH<sub>3</sub>MAK[ml/m<sup>3</sup>]: 1000MAK[mg/m<sup>3</sup>]: 4200

Peak lim: II(8)

Preg gr: D

**Chlorodifluoromethane (FC-22)**

[75-45-6]

CHClF<sub>2</sub>

applies only to the pure substance; for samples contaminated with chlorofluoromethane [593-70-4] see

Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten, 12th issue, 1986 and in English translation in Occupational Toxicants, Vol. 3, available from the publisher: Wiley-VCH, D-69451 Weinheim

MAK[ml/m<sup>3</sup>]: 500MAK[mg/m<sup>3</sup>]: 1800

Peak lim: II(8)

Preg gr: C

2-Chloro-1-(difluoromethoxy)-1,1,2-trifluoroethane → Enflurane

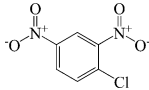
(R)-N-[(5-Chloro-3,4-dihydro-8-hydroxy-3-methyl-1-oxo-1H-2-benzopyran-7-yl)carbonyl]-L-phenylalanine → Ochratoxin A

2-Chloro-10-(3-dimethylaminopropyl)phenothiazine → Chlorpromazine  
 (2-Chloro-10-(3-dimethylaminopropyl)phenothiazine)

Chlorodimethyl ether → Monochlorodimethyl ether

**1-Chloro-2,4-dinitrobenzene**

[97-00-7]



see Section IV

Sens: Sh

**1-Chloro-2,3-epoxypropane**

(Epichlorohydrin)

[106-89-8]

see Section XII

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Sens: Sh

Carc cat: 2

Muta cat: 3B

**Chloroethane**

[75-00-3]

H<sub>3</sub>C-CH<sub>2</sub>ClMAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 3

Chloroethanoic acid → Monochloroacetic acid

**2-Chloroethanol**

[107-07-3]

ClCH<sub>2</sub>-CH<sub>2</sub>OH

VP[hPa]: 7

MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 6.7

Peak lim: II(1)

Preg gr: C

Perc abs: H

**Chlorofluoromethane (FC-31)**

[593-70-4]

CH<sub>2</sub>ClFMAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 2

**Chloroform (Trichloromethane)**

[67-66-3]

CHCl<sub>3</sub>

VP[hPa]: 211

MAK[ml/m<sup>3</sup>]: 0.5MAK[mg/m<sup>3</sup>]: 2.5

Peak lim: II(2)

Preg gr: C

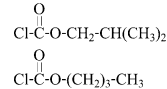
Perc abs: H

Carc cat: 4

**Chloroformic acid butyl ester**

[543-27-1;

592-34-7]



VP[hPa]: 7

MAK[ml/m<sup>3</sup>]: 0.2MAK[mg/m<sup>3</sup>]: 1.1

Peak lim: I(2)

Preg gr: C

**Chloroformic acid ethyl ester**

[541-41-3]

Cl-COO-CH<sub>2</sub>-CH<sub>3</sub>

VP[hPa]: 54

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 3

**Chloroformic acid methyl ester**

[79-22-1]

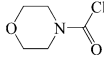


VP[hPa]: 137

MAK[ml/m<sup>3</sup>]: 0.2  
 MAK[mg/m<sup>3</sup>]: 0.78  
 Peak lim: I(2)  
 Preg gr: C

**N-Chloroformylmorpholine**

[15159-40-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.4

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**2-Chloro-N-hydroxymethylacetamide  
→ Chloroacetamide-N-methylol (CAM)**

N-(((3R)-5-Chloro-8-hydroxy-3-methyl-1-oxo-7-isochromanyl)carbonyl)-3-phenyl-L-alanine  
→ Ochratoxin A

**Chloromethane**

[74-87-3]



VP[hPa]: 5733 at 25°C

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 21  
 Peak lim: II(1)  
 Preg gr: D

**4-Chloromethyl-biphenyl**

[1667-11-4]



The substance can occur simultaneously as vapour and aerosol.

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one**

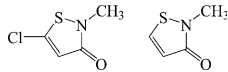
[26172-55-4;

2682-20-4]

mixture in

ratio 3:1

see Section Xc



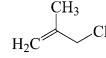
MAK[mg/m<sup>3</sup>]: 0.2 I  
 Peak lim: I(2)  
 Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

Sens: Sh

**3-Chloro-2-methylpropene**

[563-47-3]



VP[hPa]: 140

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**1-Chloro-2-nitrobenzene  
→ o-Chloronitrobenzene****1-Chloro-4-nitrobenzene  
→ p-Chloronitrobenzene****o-Chloronitrobenzene**

[88-73-3]



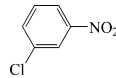
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.43

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**m-Chloronitrobenzene**

[121-73-3]



The substance can occur simultaneously as vapour and aerosol.

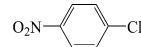
VP[hPa]: 0.129 at 25°C

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**p-Chloronitrobenzene**

[100-00-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.085

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3



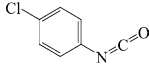
**1-Chloro-1-nitropropane**[600-25-9]  $\text{H}_3\text{C}-\text{CH}_2-\text{CHClNO}_2$ 

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**4-Chlorophenyl isocyanate**

[104-12-1]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

Chlorophora excelsa → Woods

★ **Chloropicrin**

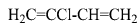
[76-06-2]



VP[hPa]: 25  
 see Section IIc

**Chloroprene**

[126-99-8]



VP[hPa]: 267  
 see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**3-Chloro-1,2-propanediol (α-Chlorohydrin)**

[96-24-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.27

MAK[ml/m<sup>3</sup>]: 0.005  
 MAK[mg/m<sup>3</sup>]: 0.023  
 Peak lim: II(8)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 3

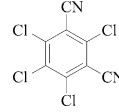
3-Chloro-1-propene → Allyl chloride

2-Chloro-2-propene nitrile

→ 2-Chloroacrylonitrile

**Chlorothalonil**

[1897-45-6]

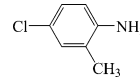


VP[hPa]: <0.013 at 40°C  
 see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**4-Chloro-o-toluidine**

[95-69-2]



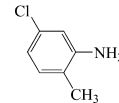
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.055 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1  
 Muta cat: 3A

**5-Chloro-o-toluidine**

[95-79-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.45

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**1-Chloro-4-(trichloromethyl)benzene**

→ p-Chlorobenzotrichloride

1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether → Isoflurane

2-Chloro-1,1,2-trifluoroethyl difluoromethyl ether → Enflurane

**Chlorotrifluoromethane (FC-13)**

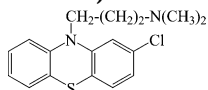
[75-72-9]



MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 4300  
 Peak lim: II(8)  
 Preg gr: D

**Chlorpromazine (2-Chloro-10-(3-dimethylaminopropyl)phenothiazine)**

[50-53-3]



see Section IV

Sens: SP

Chrome yellow → Lead chromate

**Chromium carbonyl**

[13007-92-6]

Cr(CO)<sub>6</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Chromium(III) compounds**

see Section IIb and XII

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Sens: Sh

does not apply for chromium(III) oxide and similar poorly soluble chromium(III) compounds

**Chromium(VI) compounds**

(inhalable fraction)

see Section XII

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

the chromates of barium, lead, strontium and zinc are not designated with "H"

Sens: Sh

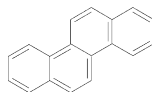
barium chromate and lead chromate are not designated with "Sh"

Carc cat: 1

Muta cat: 2

**Chrysene**

[218-01-9]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

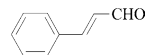
Carc cat: 2

Chrysotile (fibrous dust) → Asbestos

Chymotrypsin → Trypsin and Chymotrypsin

**Cinnamaldehyde**

[104-55-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.029

see Section IV

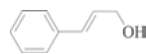
Sens: Sh

Cinnamic alcohol → Cinnamyl alcohol

Cinnamic aldehyde → Cinnamaldehyde

**Cinnamyl alcohol**

[104-54-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.012 at 25°C

see Section IV

Sens: Sh

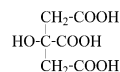
C.I. Pigment Red 104 → Lead chromate

C.I. Pigment Yellow 34 → Lead chromate

Citrates → Citric acid

**Citric acid**

[77-92-9]



see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I

Peak lim: I(2)

Preg gr: C

**Citric acid alkali metal salts**

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –The MAK value for citric acid (2 mg/m<sup>3</sup>) protects from irritation, a higher value for alkali metal salts is not justifiable.

Peak lim: –

Preg gr: –

**Coal mine dust**

(respirable fraction)

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 3

Coal tars, coal tar pitches, coal tar oils

→ Pyrolysis products of organic materials

**Cobalt**

[7440-48-4]  
and cobalt compounds (inhalable fraction)  
see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sah  
Carc cat: 2  
Muta cat: 3A

– **Metallic cobalt**

[7440-48-4] Co

– **Cobalt(II) carbonate**

[513-79-1] CoCO<sub>3</sub>

– **Cobalt(II) oxide**

[1307-96-6] CoO

– **Cobalt(II,III) oxide**

[1308-06-1] Co<sub>3</sub>O<sub>4</sub>

– **Cobalt(II) sulfate·7 H<sub>2</sub>O**

[10026-24-1] CoSO<sub>4</sub>·7 H<sub>2</sub>O  
and similar soluble salts

– **Cobalt(II) sulfide**

[1317-42-6] CoS

**Cobalt alloys**

Sens: –  
For cobalt alloys containing bio-available cobalt see  
Cobalt and cobalt compounds.

Cobalt alloys → Hard metal containing  
tungsten carbide and cobalt

Cocobolo (*Dalbergia retusa*) → Woods

**Coconut oil**

[8001-31-8]

see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
Peak lim: II(4)  
Preg gr: C

Cocus wood (*Brya ebenus*) → Woods

Coke oven emissions → Pyrolysis products of  
organic materials

Colophony → Rosin (colophony)

**Copper**

[7440-50-8] Cu

and its inorganic compounds

MAK[mg/m<sup>3</sup>]: 0.01 R  
Peak lim: II(2)  
Preg gr: C

Copra oil → Coconut oil

Coromandel (*Diospyros celebica*) → Woods

Corundum → α-Aluminium oxide

**Cotton dust**

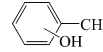
applies only to raw cotton  
see Section V

MAK[mg/m<sup>3</sup>]: 1.5 I  
Peak lim: I(1)  
Preg gr: C

p-Cresidine → 5-Methyl-o-anisidine

**Cresol (all isomers)**

[1319-77-3]



see Section XII

MAK[ml/m<sup>3</sup>]: 1  
MAK[mg/m<sup>3</sup>]: 4.5  
Peak lim: I(1)  
Preg gr: C  
Perc abs: H

– **o-Cresol**

[95-48-7]

– **m-Cresol**

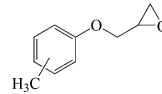
[108-39-4]

– **p-Cresol**

[106-44-5]

**Cresyl glycidyl ethers**

mixture of  
isomers  
[26447-14-3]  
o-isomer [2210-79-9]



The substance can occur simultaneously as vapour and  
aerosol.

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh  
Carc cat: 3

Cristobalite → Silica, crystalline

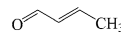
Crocidolite (fibrous dust) → Asbestos

**Crotonaldehyde**

[123-73-9;

4170-30-3]

VP[hPa]: 25



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 3  
Muta cat: 3A

**Cu-HDO**

→ N-Cyclohexylhydroxy-diazen-1-oxide,  
copper salt

Cumene → Isopropylbenzene (cumene)

Cumene hydroperoxide → α,α-Dimethylbenzyl  
hydroperoxide

**Cyanamide**

[420-04-2]

H<sub>2</sub>N-CN

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.005

MAK[ml/m<sup>3</sup>]: 0.2  
 MAK[mg/m<sup>3</sup>]: 0.35  
 Peak lim: II(1)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

**Cyanides**

(as CN)

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(1)  
 Preg gr: C  
 Perc abs: H

2-Cyanoacrylic acid methyl ester → Methyl 2-cyanoacrylate

2-Cyano-2,2-dibromoacetamide → 2,2-Dibromo-2-cyanoacetamide

Cyano(4-fluoro-3-phenoxyphenyl) methyl-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane carboxylate → Cyfluthrin

Cyanogen → Oxalonitrile

**Cyanogen chloride**

[506-77-4]

CNCl

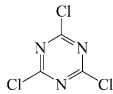
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Cyanoguanidine → Dicyanodiamide

**Cyanuric chloride**

[108-77-0]



The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.001  
 MAK[mg/m<sup>3</sup>]: 0.0076  
 Peak lim: I(2)  
 Preg gr: C  
 Sens: Sh

**Cyclohexane**

[110-82-7]



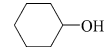
VP[hPa]: 104

see Section XII

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 700  
 Peak lim: II(4)  
 Preg gr: D

**Cyclohexanol**

[108-93-0]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Cyclohexanone**

[108-94-1]



VP[hPa]: 5

see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

Cyclohexanone peroxide

→ 1-Hydroxy-1'-hydroperoxydicyclohexyl peroxide

**Cyclohexene**

[110-83-8]

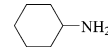


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Cyclohexylamine**

[108-91-8]



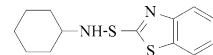
MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 8.2  
 Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (21 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

**N-Cyclohexyl-2-benzothiazolesulfenamide**

[95-33-0]

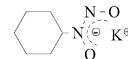


see Section IV

Sens: Sh

**Cyclohexylhydroxydiazene-1-oxide, potassium salt**

[66603-10-9]

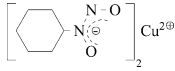


see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

**N-Cyclohexylhydroxy-diazen-1-oxide, copper salt**

[15627-09-5]



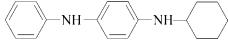
see Section Xc

MAK[mg/m<sup>3</sup>]: 0.05 R  
 corresponding to 0.01 mg Cu/m<sup>3</sup>  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

N-Cyclohexyl-N'-phenyl-1,4-benzenediamine  
 → N-Cyclohexyl-N'-phenyl-p-phenyldiamine

**N-Cyclohexyl-N'-phenyl-p-phenyldiamine**

[101-87-1]



see Section IV

Sens: Sh

**Cyclopentadiene**

[542-92-7]



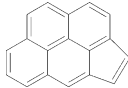
VP[hPa]: 451

see Section IIb

MAK[mL/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Cyclopenta[cd]pyrene**

[27208-37-3]

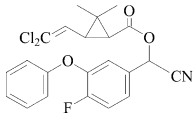


see Section III, "pyrolysis products of organic materials"

MAK[mL/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

**Cyfluthrin**

[68359-37-5]



MAK[mg/m<sup>3</sup>]: 0.01 I  
 Peak lim: I(1)  
 Preg gr: C

β-Cyfluthrin → Cyfluthrin

2,4-D → 2,4-Dichlorophenoxyacetic acid

Dalapon → 2,2-Dichloropropionic acid

Dalbergia spp. → Woods

**Dawsonite**

[12011-76-6]

(fibrous dust)

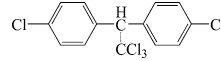
see Section III

NaAl(CO<sub>3</sub>)(OH)<sub>2</sub>

MAK[mL/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

★ **DDT (Dichlorodiphenyltrichloroethane)**

[50-29-3]



see Section IIc

DDVP → Dichlorvos

**Decaborane**

[17702-41-9]

B<sub>10</sub>H<sub>14</sub>

MAK[mL/m<sup>3</sup>]: 0.05  
 MAK[mg/m<sup>3</sup>]: 0.25  
 Peak lim: II(2)  
 Perc abs: H

Decachlorotetracyclodecanone → Chlordecone

**Decahydronaphthalene**

[91-17-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3.07

MAK[mL/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 29  
 Peak lim: II(2)  
 Preg gr: D

Decalin → Decahydronaphthalene

1,10-Decanedioic acid → Sebacic acid

**1-Decanol**

[112-30-1]

H<sub>3</sub>C-(CH<sub>2</sub>)<sub>9</sub>-OH

The substance can occur simultaneously as vapour and aerosol.

see Section Xc

MAK[mL/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 66  
 Peak lim: I(1)  
 Preg gr: C

Decyl 9-octadecenoat → n-Decyl oleate

**n-Decyl oleate**

[3687-46-5]

$$\text{CH}_2=(\text{CH}_2)_6\text{COO}-(\text{CH}_2)_9\text{CH}_3$$

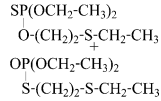
$$\text{HC}=\text{CH}-(\text{CH}_2)_7\text{CH}_3$$

see Section Xc

MAK[mL/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: D

**Demeton**

[8065-48-3]

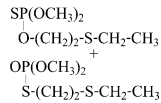


see Section XII, Acetylcholinesterase inhibitors  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H

**★ Demeton-methyl**

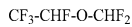
[8022-00-2]



see Section IIc

**Desflurane**

[57041-67-5]

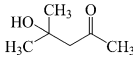


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

**Diacetone alcohol**

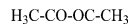
[123-42-2]



MAK[ml/m<sup>3</sup>]: 20  
MAK[mg/m<sup>3</sup>]: 96  
Peak lim: I(2)  
Preg gr: D  
Perc abs: H

**Diacetyl**

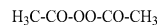
[431-03-8]



MAK[ml/m<sup>3</sup>]: 0.02  
MAK[mg/m<sup>3</sup>]: 0.071  
Peak lim: II(1)  
Preg gr: C  
Perc abs: H  
Sens: Sh  
Carc cat: 3

**Diacetyl peroxide**

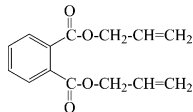
[110-22-5]



see Section Xa

**Diallyl phthalate**

[131-17-9]

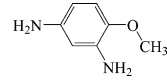


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

**2,4-Diaminoanisole**

[615-05-4]



The substance can occur simultaneously as vapour and aerosol.

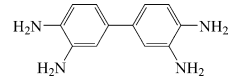
VP[hPa]: 0.063 (calculated value)

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2

1,2-Diaminobenzene → o-Phenylenediamine

1,3-Diaminobenzene → m-Phenylenediamine

1,4-Diaminobenzene → p-Phenylenediamine

**3,3'-Diaminobenzidine and its tetrahydrochloride**[91-95-2;  
7411-49-6]

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

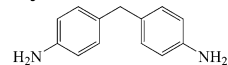
4,4'-Diamino-3,3'-dichlorodiphenylmethane  
→ 4,4'-Methylenebis(2-chloroaniline) (MOCA)

2,2'-Diaminodiethylamine  
→ Diethylenetriamine

4,4'-Diaminodiphenyl → Benzidine

**4,4'-Diaminodiphenylmethane**

[101-77-9]



see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sh  
Carc cat: 2

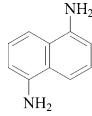
4,4'-Diaminodiphenyl sulfide  
→ 4,4'-Thiodianiline

1,2-Diaminoethane → Ethylenediamine

3,8-Diamino-5-ethyl-6-phenylphenanthridinium  
bromide → Ethidium bromide

**1,5-Diaminonaphthalene**

[2243-62-1]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2

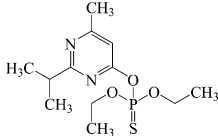
o-Dianisidine → 3,3'-Dimethoxybenzidine

Diatomaceous earth → Silica, amorphous a)  
 synthetic colloidal amorphous silica  
 [7631-86-9]

Diazenedicarboxamide → Azodicarbonamide

**Diazinon**

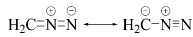
[333-41-5]



MAK[mg/m<sup>3</sup>]: 0.1 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**Diazomethane**

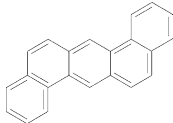
[334-88-3]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**Dibenzo[a,h]anthracene**

[53-70-3]

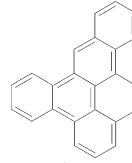


see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3A

**Dibenzo[a,e]pyrene**

[192-65-4]

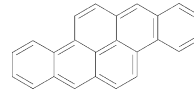


see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

**Dibenzo[a,h]pyrene**

[189-64-0]

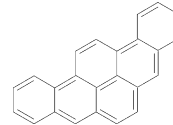


see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

**Dibenzo[a,i]pyrene**

[189-55-9]

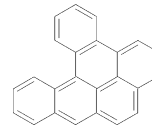


see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

**Dibenzo[a,l]pyrene**

[191-30-0]



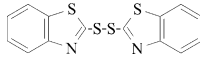
see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

Dibenzo-1,4-thiazine → Phenothiazine

**2,2'-Dibenzothiazyl disulfide**

[120-78-5]

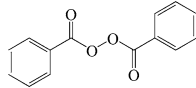


see Section IV

Sens: Sh

**Dibenzoyl peroxide**

[94-36-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $9 \times 10^{-5}$  at 25°C (calculated value)

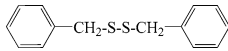
see Section Xa

MAK[mg/m<sup>3</sup>]: 5 I

Peak lim: I(1)

**Dibenzyl disulfide**

[150-60-7]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**Diborane**

[19287-45-7]

H<sub>3</sub>B-BH<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**1,2-Dibromo-3-chloropropane**

[96-12-8]

H<sub>2</sub>CCl-CHBr-CH<sub>2</sub>BrMAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Perc abs: H

Carc cat: 2

Muta cat: 2

**2,2-Dibromo-2-cyanacetamide**

[10222-01-2]

H<sub>2</sub>N-CO-CBr<sub>2</sub>-C<sup>≡</sup>N

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Sens: Sh

2,6-Dibromo-4-[2-(3,5-dibromo-4-hydroxyphenyl)propan-2-yl]phenol

→ Tetrabromobisphenol A

**1,2-Dibromo-2,4-dicyanobutane**

[35691-65-7]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Sens: Sh

**Dibromodifluoromethane**

[75-61-6]

CBr<sub>2</sub>F<sub>2</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**1,2-Dibromoethane**

[106-93-4]

BrH<sub>2</sub>CH-CH<sub>3</sub>Br

VP[hPa]: 15

MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Perc abs: H

Carc cat: 2

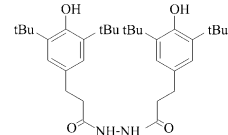
Dibromohydroxymercurifluorescein disodium salt → Merbromin

Dibutyl phosphite → Di-n-butyl phosphonate

2,6-Di-tert-butyl-p-cresol → Butylated hydroxytoluene (BHT)

**3-(3,5-Di-tert-butyl-4-hydroxyphenyl)-N'-(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propanoyl)propanehydrazide**

[32687-78-8]



see Section IIb and Xc

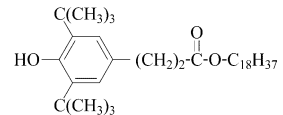
MAK[ml/m<sup>3</sup>]: -MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**3,5-Di-tert-butyl-4-hydroxyphenyl propionic acid octadecyl ester**

[2082-79-3]

VP[hPa]:  $2.5 \times 10^{-9}$ 

see Section Xc

MAK[mg/m<sup>3</sup>]: 20 I

Peak lim: II(2)

Preg gr: C



3,5-Di-tert-butyl-4-hydroxytoluene → Butylated hydroxytoluene (BHT)

N,N-Di-n-butylnitrosoamine  
→ N-Nitrosodi-n-butylamine

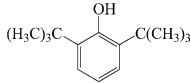
### Di-tert-butyl peroxide

[110-05-4]  $(\text{H}_3\text{C})_3\text{C}-\text{OO}-\text{C}(\text{CH}_3)_3$

see Section Xa

### 2,6-Di-tert-butylphenol

[128-39-2]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

### Di-n-butyl phosphate

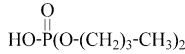
[107-66-4]

and its technical mixtures

VP[hPa]:  $7.4 \times 10^{-5}$

see Section Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3



### Di-n-butyl phosphonate

[1809-19-4]

see also

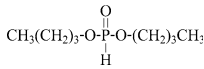
Di-n-octyl phosphonate

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $3.2 \times 10^{-7}$  at 25°C (calculated value)

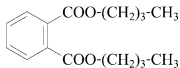
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –



### Di-n-butyl phthalate

[84-74-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.6 \times 10^{-4}$

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.05  
MAK[mg/m<sup>3</sup>]: 0.58  
Peak lim: I(2)  
Preg gr: C  
Carc cat: 3

6,6'-Di-tert-butyl-2,2'-thiodi-p-cresol  
→ 2,2'-Thiobis(4-methyl-6-tert-butylphenol)

Dicarbamoyldiimide → Azodicarbonamide

### Dicarboxylic acid anhydrides

see Section IVe

### Dicarboxylic acid (C4–C6) dimethylester, mixture

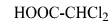
[95481-62-2]

MAK[ml/m<sup>3</sup>]: 0.75  
MAK[mg/m<sup>3</sup>]: 5  
Peak lim: I(1)  
Preg gr: C

### Dichloroacetic acid

[79-43-6]

and its salts



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.19

MAK[ml/m<sup>3</sup>]: 0.2  
MAK[mg/m<sup>3</sup>]: 1.1  
salts: 1.1 mg/m<sup>3</sup> as acid  
Peak lim: I(1)  
Preg gr: D  
Perc abs: H  
Designation with an H does not apply for the acid  
Carc cat: 4

### Dichloroacetylene

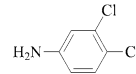
[7572-29-4]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 2

### 3,4-Dichloroaniline

[95-76-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.84 \times 10^{-3}$

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sh

### 3,4-Dichlorobenzeneamine

→ 3,4-Dichloroaniline

### 1,2-Dichlorobenzene

[95-50-1]



VP[hPa]: 1.33

see Section XII

MAK[ml/m<sup>3</sup>]: 10  
MAK[mg/m<sup>3</sup>]: 61  
Peak lim: II(2)  
Preg gr: C  
Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
Perc abs: H

**1,3-Dichlorobenzene**

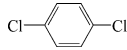
[541-73-1]



MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 12  
 Peak lim: II(2)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

**1,4-Dichlorobenzene**

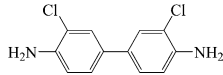
[106-46-7]



VP[hPa]: 2.3 at 25°C  
 see Section XII  
 MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 12  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

**3,3'-Dichlorobenzidine**

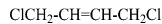
[91-94-1]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**1,4-Dichloro-2-butene**

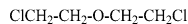
[764-41-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3A

**★ 2,2'-Dichlorodiethyl ether**

[111-44-4]



VP[hPa]: 2.66 at 30°C  
 MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 3.0  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

**Dichlorodifluoromethane (FC-12)**

[75-71-8]



MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 5000  
 Peak lim: II(2)  
 Preg gr: C

Dichlorodimethyl ether → Bischloromethyl ether

**1,1-Dichloroethane**

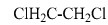
[75-34-3]



VP[hPa]: 240  
 MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 210  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 3

**1,2-Dichloroethane**

[107-06-2]



VP[hPa]: 87  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

1,2-Dichloroethene → 1,2-Dichloroethylene  
 sym

1,1-Dichloroethylene → Vinylidene chloride

**1,2-Dichloroethylene sym**

[540-59-0]

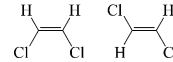
(cis [156-59-2]

and trans

[156-60-5])

VP[hPa]: 220

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 800  
 Peak lim: II(2)



1,2-Dichloroethyl methyl ether  
 → 1,2-Dichloromethoxyethane

Di-(2-chloroethyl)sulfide → Bis(β-chloroethyl)  
 sulfide (mustard gas)

2,2'-Dichloroethyl sulfide → Bis(β-chloroethyl)  
 sulfide (mustard gas)

**Dichlorofluoromethane (FC-21)**

[75-43-4]



MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 43  
 Peak lim: II(2)

Dichlorohydrin → 1,3-Dichloro-2-propanol

**Dichloromethane**

[75-09-2]



VP[hPa]: 475  
 see Section XII

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 180  
 see definition of Carcinogen Category 5 and supporting documentation  
 Peak lim: II(2)  
 Preg gr: B  
 Perc abs: H  
 Carc cat: 5

**1,2-Dichloromethoxyethane**[41683-62-9] H2ClC-CHCl-OCH3

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

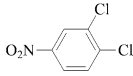
2,2'-Dichloro-N-methyldiethylamine  
 → N-Methyl-bis(2-chloroethyl)amine (nitrogen  
 mustard)

2,2'-Dichloro-4,4'-methylene dianiline  
 → 4,4'-Methylenebis(2-chloroaniline) (MOCA)

Dichloronaphthalenes → Chlorinated  
 naphthalenes

**3,4-Dichloronitrobenzene**

[99-54-7]



The substance can occur simultaneously as vapour and  
 aerosol.

VP[hPa]: 0.02 at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

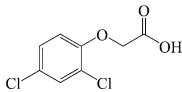
**1,1-Dichloro-1-nitroethane**[594-72-9] H3C-CCl2NO2

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2,4-Dichlorophenoxyacetic acid**

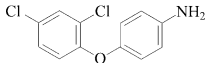
[94-75-7]

(including  
salts and  
esters)

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**4-(2,4-Dichlorophenoxy)benzenamine**

[14861-17-7]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**1,2-Dichloropropane**[78-87-5] H3C-CHCl-CH2ClVP[hPa]: 66.2 at 25°C  
see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1

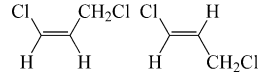
**1,3-Dichloro-2-propanol**[96-23-1] ClH2C-CH2OH-CH2Cl

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**1,3-Dichloropropene**

(cis and trans)

[542-75-6]



VP[hPa]: 40

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2

**2,2-Dichloropropionic acid**[75-99-0] H3C-CCl2-COOH

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2,2-Dichloropropionic acid, sodium salt**[127-20-8] H3C-CCl2-COO- Na+

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**1,2-Dichloro-1,1,2,2-tetrafluoroethane (FC-114)**[76-14-2] ClF2C-CClF2

MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 7100  
 Peak lim: II(8)  
 Preg gr: D

$\alpha,\alpha$ -Dichlorotoluene → Benzyl dichloride

**2,2-Dichloro-1,1,1-trifluoroethane (FC-123)**

[306-83-2]

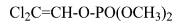


VP[hPa]: 13.2

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Dichlorvos**

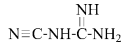
[62-73-7]



MAK[ml/m<sup>3</sup>]: 0.11  
 MAK[mg/m<sup>3</sup>]: 1  
 Peak lim: II(2)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
 Perc abs: H

**Dicyanodiamide**

[461-58-5]



VP[hPa]:  $2.3 \times 10^{-3}$   
 see Section IIb

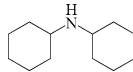
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**1,3-Dicyanotetrachlorobenzene**

→ Chlorothalonil

**Dicyclohexylamine**

[101-83-7]



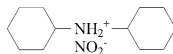
The substance can occur simultaneously as vapour and aerosol. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodicyclohexylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 0.04 at 25°C  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Dicyclohexylamine nitrite**

[3129-91-7]

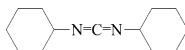


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Dicyclohexylcarbodiimide**

[538-75-0]

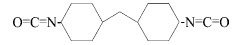


see Section IV

Sens: Sh

**Dicyclohexyl methane 4,4'-diisocyanate**

[5124-30-1]

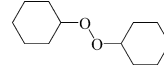


see Section IV

Sens: Sh

**Dicyclohexyl peroxide**

[1758-61-8]



see Section Xa

**Dicyclopentadiene**

[77-73-6]



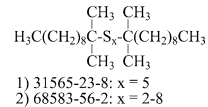
MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 2.7  
 Peak lim: I(1)  
 Preg gr: D

**Di-tert-dodecyl pentasulfide and Di-tert-dodecyl polysulfide**

[31565-23-8;

68583-56-2;

68425-15-0]



see Section Xc

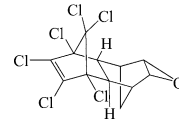
MAK[mg/m<sup>3</sup>]: 5 R

Peak lim: II(4)

Preg gr: C

**★ Dieldrin**

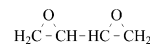
[60-57-1]



see Section IIc

**Diepoxybutane**

[1464-53-5]



Muta cat: 2

**Diesel engine emissions**

Because of the new diesel engine technology the emissions have changed significantly in quality and quantity. Since it must be assumed that these new diesel engines were introduced at the end of the 1990s, all the available epidemiological studies which were evaluated in 2007 are based on exposures to emissions from older diesel engines. The emissions from the new diesel engines can not be evaluated until appropriate studies become available.

see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 2

**Diethanolamine**[111-42-2] HO-(CH2)2-NH-(CH2)2-OH

The substance can occur simultaneously as vapour and aerosol. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethanolamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]:  $2 \times 10^{-4}$ 

MAK[mg/m<sup>3</sup>]: 1 I  
 Peak lim: I(1)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 3

**N,N-Diethanolnitrosoamine**

→ N-Nitrosodiethanolamine

★ **Diethylamine**[109-89-7] (H3C-CH2)2NH

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 253

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 6.1  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D  
 Perc abs: H

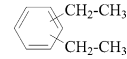
★ **2-Diethylaminoethanol**[100-37-8] (H3C-CH2)2N-CH2-CH2OH

VP[hPa]: 2

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 9.7  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(1)  
 A momentary value of 5 ml/m<sup>3</sup> (24 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C

**Diethylbenzene**

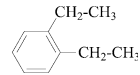
(all isomers)

– **Diethylbenzene, Mixture [25340-17-4]****1,3-Diethylbenzene [141-93-5]****1,4-Diethylbenzene [105-05-5]**

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 28  
 When exposed to the mixture the MAK value for 1,2-diethylbenzene should be observed.  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

– **1,2-Diethylbenzene**

[135-01-3]



MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 5.6  
 Peak lim: II(8)  
 Preg gr: C  
 Perc abs: H

**Diethylcarbamoyl chloride**[88-10-8] (H3C-CH2)2N-CO-Cl

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.96 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

Diethyldithiocarbamate sodium → Sodium diethyldithiocarbamate

Diethylene dioxide → 1,4-Dioxane

**Diethylene glycol**[111-46-6] HO-(CH2)2-O-(CH2)2-OH

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.027

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 44  
 Peak lim: II(4)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

**Diethylene glycol diacrylate**[4074-88-8] (CH2C=CH-COO-(CH2)2)2O

see Section IV

Sens: Sh

**Diethylene glycol dimethacrylate**[2358-84-1] O-(CH2)2-O-OC-C(CH3)=CH2  
(CH2)2-O-OC-C(CH3)=CH2

see Section IV

Sens: Sh

**Diethylene glycol dimethyl ether**[111-96-6]  $\text{H}_3\text{C-O}[(\text{CH}_2)_2\text{-O}]_2\text{-CH}_3$ 

VP[hPa]: 0.6

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 5.6  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

**Diethylene glycol dinitrate**[693-21-0]  $\text{O}[(\text{CH}_2)_2\text{-ONO}_2]_2$ 

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Diethylene glycol monobutyl ether**[112-34-5]  $\text{CH}_3(\text{CH}_2)_3\text{-O}-(\text{CH}_2)_2\text{-OH}$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.027

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 67  
 MAK value applies for the sum of the concentrations of diethylene glycol monobutyl ether and its acetate in the air.  
 Peak lim: I(1.5)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

**Diethylene glycol monobutyl ether acetate**[124-17-4]  $\text{CH}_3\text{-C}(=\text{O})\text{-O}[(\text{CH}_2)_2\text{-O}]_2\text{-}(\text{CH}_2)_3\text{-CH}_3$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.053

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 85  
 MAK value applies for the sum of the concentrations of diethylene glycol monobutyl ether and its acetate in the air.  
 Peak lim: I(1.5)  
 Preg gr: C

**Diethylene glycol monoethyl ether**[111-90-0]  $\text{CH}_3(\text{C-O-CH}_2)_2\text{-CH}_2\text{OH}$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.13

MAK[mg/m<sup>3</sup>]: 50 I  
 Peak lim: I(2)  
 Preg gr: C

**Diethylenetriamine**[111-40-0]  $(\text{H}_2\text{N-CH}_2\text{-CH}_2)_2\text{NH}$ 

see Section IV

Sens: Sh

**Diethylenetriaminepenta(methylene-phosphonic acid)**[15827-60-8]  $\text{N}((\text{CH}_2)_2\text{-N}(\text{CH}_2\text{-PO}_3\text{H}_2))_2$   
and its sodium salts [22042-96-2] see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

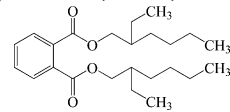
Diethylene oximide → Morpholine

N,N-Diethylethanolamine  
→ 2-Diethylaminoethanol

Diethyl ether → Ethyl ether

**Di(2-ethylhexyl)phthalate (DEHP)**

[117-81-7]

VP[hPa]:  $8.6 \times 10^{-6}$ 

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

O,O-Diethyl O-(4-nitrophenyl) thiophosphate  
→ ParathionN,N-Diethylnitrosoamine  
→ N-Nitrosodiethylamine**Diethyl sulfate**[64-67-5]  $(\text{H}_3\text{C-CH}_2\text{-O})_2\text{SO}_2$ 

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 2

Difluorodibromomethane  
→ Dibromodifluoromethane**1,1-Difluoroethylene**[75-38-7]  $\text{H}_2\text{C=CF}_2$ 

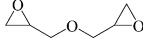
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

2-Difluoromethyl 1,2,2,2-tetrafluoroethyl ether  
→ Desflurane

Diformyl → Glyoxal

**Diglycidyl ether (DGE)**

[2238-07-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.12

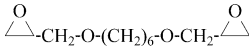
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

Diglycidyl hexahydrophthalate

→ Hexahydrophthalic acid diglycidylester

**Diglycidyl hexanediol**

[16096-31-4]



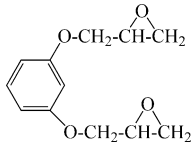
see Section IV

Sens: Sh

1,3-Diglycidyl oxybenzene → Diglycidyl resorcinol ether

**Diglycidyl resorcinol ether**

[101-90-6]



MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sh
Carc cat:	2

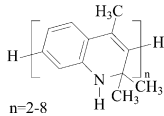
Diglycolamine → 2-(2-Aminoethoxy)ethanol

Dihydro-2(3H)-furanone →  $\gamma$ -Butyrolactone

1,2-Dihydro-5-nitroacenaphthylene  
→ 5-Nitroacenaphthene

**1,2-Dihydro-2,2,4-trimethyl-quinoline polymer**

[26780-96-1]



see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

1,4-Dihydroxybenzene → Hydroquinone

4,4'-Dihydroxydiphenylpropane

→ Bisphenol A

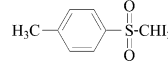
1,2-Dihydroxyethane → Ethylene glycol

2,2'-Dihydroxyethyl ether → Diethylene glycol

1,2-Dihydroxypropane → Propylene glycol

**4-(Diiodomethylsulfonyl)-toluene**

[20018-09-1]

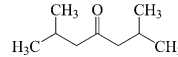


see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**Diisobutyl ketone**

[108-83-8]



see Section IIb

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

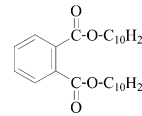
**Diisocyanates**

see Section IVe

4,4'-Diisocyanato-methylenedicyclohexane  
→ Dicyclohexyl methane 4,4'-diisocyanate

**Diisodecyl phthalate**

[26761-40-0]

VP[hPa]: 3×10<sup>-7</sup>

see Section Xc

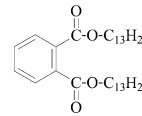
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	3

N,N-Diisopropylnitrosoamine

→ N-Nitrosodiisopropylamine

**Diisotridecyl phthalate**

[27253-26-5]

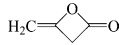


see Section Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	3

**Diketene**

[674-82-8]



see documentation "Ketene"

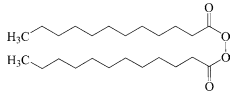
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

2,3-Diketobutane → Diacetyl

**Dilauroyl peroxide**

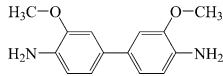
[105-74-8]



see Section Xa

**3,3'-Dimethoxybenzidine**

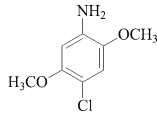
[119-90-4]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**2,5-Dimethoxy-4-chloroaniline**

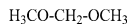
[6358-64-1]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**Dimethoxymethane**

[109-87-5]

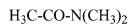


VP[hPa]: 440

MAK[ml/m<sup>3</sup>]: 500  
 MAK[mg/m<sup>3</sup>]: 1600  
 Peak lim: II(2)  
 Preg gr: C

**N,N-Dimethylacetamide**

[127-19-5]



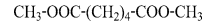
VP[hPa]: 1.3

see Section XII

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 18  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**Dimethyl adipate**

[627-93-0]



see also Dicarboxylic acid (C4-

C6) dimethylester

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**★ Dimethylamine**

[124-40-3]



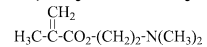
Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 3.7  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 Preg gr: D

1,1-Dimethylaminoethane → tert-Butylamine

**N,N'-(Dimethylamino)ethyl methacrylate**

[2867-47-2]

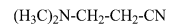


see Section IV

Sens: Sh

**Dimethylaminopropionitrile**

[1738-25-6]



see Section IIb

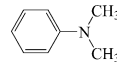
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Dimethylaminosulfochloride

→ Dimethylsulfamoyl chloride

**N,N-Dimethylaniline**

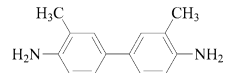
[121-69-7]



MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 25  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 3

**3,3'-Dimethylbenzidine**

[119-93-7]

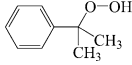


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2



**$\alpha,\alpha$ -Dimethylbenzyl hydroperoxide**

[80-15-9]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $4.4 \times 10^{-3}$  at 25°C  
see Section Xa

1,1'-Dimethyl-4,4'-bipyridinium → Paraquat dichloride

2,2-Dimethylbutane → Hexane (all isomers except n-Hexane) and Methylcyclopentane

2,3-Dimethylbutane → Hexane (all isomers except n-Hexane) and Methylcyclopentane

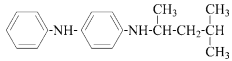
Dimethyl butanedioate → Dimethyl succinate

1,3-Dimethylbutyl acetate → sec-Hexyl acetate

N-(1,3-Dimethylbutyl)-N'-phenyl-1,4-benzene-diamine → N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine

**N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenyl-enediamine**

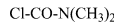
[793-24-8]



MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: II(2)  
Preg gr: C  
Sens: Sh

**Dimethylcarbamoyl chloride**

[79-44-7]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2

3,3'-Dimethyl-4,4'-diaminodiphenylmethane  
→ 4,4'-Methylenebis(2-methylaniline)

Dimethyl diketone → Diacetyl

**Dimethyl ether**

[115-10-6]

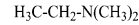


VP[hPa]: 5200

MAK[ml/m<sup>3</sup>]: 1000  
MAK[mg/m<sup>3</sup>]: 1900  
Peak lim: II(8)  
Preg gr: D

**★ N,N-Dimethylethylamine**

[598-56-1]



Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine and N-nitrosomethylethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 527-580

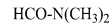
MAK[ml/m<sup>3</sup>]: 2  
MAK[mg/m<sup>3</sup>]: 6.1  
Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
Peak lim: I(2)  
A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
Preg gr: D

4-(1,1-Dimethylethyl)-1,2-benzenediol  
→ p-tert-Butylcatechol

2-(4-(1,1-Dimethylethyl)phenoxy)  
methyloxirane → p-tert-Butylphenyl glycidyl ether

**N,N-Dimethylformamide**

[68-12-2]

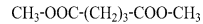


see Section XII

MAK[ml/m<sup>3</sup>]: 5  
MAK[mg/m<sup>3</sup>]: 15  
Peak lim: II(2)  
Preg gr: B  
prerequisite for Group C see documentation  
Perc abs: H  
Carc cat: 4

**Dimethyl glutarate**

[1119-40-0]



see also Dicarboxylic acid (C4–C6) dimethylester

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.13  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

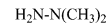
Dimethyl glyoxal → Diacetyl

2,6-Dimethyl-4-heptanone → Diisobutyl ketone

Dimethyl hexanedioate → Dimethyl adipate

**1,1-Dimethylhydrazine**

[57-14-7]



VP[hPa]: 209.31 at 25°C

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sh  
Carc cat: 2  
Muta cat: 3A

**1,2-Dimethylhydrazine**

[540-73-8]

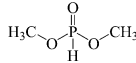


VP[hPa]: 93.19 at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3A

**Dimethyl hydrogen phosphite**

[868-85-9]



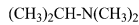
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**3,7-Dimethyl-7-hydroxyoctanal**

→ Hydroxycitronellal

**N,N-Dimethylisopropylamine**

[996-35-0]



VP[hPa]: 170

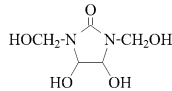
MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.6  
 Peak lim: I(2)  
 Preg gr: D

**N,N-Dimethylnitrosoamine**

→ N-Nitrosodimethylamine

**Dimethylol dihydroxyethyleneurea**

[1854-26-8]

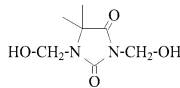


see Section IV

Sens: Sh

**1,3-Dimethylol-5,5-dimethyl hydantoin**

[6440-58-0]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

Dimethyl pentanedioate → Dimethyl glutarate

Dimethyl phosphonate → Dimethyl hydrogen phosphite

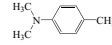
N,N-Dimethyl-2-propanamine → N,

N-Dimethylisopropylamine

1,1-Dimethylpropyl acetate → Amyl acetate (all isomers)

**N,N-Dimethyl-p-toluidine**

[99-97-8]



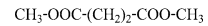
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3B

**Dimethyl succinate**

[106-65-0]



see also Dicarboxylic acid (C4–

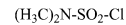
C6) dimethylester

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Dimethylsulfamoyl chloride**

[13360-57-1]



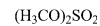
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3 at 44°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Dimethyl sulfate**

[77-78-1]



see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Dimethyl sulfide**

[75-18-3]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Dimethyl sulfoxide**

[67-68-5]



MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 160  
 Peak lim: I(2)  
 Preg gr: B  
 prerequisite for Group C see documentation  
 Perc abs: H

Dimethyltin compounds → Methyltin compounds

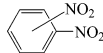
Dimethyltin bis(2-ethylhexylmercaptoacetate) [DMT(2-EHMA)<sub>2</sub>] → Methyltin compounds

Dimethyltin bis(isooctylmercaptoacetate) [DMT(IOMA)<sub>2</sub>] → Methyltin compounds

Dinickel trioxide → Nickel and nickel compounds

**Dinitrobenzene (all isomers)**

[25154-54-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.0013 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

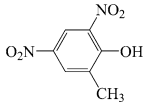
– 1,2-Dinitrobenzene  
 [528-29-0]

– 1,3-Dinitrobenzene  
 [99-65-0]

– 1,4-Dinitrobenzene  
 [100-25-4]

**4,6-Dinitro-o-cresol**

[534-52-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 1.6×10<sup>-4</sup> at 25°C

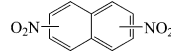
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

Dinitrogen monoxide → Nitrous oxide

**Dinitronaphthalene (all isomers)**

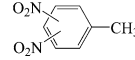
[27478-34-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Dinitrotoluene (mixtures of isomers)**

[25321-14-6]



The substance can occur simultaneously as vapour and aerosol.

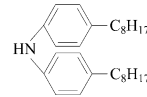
VP[hPa]: 5.3×10<sup>-4</sup> at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Dinonyl-naphthalenesulfonic acid calcium salt → Calcium bis(dinonylnaphthalenesulphonate)

**4,4'-Dioctyldiphenylamine**

[101-67-7]



see Section IIb and Xc

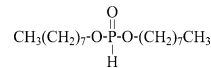
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Dioctyl phosphite → Di-n-octyl phosphonate

**Di-n-octyl phosphonate**

[1809-14-9]

see also



Di-n-butyl phosphonate

VP[hPa]: 2.1×10<sup>-7</sup> at 25°C

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Di-sec-octyl phthalate → Di(2-ethylhexyl) phthalate (DEHP)

Di-n-octyltin compounds → n-Octyltin compounds

Diospyros spp. → Woods

Dioxacyclopentane → 1,3-Dioxolane (Dioxacyclopentane)

**1,4-Dioxane**

[123-91-1]

VP[hPa]: 41  
see Section XII

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 37  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

**1,3-Dioxolane (Dioxacyclopentane)**

[646-06-0]



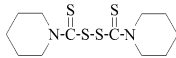
VP[hPa]: 105

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 150  
 Peak lim: II(2)  
 Preg gr: B  
 Perc abs: H

3,6-Dioxyoctane-1,8-diyl dimethacrylate  
 → Triethylene glycol dimethacrylate

**Dipentamethylenethiuram disulfide**

[94-37-1]



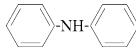
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

Diphenyl → Biphenyl

**Diphenylamine**

[122-39-4]



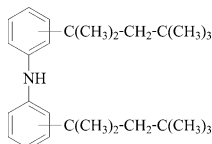
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.33  
see Section Xc

MAK[mg/m<sup>3</sup>]: 5 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 3

**Diphenylamine, octylated (Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene)**

[68411-46-1]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Diphenylamine, reaction products with styrene and 2,4,4-trimethylpentene**

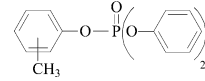
[68921-45-9]

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Diphenyl cresyl phosphate**

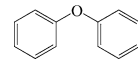
[26444-49-5]

VP[hPa]: <0.01  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Diphenyl ether**

[101-84-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.027 at 25°C

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 7.1  
 Peak lim: I(1)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

1,2-Diphenylhydrazine → Hydrazobenzene

Diphenylmethane-4,4'-diisocyanate

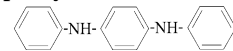
→ 4,4'-Methylene diphenyl diisocyanate (MDI)

N,N-Diphenylnitrosamine

→ N-Nitrosodiphenylamine

**N,N-Diphenyl-p-phenylenediamine**

[74-31-7]



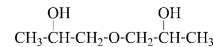
see Section IV

Sens: Sh

Diphosphorus pentoxide → Phosphorus pentoxide

**Dipropylene glycol**

[25265-71-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.043 at 25°C  
see Section Xc

MAK[mg/m<sup>3</sup>]: 100 I  
 Peak lim: II(2)  
 Preg gr: C

**Dipropylene glycol monomethyl ether**

[34590-94-8]  $\text{H}_3\text{CO-CO}_3\text{H}_6\text{-O-C}_3\text{H}_6\text{-OH}$   
(mixture of isomers)

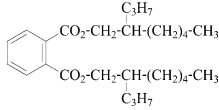
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.7 at 25°C

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 310  
Peak lim: I(1)  
Preg gr: D

**Di(2-propylheptyl) phthalate (DPPH)**

[53306-54-0]



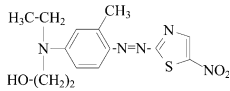
MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

**N,N-Di-n-propylnitrosoamine**

→ N-Nitrosodi-n-propylamine

**Disodium 2',7'-dibromo-4'-(hydroxymercury) fluorescein → Merbromin****Disperse blue 106/124**

[68516-81-4;  
15141-18-1]

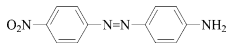


see Section IV

Sens: Sh

**Disperse Orange 3**

[730-40-5]

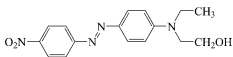


see Section IV

Sens: Sh

**Disperse Red 1**

[2872-52-8]

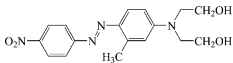


see Section IV

Sens: Sh

**Disperse Red 17**

[3179-89-3]

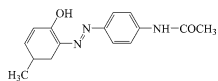


see Section IV

Sens: Sh

**Disperse Yellow 3**

[2832-40-8]



see Section IV

Sens: Sh

Distemonanthus benthamianus → Woods

**Distillates (petroleum)**

[64742-47-8]  
hydrotreated light (aerosol)  
VP[hPa]: 0.6  
see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
Peak lim: II(4)  
Preg gr: C  
Carc cat: 3

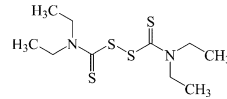
**Distillates (petroleum)**

[64742-47-8]  
hydrotreated light (vapour)  
VP[hPa]: 0.6  
see Section Xc

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 350  
Peak lim: II(2)  
Preg gr: C  
Carc cat: 3

**Disulfiram**

[97-77-8]



Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: II(8)  
Preg gr: D  
Sens: Sh

Disulfur chloride → Sulfur monochloride

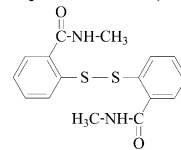
Disulfur decafluoride → Sulfur pentafluoride

2,2'-Dithiobisbenzothiazole

→ 2,2'-Dibenzothiazyl disulfide

**2,2'-Dithiobis(N-methylbenzamide)**

[2527-58-4]



see Section IIb and Xc

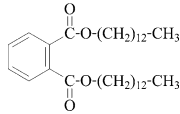
MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh

Dithiocarb → Sodium diethyldithiocarbamate

Dithiocarb sodium → Sodium diethyldithiocarbamate

**Ditridecyl phthalate**

[119-06-2]

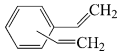


see Section Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Divinylbenzene (all isomers)**

[1321-74-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.9 at 25°C

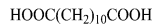
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Docosanoic acid → Behenic acid

**Dodecanedioic acid**

[693-23-2]



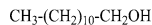
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Dodecanoic acid → Lauric acid

**1-Dodecanol**

[112-53-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.1 \times 10^{-3}$ 

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Dodecyl alcohol → 1-Dodecanol

DOP → Di(2-ethylhexyl)phthalate (DEHP)

Douka (*Tieghemella africana*) → Woods

DPHP → Di(2-propylheptyl) phthalate (DPHP)

**Dust, general threshold limit value (inhalable fraction)**

see Section Vf and g

MAK[mg/m<sup>3</sup>]: 4 I**Dust, general threshold limit value (respirable fraction)**

(biopersistent granular dusts)

except for ultrafine particles; see Section Vh  
 see Section Vf

MAK[mg/m<sup>3</sup>]: 0.3  
 for dusts with a density of 1 g/cm<sup>3</sup>  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 4

**Dusts**

see Section V

**Dusts containing enzymes**

see Section IVe

East Indian rosewood (*Dalbergia latifolia*)

→ Woods

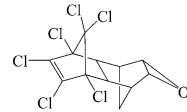
Ebony (*Diospyros* spp.) → Woods

EDTA → Ethylenediaminetetraacetic acid (EDTA)

Endothiapepsin → Microbial rennets:  
 endothiapepsin and mucorpepsin

**Endrin**

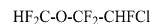
[72-20-8]



MAK[mg/m<sup>3</sup>]: 0.05 I  
 Peak lim: II(8)  
 Preg gr: C  
 Perc abs: H

**Enflurane**

[13838-16-9]



VP[hPa]: 232

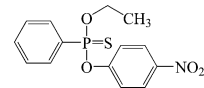
MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 150  
 Peak lim: II(8)  
 Preg gr: C

Entandrophragma spp. → Woods

Epichlorohydrin → 1-Chloro-2,3-epoxypropane

**★ EPN (O-Ethyl O-(4-nitrophenyl)phenylthiophosphonate)**

[2104-64-5]



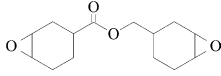
see Section IIc

1,2-Epoxy-3-allyloxypropane → Allyl glycidyl ether

1,2-Epoxybutane → 1,2-Butylene oxide

**3,4-Epoxy cyclohexane carboxylic acid (3,4-epoxycyclohexylmethyl) ester**

[2386-87-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 3

1,2-Epoxy-4-(epoxyethyl)cyclohexane  
 → 4-Vinyl-1-cyclohexene dioxide

1,2-Epoxy-3-isopropoxypropane → Isopropyl glycidyl ether (IGE)

**1,2-Epoxypropane**

[75-56-9]



see Section XII

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 4,8  
 Peak lim: I(2)  
 Preg gr: C  
 Sens: Sh  
 Carc cat: 4

2,3-Epoxy-1-propanol → Glycidol

2,3-Epoxypropyl methacrylate → Glycidyl methacrylate

2,3-Epoxypropyl-o-tolylether → Cresyl glycidyl ethers

(2,3-Epoxypropyl)trimethylammonium chloride  
 → Glycidyl trimethylammonium chloride

**Erionite**

[12510-42-8]

(Ca,Na,K)<sub>2</sub>[Al<sub>3</sub>Si<sub>9</sub>O<sub>24</sub>] · 9 H<sub>2</sub>O(fibrous dust)  
see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 1

Ethanedial → Glyoxal

1,2-Ethanediol → Ethylene glycol

N,N'-1,2-Ethanediybis[N-(carboxymethyl)glycine] → Ethylenediaminetetraacetic acid (EDTA)

**★ Ethanethiol**

[75-08-1]

H<sub>3</sub>C-CH<sub>2</sub>SH

VP[hPa]: 590

MAK[ml/m<sup>3</sup>]: 0,5  
 MAK[mg/m<sup>3</sup>]: 1,3  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Section Ie  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

**Ethanol**

[64-17-5]

H<sub>3</sub>C-CH<sub>2</sub>OH

VP[hPa]: 59

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 380  
 see definition of Carcinogen Category 5 and supporting documentation  
 Peak lim: II(4)  
 Preg gr: C  
 Carc cat: 5  
 Muta cat: 5

Ethanolamine → 2-Aminoethanol

Ethene → Ethylene

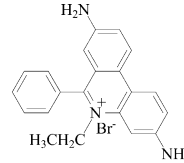
N-Ethenylcarbazole → Vinylcarbazole

4-Ethenylcyclohexene → 4-Vinylcyclohexene

1-(Ethenyloxy)-2-methylpropane → Isobutyl vinyl ether

**Ethidium bromide**

[1239-45-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3  
 Muta cat: 3B

2-Ethoxy-6-amino-naphthalene

→ 6-Amino-2-ethoxynaphthalene

**2-Ethoxyethanol**

[110-80-5]

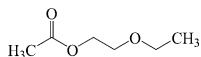
H<sub>3</sub>C-CH<sub>2</sub>O-CH<sub>2</sub>-CH<sub>2</sub>OHVP[hPa]: ~ 5  
see Section XII

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 7,5  
 MAK value applies for the sum of the concentrations of 2-ethoxyethanol and 2-ethoxyethyl acetate in the air.  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

2-(2-Ethoxyethoxy)ethanol → Diethylene glycol monoethyl ether

### 2-Ethoxyethyl acetate

[111-15-9]

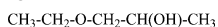


see Section XII

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 MAK value applies for the sum of the concentrations of 2-ethoxyethanol and 2-ethoxyethyl acetate in the air.  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

### 1-Ethoxy-2-propanol

[1569-02-4]

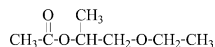


VP[hPa]: 10  
 see Section XII

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 86  
 MAK value applies for the sum of the concentrations of 1-ethoxy-2-propanol and 1-ethoxy-2-propyl acetate in the air.  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

### 1-Ethoxy-2-propyl acetate

[54839-24-6]



VP[hPa]: 2  
 see Section XII

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 120  
 MAK value applies for the sum of the concentrations of 1-ethoxy-2-propanol and 1-ethoxy-2-propyl acetate in the air.  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

### Ethyl acetate

[141-78-6]

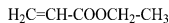


VP[hPa]: 97

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 750  
 Peak lim: I(2)  
 Preg gr: C

### ★ Ethyl acrylate

[140-88-5]



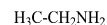
VP[hPa]: 39

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 8.3  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

Ethyl alcohol → Ethanol

### ★ Ethylamine

[75-04-7]

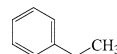


VP[hPa]: 990

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 9.4  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 10 ml/m<sup>3</sup> (19 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D

### Ethylbenzene

[100-41-4]



VP[hPa]: 9  
 see Section XII

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 88  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

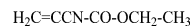
Ethyl bromide → Bromoethane

Ethyl carbamate → Carbamic acid ethyl ester

Ethyl chloride → Chloroethane

### Ethyl 2-cyanoacrylate

[7085-85-0]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

### 5-Ethyl-3,7-dioxo-1-azabicyclo[3.3.0]octane (EDAO)

[7747-35-5]



releases formaldehyde  
 see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

### Ethylene

[74-85-1]



see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

Ethylenebis(oxyethylene)methacrylate  
 → Triethylene glycol dimethacrylate



Ethylene chlorohydrin → 2-Chloroethanol

### Ethylenediamine

[107-15-3]  $\text{H}_2\text{NCH}_2\text{-CH}_2\text{NH}_2$

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sah

### Ethylenediaminetetraacetic acid (EDTA)

[60-00-4]  $(\text{HO}_2\text{C-CH}_2)_2\text{N-CH}_2\text{-CH}_2\text{-N}(\text{CH}_2\text{-CO}_2\text{H})_2$

Avoid exposure to mixtures with iron compounds (formation of FeEDTA).

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Ethylene dibromide → 1,2-Dibromoethane

Ethylene dichloride → 1,2-Dichloroethane

### Ethylene glycol

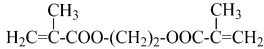
[107-21-1] 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.053

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 26  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

### Ethylene glycol dimethacrylate

[97-90-5] 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.25 at 25°C (calculated value)

see Section IV

Sens: Sh

### Ethylene glycol dinitrate

[628-96-6]  $\text{O}_2\text{NH-O}(\text{CH}_2)_2\text{-OH-NO}_2$

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.096 at 25°C

see Section XII

MAK[ml/m<sup>3</sup>]: 0.01  
 MAK[mg/m<sup>3</sup>]: 0.063  
 MAK value applies for the sum of the concentrations of ethylene glycol dinitrate, nitroglycerin and propylene glycol dinitrate in the air.  
 Peak lim: II(1)  
 Preg gr: C  
 Perc abs: H

Ethylene glycol isopropyl ether

→ 2-Isopropoxyethanol

Ethylene glycol methacrylate  
 → 2-Hydroxyethyl methacrylate

Ethylene glycol monoacrylate → Acrylic acid  
 2-hydroxyethyl ester

Ethylene glycol monobutyl ether  
 → 2-Butoxyethanol

Ethylene glycol monobutyl ether acetate  
 → 2-Butoxyethyl acetate

Ethylene glycol monoethyl ether  
 → 2-Ethoxyethanol

Ethylene glycol monoethyl ether acetate  
 → 2-Ethoxyethyl acetate

Ethylene glycol monomethyl ether  
 → 2-Methoxyethanol

Ethylene glycol monomethyl ether acetate  
 → 2-Methoxyethyl acetate

Ethylene glycol monophenyl ether  
 → 2-Phenoxyethanol

Ethylene glycol mono-n-propyl ether  
 → 2-Propoxyethanol

Ethylene glycol monopropyl ether acetate  
 → 2-Propoxyethyl acetate

### Ethylene oxide

[75-21-8]

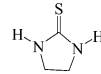


see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 2

### Ethylene thiourea (Imidazoline-2-thione)

[96-45-7]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Ethylenimine**

[151-56-4]

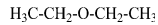


VP[hPa]: 214

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 2

**Ethyl ether**

[60-29-7]

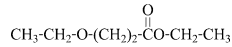


VP[hPa]: 587

MAK[ml/m<sup>3</sup>]: 400  
 MAK[mg/m<sup>3</sup>]: 1200  
 Peak lim: I(1)  
 Preg gr: D

**Ethyl-3-ethoxypropionate**

[763-69-9]



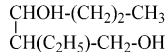
MAK[ml/m<sup>3</sup>]: 100  
 MAK[mg/m<sup>3</sup>]: 610  
 Peak lim: I(1)  
 Preg gr: C  
 Perc abs: H

Ethyl formate → Formic acid ethyl ester

Ethyl glycol → 2-Ethoxyethanol

**2-Ethyl-1,3-hexanediol**

[94-96-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: &lt;0.01

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2-Ethylhexanoic acid**

[149-57-5]



The substance can occur simultaneously as vapour and aerosol.

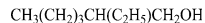
VP[hPa]: 0.04

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2-Ethylhexanol**

[104-76-7]



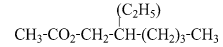
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.18 at 25°C

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 54  
 Peak lim: I(1)  
 Preg gr: C

**2-Ethylhexyl acetate**

[103-09-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.31 at 25°C

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 71  
 Peak lim: I(1)  
 Preg gr: C

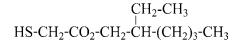
2-Ethylhexyl acrylate → Acrylic acid

2-ethylhexyl ester

2-Ethylhexyl alcohol → 2-Ethylhexanol

**2-Ethylhexyl mercaptoacetate**

[7659-86-1]



see Section IV

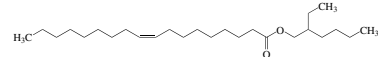
Sens: Sh

2-Ethylhexyl (Z)-octadec-9-enoate

→ 2-Ethylhexyl oleate

**2-Ethylhexyl oleate**

[26399-02-0]

VP[hPa]:  $2.4 \times 10^{-5}$  (calculated value)

see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: D

2-Ethylhexyl thioglycolate → 2-Ethylhexyl mercaptoacetate

2-Ethyl-2-(hydroxymethyl)-1,3-propanediol triacrylate → Trimethylolpropane triacrylate

Ethylidene chloride → 1,1-Dichloroethane

Ethyl mercaptan → Ethanethiol

Ethyl(2-mercaptobenzoato-S)mercury sodium salt → Thimerosal

Ethyl mercury → Mercury, organic compounds

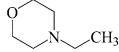
Ethyl methacrylate → Methacrylic acid ethyl ester

Ethyl methyl ketoxime → Butanone oxime

Ethyl 2-methyl-2-propenoate → Methacrylic acid ethyl ester

**N-Ethylmorpholine**

[100-74-3]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

O-Ethyl O-(4-nitrophenyl)phenylthio-  
 phosphonate → EPN (O-Ethyl  
 O-(4-nitrophenyl)phenylthiophosphonate)

4,4'-(2-Ethyl-2-nitro-1,3-propanediyl)  
 bismorpholin → 4-(2-Nitrobutyl)morpholine  
 (70% w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-pro-  
 pandiyl)bismorpholin (20% w/w)

N-Ethyl-N-nitrosoaniline  
 → N-Nitrosoethylphenylamine

**N-Ethyl-2-pyrrolidone**[2687-91-4]  
(vapour)

The substance can occur simultaneously as vapour and  
 aerosol.

VP[hPa]: 0.18

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 23  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

Ethyl silicate → Silicic acid tetraethyl ester

**Ethyltin compounds**

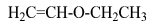
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: –

For ethyltin compounds whose organic ligands were  
 already designated with “Sa” or “Sh”, these designations  
 also apply.

**Ethyl vinyl ether**

[109-92-2]



see Section IIb

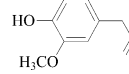
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Etidronic acid

→ 1-Hydroxyethylidene-1,1-diphosphonic acid

**Eugenol**

[97-53-0]



The substance can occur simultaneously as vapour and  
 aerosol.

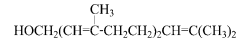
VP[hPa]: <0.1  
 see Section IV

Sens: Sh

F 134a → 1,1,1,2-Tetrafluoroethane

**Farnesol**

[4602-84-0]



see Section IV

Sens: Sh

★ **Fatty acids, C14–18 and C16–18-  
 unsaturated**

[67701-06-8]

VP[hPa]: <1.87×10<sup>-6</sup> at 25°C  
 see Section IIb and Xc

MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Fatty alcohol ethoxylates, C16–18 and C18-  
 unsaturated**

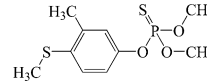
[68920-66-1]

VP[hPa]: 5.5×10<sup>-5</sup> (calculated value)  
 see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

★ **Fenthion**

[55-38-9]



see Section IIc

**Ferbam**

[14484-64-1]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Ferrovanadium**

[12604-58-9]

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Fibrous dust, inorganic**

see Section III

**Fluorides**

[16984-48-8]  
(as Fluoride)  
see Section XII

MAK[ml/m<sup>3</sup>]: 1 I  
Peak lim: II(4)  
Preg gr: C  
Classification in Pregnancy Risk Group C was  
re-evaluated in 2011 and confirmed.  
Perc abs: H

**Fluorine**

[7782-41-4] F<sub>2</sub>  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Fluorocarbon 134a → 1,1,1,2-Tetrafluoroethane

Fluorotrchloromethane  
→ Trichlorofluoromethane (FC-11)

**Formaldehyde**

[50-00-0] HCHO

MAK[ml/m<sup>3</sup>]: 0.3  
MAK[mg/m<sup>3</sup>]: 0.37  
During exposure to mixtures it should be ensured that  
irritant effects do not occur.  
Peak lim: I(2)  
A momentary value of 1 ml/m<sup>3</sup> (1.2 mg/m<sup>3</sup>) should not be  
exceeded.  
Preg gr: C  
Sens: Sh  
Carc cat: 4  
Muta cat: 5

**Formaldehyde condensation products with  
p-tert-butylphenol**

(low molecular)  
see Section IV

Sens: Sh

**Formaldehyde condensation products with  
phenol**

(low-molecular)  
see Section IV

Sens: Sh

**Formamide**

[75-12-7] NH<sub>2</sub>-CHO  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H

**Formic acid**

[64-18-6] HCOOH  
VP[hPa]: 42

MAK[ml/m<sup>3</sup>]: 5  
MAK[mg/m<sup>3</sup>]: 9.5  
Peak lim: I(2)  
Preg gr: C

**Formic acid ethyl ester**

[109-94-4] HCOOCH<sub>2</sub>-CH<sub>3</sub>  
VP[hPa]: 256

MAK[ml/m<sup>3</sup>]: 100  
MAK[mg/m<sup>3</sup>]: 310  
Peak lim: I(1)  
Preg gr: C  
Perc abs: H

**Formic acid methyl ester**

[107-31-3] HCO-OCH<sub>3</sub>  
VP[hPa]: 640  
see Section XII

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 120  
Peak lim: II(2)  
Preg gr: C  
Perc abs: H

**Fragrance components**

see Section IVe

Fraké (Terminalia superba) → Woods

Framiré (Terminalia ivorensis) → Woods

**Fumes**

see Section V

2-Furaldehyde → Furfural

**Furan**

[110-00-9]



MAK[ml/m<sup>3</sup>]: 0.02  
MAK[mg/m<sup>3</sup>]: 0.056  
Peak lim: II(2)  
Preg gr: D  
Perc abs: H  
Carc cat: 4

**Furfural**

[98-01-1]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 3

**Furfuryl alcohol**

[98-00-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

Gallium arsenide → Arsenic

**Gasolines**

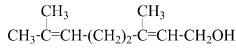
see Section Xb

Gedu nohor (*Entandrophragma angolense*)

→ Woods

**Geraniol**

[106-24-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.3

see Section IV

Sens: Sh

**Germanium tetrahydride**

[7782-65-2]

GeH<sub>4</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

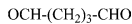
**Glass fibres (fibrous dust)**

see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**Glutaraldehyde**

[111-30-8]



MAK[ml/m<sup>3</sup>]: 0.05  
 MAK[mg/m<sup>3</sup>]: 0.21  
 Peak lim: I(2)

A momentary value of 0.2 ml/m<sup>3</sup> (0.83 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

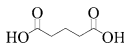
Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

Sens: Sah

Carc cat: 4

**Glutaric acid**

[110-94-1]

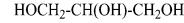


MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: I(2)  
 Preg gr: C

Glutaric acid, dimethyl ester → Dimethyl glutarate

**Glycerol**

[56-81-5]



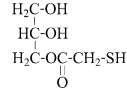
see Section Xc

MAK[mg/m<sup>3</sup>]: 200 I  
 Peak lim: I(2)  
 Preg gr: C

Glycerol trinitrate → Nitroglycerin

**Glyceryl monothioglycolate**

[30618-84-9]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 1.2×10<sup>-5</sup> at 25°C

see Section IV

Sens: Sh

**Glycidol**

[556-52-5]



see Section XII

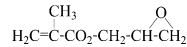
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 3A

**Glycidyl compounds (epoxides)**

see Section IVe

**Glycidyl methacrylate**

[106-91-2]

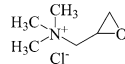


see Section IV

Sens: Sh

**Glycidyl trimethylammonium chloride**

[3033-77-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2

Glycol → Ethylene glycol

Glycol dinitrate → Ethylene glycol dinitrate

Glycolic acid n-butylester → Hydroxyacetic acid butyl ester

**Glyoxal**

[107-22-2]	OHC-CHO
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sh
Carc cat:	3

**Gold**

[7440-57-5]	Au
and its inorganic compounds see Section IIb	
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sh
only soluble gold compounds	

Gonystylus bancanus → Woods

Granular biopersistent dusts → Dust, general  
threshold limit value (respirable fraction)

**Graphite**

[7782-42-5]	C
(inhalable fraction) see Section Vf and g	
MAK[mg/m <sup>3</sup> ]:	4 I
Preg gr:	C

**Graphite**

[7782-42-5]	C
(respirable fraction) except for ultrafine particles; see Section Vh see Section Vf	
MAK[mg/m <sup>3</sup> ]:	0.3 R
multiplied with the material density	
Peak lim:	II(8)
Preg gr:	C
Carc cat:	4

Grevillea robusta → Woods

**Hafnium**

[7440-58-6]	Hf
and its compounds see Section IIb	
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**Halloysite**

[12298-43-0]	Al <sub>2</sub> (Si <sub>2</sub> O <sub>7</sub> ) · x H <sub>2</sub> O
(fibrous dust) see Section III	
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	3

**Halothane**

[151-67-7]	BrClHC-CF <sub>3</sub>
VP[hPa]: 242 see Section XII	
MAK[ml/m <sup>3</sup> ]:	5
MAK[mg/m <sup>3</sup> ]:	41
Peak lim:	II(8)
Preg gr:	B

Hard coal dust → Coal mine dust

**Hard metal containing tungsten carbide and cobalt**

(inhalable fraction)	
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Sens:	Sah
Carc cat:	1
Muta cat:	3A

HDDA → 1,6-Hexanediol diacrylate

Hemicellulases → Xylanases

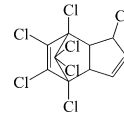
Hemimellitene (1,2,3-Trimethylbenzene)  
→ Trimethylbenzene (all isomers)

Hempa → Hexamethylphosphoric acid triamide

HEOD → Dieldrin

**Heptachlor**

[76-44-8]



MAK[mg/m <sup>3</sup> ]:	0.05 I
Peak lim:	II(8)
Preg gr:	D
Perc abs:	H
Carc cat:	4

Heptadecafluoro-1-octanesulfonic acid  
→ Perfluorooctanesulfonic acid (PFOS)

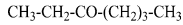
**n-Heptane**

[142-82-5]	H <sub>3</sub> C-C <sub>5</sub> H <sub>10</sub> -CH <sub>3</sub>
VP[hPa]: 48 see Section XII	
MAK[ml/m <sup>3</sup> ]:	500
MAK[mg/m <sup>3</sup> ]:	2100
Peak lim:	I(1)
Preg gr:	D

1,7-Heptanedicarbonic acid → Azelaic acid

**3-Heptanone**

[106-35-4]

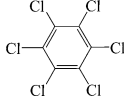


VP[hPa]: 1.5

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 47  
 Peak lim: I(2)  
 Preg gr: D

**Hexachlorobenzene**

[118-74-1]

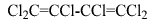


see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 4

**Hexachloro-1,3-butadiene**

[87-68-3]



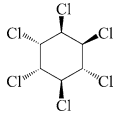
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.29 at 25°C

MAK[ml/m<sup>3</sup>]: 0.02  
 MAK[mg/m<sup>3</sup>]: 0.22  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

**α-Hexachlorocyclohexane**

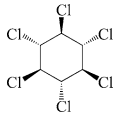
[319-84-6]



MAK[mg/m<sup>3</sup>]: 0.5 I  
 Peak lim: II(8)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 4

**β-Hexachlorocyclohexane**

[319-85-7]



MAK[mg/m<sup>3</sup>]: 0.1 I  
 Peak lim: II(8)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 4

γ-Hexachlorocyclohexane → Lindane  
 (γ-1,2,3,4,5,6-Hexachlorocyclohexane)

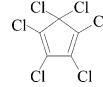
**1,2,3,4,5,6-Hexachlorocyclohexane**

techn. mixture of α-HCH [319-84-6] and β-HCH [319-85-7]

MAK[mg/m<sup>3</sup>]: 0.1 I  
 (Conc. α-HCH divided by 5) + Conc. β-HCH = 0.1  
 Peak lim: II(8)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 4

**Hexachlorocyclopentadiene**

[77-47-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1 at 25°C

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Hexachloroethane**

[67-72-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.4

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 9.8  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 3

Hexachloronaphthalenes → Chlorinated naphthalenes

Hexadecanoic acid → Palmitic acid

**1-Hexadecanol**

[36653-82-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: &lt;0.01

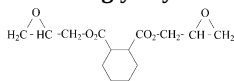
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

1,1,1,3,3,3-Hexafluoro-2-(fluoromethoxy)  
 propane → Sevoflurane

**Hexahydrophthalic acid diglycidylester**

[5493-45-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 3

**Hexahydrophthalic anhydride**

[85-42-7]



The substance can occur simultaneously as vapour and aerosol.

see Section IV

Sens: Sa

**Hexahydro-1,3,5-triethyl-s-triazine**

→ 1,3,5-Triethylhexahydro-1,3,5-triazine

**Hexahydro-1,3,5-tris(hydroxyethyl)-s-triazine**

→ N,N',N''-Tris(β-hydroxyethyl)

hexahydro-1,3,5-triazine

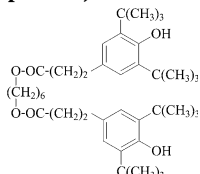
**Hexahydro-1,3,5-tris(2-hydroxypropyl)-s-**

triazine → N,N',N''-Tris(β-hydroxypropyl)

hexahydro-1,3,5-triazine

**Hexamethylene bis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate)**

[35074-77-2]



see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I  
 Peak lim: II(2)  
 Preg gr: C

**1,6-Hexamethylene diacrylate**

→ 1,6-Hexanediol diacrylate

**1,6-Hexamethylene diisocyanate**

[822-06-0]

OCN-(CH<sub>2</sub>)<sub>6</sub>-NCO

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.007

MAK[ml/m<sup>3</sup>]: 0.005  
 MAK[mg/m<sup>3</sup>]: 0.035  
 Peak lim: I(1)

A momentary value of 0.01 ml/m<sup>3</sup> (0.070 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D  
 Sens: Sah

**Hexamethylenetetramine**

[100-97-0]



releases formaldehyde  
 see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**Hexamethylphosphoric acid triamide**

[680-31-9]

OP[N(CH<sub>3</sub>)<sub>2</sub>]<sub>3</sub>

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2  
 Muta cat: 2

**n-Hexane**

[110-54-3]

H<sub>3</sub>C-(CH<sub>2</sub>)<sub>4</sub>-CH<sub>3</sub>

VP[hPa]: 160  
 see Section XII

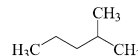
MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 180  
 Peak lim: II(8)  
 Preg gr: C

**Hexane (all isomers except n-Hexane) and Methylcyclopentane**

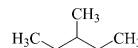
MAK[ml/m<sup>3</sup>]: 500  
 MAK[mg/m<sup>3</sup>]: 1800  
 Peak lim: II(2)  
 Preg gr: D

**– 2-Methylpentane**

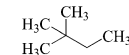
[107-83-5]

**– 3-Methylpentane**

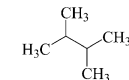
[96-14-0]

**– 2,2-Dimethylbutane**

[75-83-2]

**– 2,3-Dimethylbutane**

[79-29-8]

**– Methylcyclopentane**

[96-37-7]



1,6-Hexanedioic acid → Adipic acid



**1,6-Hexanediol diacrylate**[13048-33-4]  $\text{H}_2\text{C}=\text{CH}-\text{COO}-(\text{CH}_2)_6-\text{OOC}-\text{CH}=\text{CH}_2$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.014 at 50°C

see Section IV

Sens: Sh

1,6-Hexanediol diglycidylether → Diglycidyl hexanediol

2,2'-[1,6-Hexanediybis(oxymethylene)] bisoxirane → Diglycidyl hexanediol

**1-Hexanol**[111-27-3]  $\text{H}_3\text{C}-(\text{CH}_2)_4-\text{CH}_2\text{OH}$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.93

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**2-Hexanone**[591-78-6]  $\text{H}_3\text{C}-(\text{CH}_2)_3-\text{CO}-\text{CH}_3$ 

see Section XII

MAK[ml/m<sup>3</sup>]: 5MAK[mg/m<sup>3</sup>]: 21

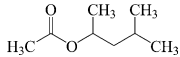
Peak lim: II(8)

Perc abs: H

Hexone → 4-Methyl-2-pentanone

**sec-Hexyl acetate**

[108-84-9]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**2-Hexyl-1-decanol**[2425-77-6]  $\text{HO}-\text{CH}_2-\text{CH}(\text{C}_6\text{H}_{13})-(\text{CH}_2)_7-\text{CH}_3$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.004 at 38°C

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Hexylene glycol**[107-41-5]  $\text{H}_3\text{C}-\text{CH}(\text{OH})-\text{CH}_2-\text{C}(\text{OH})(\text{CH}_3)_2$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.07

see Section Xc

MAK[ml/m<sup>3</sup>]: 10MAK[mg/m<sup>3</sup>]: 49

Peak lim: I(2)

Preg gr: D

HFC 134a → 1,1,1,2-Tetrafluoroethane

HMPA → Hexamethylphosphoric acid triamide

Honduras rosewood (*Dalbergia stevensonii*)

→ Woods

**Hydraulic fluids**

see Section Xc

**Hydrazine**[302-01-2]  $\text{H}_2\text{N}-\text{NH}_2$ 

VP[hPa]: 13

see Section XII

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Sens: Sh

Carc cat: 2

**Hydrazine hydrate**[7803-57-8]  $\text{H}_2\text{N}-\text{NH}_2 \cdot \text{H}_2\text{O}$ 

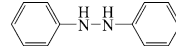
and hydrazine salts

see Section IV

Sens: Sh

**Hydrazobenzene**

[122-66-7]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 2

**Hydrazoic acid**[7782-79-8]  $\text{HN}_3$ MAK[ml/m<sup>3</sup>]: 0.1MAK[mg/m<sup>3</sup>]: 0.18

Peak lim: I(2)

Hydrocarbon solvent C<sub>6</sub>–C<sub>13</sub> dearomatised

→ Naphtha (petroleum)

Hydrochloric acid → Hydrogen chloride

Hydrocyanic acid → Hydrogen cyanide

**Hydrogen bromide**

[10035-10-6] HBr  
 MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 6.7  
 Peak lim: I(1)  
 Preg gr: D

**Hydrogen chloride**

[7647-01-0] HCl  
 MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 3.0  
 Peak lim: I(2)  
 Preg gr: C

**Hydrogen cyanide**

[74-90-8] HCN  
 VP[hPa]: 800  
 MAK[ml/m<sup>3</sup>]: 1.9  
 MAK[mg/m<sup>3</sup>]: 2.1  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**Hydrogen fluoride**

[7664-39-3] HF  
 VP[hPa]: 1033  
 see Section XII  
 MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 0.83  
 Peak lim: I(2)  
 Preg gr: C

**Hydrogen peroxide**

[7722-84-1] H<sub>2</sub>O<sub>2</sub>  
 MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 0.71  
 Peak lim: I(1)  
 Preg gr: C  
 Carc cat: 4

**★ Hydrogen selenide**

[7783-07-5] H<sub>2</sub>Se  
 MAK[ml/m<sup>3</sup>]: 0.006  
 MAK[mg/m<sup>3</sup>]: 0.02  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 3

**Hydrogen sulfide**

[7783-06-4] H<sub>2</sub>S  
 MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 7.1  
 Peak lim: I(2)  
 Preg gr: C

α-Hydro-ω-hydroxy-poly[oxy(methyl-1,2-ethandiyl)] → Polypropylene glycol (PPG)

**Hydroquinone**

[123-31-9] 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.015  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3A

**Hydroxyacetic acid butyl ester**

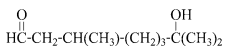
[7397-62-8] HO-CH<sub>2</sub>-CO-O-CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>3</sub>

see Section IIb  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

3-Hydroxyaniline → 3-Aminophenol

p-Hydroxyaniline → p-Aminophenol

**Hydroxycitronellal**

[107-75-5] 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: <1  
 see Section IV  
 Sens: Sh

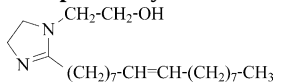
2-(2-Hydroxyethoxy)-ethylamine

→ 2-(2-Aminoethoxy)ethanol

2-Hydroxyethyl acrylate → Acrylic acid

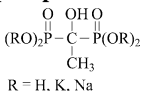
2-hydroxyethyl ester

**1-Hydroxyethyl-2-heptadecenyl-imidazoline**

[21652-27-7] 

see Section IIb and Xc  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

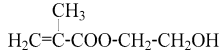
**1-Hydroxyethylidene-1,1-diphosphonic acid**

[2809-21-4]   
 and its sodium and potassium salts  
 R = H, K, Na

see Section IIb and Xc  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2-Hydroxyethyl methacrylate**

[868-77-9]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

N-(2-Hydroxyethyl)-3-methyl-2-quinoxaline-carboxamide 1,4-dioxide → Olaquinox  
 (N-(2-Hydroxyethyl)-3-methyl-2-quinoxaline-carboxamide 1,4-dioxide)

β-Hydroxyethyl phenylether  
 → 2-Phenoxyethanol

1-(2-Hydroxyethyl)piperidine  
 → N-(2-Hydroxyethyl)piperidine

**N-(2-Hydroxyethyl)piperidine**

[3040-44-6]



The substance can occur simultaneously as vapour and aerosol.

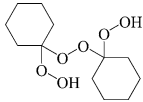
VP[hPa]: 0.217

see Section Xc

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 Peak lim: I(1)  
 A momentary value of 5 ml/m<sup>3</sup> (27 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D  
 Sens: Sh

**1-Hydroxy-1'-hydroperoxydicyclohexyl peroxide**

[78-18-2]



see Section Xa

**Hydroxylamine**

[7803-49-8]

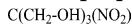
and its salts  
see Section IV

Sens: Sh

1-Hydroxy-2-methoxy-4-(1-propenyl)benzene  
 → Isoeugenol

**2-Hydroxymethyl-2-nitro-1,3-propanediol**

[126-11-4]



use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4"

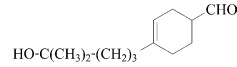
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

4-Hydroxy-4-methylpentan-2-one → Diacetone alcohol

**4-(4-Hydroxy-4-methyl pentyl)-3-cyclohexene-1-carboxaldehyde (Lyral)**

[31906-04-4]



see Section IV

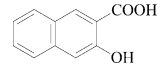
Sens: Sh

N-4-((2-Hydroxy-5-methylphenyl)azo)phenyl)acetamide → Disperse Yellow 3

1-(Hydroxymethyl)propylamine  
 → 2-Aminobutanol

**3-Hydroxy-2-naphthalenecarboxylic acid**

[92-70-6]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

3-Hydroxy-2-naphthoic acid  
 → 3-Hydroxy-2-naphthalenecarboxylic acid

4-Hydroxy-3-nitroaniline  
 → 2-Nitro-4-aminophenol

12-Hydroxyoctadecanoic acid  
 → 12-Hydroxystearic acid

3-Hydroxyphenol → Resorcinol

1-Hydroxy-2-phenoxyethane  
 → 2-Phenoxyethanol

2-Hydroxy-1,2,3-propanetricarboxylic acid  
 → Citric acid

Hydroxypropyl acrylate → Acrylic acid hydroxypropyl ester (all isomers)

2-Hydroxypropylamine → 1-Amino-2-propanol

2-Hydroxypropyl methacrylate → Methacrylic acid 2-hydroxypropyl ester

2-Hydroxypropyl 2-methyl-2-propenoate  
 → Methacrylic acid 2-hydroxypropyl ester

1-Hydroxy-2(1H)-pyridinethione sodium salt  
 → Sodium pyrrithione

**12-Hydroxystearic acid**[106-14-9]  $\text{H}_3\text{C}(\text{CH}_2)_5\text{CH}(\text{OH})(\text{CH}_2)_{10}\text{CO}_2\text{H}$ 

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Hydroxytoluene → Benzyl alcohol

1-Hydroxy-2,4,5-trichlorobenzene  
 → 2,4,5-Trichlorophenol

IBOA → Isobornyl acrylate

Idigbo (*Terminalia ivorensis*) → Woods

Imazalil

→ 1-(2-Allyloxy)-2-(2,4-dichlorophenyl)  
 ethyl)-1H-imidazole

**Imidazole**

[288-32-4]



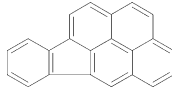
VP[hPa]:  $3.3 \times 10^{-3}$   
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

2-Imidazolidinethione → Ethylene thiourea  
 (Imidazoline-2-thione)

Incense cedar (*Calocedrus decurrens*) → Woods**Indenof[1,2,3-cd]pyrene**

[193-39-5]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Indian ebony (*Diospyros ebenum*) → Woods**Indium phosphide**

[22398-80-7]

InP

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**Iodine**

[7553-56-2]

I<sub>2</sub>

and inorganic iodides

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.31 at 25°C  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Iodomethane**

[74-88-4]

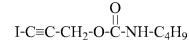
H<sub>3</sub>C I

VP[hPa]: 438

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**3-Iodo-2-propynyl butylcarbamate**

[55406-53-6]



The substance can occur simultaneously as vapour and aerosol.

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.005  
 MAK[mg/m<sup>3</sup>]: 0.058  
 Peak lim: I(2)  
 Preg gr: C  
 Sens: Sh

Ipe (*Tabebuia* spp.) → WoodsIpe peroba (*Paratecoma peroba*) → Woods

IPPD

→ N-Isopropyl-N'-phenyl-p-phenylenediamine

Iroko (*Chlorophora excelsa*) → Woods**Iron oxides**(inhalable fraction) FeO; Fe<sub>2</sub>O<sub>3</sub>

[1345-25-1; 1309-37-1; 1309-38-2; 1317-61-9]

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

with the exception of iron oxides which are not biologically available

**Iron pentacarbonyl**

[13463-40-6]

Fe(CO)<sub>5</sub>

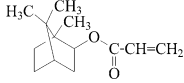
MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.81  
 Peak lim: I(2)  
 Preg gr: D  
 Perc abs: H

Isatoic anhydride → N-Carboxyanthranilic anhydride

Isoamyl alcohol (3-Methyl-1-butanol)  
→ Pentanol (isomers)

### Isobornyl acrylate

[5888-33-5]



see Section IV

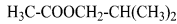
Sens: Sh

Isobutane → Butane (both isomers)

Isobutenyl chloride  
→ 3-Chloro-2-methylpropene

### Isobutyl acetate

[110-19-0]

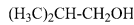


VP[hPa]: 18

MAK[ml/m<sup>3</sup>]: 100  
MAK[mg/m<sup>3</sup>]: 480  
Peak lim: I(2)  
Preg gr: C

### Isobutanol

[78-83-1]

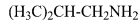


VP[hPa]: 11.7

MAK[ml/m<sup>3</sup>]: 100  
MAK[mg/m<sup>3</sup>]: 310  
Peak lim: I(1)  
Preg gr: C

### ★ Isobutylamine

[78-81-9]



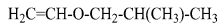
MAK[ml/m<sup>3</sup>]: 2  
MAK[mg/m<sup>3</sup>]: 6.1  
Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
Peak lim: I(2)  
A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.  
Preg gr: D

Isobutyl chloroformate → Chloroformic acid butyl ester

Isobutyl phosphate → Triisobutyl phosphate

### Isobutyl vinyl ether

[109-53-5]



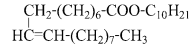
MAK[ml/m<sup>3</sup>]: 20  
MAK[mg/m<sup>3</sup>]: 83  
Peak lim: I(1)  
Preg gr: D

Isocyanatobenzene → Phenyl isocyanate

Isocyanic acid p-chlorophenyl ester  
→ 4-Chlorophenyl isocyanate

### Isodecyl oleate

[59231-34-4]

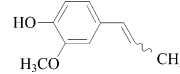


see Section Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: 5 R  
Peak lim: II(4)  
Preg gr: D

### Isoeugenol

[97-54-1]



The substance can occur simultaneously as vapour and aerosol.

see Section IV

Sens: Sh

– **trans-Isoeugenol**

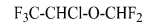
[5932-68-3]

– **cis-Isoeugenol**

[5912-86-7]

### Isoflurane

[26675-46-7]



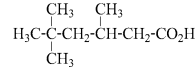
VP[hPa]: 320

MAK[ml/m<sup>3</sup>]: 2  
MAK[mg/m<sup>3</sup>]: 15  
Peak lim: II(8)  
Preg gr: D

### Isononanoic acid

[3302-10-1]

[26896-18-4]



The substance can occur simultaneously as vapour and aerosol.

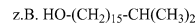
VP[hPa]: 0.04

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

### Isooctadecanol

[27458-93-1]



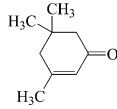
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Isoptane → Pentane (all isomers)

**Isophorone**

[78-59-1]



The substance can occur simultaneously as vapour and aerosol.

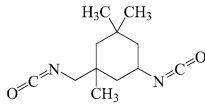
VP[hPa]: 0.33

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 Peak lim: I(2)  
 Preg gr: C  
 Carc cat: 3

Isophorone diamine → 3-Aminomethyl-3,5,5-trimethyl-cyclohexylamine (Isophorone diamine)

**Isophorone diisocyanate**

[4098-71-9]



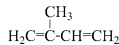
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 4×10<sup>-4</sup>

MAK[ml/m<sup>3</sup>]: 0.005  
 MAK[mg/m<sup>3</sup>]: 0.046  
 Peak lim: I(1)  
 A momentary value of 0.01 ml/m<sup>3</sup> (0.092 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: D  
 Sens: Sah

**Isoprene (2-Methyl-1,3-butadiene)**

[78-79-5]



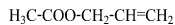
VP[hPa]: 733

MAK[ml/m<sup>3</sup>]: 3  
 MAK[mg/m<sup>3</sup>]: 8.5  
 see definition of Carcinogen Category 5 and supporting documentation  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 5  
 Muta cat: 5

Isopropanolamine → 1-Amino-2-propanol

**Isopropenyl acetate**

[108-22-5]

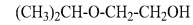


MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 46  
 Peak lim: I(2)  
 Preg gr: D

Isopropenylbenzene →  $\alpha$ -Methyl styrene

**2-Isopropoxyethanol**

[109-59-1]



MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 43  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

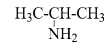
2-Isopropoxyphenyl N-methylcarbamate  
 → Propoxur

Isopropyl acetate → Propylacetate

Isopropyl alcohol → 2-Propanol

**★ Isopropylamine**

[75-31-0]



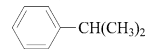
VP[hPa]: 637

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 12  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 10 ml/m<sup>3</sup> (25 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C

Isopropylated triphenyl phosphate → Triphenyl phosphate, isopropylated

**Isopropylbenzene (cumene)**

[98-82-8]



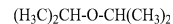
VP[hPa]: 4

see Section XII

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 50  
 Peak lim: II(4)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 3

**Isopropyl ether**

[108-20-3]

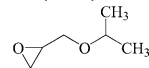


VP[hPa]: 180

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 850  
 Peak lim: I(2)  
 Preg gr: C

**Isopropyl glycidyl ether (IGE)**

[4016-14-2]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

4,4'-Isopropylidenediphenol → Bisphenol A

4,4'-Isopropylidenediphenol diglycidyl ether  
→ Bisphenol A diglycidyl ether

4-Isopropylnitrobenzene → p-Nitrocumene

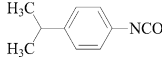
### Isopropyl oil

residue of isopropyl alcohol production

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

### 4-Isopropylphenyl isocyanate

[31027-31-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh

### N-Isopropyl-N'-phenyl-p-phenylenediamine

[101-72-4]



MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: II(2)  
Preg gr: C  
Sens: Sh

Isostearyl alcohol → Isooctadecanol

### Isotridecanol

[27458-92-0]

see Section IIb and Xc

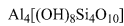
MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Isotridecyl alcohol → Isotridecanol

Kambala (*Chlorophora excelsa*) → Woods

### Kaolinite

[1332-58-7]



quartz content must be considered separately

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

Kepona → Chlordecone

### Kerosine (petroleum)

(aerosol)  
[8008-20-6]  
see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
Peak lim: II(4)  
Preg gr: C  
Carc cat: 3  
applies to skin contact

### Kerosine (petroleum)

(vapour)  
[8008-20-6]  
see Section Xc

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 350  
Peak lim: II(2)  
Preg gr: C  
Carc cat: 3  
applies to skin contact

### Ketene

[463-51-4]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

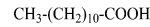
Khaya spp. → Woods

Lapacho (*Tabebuia avellaneda*) → Woods

Laughing gas → Nitrous oxide

### Lauric acid

[143-07-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $2.3 \times 10^{-5}$  at 25°C

see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: I(2)  
Preg gr: D

Lauryl alcohol → 1-Dodecanol

Laurylamine dipropylenediamine → N-(3-Aminopropyl)-N-dodecylpropane-1,3-diamine

### Lead

[7439-92-1]

Pb

and its inorganic compounds  
(inhalable fraction)

except lead arsenate and lead chromate

see Section XII

MAK[mg/m<sup>3</sup>]: 0.004 I  
Peak lim: II(8)  
Preg gr: A  
Carc cat: 4  
Muta cat: 3A

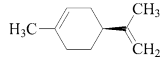
Lead arsenate → Arsenic

Lead chromate → Chromium(VI) compounds and

Limba (*Terminalia superba*) → Woods

### D-Limonene

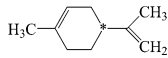
[5989-27-5]



MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 28  
 Peak lim: II(4)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

### D,L-Limonene

[138-86-3]  
 and similar mixtures

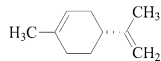


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

### L-Limonene

[5989-54-8]

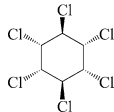


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

### Lindane (γ-1,2,3,4,5,6-Hexachlorocyclohexane)

[58-89-9]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $5.6 \times 10^{-5}$   
 see Section XII

MAK[mg/m<sup>3</sup>]: 0.1 I  
 Peak lim: II(8)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

### Lithium

[7439-93-2]

and highly irritating lithium compounds (as lithium amide, hydride, hydroxide, nitride, oxide, tetrahydroaluminate, tetrahydroborate)  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Li

### Lithium compounds, inorganic

(as Li [7439-93-2]) except for lithium and highly irritating lithium compounds (as lithium amide, hydride, hydroxide, nitride, oxide, tetrahydroaluminate, tetrahydroborate)

MAK[mg/m<sup>3</sup>]: 0.2 I  
 Peak lim: I(1)  
 Preg gr: C

### Lithium-12-hydroxystearate

[7620-77-1]

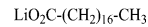


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

### Lithium stearate

[4485-12-5]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

### Lubricants

Lubricants contain mixtures of hydrocarbons which can occur as particle-vapour mixtures because of their composition.

see Section Xc

Lyral → 4-(4-Hydroxy-4-methylpentyl)-3-cyclohexene-1-carboxaldehyde (Lyral)

Macassar ebony (*Diospyros celebica*) → Woods

Machaerium scleroxylon → Woods

### Magnesium oxide

[1309-48-4]

MgO

(inhalable fraction)  
 see Section Vf and g

MAK[mg/m<sup>3</sup>]: 4 I  
 Preg gr: C

### Magnesium oxide

[1309-48-4]

MgO

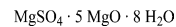
(respirable fraction)

except for ultrafine particles; see Section Vh  
 see Section Vf

MAK[mg/m<sup>3</sup>]: 0.3  
 multiplied with the material density  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 4

### Magnesium oxide sulfate

[12286-12-3]



(fibrous dust)  
 see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3



**Magnesium oxide fume**

[1309-48-4]

MgO

see Section IIb and Vh

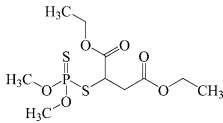
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Mahogany, African (*Khaya* spp.) → Woods

Mahogany, American (*Swietenia* spp.)  
 → Woods

Makoré (*Tieghemella heckelii*) → Woods★ **Malathion**

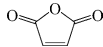
[121-75-5]



see Section IIc

**Maleic anhydride**

[108-31-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.151

MAK[ml/m<sup>3</sup>]: 0.02  
 MAK[mg/m<sup>3</sup>]: 0.081  
 Peak lim: I(1)  
 A momentary value of 0.05 ml/m<sup>3</sup> (0.20 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C  
 Sens: Sah

**Manganese**

[7439-96-5]

Mn

and its inorganic compounds  
 (inhalable fraction)  
 see Section XII

MAK[mg/m<sup>3</sup>]: 0.2 I  
 Peak lim: II(8)  
 Permanganates: Peak limitation category II(1)  
 Preg gr: C

Manganese(II,III) oxide → Manganese

**Manganese**

[7439-96-5]

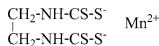
Mn

and its inorganic compounds  
 (respirable fraction)  
 see Section XII

MAK[mg/m<sup>3</sup>]: 0.02 R  
 Peak lim: II(8)  
 Permanganates: Peak limitation category II(1)  
 Preg gr: C

**Manganese ethylenebis(dithiocarbamate) (Maneb)**

[12427-38-2]



see Section IV

Sens: Sh

Manganous-manganic oxide → Manganese

**Man-made mineral fibres (fibrous dust)**

see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Pruno (*Mansonia altissima*) → Woods

Mansonia altissima → Woods

Mastic asphalt → Bitumen (high-temperature processing, vapours and aerosols)

MBT → 2-Mercaptobenzothiazole

MDI → 4,4'-Methylene diphenyl diisocyanate (MDI)

MDI oligomers → "polymeric MDI"

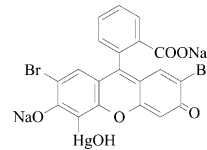
Mechlorethamine → N-Methyl-bis  
 (2-chloroethyl)amine (nitrogen mustard)

**Medicines, carcinogenic**

see Section III

**Merbromin**

[129-16-8]



see Section IV

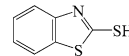
Sens: Sh

2-Mercaptoacetates → Thioglycolates

Mercaptoacetic acid → Thioglycolic acid

**2-Mercaptobenzothiazole**

[149-30-4]



VP[hPa]: <math>2.53 \times 10^{-6}</math> at 25°C  
 see Section Xc

MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh  
 Carc cat: 3

2-Mercaptobenzothiazole disulfide

→ 2,2'-Dibenzothiazyl disulfide

2-Mercaptoimidazoline → Ethylene thiourea  
 (Imidazoline-2-thione)

**Mercury**

[7439-97-6]  
and its inorganic compounds (as Hg)

Hg

see Section XII

MAK[mg/m<sup>3</sup>]: 0.02 I  
Peak lim: II(8)  
Preg gr: D  
Perc abs: H  
Sens: Sh  
Carc cat: 3

**Mercury, organic compounds**

see Section XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sh  
Carc cat: 3

Mesitylene (1,3,5-Trimethylbenzene)  
→ Trimethylbenzene (all isomers)

Mesityl oxide → 4-Methyl-3-penten-2-one

**Metal-working fluids**

Metal-working fluids contain mixtures of hydrocarbons which can occur as particle-vapour mixtures as a result of their composition.

see Section Xc

**Metal-working fluids which contain nitrite or nitrite-forming compounds and substances which react with nitrite to yield nitrosamines**

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

**Methacrylic acid**

[79-41-4]

H2C=C(CH3)-COOH

VP[hPa]: 0.9

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 180  
Peak lim: I(2)  
Preg gr: C

**Methacrylic acid ethyl ester**

[97-63-2]

H2C=C(CH3)-COOCH2-CH3

see Section IV

Sens: Sh

Methacrylic acid 2-hydroxyethyl ester  
→ 2-Hydroxyethyl methacrylate

**Methacrylic acid 2-hydroxypropyl ester**

[923-26-2]

H2C=C(CH3)-CO-O-CH2-CH(OH)-CH3

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.096 at 25°C (calculated value)  
see Section IV

Sens: Sh

**★ Methacrylic acid methyl ester**

[80-62-6]

H2C=C(CH3)-COOCH3

VP[hPa]: 47

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 210  
Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
Peak lim: I(2)  
Preg gr: C  
Sens: Sh

N,N'-Methanetetraylbis(cyclohexyl)amine  
→ Dicyclohexylcarbodiimide

**★ Methanethiol**

[74-93-1]

H3CSH

VP[hPa]: 1710

MAK[ml/m<sup>3</sup>]: 0.5  
MAK[mg/m<sup>3</sup>]: 1.0  
Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
Peak lim: I(1)  
Preg gr: D

**Methanol**

[67-56-1]

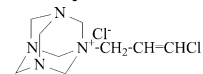
H3COH

VP[hPa]: 128  
see Section XII

MAK[ml/m<sup>3</sup>]: 100  
MAK[mg/m<sup>3</sup>]: 130  
Peak lim: II(2)  
Preg gr: C  
Perc abs: H

**Methenamine 3-chloroallylchloride**

[4080-31-3]



releases formaldehyde

see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: II(2)  
Preg gr: B  
Sens: Sh

**Methoxyacetic acid**

[625-45-6]

H3C-O-CH2-COOH

VP[hPa]: 1.8

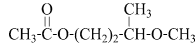
MAK[ml/m<sup>3</sup>]: 1  
MAK[mg/m<sup>3</sup>]: 3.7  
Peak lim: II(2)  
Preg gr: B  
Perc abs: H

2-Methoxyaniline → o-Anisidine

4-Methoxyaniline → p-Anisidine

### 3-Methoxy-n-butyl acetate

[4435-53-4]



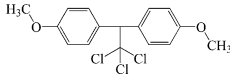
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

2-Methoxycarbonyl-1-methylvinyl dimethyl phosphate → Mevinphos

### Methoxychlor (DMDT)

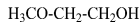
[72-43-5]



MAK[mg/m<sup>3</sup>]: 1 I  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

### 2-Methoxyethanol

[109-86-4]



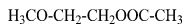
VP[hPa]: ~ 11  
 see Section XII

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.2  
 MAK value applies for the sum of the concentrations of 2-methoxyethanol and 2-methoxyethyl acetate in the air.  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

2-[2-(2-Methoxyethoxy)ethoxy]ethanol  
 → Triethylene glycol monomethyl ether

### 2-Methoxyethyl acetate

[110-49-6]



VP[hPa]: 9  
 see Section XII

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 4.9  
 MAK value applies for the sum of the concentrations of 2-methoxyethanol and 2-methoxyethyl acetate in the air.  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

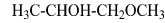
2-Methoxy-5-methylaniline  
 → 5-Methyl-o-anisidine

2-Methoxy-2-methylpropane → tert-Butyl methyl ether

1-Methoxy-2-nitrobenzene → 2-Nitroanisole

### 1-Methoxy-2-propanol

[107-98-2]



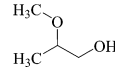
VP[hPa]: 12  
 see Section XII

MAK[ml/m<sup>3</sup>]: 100  
 MAK[mg/m<sup>3</sup>]: 370  
 Peak lim: I(2)  
 Preg gr: C

2-Methoxy-1-propanol  
 → 2-Methoxypropanol-1

### 2-Methoxypropanol-1

[1589-47-5]



VP[hPa]: 6

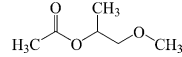
MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 19  
 MAK value applies for the sum of the concentrations of 2-methoxypropanol-1 and 2-methoxypropylacetate-1 in the air.  
 Peak lim: I(2)  
 Preg gr: B  
 Perc abs: H

2-Methoxy-4-(2-propenyl)phenol → Eugenol

2-Methoxy-4-(1-propenyl)phenol → Isoeugenol

### 1-Methoxypropyl-2-acetate

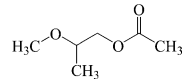
[108-65-6]



MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 270  
 Peak lim: I(1)  
 Preg gr: C

### 2-Methoxypropylacetate-1

[70657-70-4]



VP[hPa]: 4.17 at 25°C

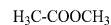
MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 27  
 MAK value applies for the sum of the concentrations of 2-methoxypropanol-1 and 2-methoxypropylacetate-1 in the air.  
 Peak lim: I(2)  
 Preg gr: B  
 Perc abs: H

2-Methoxypropyl-1-acetate  
 → 2-Methoxypropylacetate-1

2-Methyl-2,4-pentanediol → Hexylene glycol

### Methyl acetate

[79-20-9]



VP[hPa]: 220

MAK[ml/m<sup>3</sup>]: 100  
 MAK[mg/m<sup>3</sup>]: 310  
 Peak lim: I(4)  
 Preg gr: C

**Methyl acetylene**

[74-99-7]

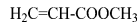


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**★ Methyl acrylate**

[96-33-3]



VP[hPa]: 89

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 7.1  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

Methylal → Dimethoxymethane

Methyl alcohol → Methanol

2-Methylallyl chloride

→ 3-Chloro-2-methylpropene

**★ Methylamine**

[74-89-5]



MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 6.4  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 10 ml/m<sup>3</sup> (13 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C

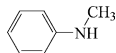
1-Methyl-2-amino-5-chlorobenzene

→ 4-Chloro-o-toluidine

4-Methylanilin → p-Toluidine

**N-Methylaniline**

[100-61-8]

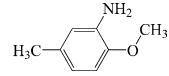


Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosomethylaniline, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 2.2  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 3

**5-Methyl-o-anisidine**

[120-71-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.033 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

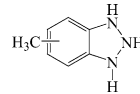
**Methylarsenic compounds**

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1  
 Muta cat: 3A

Methyl benzimidazol-2-ylcarbamate  
 → Carbendazim

**Methyl-1H-benzotriazole**

[29385-43-1]

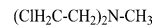


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**N-Methyl-bis(2-chloroethyl)amine (nitrogen mustard)**

[51-75-2]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 1  
 Muta cat: 2

**Methyl bromide**

[74-83-9]



see Section XII

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.9  
 Peak lim: I(2)  
 Preg gr: C  
 Carc cat: 3

2-Methyl-1,3-butadiene → Isoprene  
 (2-Methyl-1,3-butadiene)

1-Methylbutyl acetate → Amyl acetate (all isomers)

2-Methylbutyl acetate → Amyl acetate (all isomers)

3-Methylbutyl acetate → Amyl acetate (all isomers)

Methyl-tert-butyl ether → tert-Butyl methyl ether

Methyl butyl ketone → 2-Hexanone

Methyl chloride → Chloromethane

Methyl chloroacetate → Chloroacetic acid methyl ester

Methyl chloroform → 1,1,1-Trichloroethane

Methyl chloroformate → Chloroformic acid methyl ester

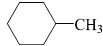
### Methyl 2-cyanoacrylate

[137-05-3]  $H_2C=CCN-CO-OCH_3$

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 9.2  
 Peak lim: I(1)  
 Preg gr: D

### Methylcyclohexane

[108-87-2]



VP[hPa]: 48

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 810  
 Peak lim: II(2)  
 Preg gr: D

### Methylcyclohexanol (all isomers)

[25639-42-3]

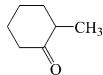


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

### 1-Methylcyclohexan-2-one

[583-60-8]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Methylcyclopentane → Hexane (all isomers except n-Hexane) and Methylcyclopentane

Methyl demeton → Demeton-methyl

### Methyldiethanolamine

[105-59-9]  $H_3C-N(CH_2-CH_2OH)_2$

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $2.7 \times 10^{-4}$  at 25°C  
 see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

### 4-Methyl-1,3-dioxolan-2-one

[108-32-7]



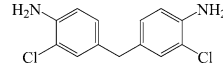
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.04  
 see Section Xc

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 8.5  
 Peak lim: I(1)  
 Preg gr: C

### 4,4'-Methylenebis(2-chloroaniline) (MOCA)

[101-14-4]



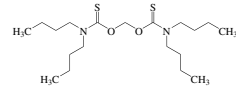
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Methylene bis(4-cyclohexylisocyanate)  
 → 4,4'-Diisocyanato-methylenedicyclohexane

### Methylenebis(dibutylthiocarbamate)

[10254-57-6]

(inhalable fraction)



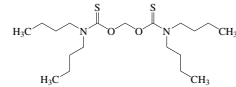
see Section Xc

MAK[mg/m<sup>3</sup>]: 20 I  
 Peak lim: II(8)  
 Preg gr: D

### Methylenebis(dibutylthiocarbamate)

[10254-57-6]

(respirable fraction)

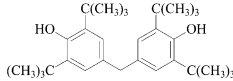


see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: D

**4,4'-Methylenebis(2,6-di-tert-butylphenol)**

[118-82-1]



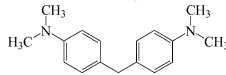
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

4,4'-Methylenebis(N,N-diglycidylaniline)  
 → Tetraglycidyl-4,4'-methylenedianiline

**4,4'-Methylenebis(N,N-dimethylaniline)**

[101-61-1]

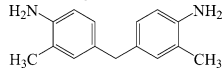


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

4,4'-Methylenebis(N,N-dimethyl)benzenamine  
 → 4,4'-Methylenebis(N,N-dimethylaniline)

**4,4'-Methylenebis(2-methylaniline)**

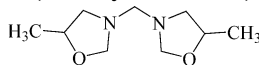
[838-88-0]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**N,N'-Methylenebis(5-methyloxazolidine)**

[66204-44-2]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

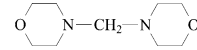
2,2'-(Methylenebis(p-phenyleneoxymethylene))  
 bisoxirane → Bisphenol F diglycidyl ether

Methylene chloride → Dichloromethane

4,4'-Methylene dianiline  
 → 4,4'-Diaminodiphenylmethane

**4,4'-Methylenedimorpholine**

[5625-90-1]



releases formaldehyde

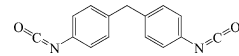
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

**4,4'-Methylene diphenyl diisocyanate (MDI)**

[101-68-8]

(inhalable fraction) see

also  
"polymeric MDI"

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 7×10<sup>-6</sup>

see Section XII

MAK[mg/m<sup>3</sup>]: 0.05 I

Peak lim: I(1)

A momentary value of 0.1 mg/m<sup>3</sup> should not be exceeded.

Preg gr: C  
 Perc abs: H  
 Sens: Sah  
 Carc cat: 4

Methyl ether → Dimethyl ether

2-(1-Methylethoxy)ethanol

→ 2-Isopropoxyethanol

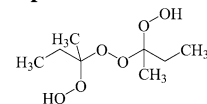
4,4'-(1-Methylethylidene)bisphenol

→ Bisphenol A

Methyl ethyl ketone → 2-Butanone

**Methyl ethyl ketone peroxide**

[1338-23-4]



see Section Xa

Methyl ethyl ketoxime → Butanone oxime

1-(1-Methylethyl)-4-nitrobenzene

→ p-Nitrocumene

N,N-Methylethylnitrosoamine

→ N-Nitrosomethylethylamine

N-(1-Methylethyl)-N'-phenyl-1,4-benzene-diamine

→ N-Isopropyl-N'-phenyl-p-phenylenediamine

Methyl formate → Formic acid methyl ester

Methyl glycol → 2-Methoxyethanol

Methyl glycol acetate → 2-Methoxyethyl acetate

### 5-Methyl-3-heptanone

[541-85-5]  $\text{CH}_3\text{-CH}_2\text{-CO-CH}_2\text{-CH(CH}_3\text{)-CH}_2\text{-CH}_3$

VP[hPa]: 2.4

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 53  
 Peak lim: I(2)  
 Preg gr: D

### Methyl-2-hexanone

[110-12-3]  $\text{CH}_3\text{-CO-CH}_2\text{-CH}_2\text{-CH}_2\text{(CH}_3\text{)}_2$

VP[hPa]: 6

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 47  
 Peak lim: I(2)  
 Preg gr: D

Methyl isobutyl carbinol  
 → 4-Methyl-2-pentanol

Methyl isobutyl ketone  
 → 4-Methyl-2-pentanone

### Methyl isocyanate

[624-83-9]  $\text{H}_3\text{C-NCO}$

VP[hPa]: 513

MAK[ml/m<sup>3</sup>]: 0.01  
 MAK[mg/m<sup>3</sup>]: 0.024  
 Peak lim: I(1)  
 Preg gr: D

### 2-Methyl-4-isothiazolin-3-one

[2682-20-4]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

2-Methyl-4-isothiazolin-3-one → 5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one

### 2-Methylisothiazolone

→ 2-Methyl-4-isothiazolin-3-one

Methyl mercaptan → Methanethiol

Methyl mercury → Mercury, organic compounds

Methyl methacrylate → Methacrylic acid methyl ester

2-Methyl-4-[(2-methylphenyl)azo]benzenamine  
 → o-Aminoazotoluene

N-Methyl-1-naphthyl carbamate → Carbaryl (1-Naphthyl methylcarbamate)

1-Methyl-3-nitrobenzene → 3-Nitrotoluene

1-Methyl-4-nitrobenzene → 4-Nitrotoluene

2,2'-[[3-Methyl-4-[(4-nitrophenyl)azo]phenyl]-imino]bisethanol → Disperse Red 17

N-Methyl-N-nitrosoaniline

→ N-Nitrosomethylphenylamine

(Z)-N-Methyl-N-(1-oxo-9-octadecenyl)glycine  
 → Oleyl sarcosine

2-Methylpentane → Hexane (all isomers except n-Hexane) and Methylcyclopentane

3-Methylpentane → Hexane (all isomers except n-Hexane) and Methylcyclopentane

2-Methyl-2,4-pentanediol → Hexylene glycol

### 4-Methyl-2-pentanol

[108-11-2]  $(\text{H}_3\text{C})_2\text{CH-CH}_2\text{-CHOH-CH}_3$

VP[hPa]: 7

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 85  
 Peak lim: I(1)  
 Preg gr: D

### 4-Methyl-2-pentanone

[108-10-1]  $(\text{H}_3\text{C})_2\text{CH-CH}_2\text{-CO-CH}_3$

VP[hPa]: 21

see Section XII

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 83  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

2-Methyl-2-penten-4-one

→ 4-Methyl-3-penten-2-one

### 4-Methyl-3-penten-2-one

[141-79-7]  $(\text{H}_3\text{C})_2\text{C=CH-CO-CH}_3$

VP[hPa]: 19.31 at 25°C

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 8.1  
 Peak lim: I(2)  
 Preg gr: D  
 Perc abs: H

2-[(2-Methylphenoxy)-methyl]oxirane  
 → Cresyl glycidyl ethers

4-Methylphenyl diiodomethyl sulfone  
 → 4-(Diiodomethylsulfonyl)-toluene

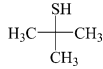
Methylphenyl diphenyl phosphate → Diphenyl cresyl phosphate

6-[(4-Methylphenyl)sulfonylamino]hexanoic acid → N-Tosyl-6-aminocaproic acid

2-Methyl-1-propanamine → Isobutylamine

### 2-Methyl-2-propanethiol

[75-66-1]



VP[hPa]: 241

MAK[ml/m<sup>3</sup>]: 1

MAK[mg/m<sup>3</sup>]: 3.7

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: II(2)

Preg gr: C

Perc abs: H

Sens: Sh

2-Methyl-2-propenoic acid 1,2-ethanediyl ester → Ethylene glycol dimethacrylate

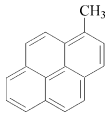
2-Methyl-2-propenoic acid 2-hydroxyethyl ester → 2-Hydroxyethyl methacrylate

2-Methyl-2-propenoic acid 2-hydroxypropyl ester → Methacrylic acid 2-hydroxypropyl ester

Methyl propyl ketone → 2-Pentanone

### 1-Methylpyrene

[2381-21-7]



see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

### N-Methyl-2-pyrrolidone

[872-50-4]

(vapour)



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.32

see Section XII

MAK[ml/m<sup>3</sup>]: 20

MAK[mg/m<sup>3</sup>]: 82

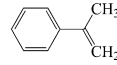
Peak lim: I(2)

Preg gr: C

Perc abs: H

### α-Methyl styrene

[98-83-9]



VP[hPa]: 3

MAK[ml/m<sup>3</sup>]: 50

MAK[mg/m<sup>3</sup>]: 250

Peak lim: I(2)

Preg gr: D

### Methyl styrene (all isomers)

[25013-15-4]

2-Methylstyrene [611-15-4]

3-Methylstyrene [100-80-1]

4-Methylstyrene [622-97-9]

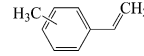
VP[hPa]: 1.5-2

MAK[ml/m<sup>3</sup>]: 20

MAK[mg/m<sup>3</sup>]: 98

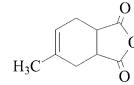
Peak lim: I(2)

Preg gr: D



### Methyltetrahydrophthalic anhydride

[11070-44-3]

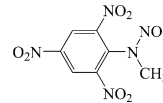


see Section IV

Sens: Sa

### N-Methyl-N,2,4,6-tetranitroaniline

[479-45-8]



MAK[ml/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Sens: Sh

Carc cat: 3



**Methyltin compounds**

(as Sn [7440-31-5])

– **Monomethyltin compounds**

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.004MAK[mg/m<sup>3</sup>]: 0.02

Peak lim: I(1)

Preg gr: C

Sens: –

For methyltin compounds whose organic ligands were already designated with “Sa” or “Sh”, these designations also apply.

– **except**– **Methyltin tris(isooctylmercaptoacetate) (MMT (IOMA)<sub>3</sub>)**

[54849-38-6]

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.02 at 25°C

MAK[ml/m<sup>3</sup>]: 0.2MAK[mg/m<sup>3</sup>]: 1

Peak lim: II(2)

Preg gr: B

Sens: –

For methyltin compounds whose organic ligands were already designated with “Sa” or “Sh”, these designations also apply.

– **a n d**– **Bis[methyltin di(isooctylmercaptoacetate)]sulfide**– **a n d**– **Bis[methyltin di(2-mercaptoethyleolate)]sulfide**

[59118-99-9]

– **Dimethyltin compounds**

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.004MAK[mg/m<sup>3</sup>]: 0.02

Peak lim: I(1)

Preg gr: C

Sens: –

For methyltin compounds whose organic ligands were already designated with “Sa” or “Sh”, these designations also apply.

– **except**– **Dimethyltin bis(isooctylmercaptoacetate) (DMT (IOMA)<sub>2</sub>)**

[26636-01-1]

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $4.4 \times 10^{-3}$  at 25°CMAK[ml/m<sup>3</sup>]: 0.01MAK[mg/m<sup>3</sup>]: 0.05

Peak lim: II(2)

Preg gr: C

Sens: –

For methyltin compounds whose organic ligands were already designated with “Sa” or “Sh”, these designations also apply.

– **a n d**– **Dimethyltin bis(2-ethylhexylmercaptoacetate) (DMT (2-EHMA)<sub>2</sub>)**

[57583-35-4]

VP[hPa]:  $4.4 \times 10^{-3}$  at 25°C– **a n d**– **Bis[dimethyltin(isooctylmercaptoacetate)]sulfide**– **a n d**– **Bis[dimethyltin(2-mercaptoethyleolate)]sulfide**– **Trimethyltin compounds**

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.001MAK[mg/m<sup>3</sup>]: 0.005

Peak lim: II(4)

Preg gr: D

Perc abs: H

Sens: –

For methyltin compounds whose organic ligands were already designated with “Sa” or “Sh”, these designations also apply.

– **Tetramethyltin**

[594-27-4]

(CH<sub>3</sub>)<sub>4</sub>Sn

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 147 at 25°C

MAK[ml/m<sup>3</sup>]: 0.001MAK[mg/m<sup>3</sup>]: 0.005

Peak lim: II(4)

Preg gr: D

Perc abs: H

Methyl tribromide → Tribromomethane

Methyltriglycol → Triethylene glycol monomethyl ether

**Methyl vinyl ether**

[107-25-5]

H<sub>2</sub>C=CH-O-CH<sub>3</sub>

VP[hPa]: 1756

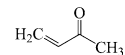
MAK[ml/m<sup>3</sup>]: 200MAK[mg/m<sup>3</sup>]: 480

Peak lim: II(2)

Preg gr: C

**Methyl vinyl ketone**

[78-94-4]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

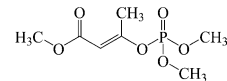
Preg gr: –

Perc abs: H

Sens: Sh

★ **Mevinphos**

[7786-34-7]



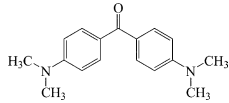
see documentation “Phosdrin”. The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.7 \times 10^{-4}$ 

see Section IIc

**Michler's ketone**

[90-94-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**Microbial rennets: endothiapsin and mucorpepsin**

see Section IV

Sens: Sa

**Mineral oils (petroleum), severely refined**

[92062-35-6; 72623-83-7; 92045-44-8; 92045-45-9]

MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: C

**Mist**

see Section V

Molybdocene dichloride → Molybdenum

**Molybdenum**

[7439-98-7]

Mo

and its compounds apart from  
 molybdenum trioxide  
 see Section IIb and XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Molybdenum(VI) oxide → Molybdenum trioxide

**Molybdenum trioxide**

[1313-27-5]

MoO<sub>3</sub>

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

Molybdic anhydride → Molybdenum trioxide

Molybdic trioxide → Molybdenum trioxide

**Monochloroacetic acid**

[79-11-8]

ClCH<sub>2</sub>-COOH

see also Sodium  
 monochloroacetate

The substance can occur simultaneously as vapour and  
 aerosol. See also Sodium monochloroacetate.

VP[hPa]: 0.021

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 2.0  
 Peak lim: I(2)  
 Preg gr: C

Monochlorodifluoromethane

→ Chlorodifluoromethane (FC-22)

**Monochlorodimethyl ether**

[107-30-2]

H<sub>3</sub>C-O-CH<sub>2</sub>Cl

The classification in Category 1 applies to technical  
 monochlorodimethyl ether which can be contaminated with  
 up to 7% bischloromethyl ether.

VP[hPa]: 213

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 1

Monochloronaphthalenes → Chlorinated naphthalenes

**Monocyclic aromatic amino and nitro compounds**

see Section III

Monoisopropanolamine → 1-Amino-2-propanol

**Monomethylhydrazine**

[60-34-4]

H<sub>3</sub>C-NH-NH<sub>2</sub>

VP[hPa]: 66.66 at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3B

Monomethyltin compounds → Methyltin compounds

Mono-n-octyltin compounds → n-Octyltin compounds

**Montmorillonite**

[1318-93-0]

Na<sub>0,33</sub>(Al<sub>1,67</sub>Mg<sub>0,33</sub>)(OH)<sub>2</sub>[Si<sub>4</sub>O<sub>10</sub>] · nH<sub>2</sub>O

and Bentonite [1302-78-9]

quartz content must be considered separately

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

★ **Morpholine**

[110-91-8]



Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosomorpholine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 9.8

MAK[ml/m<sup>3</sup>]: 5MAK[mg/m<sup>3</sup>]: 18

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(1)

A momentary value of 10 ml/m<sup>3</sup> (36 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

**2-(Morpholiniothio)benzothiazole**

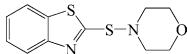
→ 2-(4-Morpholinylmercapto)benzothiazole

**Morpholinyl carbonyl chloride**

→ N-Chloroformylmorpholine

**2-(4-Morpholinylmercapto)benzothiazole**

[102-77-2]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

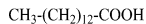
Sens: Sh

**Mucorpepsin → Microbial rennets:**

endothiapsin and mucorpepsin

**Myristic acid**

[544-63-8]



see Section IIb and Xc

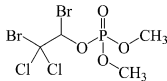
MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Naled**

[300-76-5]

MAK[mg/m<sup>3</sup>]: 0.5 I

Peak lim: II(2)

Preg gr: C

Perc abs: H

Sens: Sh

**Naphtha (petroleum)**

hydrotreated, heavy

[64742-48-9]

see Section Xc

MAK[ml/m<sup>3</sup>]: 50MAK[mg/m<sup>3</sup>]: 300

Peak lim: II(2)

Preg gr: D

**Naphthalene → Decahydronaphthalene****Naphthalene**

[91-20-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.072

see Section III, "pyrolysis products of organic materials"

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

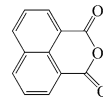
Perc abs: H

Carc cat: 2

Muta cat: 3B

**1,8-Naphthalic anhydride**

[81-84-5]



see Section IV

Sens: Sh

**Naphthenic acids and sodium, calcium, potassium naphthenates**

[1338-24-5; 61790-13-4; 61789-36-4; 66072-08-0]

(technical mixtures)

see Section Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

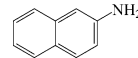
Peak lim: –

Preg gr: –

Carc cat: 3

**2-Naphthylamine**

[91-59-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3.4×10<sup>-4</sup> at 25°C

see Section XII

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

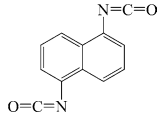
Perc abs: H

Carc cat: 1

Muta cat: 3A

**1,5-Naphthylene diisocyanate**

[3173-72-6]



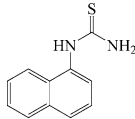
The substance can occur simultaneously as vapour and aerosol.

see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sa  
 Carc cat: 3

**1-Naphthylthiourea**

[86-88-4]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

Natural latex → Natural rubber latex

Natural rubber → Natural rubber latex

**Natural rubber latex**

[9006-04-6]

see Section IV

Sens: Sah

**Nemalite**

[1317-43-7]

(fibrous dust)

see Section III

Mg(OH)<sub>2</sub>

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Nickel and nickel compounds**

(inhalable fraction)

Regarding compounds which have been found to be unequivocally carcinogenic in man, see documentation. see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sah  
 There is sufficient evidence of sensitizing effects on the respiratory tract only for water-soluble nickel compounds.  
 Carc cat: 1

– **Metallic nickel**

[7440-02-0] Ni

– **Nickel acetate**[373-02-4] Ni(OOC-CH<sub>3</sub>)<sub>2</sub>  
and similar soluble salts– **Nickel carbonate**[3333-67-3] NiCO<sub>3</sub>– **Nickel chloride**[7718-54-9] NiCl<sub>2</sub>– **Nickel monoxide**

[1313-99-1] NiO

– **Nickel dioxide**[12035-36-8] NiO<sub>2</sub>– **Nickel sesquioxide**[1314-06-3] Ni<sub>2</sub>O<sub>3</sub>– **Nickel hydroxide**[12054-48-7] Ni(OH)<sub>2</sub>– **Nickel sulfide**

[16812-54-7] NiS

– **Nickel subsulfide**[12035-72-2] Ni<sub>3</sub>S<sub>2</sub>– **Nickel sulfate**[7786-81-4] NiSO<sub>4</sub>**Nickel alloys**

Sens: –

For nickel alloys containing bio-available nickel see Nickel and nickel compounds.

**Nickel titanate yellow pigment**

[8007-18-9]

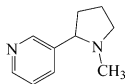
(Ti,Sb,Ni)O<sub>2</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Nicotine**

[54-11-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.056

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Nitric acid**

[7697-37-2]

HNO<sub>3</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Nitrilotriacetic acid**

[139-13-9]

N(CH<sub>2</sub>OOH)<sub>3</sub>

and its sodium salts

Avoid simultaneous exposure to iron compounds (formation of FeNTA).

MAK[mg/m<sup>3</sup>]: 2  
 as acid  
 Peak lim: II(4)  
 Preg gr: C  
 Carc cat: 4

– **Monosodium nitrilotriacetate**  
 [18994-66-6]

– **Disodium nitrilotriacetate**  
 [15467-20-6]

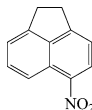
– **Disodium nitrilotriacetate monohydrate**  
 [23255-03-0]

– **Trisodium nitrilotriacetate**  
 [5064-31-3]

– **Trisodium nitrilotriacetate monohydrate**  
 [18662-53-8]

**5-Nitroacenaphthene**

[602-87-9]



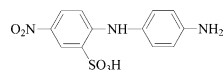
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $3.6 \times 10^{-5}$  at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**4-Nitro-4'-aminodiphenylamine-2-sulfonic acid**

[91-29-2]

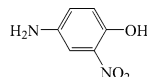


see Section IV

Sens: Sh

**2-Nitro-4-aminophenol**

[119-34-6]

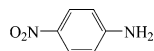


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

4-Nitro-2-aminotoluene → 5-Nitro-o-toluidine

**4-Nitroaniline**

[100-01-6]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**2-Nitroanisole**

[91-23-6]



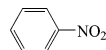
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $4.8 \times 10^{-3}$  at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**Nitrobenzene**

[98-95-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.3

see Section XII

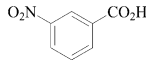
MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.51  
 Peak lim: II(4)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

2-Nitro-1,4-benzenediamine

→ 2-Nitro-p-phenylenediamine

**3-Nitrobenzoic acid**

[121-92-6]

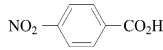


VP[hPa]:  $5 \times 10^{-5}$  at 25°C (calculated value)  
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H

**4-Nitrobenzoic acid**

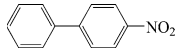
[62-23-7]



MAK[mg/m<sup>3</sup>]: 1 I  
Peak lim: I(2)  
Preg gr: D  
Carc cat: 3

**4-Nitrobiphenyl**

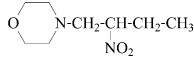
[92-93-3]



MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2

**4-(2-Nitrobutyl)morpholine (70% w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-propanediyl)bis-morpholin (20% w/w)**

[2224-44-4;  
1854-23-5]  
(mixture)



In this mixture formaldehyde can be released and nitrosamines formed. Use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4".  
see Section Xc

MAK[ml/m<sup>3</sup>]: 0.5  
MAK[mg/m<sup>3</sup>]: 4.2  
Peak lim: I(2)  
Preg gr: D  
Sens: Sh

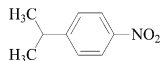
o-Nitrochlorobenzene → o-Chloronitrobenzene

m-Nitrochlorobenzene  
→ m-Chloronitrobenzene

p-Nitrochlorobenzene → p-Chloronitrobenzene

**p-Nitrocumene**

[1817-47-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.02 at 25°C (calculated value)  
see Section IV

Sens: Sh

4-Nitrodiphenyl → 4-Nitrobiphenyl

**Nitroethane**

[79-24-3]

H<sub>3</sub>C-CH<sub>2</sub>-NO<sub>2</sub>

VP[hPa]: 20.8

MAK[ml/m<sup>3</sup>]: 10  
MAK[mg/m<sup>3</sup>]: 31  
Peak lim: II(4)  
Preg gr: D  
Perc abs: H

4-Nitro-4'-[N-ethyl-N-(2-hydroxyethyl)-amino] azobenzene → Disperse Red 1

**Nitrogen dioxide**

[10102-44-0]

NO<sub>2</sub>

VP[hPa]: 960

MAK[ml/m<sup>3</sup>]: 0.5  
MAK[mg/m<sup>3</sup>]: 0.95  
Peak lim: I(1)  
Preg gr: D  
Carc cat: 3

**Nitrogen monoxide**

[10102-43-9]

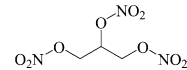
NO

MAK[ml/m<sup>3</sup>]: 0.5  
MAK[mg/m<sup>3</sup>]: 0.63  
Peak lim: I(2)  
Preg gr: D

Nitrogen oxide → Nitrous oxide

**Nitroglycerin**

[55-63-0]



see Section XII

MAK[ml/m<sup>3</sup>]: 0.01  
MAK[mg/m<sup>3</sup>]: 0.094  
MAK value applies for the sum of the concentrations of ethylene glycol dinitrate, nitroglycerin and propylene glycol dinitrate in the air.  
Peak lim: II(1)  
Preg gr: C  
Perc abs: H  
Carc cat: 3

Nitroglycol → Ethylene glycol dinitrate

**Nitromethane**

[75-52-5]

H<sub>3</sub>C-NO<sub>2</sub>

VP[hPa]: 37

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 3

**1-Nitronaphthalene**

[86-57-7]



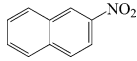
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.002 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**2-Nitronaphthalene**

[581-89-5]



The substance can occur simultaneously as vapour and aerosol.

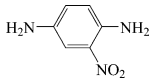
VP[hPa]: 3.5 × 10<sup>-4</sup> at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

4-(4-Nitrophenylazo)aniline → Disperse Orange 3

**2-Nitro-p-phenylenediamine**

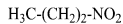
[5307-14-2]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 3

**1-Nitropropane**

[108-03-2]

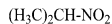


Technical products measurably contaminated with 2-nitropropane, see 2-Nitropropane.

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 7.4  
 Peak lim: I(8)  
 Preg gr: D  
 Perc abs: H

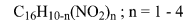
**2-Nitropropane**

[79-46-9]



VP[hPa]: 17

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Nitropyrenes (Mono-, Di-, Tri-, Tetra-) (isomers)**

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Nitrosamines (formed from amines)**

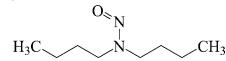
see Section III

N-Nitroso-bis(2-hydroxyethyl)amine  
 → N-Nitrosodiethanolamine

N-Nitroso-cyclohexylhydroxylamine,  
 potassium salt  
 → Cyclohexylhydroxydiazene-1-oxide,  
 potassium salt

**N-Nitrosodi-n-butylamine**

[924-16-3]



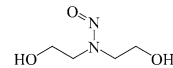
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.06 at 25°C

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**N-Nitrosodiethanolamine**

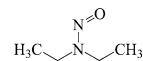
[1116-54-7]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**N-Nitrosodiethylamine**

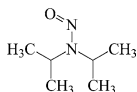
[55-18-5]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**N-Nitrosodiisopropylamine**

[601-77-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.35 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

**N-Nitrosodimethylamine**

[62-75-9]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

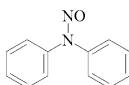
Preg gr: –

Perc abs: H

Carc cat: 2

**N-Nitrosodiphenylamine**

[86-30-6]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

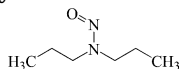
Peak lim: –

Preg gr: –

Carc cat: 3

**N-Nitrosodi-n-propylamine**

[621-64-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.12 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

**Nitrosoethylaniline**

→ N-Nitrosoethylphenylamine

**N-Nitrosoethylphenylamine**

[612-64-6]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

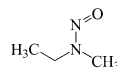
Carc cat: 2

**Nitrosomethylaniline**

→ N-Nitrosomethylphenylamine

**N-Nitrosomethylethylamine**

[10595-95-6]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

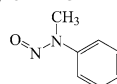
Preg gr: –

Perc abs: H

Carc cat: 2

**N-Nitrosomethylphenylamine**

[614-00-6]

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

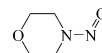
Preg gr: –

Perc abs: H

Carc cat: 2

**N-Nitrosomorpholine**

[59-89-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.05 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

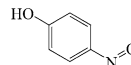
Preg gr: –

Perc abs: H

Carc cat: 2

**4-Nitrosophenol**

[104-91-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.20 at 25°C (calculated value)

see Section IV

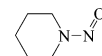
p-Nitrosophenol → 4-Nitrosophenol

**N-Nitroso-N-phenylaniline**

→ N-Nitrosodiphenylamine

**N-Nitrosopiperidine**

[100-75-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.12 at 25°C (calculated value)

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2



**N-Nitrosopyrrolidine**

[930-55-2]



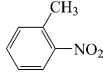
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.08

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2

**2-Nitrotoluene**

[88-72-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.20

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2
Muta cat:	3B

**3-Nitrotoluene**

[99-08-1]



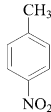
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.20

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

**4-Nitrotoluene**

[99-99-0]



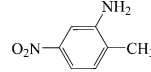
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.22 at 25°C

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	3

**5-Nitro-o-toluidine**

[99-55-8]



MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	2

**Nitrous oxide**

[10024-97-2]

N<sub>2</sub>O

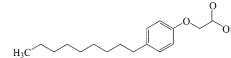
MAK[ml/m <sup>3</sup> ]:	100
MAK[mg/m <sup>3</sup> ]:	180
Peak lim:	II(2)
Preg gr:	C

3,3,4,4,5,5,6,6,6-Nonafluoro-1-hexene  
→ 1H,1H,2H-Perfluorohexene

Nonanedionic acid → Azelaic acid

**(4-Nonylphenoxy)acetic acid**

[3115-49-9]



see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

Oak (*Quercus* spp.) → Woods

**Oakmoss extracts**

see Section IV

Sens: Sh

**Oak wood dust**

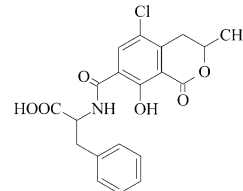
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	1

Dusts have been shown epidemiologically to be unequivocally carcinogenic. The active carcinogenic principle has not been identified to date.

Obeche (*Triplochiton scleroxylon*) → Woods

**Ochratoxin A**

[303-47-9]

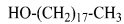
VP[hPa]: 4.4×10<sup>-16</sup>

Carc cat:	2
Muta cat:	3B

Octadecanoic acid → Stearic acid

**1-Octadecanol**

[112-92-5]



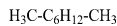
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

9-Octadecenoic acid → Oleic acid

9-Octadecenoic acid decyl ester → n-Decyl oleate

Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate  
 → 3,5-Di-tert-butyl-4-hydroxyphenyl propionic acid octadecyl ester

**Octane (all isomers except trimethylpentane isomers)**

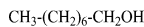
VP[hPa]: 15

MAK[ml/m<sup>3</sup>]: 500  
 MAK[mg/m<sup>3</sup>]: 2400  
 Peak lim: II(2)  
 Preg gr: D

1,8-Octanedicarboxylic acid → Sebacic acid

**1-Octanol**

[111-87-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1 at 25°C

see Section Xc

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 54  
 Peak lim: I(1)  
 Preg gr: C

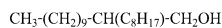
n-Octanol → 1-Octanol

Octyl acetate → 2-Ethylhexyl acetate

Octyl alcohol → 1-Octanol

**2-Octyl-1-dodecanol**

[5333-42-6]



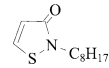
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

2-Octyldodecyl alcohol → 2-Octyl-1-dodecanol

**2-Octyl-4-isothiazolin-3-one**

[26530-20-1]



see Section Xc

MAK[mg/m<sup>3</sup>]: 0.05 I  
 Peak lim: I(2)  
 Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

Perc abs: H  
 Sens: Sh

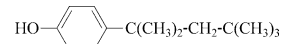
2-Octyl-4-isothiazolin-3-one  
 → 2-Octyl-4-isothiazolin-3-one

2-Octyl-3(2H)-isothiazolone  
 → 2-Octyl-4-isothiazolin-3-one

4-Octyl-N-(4-octylphenyl)benzenamine  
 → 4,4'-Dioctyldiphenylamine

**4-tert-Octylphenol**

[140-66-9]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.01

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 4.3  
 Peak lim: I(1)  
 Preg gr: D

**n-Octyltin compounds**

(as Sn [7440-31-5])

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.002  
 MAK[mg/m<sup>3</sup>]: 0.0098  
 Peak lim: II(2)  
 Perc abs: H  
 Sens: –

For octyltin compounds whose organic ligands were already designated with "Sa" or "Sh", these designations also apply.

Carc cat: 4

**– Mono-n-octyltin compounds**

Preg gr: C

**– Di-n-octyltin compounds**

Preg gr: B

**– Tri-n-octyltin compounds**

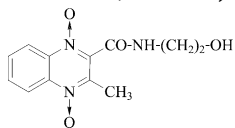
Preg gr: B

**– Tetra-n-octyltin**

Preg gr: D

**Olaquinox (N-(2-Hydroxyethyl)-3-methyl-2-quinoxalinecarboxamide 1,4-dioxide)**

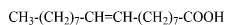
[23696-28-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: SP  
 Carc cat: 3  
 Muta cat: 2

**Oleic acid**

[112-80-1]



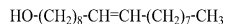
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Oleic acid decyl ester → n-Decyl oleate

**Oleyl alcohol**

[143-28-2]

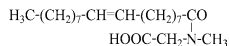


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Oleyl sarcosine**

[110-25-8]

VP[hPa]: 4×10<sup>-7</sup>

see Section Xc

MAK[mg/m<sup>3</sup>]: 0.05 I  
 Peak lim: II(2)  
 Preg gr: D

Organomercury compounds → Mercury, organic compounds

Organotin compounds → Tin compounds, organic (n-Butyl-)

Orthoarsenic acid → Arsenic

Orthophosphoric acid → Phosphoric acid

**Osmium tetroxide**

[20816-12-0]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

1-Oxa-4-azacyclohexane → Morpholine

Oxacyclopentadiene → Furan

**Oxalonitrile**

[460-19-5]

NC-CN

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 11  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H

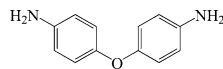
3-Oxapentane-1,5-diol → Diethylene glycol

Oxirane → Ethylene oxide

Oxybispropanol → Dipropylene glycol

**4,4'-Oxydianiline**

[101-80-4]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

2,2'-Oxydiethanol → Diethylene glycol

N-Oxydiethylenebenzothiazole-2-sulfenamide  
→ 2-(4-Morpholinylmercapto)benzothiazole**Ozone**

[10028-15-6]

O<sub>3</sub>

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

PAH → Polycyclic aromatic hydrocarbons (PAH)

**Palladium**

[7440-05-3]

and palladium compounds  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

– **Metallic palladium**

[7440-05-3]

Pd

Sens: –

– **Palladium chloride**

[7647-10-1]

PdCl<sub>2</sub>

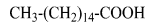
Sens: Sh

– **bioavailable palladium(II) compounds**

Sens: Sh

**Palmitic acid**

[57-10-3]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Palygorskite (fibrous dust) → Attapulgite

Pao ferro (Machaerium scleroxylon) → Woods

**Papain**

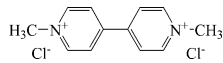
[9001-73-4]

see Section IV

Sens: Sa

Paraffin oil → White mineral oil  
(pharmaceutical)**★ Paraquat dichloride**

[1910-42-5]

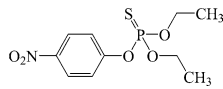


see Section IIc

Paratecoma peroba → Woods

**★ Parathion**

[56-38-2]



see Section IIc

Passive smoking → Sidestream smoke (passive smoking at the workplace)

PCBs → Chlorinated biphenyls

PCP → Pentachlorophenol

PEG → Polyethylene glycol (average molecular weight 200–600)

Pencil cedar (Calocedrus decurrens) → Woods

**Pentaborane**

[19624-22-7]



VP[hPa]: 213

MAK[ml/m<sup>3</sup>]: 0.005  
 MAK[mg/m<sup>3</sup>]: 0.013  
 Peak lim: II(2)

**Pentachloroethane**

[76-01-7]

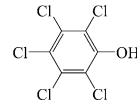


MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 17  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 3

Pentachloronaphthalenes → Chlorinated naphthalenes

**Pentachlorophenol**

[87-86-5]

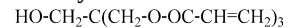


see Section XIII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Pentadecafluorooctanoic acid  
→ Perfluorooctanoic acid (PFOA)**Pentaerythritol triacrylate**

[3524-68-3]



see Section IV

Sens: Sh

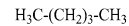
**Pentane (all isomers)**

VP[hPa]: 573

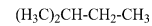
MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 3000  
 Peak lim: II(2)  
 Preg gr: C

– **n-Pentane**

[109-66-0]

– **Isopentane**

[78-78-4]

– **tert-Pentane**

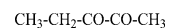
[463-82-1]



1,5-Pentanedial → Glutaraldehyde

**2,3-Pentanedione**

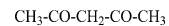
[600-14-6]



MAK[ml/m<sup>3</sup>]: 0.02  
 MAK[mg/m<sup>3</sup>]: 0.083  
 Peak lim: II(1)  
 Preg gr: D  
 Perc abs: H  
 Sens: Sh

**2,4-Pentanedione**

[123-54-6]



MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 83  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**Pentanol (isomers)**



MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 73  
 Peak lim: I(2)  
 Preg gr: C

– **1-Pentanol**  
 [71-41-0]

VP[hPa]: 2.93 at 25°C

– **2-Pentanol**

[6032-29-7]

VP[hPa]: 8.13 at 25°C

– **3-Pentanol**

[584-02-1]

VP[hPa]: 11.7 at 25°C

– **2-Methyl-1-butanol**

[137-32-6]

VP[hPa]: 4.15 at 25°C

– **2-Methyl-2-butanol**

[75-85-4]

VP[hPa]: 19 at 25°C

– **3-Methyl-1-butanol**

[123-51-3]

VP[hPa]: 3.15 at 25°C

– **3-Methyl-2-butanol**

[598-75-4]

VP[hPa]: 12.17 at 25°C

– **2,2-Dimethyl-1-propanol**

[75-84-3]

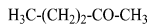
VP[hPa]: 21.28

– **Mixture of isomers, Pentanol**

[30899-19-5; 94624-12-1]

**2-Pentanone**

[107-87-9]



VP[hPa]: 16

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

1-Pentyl acetate → Amyl acetate (all isomers)

3-Pentyl acetate → Amyl acetate (all isomers)

Pentyl acetate → Amyl acetate (all isomers)

2-Pentyl-3-phenylpropenoic aldehyde

→  $\alpha$ -Amylcinnamaldehyde

**Pepsin**

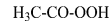
[9001-75-6]

see Section IV

Sens: Sa

**Peracetic acid**

[79-21-0]



VP[hPa]: 19.3 at 25°C  
 see Section Xa

MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.32  
 Peak lim: I(1)  
 Preg gr: C  
 Carc cat: 4

Perchloroethylene → Tetrachloroethene

Tetrachloroethylene → Tetrachloroethene

**Perchloromethyl mercaptan**

[594-42-3]

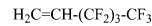


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**1H,1H,2H-Perfluorohexene**

[19430-93-4]

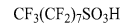


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Perfluorooctanesulfonic acid (PFOS)**

[1763-23-1]



and its salts

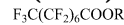
VP[hPa]: 0.69

see Section XII

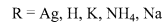
MAK[mg/m<sup>3</sup>]: 0.01 I  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H  
 Carc cat: 3

**Perfluorooctanoic acid (PFOA)**

[335-67-1]



and its salts



VP[hPa]: 0.69

see Section XII

MAK[mg/m<sup>3</sup>]: 0.005 I  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H  
 Carc cat: 4

Perhydronaphthalene → Decahydronaphthalene

Peroxydisulfuric acid diammonium salt

→ Ammonium persulfate

Petroleum, distillates → Distillates (petroleum)

**Petroleum sulfonates, calcium salts  
(technical mixture in mineral oil)**

[61789-86-4]

see Section Xc

MAK[ml/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: D

**Petroleum sulfonates, sodium salts**

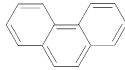
[68608-26-4]

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Phenanthrene**

[85-01-8]



see documentation "Polycyclic Aromatic Hydrocarbons (PAH)"

see Section III, "pyrolysis products of organic materials"

Peak lim: –  
 Preg gr: –  
 Perc abs: H

Phenethyl alcohol → 2-Phenyl-1-ethanol

**Phenol**

[108-95-2]



The substance can occur simultaneously as vapour and aerosol.

see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3  
 Muta cat: 3B

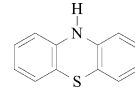
Phenol → Formaldehyde condensation products with phenol

Phenol, 2(or 4)-C9–10-branched alkyl derivs., phosphorothioates → Tris[(2- or 4-)C9–C10-isoalkylphenyl]phosphorothioate

Phenol, isopropylated, phosphate → Triphenyl phosphate, isopropylated

**Phenothiazine**

[92-84-2]



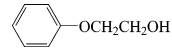
phototoxic effect

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**2-Phenoxyethanol**

[122-99-6]



The substance can occur simultaneously as vapour and aerosol.

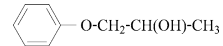
VP[hPa]: 0.01 at 25°C

see Section Xc

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 5.7  
 Peak lim: I(1)  
 Preg gr: C

**1-Phenoxy-2-propanol**

[770-35-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.03 at 25°C

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Phenylacrolein → Cinnamaldehyde

γ-Phenylallyl alcohol → Cinnamyl alcohol

N-Phenyl aniline → Diphenylamine

**Phenyl arsenic compounds**

[637-03-6]

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

p-Phenylazoaniline → p-Aminoazobenzene

Phenylbenzene → Biphenyl

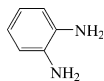
N-Phenylbenzene amin → Diphenylamine

N-Phenyl-1,4-benzenediamine  
→ 4-Aminodiphenylamine

Phenyl Cellosolve → 2-Phenoxyethanol

**o-Phenylenediamine**

[95-54-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.1 \times 10^{-3}$ MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

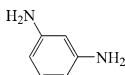
Preg gr: –

Sens: Sh

Carc cat: 3

**m-Phenylenediamine**

[108-45-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $3.8 \times 10^{-4}$ MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

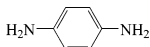
Perc abs: H

Sens: Sh

Carc cat: 3

**p-Phenylenediamine**

[106-50-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.01

MAK[mg/m<sup>3</sup>]: 0.1 I

Peak lim: II(2)

Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

Perc abs: H

Sens: Sh

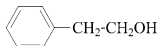
The "Ursol-Asthma" which used to be observed frequently, especially in persons dyeing furs with p-phenylenediamine, has not been demonstrated unequivocally to involve respiratory allergy to p-phenylenediamine; see

Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (18th issue, 1992) and in English translation in Occupational Toxicants Volume 6, VCH-Verlagsgesellschaft mbH, Weinheim 1994

Carc cat: 3

**2-Phenyl-1-ethanol**

[60-12-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.08

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

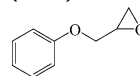
Preg gr: –

Perc abs: H

Phenyl ether → Diphenyl ether

**Phenyl glycidyl ether (PGE)**

[122-60-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.013 at 25°C

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

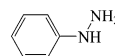
Perc abs: H

Sens: Sh

Carc cat: 2

**Phenylhydrazine**

[100-63-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.035 at 25°C

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

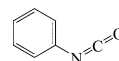
Perc abs: H

Sens: Sh

Carc cat: 3

**Phenyl isocyanate**

[103-71-9]



see Section IV

Sens: Sah

Phenyl mercury → Mercury, organic compounds

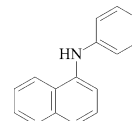
Phenylmethanal → Benzaldehyde

2-(Phenylmethylene)-heptanal

→ α-Amylcinnamaldehyde

**N-Phenyl-1-naphthylamine**

[90-30-2]



VP[hPa]: 0.000011

see Section Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: 2 I

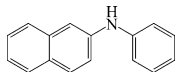
Peak lim: II(2)

Preg gr: C

Sens: Sh

**N-Phenyl-2-naphthylamine**

[135-88-6]



VP[hPa]: &lt;0.000011 (calculated value)

see Section XII

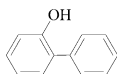
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 1  
 Muta cat: 3A

4-Phenylnitrobenzene → 4-Nitrobiphenyl

**o-Phenylphenol**

[90-43-7]

see also Sodium o-phenylphenol



The substance can occur simultaneously as vapour and aerosol.

see Section Xc

MAK[mg/m<sup>3</sup>]: 5 I  
 Peak lim: I(1)  
 Preg gr: C  
 Carc cat: 4

N-Phenyl-p-phenylenediamine

→ 4-Aminodiphenylamine

N-Phenyl-p-phenylenediamine

→ 4-Aminodiphenylamine

3-Phenyl-2-propenal → Cinnamaldehyde

2-Phenylpropene →  $\alpha$ -Methyl styrene

3-Phenyl-2-propen-1-ol → Cinnamyl alcohol

**Phenyltin compounds**

(as Sn [7440-31-5])

The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: 0.0004  
 MAK[mg/m<sup>3</sup>]: 0.002  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

Phosdrin → Mevinphos

**Phosgene**

[75-44-5]

COCl<sub>2</sub>

MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.41  
 Peak lim: I(2)  
 Preg gr: C

**Phosphine**

[7803-51-2]

PH<sub>3</sub>

MAK[ml/m<sup>3</sup>]: 0.1  
 MAK[mg/m<sup>3</sup>]: 0.14  
 Peak lim: II(2)  
 Preg gr: C

Phosphomolybdic acid → Molybdenum

**Phosphoric acid**

[7664-38-2]

H<sub>3</sub>PO<sub>4</sub>

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: I(2)  
 Preg gr: C

Phosphoric acid methylphenyl diphenyl ester  
→ Diphenyl cresyl phosphatePhosphoric acid tributyl ester → Tributyl  
phosphate**Phosphorus, red**

[7723-14-0]

P<sub>n</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Phosphorus, white/yellow**[7723-14-0;  
12185-10-3]P<sub>4</sub>

MAK[mg/m<sup>3</sup>]: 0.01 I  
 Peak lim: II(2)  
 Preg gr: C

**Phosphorus oxychloride**

[10025-87-3]

POCl<sub>3</sub>

VP[hPa]: 36

MAK[ml/m<sup>3</sup>]: 0.02  
 MAK[mg/m<sup>3</sup>]: 0.13  
 Peak lim: I(1)  
 Preg gr: C

**Phosphorus pentachloride**

[10026-13-8]

PCl<sub>5</sub>

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.016

MAK[mg/m<sup>3</sup>]: 1 I  
 Peak lim: I(1)  
 Preg gr: C

**Phosphorus pentasulfide**

[1314-80-3]

P<sub>2</sub>S<sub>5</sub>

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –



**Phosphorus pentoxide**[1314-56-3] P2O5MAK[ml/m<sup>3</sup>]: 2 I  
Peak lim: I(2)  
Preg gr: C**Phosphorus trichloride**[7719-12-2] PCl3

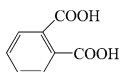
VP[hPa]: 129.7

MAK[ml/m<sup>3</sup>]: 0.1  
MAK[mg/m<sup>3</sup>]: 0.57  
Peak lim: I(1)  
Preg gr: C

Phosphoryl chloride → Phosphorus oxychloride

**o-Phthalic acid**

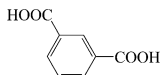
[88-99-3]



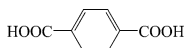
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –**m-Phthalic acid**

[121-91-5]

MAK[mg/m<sup>3</sup>]: 5 I  
Peak lim: I(2)  
Preg gr: C**p-Phthalic acid**

[100-21-0]

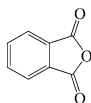
MAK[mg/m<sup>3</sup>]: 5 I  
Peak lim: I(2)  
Preg gr: C

Phthalic acid diallyl ester → Diallyl phthalate

Phthalic acid diisodecyl ester → Diisodecyl phthalate

**Phthalic anhydride**

[85-44-9]



see Section IIb

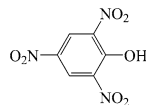
MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sa**Phytases**

see Section IV

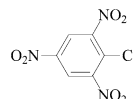
Sens: Sa

**Picric acid**

[88-89-1]

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Sens: Sh  
Carc cat: 3**Picryl chloride**

[88-88-0]



see Section IV

Sens: Sh

**Pigment Yellow 12, Pigment Yellow 13, Pigment Yellow 83**

[6358-85-6; 5102-83-0; 5567-15-7]

MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density x 0.5;  
corresponds to an assumed agglomerate density at a  
packing factor of 50%, see documentation  
Peak lim: II(8)  
Preg gr: C  
Carc cat: 4**Piperazine**

[110-85-0]



The substance can occur simultaneously as vapour and aerosol. Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N,N'-dinitrosopiperazine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 0.21  
see Section IIb and XcMAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sah

1-Piperidineethanol → N-(2-Hydroxyethyl) piperidine

2-Piperidinoethanol → N-(2-Hydroxyethyl) piperidine

2-Piperidin-1-ylethanol → N-(2-Hydroxyethyl) piperidine

**Plant or animal proteins**

see Section IVe

Plants containing sesquiterpene lactones  
→ Sesquiterpene lactones

**Platinum compounds (Chloroplatinates)**

A peak concentration of 2 µg/m<sup>3</sup> should not be exceeded.

see Section IIb

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sah

pMDI → “polymeric MDI”

**Polyalphaolefins, several CAS Nos, e.g.**

[68649-11-6] 
$$\text{H}_3\text{C}-(\text{CH}_2)_9-\text{CH}-(\text{CH}_2)_7-\text{CH}_3$$
  

$$\text{CH}_3$$

VP[hPa]: 0.019

see Section Xc

MAK[mg/m <sup>3</sup> ]:	5 R
Peak lim:	II(4)
Preg gr:	C

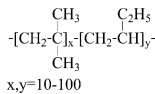
**Polybutenes and Polyisobutenes**

see Section IIb and Xc

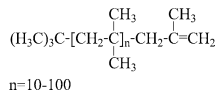
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**– Polybutenes**

[9003-29-6]

**– Polyisobutenes**

[9003-27-4]



Polychlorinated biphenyls → Chlorinated biphenyls

**Polycyclic aromatic hydrocarbons (PAH)**

see Section III, “pyrolysis products of organic materials” and section XII

Perc abs:	H
-----------	---

Poly(1,2-dihydro-2,2,4-trimethyl-quinoline)

→ 1,2-Dihydro-2,2,4-trimethyl-quinoline

polymer

**Polydimethyl siloxanes, linear**

[63148-62-9; (CH<sub>3</sub>)<sub>2</sub>Si-[O-Si(CH<sub>3</sub>)<sub>2</sub>]<sub>n</sub>-O-Si(CH<sub>3</sub>)<sub>2</sub>]

9006-65-9; n > 14

9016-00-6]

see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**Polyethylene glycol (average molecular weight 200–600)**

[25322-68-3]

HO(CH<sub>2</sub>-CH<sub>2</sub>-O)<sub>x</sub>H; x > 4

Because formation of a mist is possible, exposure should be minimized for reasons of occupational safety and hygiene.

VP[hPa]: <0.1

see Section Xc

MAK[mg/m <sup>3</sup> ]:	250 I
Peak lim:	II(2)
Preg gr:	C

**Polyethylene glycol (average molecular weight > 600)**

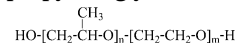
[25322-68-3]

see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**Polyethylenepolypropylene glycol**

[9003-11-6]



see Section IIb and Xc

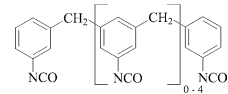
MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**“polymeric MDI”**

[9016-87-9]

(inhalable fraction) see also

4,4'-Methylene diphenyl diisocyanate (MDI)



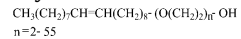
“polymeric MDI” (pMDI) is a technical grade MDI, containing 30–80% w/w 4,4'-methylene diphenyl isocyanate (MDI); the remainder consists of MDI oligomers and MDI homologues.

MAK[mg/m <sup>3</sup> ]:	0.05 I
Peak lim:	I(1)
A momentary value of 0.1 mg/m <sup>3</sup> should not be exceeded.	
Preg gr:	C
Perc abs:	H
Sens:	Sah
Carc cat:	4

Poly(oxy-1,2-ethanediyl)-ω-alkoxy-α-acetic acid → Alkyl ether carboxylic acids

**Polyoxyethylene oleyl ether**

[9004-98-2]

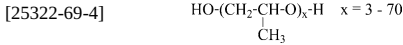


see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

Poly(oxy-1,2-propanediyl)-ω-alkoxy-α-acetic acid → Alkyl ether carboxylic acids

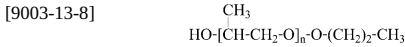
**Polypropylene glycol (PPG)**



see Section IIb and Xc

- MAK[ml/m<sup>3</sup>]: –
- MAK[mg/m<sup>3</sup>]: –
- Peak lim: –
- Preg gr: –

**Poly(propylene glycol) n-butyl ether**



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.7 \times 10^{-3}$  at 30°C

see Section IIb and Xc

- MAK[ml/m<sup>3</sup>]: –
- MAK[mg/m<sup>3</sup>]: –
- Peak lim: –
- Preg gr: –

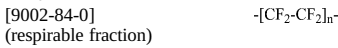
**Polytetrafluoroethene**



see Section Vf and g and Xc

- MAK[mg/m<sup>3</sup>]: 4 I
- Preg gr: C

**Polytetrafluoroethene**



except for ultrafine particles; see Section Vh

see Section Vf and Xc

- MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density
- Peak lim: II(8)
- Preg gr: C
- Carc cat: 4

**Polyvinyl chloride**



except for ultrafine particles; see Section Vh

see Section Vf

- MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density
- Peak lim: II(8)
- Preg gr: C
- Carc cat: 4

**Portland cement dust**

[65997-15-1]

Cr(VI) content and quartz level to be assessed separately

- MAK[mg/m<sup>3</sup>]: –
- Peak lim: –
- Preg gr: –
- Sens: –

Is valid only for low-chromate cement containing less than 2 ppm (2 mg/kg) of chromium(VI). Refer to the chromium(VI) compounds for cement with a higher chromium(VI) content.

- Carc cat: 3

Potassium benzoate → Benzoic acid alkali salts

Potassium citrate → Citric acid

Potassium citrate → Citric acid alkali metal salts

**Potassium cyanide**

[151-50-8] KCN

- MAK[mg/m<sup>3</sup>]: 5.0 I
- Peak lim: II(1)
- Preg gr: C
- Perc abs: H

Potassium dichloroacetate → Dichloroacetic acid

Potassium metabisulfite → Sulfites

Potassium perfluorooctanoate  
→ Perfluorooctanoic acid (PFOA)

Potassium persulfate → Alkali persulfates

**Potassium titanates (fibrous dust)**

several CAS Nos and formulas, e.g.

see Section III

- MAK[ml/m<sup>3</sup>]: –
- MAK[mg/m<sup>3</sup>]: –
- Peak lim: –
- Preg gr: –
- Carc cat: 2

– Potassium titanate

[12030-97-6] K<sub>2</sub>TiO<sub>3</sub>

– Potassium titanate

[12056-46-1] K<sub>2</sub>Ti<sub>2</sub>O<sub>5</sub>

– Potassium titanate

[12056-49-4] K<sub>2</sub>Ti<sub>4</sub>O<sub>9</sub>

– Potassium titanate

[12056-51-8] K<sub>2</sub>Ti<sub>6</sub>O<sub>13</sub>

– Potassium titanate

[59766-31-3] K<sub>2</sub>Ti<sub>8</sub>O<sub>17</sub>

**Propane**

[74-98-6] H<sub>3</sub>C-CH<sub>2</sub>-CH<sub>3</sub>

- MAK[ml/m<sup>3</sup>]: 1000
- MAK[mg/m<sup>3</sup>]: 1800
- Peak lim: II(4)
- Preg gr: D

1,3-Propanedicarboxylic acid → Glutaric acid

1,2-Propanediol → Propylene glycol

**1,3-Propane sultone**

[1120-71-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.48

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 1  
 Muta cat: 3A

1,2,3-Propanetriol → Glycerol

**2-Propanol**

[67-63-0]

(H<sub>3</sub>C)<sub>2</sub>CHOH

VP[hPa]: 44

see Section XII

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 500  
 Peak lim: II(2)  
 Preg gr: C

**Propargyl alcohol**

[107-19-7]

HC≡C-CH<sub>2</sub>OH

VP[hPa]: 11.6

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 4.7  
 Peak lim: I(2)  
 Preg gr: D  
 Perc abs: H

2-Propenal → Acrolein

2-Propenoic acid 1,4-butanediyl ester  
→ 1,4-Butanediol diacrylate2-Propenoic acid 1,2-ethanediylbis  
(oxy-2,1-ethanediyl)ester → Triethylene glycol  
diacrylate2-Propenoic acid 2-hydroxyethyl ester  
→ Acrylic acid 2-hydroxyethyl ester2-Propenoic acid 2-(hydroxymethyl)-2-(((1-ox-  
o-2-propenyl)oxy)-methyl)-1,3-propanediyl  
ester → Pentaerythritol triacrylate2-Propenoic acid hydroxypropyl ester  
→ Acrylic acid hydroxypropyl ester (all  
isomers)2-Propenoic acid oxydi-2,1-ethanediyl ester  
→ Diethylene glycol diacrylate

2-Propen-1-ol → Allyl alcohol

4-Propenyl-2-methoxyphenol → Isoeugenol

**β-Propiolactone**

[57-57-8]



MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**Propionic acid**

[79-09-4]

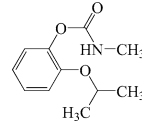
H<sub>3</sub>C-CH<sub>2</sub>-COOH

VP[hPa]: 4

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 31  
 Peak lim: I(2)  
 Preg gr: C

**★ Propoxur**

[114-26-1]



see Section IIc

**2-Propoxyethanol**

[2807-30-9]

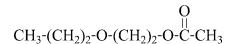
CH<sub>3</sub>-(CH<sub>2</sub>)<sub>2</sub>-O-(CH<sub>2</sub>)<sub>2</sub>-OH

VP[hPa]: 6.4 at 25°C

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 43  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

2-Propoxyethanol acetate → 2-Propoxyethyl  
acetate**2-Propoxyethyl acetate**

[20706-25-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.67

MAK[ml/m<sup>3</sup>]: 20  
 MAK[mg/m<sup>3</sup>]: 120  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

**Propylacetate**

VP[hPa]: 33

MAK[ml/m<sup>3</sup>]: 100  
 MAK[mg/m<sup>3</sup>]: 420  
 Peak lim: I(2)

**– n-Propyl acetate**

[109-60-4]

H<sub>3</sub>C-COOCH<sub>2</sub>-CH<sub>2</sub>-CH<sub>3</sub>

Preg gr: D

**– Isopropyl acetate**

[108-21-4]

H<sub>3</sub>C-COOCH(CH<sub>3</sub>)<sub>2</sub>

Preg gr: C

Propyl allyl disulfide → Allyl propyl disulfide

n-Propyl bromide → 1-Bromopropane

Propyl Cellosolve → 2-Propoxyethanol

Propylene carbonate  
→ 4-Methyl-1,3-dioxolan-2-one

Propylene dichloride → 1,2-Dichloropropane

**Propylene glycol**[57-55-6] CH3-CH(OH)-CH2OH

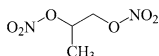
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.11

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –**Propylene glycol dinitrate**

[6423-43-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.084

MAK[ml/m<sup>3</sup>]: 0.01  
MAK[mg/m<sup>3</sup>]: 0.069  
MAK value applies for the sum of the concentrations of ethylene glycol dinitrate, nitroglycerin and propylene glycol dinitrate in the air.  
Peak lim: II(1)  
Preg gr: C  
Perc abs: HPropylene glycol 1-methyl ether  
→ 1-Methoxy-2-propanolPropylene glycol 2-methyl ether  
→ 2-Methoxypropanol-1Propylene glycol 1-methyl ether-2-acetate  
→ 1-Methoxypropyl-2-acetatePropylene glycol 2-methyl ether-1-acetate  
→ 2-Methoxypropylacetate-1

Propylene glycol monoacrylate → Acrylic acid hydroxypropyl ester (all isomers)

Propylene glycol monoethyl ether  
→ 1-Ethoxy-2-propanol**Propylene imine**

[75-55-8]

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2  
Muta cat: 3B

Propylene oxide → 1,2-Epoxypropane

**n-Propyl nitrate**

[627-13-4]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Propyne → Methyl acetylene

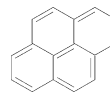
Pseudocumene (1,2,4-Trimethylbenzene)  
→ Trimethylbenzene (all isomers)

PTBBA → p-tert-Butylbenzoic acid

PVC → Polyvinyl chloride

**Pyrene**

[129-00-0]



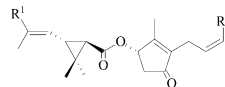
see documentation “Polycyclic Aromatic Hydrocarbons (PAH)”

see Section III, “pyrolysis products of organic materials”

Perc abs: H

**Pyrethrum**

[8003-34-7]



see Section IIb and XII

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Sens: Sh

does not apply for the constituents of insecticides (pyrethrins and cinerins) or for synthetic derivatives (pyrethroids) but only for the constituents of the plant drug and its crude extracts, including α-methylene sesquiterpene lactones (e.g. pyrethrosin)

**Pyridine**

[110-86-1]



VP[hPa]: 20

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 3

**Pyrolysis products of organic materials**

see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Pyrrolidine**

[123-75-1]



Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosopyrrolidine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

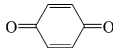
Quartz → Silica, crystalline

Quartz glass → Silica, amorphous b) quartz glass [60676-86-0], fused silica [60676-86-0], silica fume (calcined) [69012-64-2], diatomaceous earth [68855-54-9]

Quercus spp. → Woods

**Quinone**

[106-51-4]



VP[hPa]: 0.12

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh  
 Carc cat: 3  
 Muta cat: 3B

Quinone oxime → 4-Nitrosophenol

Ramin (Gonystylus bancanus) → Woods

Refrigerant 134a → 1,1,1,2-Tetrafluoroethane

rennets, microbial → Microbial rennets:  
 endothiapsin and mucorpepsin

**Resorcinol**

[108-46-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 3×10<sup>-4</sup> at 25°C

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh

Resorcinol bis(2,3-epoxypropyl)ether  
 → Diglycidyl resorcinol ether

Resorcinol diglycidyl ether → Diglycidyl  
 resorcinol ether

**Rhodium**

[7440-16-6]

Rh

and its inorganic compounds

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

**Ricinus protein**

see Section IV

Sens: Sa

**Rock wool (fibrous dust)**

see Section III

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

Rosewood (Dalbergia spp.) → Woods

**Rosin (colophony)**

[8050-09-7]

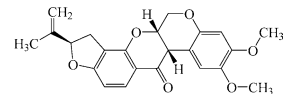
see Section IV

Sens: Sh

An immunological genesis of the asthma often seen in persons working with materials containing rosin has not been proved.

**Rotenone**

[83-79-4]



see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Rubber components**

see Section IV

- **Dithiocarbamates**  
Sens: Sh
- **Thiazoles**  
Sens: Sh
- **p-Phenylenediamine compounds**  
Sens: Sh
- **Thiurams**  
Sens: Sh

Rye → Cereal flour dusts

Santos rosewood (*Machaerium scleroxylon*)

→ Woods

Sapele (*Entandrophragma* spp.) → Woods

Sapupira, (black) sucupira (*Bowdichia nitida*)

→ Woods

**Sebacic acid**

[111-20-6]  $\text{HO}_2\text{C}-(\text{CH}_2)_8-\text{CO}_2\text{H}$

see Section IIb and Xc

- MAK[ml/m<sup>3</sup>]: -
- MAK[mg/m<sup>3</sup>]: -
- Peak lim: -
- Preg gr: -

**Selenium**

[7782-49-2] Se

and its inorganic compounds (as Se)

see Section XII

- MAK[mg/m<sup>3</sup>]: 0.02 I
- Peak lim: II(8)
- Preg gr: C
- Perc abs: H
- Carc cat: 3

**Sepiolite (fibrous dust)**

several CAS Nos and formulas, e.g.

see Section III

- MAK[ml/m<sup>3</sup>]: -
- MAK[mg/m<sup>3</sup>]: -
- Peak lim: -
- Preg gr: -
- Carc cat: 3

- **Sepiolite**  
[18307-23-8]  $\text{Mg}_9\text{H}_6(\text{SiO}_3)_{12} \cdot 10 \text{H}_2\text{O}$

- **Sepiolite**  
[15501-74-3]  $\text{Mg}_2\text{H}_2(\text{SiO}_3)_3 \cdot \text{H}_2\text{O}$

**Sesquiterpene lactones**

see Section IV

- Sens: Sh
- **Alantolactone**  
[546-43-0]
- **Anthecotulide**  
[23971-84-8]
- **Arteglasin A**  
[33204-39-6]
- **Carabrone**  
[1748-81-8]
- **Costunolide**  
[553-21-9]
- **Dehydrocostus lactone**  
[477-43-0]
- **(+)-Frullanolide and (-)-Frullanolide**  
[40776-40-7; 27579-97-1]
- **Helenalin**  
[6754-13-8]
- **Isoalantolactone**  
[470-17-7]
- **Lactucin**  
[1891-29-8]
- **Laurenobolide**  
[35001-25-3]
- **Parthenin**  
[508-59-8]
- **Parthenolide**  
[20554-84-1]
- **α-Peroxyachifolide**  
[134954-21-5]
- **Pyrethrosin**  
[28272-18-6]

**Sevoflurane**

[28523-86-6]  $(\text{CF}_3)_2\text{CH-O-CH}_2\text{F}$

see Section IIb

- MAK[ml/m<sup>3</sup>]: -
- MAK[mg/m<sup>3</sup>]: -
- Peak lim: -
- Preg gr: -

**Sidestream smoke (passive smoking at the workplace)**

- MAK[ml/m<sup>3</sup>]: -
- MAK[mg/m<sup>3</sup>]: -
- Peak lim: -
- Preg gr: -
- Carc cat: 1

★ **Silica, amorphous a) synthetic colloidal**

**amorphous silica [7631-86-9]**

including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review period  
see Section V

MAK[mg/m<sup>3</sup>]: 0.02 R  
Peak lim: II(8)  
Preg gr: C

**Silica, amorphous b) quartz glass**

**[60676-86-0], fused silica [60676-86-0], silica fume (calcined) [69012-64-2], diatomaceous earth [68855-54-9]**

see Section V

MAK[mg/m<sup>3</sup>]: 0.3 R  
Preg gr: C

**Silica, crystalline**

(respirable fraction)

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 1

– **Quartz**

[14808-60-7]

– **Cristobalite**

[14464-46-1]

– **Tridymite**

[15468-32-3]

**Silicic acid tetraethyl ester**

[78-10-4] Si(OCH<sub>2</sub>-CH<sub>3</sub>)<sub>4</sub>

VP[hPa]: ~2

MAK[ml/m<sup>3</sup>]: 10  
MAK[mg/m<sup>3</sup>]: 86  
Peak lim: I(1)  
Preg gr: D

**Silicon carbide**

[409-21-2] SiC  
(fibrous dust)  
see Section III

MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 2

**Silicon carbide**

[409-21-2] SiC  
(without fibres)  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Silicon dioxide → Silica, crystalline

Silicone → Polydimethyl siloxanes, linear

Silicone oil → Polydimethyl siloxanes, linear

**Silver**

[7440-22-4] Ag

MAK[mg/m<sup>3</sup>]: 0.1 I  
Peak lim: II(8)  
Preg gr: D

Silver perfluorooctanoate → Perfluorooctanoic acid (PFOA)

**Silver salts**

(as Ag [7440-22-4])

MAK[mg/m<sup>3</sup>]: 0.01 I  
Peak lim: I(2)  
Preg gr: D

**Slag wool (fibrous dust)**

see Section III

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

Sodium citrate → Citric acid

**Sodium azide**

[26628-22-8] N<sub>3</sub>Na

MAK[mg/m<sup>3</sup>]: 0.2 I  
Peak lim: I(2)  
Preg gr: D

Sodium benzoate → Benzoic acid alkali salts

Sodium bisulfite → Sulfites

**Sodium cyanide**

[143-33-9] NaCN

MAK[mg/m<sup>3</sup>]: 3.8 I  
Peak lim: II(1)  
Preg gr: C  
Perc abs: H

Sodium dichloroacetate → Dichloroacetic acid

**Sodium diethyldithiocarbamate**

[148-18-5] S  
(CH<sub>3</sub>-CH<sub>2</sub>)<sub>2</sub>N-C-SNa

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III “Amines which form carcinogenic nitrosamines on nitrosation”.

see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: II(2)  
Preg gr: D  
Sens: Sh

Sodium ethylmercurithiosalicylate  
→ Thimerosal



**Sodium fluoroacetate**

[62-74-8]  $FCH_2COO^- Na^+$

MAK[mg/m<sup>3</sup>]: 0.05 I  
 Peak lim: II(4)  
 Preg gr: B  
 Perc abs: H

**Sodium hydroxide**

[1310-73-2] NaOH

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Sodium metabisulfite → Sulfites

Sodium molybdate → Molybdenum

**Sodium monochloroacetate**

[3926-62-3]  $ClCH_2-COONa$

see also Monochloroacetic acid

MAK[mg/m<sup>3</sup>]: 2 I  
 as monochloroacetic acid  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

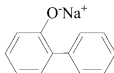
Sodium perfluorooctanoate  
 → Perfluorooctanoic acid (PFOA)

Sodium persulfate → Alkali persulfates

Sodium petroleum sulfonates → Petroleum sulfonates, sodium salts

**Sodium o-phenylphenol**

[132-27-4]



see Section Xc

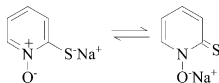
MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: I(1)  
 Preg gr: C  
 Carc cat: 4

Sodium polyacrylate → Acrylic acid polymer (neutralized, cross-linked)

Sodium pyridinethione → Sodium pyrrithione

**Sodium pyrrithione**

[3811-73-2; 15922-78-8]



see Section Xc

MAK[mg/m<sup>3</sup>]: 0.2 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

Sodium tetraborate pentahydrate → Boric acid

**Sodium trichloroacetate**

[650-51-1]  $Cl_3C-COONa$

see also Trichloroacetic acid

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: I(1)  
 Preg gr: C  
 Perc abs: H

Sodium warfarin → Warfarin

Soot → Carbon black

**Soya bean constituents**

see Section IV

Sens: Sa

**Stearic acid**

[57-11-4]  $CH_3-(CH_2)_{16}-COOH$

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Stibine**

[7803-52-3]  $SbH_3$

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Stoddard solvent → Naphtha (petroleum)

**Strontium**

[7440-24-6] Sr

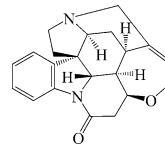
and its inorganic compounds  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Strontium chromate → Chromium(VI) compounds

**Strychnine**

[57-24-9]

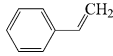


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Styrene**

[100-42-5]



VP[hPa]: 6

see Section XII

MAK[ml/m<sup>3</sup>]: 20MAK[mg/m<sup>3</sup>]: 86

see definition of Carcinogen Category 5 and supporting documentation

Peak lim: II(2)

Preg gr: C

Carc cat: 5

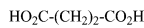
**Subtilisin**

see Section IV

Sens: Sa

**Succinic acid**

[110-15-6]



see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I

Peak lim: I(2)

Preg gr: C

**Sulfites**

[14265-45-3]

Causes pseudoallergic reactions, see  
Toxikologisch-arbeitsmedizinische Begründung von  
MAK-Werten (26th issue 1998).  
see Section IV

Sulfonic acid, petroleum, sodium salts  
→ Petroleum sulfonates, sodium salts

Sulfonic acids, petroleum, calcium salts  
→ Petroleum sulfonates, calcium salts  
(technical mixture in mineral oil)

Sulfotep → TEDP

**Sulfur dioxide**

[7446-09-5]

MAK[ml/m<sup>3</sup>]: 1MAK[mg/m<sup>3</sup>]: 2.7

Peak lim: I(1)

A momentary value of 1 ml/m<sup>3</sup> (2.7 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

**★ Sulfur hexafluoride**

[2551-62-4]



The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.

VP[hPa]: 23670 at 25°C

MAK[ml/m<sup>3</sup>]: 5000MAK[mg/m<sup>3</sup>]: 30000

Peak lim: II(8)

Preg gr: C

**Sulfuric acid**

[7664-93-9]

MAK[mg/m<sup>3</sup>]: 0.1 I

Peak lim: I(1)

A momentary value of 0.2 mg/m<sup>3</sup> should not be exceeded.

Preg gr: C

Carc cat: 4

**Sulfur monochloride**

[10025-67-9]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Sulfur pentafluoride**

[5714-22-7]



see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Swietenia spp. → Woods

Sylvic acid → Abietic acid

2,4,5-T → 2,4,5-Trichlorophenoxyacetic acid

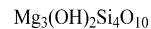
Tabebuia avellanedae → Woods

Tabebuia serratifolia → Woods

Tabebuia spp. → Woods

**Talc**

[14807-96-6]

(without asbestos fibres)  
(respirable fraction)MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Carc cat: 3

Talleol → Tall oil, distilled

Tall oil derivatives (abietic acid) → Abietic acid

Tall oil derivatives (oleic acid) → Oleic acid

**Tall oil, distilled**

[8002-26-4]

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Sens: Sh

only applies to tall oil distillates containing abietic acid,  
see also Toxikologisch-arbeitsmedizinische Begründung  
von MAK-Werten (34th issue 2002)

Tall oil rosin and fatty acids → Tall oil, distilled

**Tantalum**

[7440-25-7] Ta  
(inhalable fraction)  
see Section Vf and g

MAK[mg/m<sup>3</sup>]: 4 I  
Preg gr: C

**Tantalum**

[7440-25-7] Ta  
(respirable fraction)  
except for ultrafine particles; see Section Vh  
see Section Vf

MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density  
Peak lim: II(8)  
Preg gr: C  
Carc cat: 4

**Tartaric acid**

[87-69-4] HO<sub>2</sub>C-CHOH-CHOH-CO<sub>2</sub>H  
see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
Peak lim: I(2)  
Preg gr: C

TBTO → n-Butyltin compounds

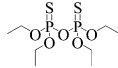
TCDD → 2,3,7,8-Tetrachlorodibenzo-p-dioxin

Teak (*Tectona grandis*) → Woods

*Tectona grandis* → Woods

**TEDP**

[3689-24-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 2.2×10<sup>-4</sup>

MAK[ml/m<sup>3</sup>]: 0.01  
MAK[mg/m<sup>3</sup>]: 0.13  
Peak lim: II(2)  
Preg gr: C  
Perc abs: H

**Tellurium**

[13494-80-9] Te  
and its inorganic compounds  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

**★ TEPP**

[107-49-3] [(H<sub>3</sub>C-CH<sub>2</sub>-O)<sub>2</sub>PO]<sub>2</sub>O

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.03  
see Section IIc

Terephthalic acid → p-Phthalic acid

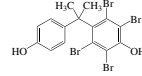
*Terminalia* spp. → Woods

3,3',4,4'-Tetraminobiphenyl

→ 3,3'-Diaminobenzidine and its tetrahydrochloride

**★ Tetrabromobisphenol A**

[79-94-7]



VP[hPa]: 1.19×10<sup>-7</sup>

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2

Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.

**1,1,2,2-Tetrabromoethane**

[79-27-6] Br<sub>2</sub>HC-CHBr<sub>2</sub>

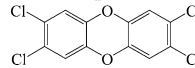
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

2,4,5,6-Tetrachloro-1,3-benzenedicarbonitrile  
→ Chlorothalonil

**2,3,7,8-Tetrachlorodibenzo-p-dioxin**

[1746-01-6]



MAK[mg/m<sup>3</sup>]: 1.0E-8 I  
Peak lim: II(8)  
Preg gr: C  
Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
Perc abs: H  
Carc cat: 4

**1,1,1,2-Tetrachloro-2,2-difluoroethane (FC-112a)**

[76-11-9] ClF<sub>2</sub>C-CCl<sub>3</sub>

MAK[ml/m<sup>3</sup>]: 200  
MAK[mg/m<sup>3</sup>]: 1700  
Peak lim: II(2)  
Preg gr: D

**1,1,2,2-Tetrachloro-1,2-difluoroethane (FC-112)**

[76-12-0] Cl<sub>2</sub>FC-CCl<sub>2</sub>F

MAK[ml/m<sup>3</sup>]: 200  
MAK[mg/m<sup>3</sup>]: 1700  
Peak lim: II(2)  
Preg gr: D

**1,1,2,2-Tetrachloroethane**[79-34-5]  $\text{Cl}_2\text{HC}-\text{CHCl}_2$ 

VP[hPa]: 6.4

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 14  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H  
 Carc cat: 4

**Tetrachloroethene**[127-18-4]  $\text{Cl}_2\text{C}=\text{CCl}_2$ VP[hPa]: 19  
see Section XII

MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 69  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 3

Tetrachloroisophthalonitrile → Chlorothalonil

**Tetrachloromethane**[56-23-5]  $\text{CCl}_4$ VP[hPa]: 120  
see Section XII

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 3.2  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

Tetrachloronaphthalenes → Chlorinated naphthalenes

$\alpha,\alpha,\alpha,4$ -Tetrachlorotoluene  
 → p-Chlorobenzotrichloride

Tetradecanoic acid → Myristic acid

**1-Tetradecanol**[112-72-1]  $\text{HO}-(\text{CH}_2)_{13}-\text{CH}_3$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.5 \times 10^{-4}$  at 25°C (calculated value)  
see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Tetraethyl diphosphate → TEPP

**Tetraethylene glycol diacrylate**[17831-71-9]  $\text{O}-(\text{CH}_2-\text{CH}_2-\text{O})_2-\text{OC}-\text{CH}=\text{CH}_2$   
 $(\text{CH}_2-\text{CH}_2-\text{O})_2-\text{OC}-\text{CH}=\text{CH}_2$ 

see Section IV

Sens: Sh

**Tetraethylene glycol dimethacrylate**[109-17-1]  $\text{O}-(\text{CH}_2-\text{CH}_2-\text{O})_2-\text{OC}-\text{C}(\text{CH}_3)=\text{CH}_2$   
 $(\text{CH}_2-\text{CH}_2-\text{O})_2-\text{OC}-\text{C}(\text{CH}_3)=\text{CH}_2$ 

see Section IV

Sens: Sh

**Tetraethyllead**[78-00-2]  $\text{Pb}(\text{C}_2\text{H}_5)_4$   
(as Pb)

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.35 at 25°C  
see Section XII

MAK[mg/m<sup>3</sup>]: 0.05  
 Peak lim: II(2)  
 Preg gr: B  
 Perc abs: H

Tetraethyl silicate → Silicic acid tetraethyl ester

**1,1,1,2-Tetrafluoroethane**[811-97-2]  $\text{F}_3\text{C}-\text{CH}_2\text{F}$ 

VP[hPa]: 5700

MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 4200  
 Peak lim: II(8)  
 Preg gr: C

**Tetrafluoroethene**[116-14-3]  $\text{F}_2\text{C}=\text{CF}_2$ 

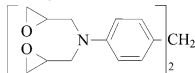
MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

**trans-1,3,3,3-Tetrafluoropropene**[29118-24-9] 

MAK[ml/m<sup>3</sup>]: 1000  
 MAK[mg/m<sup>3</sup>]: 4700  
 Peak lim: II(2)  
 Preg gr: C

**2,3,3,3-Tetrafluoropropene**[754-12-1]  $\text{H}_2\text{C}=\text{CF}-\text{CF}_3$ 

MAK[ml/m<sup>3</sup>]: 200  
 MAK[mg/m<sup>3</sup>]: 950  
 Peak lim: II(2)  
 Preg gr: C

**Tetraglycidyl-4,4'-methylenedianiline**[28768-32-3] 

see Section IV

Sens: Sh

**Tetrahydrobenzotriazole**

[6789-99-7]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Tetrahydrofuran**

[109-99-9]



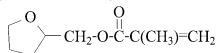
VP[hPa]: 200

see Section XII

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 150  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

**Tetrahydrofurfuryl methacrylate**

[2455-24-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 9.4×10<sup>-3</sup>

see Section IV

Sens: Sh

3a,4,7,7a-Tetrahydro-4,7-methanoindene  
 → Dicyclopentadiene

Tetrahydromethyl-1,3-isobenzofurandione  
 → Methyltetrahydrophthalic anhydride

**Tetrahydronaphthalene**

[119-64-2]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.24

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 Peak lim: I(1)  
 Preg gr: C

Tetrahydro-1,4-oxazine → Morpholine

★ **Tetrahydrothiophene (THT)**

[110-01-0]



MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 183

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(1)  
 Preg gr: C

1,3,4,6-Tetra(hydroxymethyl)-1,3,4,6-tetraaza-bicyclooctan-2,5-dione → Tetramethylol acetylenediurea

1,3,4,6-Tetrakis(hydroxymethyl)-3a,6a-dihydroimidazo[4,5-d]imidazole-2,5-dione  
 → Tetramethylol acetylenediurea

Tetralene → Tetrahydronaphthalene

4-(1,1,3,3-Tetramethylbutyl)phenol  
 → 4-tert-Octylphenol

Tetramethyl diaminobenzophenon → Michler's ketone

Tetramethyl diaminodiphenylacetimine  
 → Auramine

Tetramethyl diaminodiphenylacetimine hydrochloride → Auramine

N,N,N',N'-Tetramethyl-4,4'-diaminodiphenylmethane → 4,4'-Methylenebis(N,N-dimethylaniline)

**Tetramethyllead**

[75-74-1]

(as Pb)

Pb(CH<sub>3</sub>)<sub>4</sub>

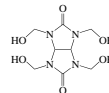
VP[hPa]: 30

see Section XII

MAK[mg/m<sup>3</sup>]: 0.05  
 Peak lim: II(2)  
 Preg gr: B  
 Perc abs: H

★ **Tetramethylol acetylenediurea**

[5395-50-6]



releases formaldehyde

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 7.6×10<sup>-10</sup> at 25°C (calculated value)

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.046  
 MAK[mg/m<sup>3</sup>]: 0.5 I  
 Peak lim: I(2)  
 Preg gr: C  
 Sens: Sh  
 Carc cat: 4  
 Muta cat: 5

**Tetramethyl succinonitrile**[3333-52-6]  $\text{NC-C(CH}_3)_2\text{-C(CH}_3)_2\text{-CN}$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $9.8 \times 10^{-3}$ 

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

Tetramethylthiuram disulfide → Thiram

Tetramethyltin → Methyltin compounds

**Tetramethyl urea (TMU)**[632-22-4]  $((\text{CH}_3)_2\text{N})_2\text{CO}$ 

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Tetranitromethane**[509-14-8]  $\text{C(NO}_2)_4$ 

VP[hPa]: 11

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Tetryl → N-Methyl-N,2,4,6-tetranitroaniline

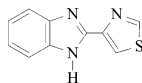
**Thallium, soluble compounds**

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Thiabendazole**

[148-79-8]



see Section Xc

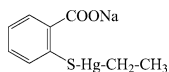
MAK[mg/m<sup>3</sup>]: 20 I  
 Peak lim: II(2)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
 Muta cat: 5

2-(4'-Thiazolyl)benzimidazole

→ Thiabendazole

**Thimerosal**

[54-64-8]



see Section IV

Sens: Sh

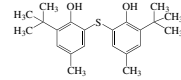
2,2'-Thiobis(6-tert-butyl-p-cresol)

→ 2,2'-Thiobis(4-methyl-6-tert-butylphenol)

2,2'-Thiobis(4,6-dichlorophenol) → Bithionol

**2,2'-Thiobis(4-methyl-6-tert-butylphenol)**

[90-66-4]

VP[hPa]:  $1 \times 10^{-5}$ 

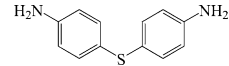
see Section Vf and g and Xc

MAK[mg/m<sup>3</sup>]: 4 I  
 Preg gr: D

Thiocarbamide → Thiourea

**4,4'-Thiodianiline**

[139-65-1]

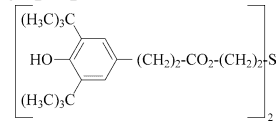


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 2

p,p'-Thiodianiline → 4,4'-Thiodianiline

**2,2'-Thiodiethylene Bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]**

[41484-35-9]



see Section Xc

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: D

**Thioglycolates**

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh

**Thioglycolic acid**

[68-11-1]

 $\text{HS-CH}_2\text{-COOH}$ 

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh

Thioglycolic acid monoglyceryl ester

→ Glycerol monothioglycolate

Thiomersal → Thimerosal

Thiomersalate → Thimerosal

**Thiourea**[62-56-6]  $\text{H}_2\text{N-CS-NH}_2$ 

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh SP  
 Carc cat: 3

**Thiram**[137-26-8]  $[(\text{H}_3\text{C})_2\text{N-CS})_2\text{S}_2$ 

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III “Amines which form carcinogenic nitrosamines on nitrosation”.

MAK[mg/m<sup>3</sup>]: 1 I  
 Peak lim: II(2)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.  
 Sens: Sh

THU → Thiourea

Thuja spp. → Woods

Tieghemella spp. → Woods

**Tin**[7440-31-5] Sn  
and its inorganic compounds  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Tin compounds, organic (n-Butyl-)

→ n-Butyltin compounds

Tin compounds, organic (Ethyl-) → Ethyltin compounds

Tin compounds, organic (Methyl-) → Methyltin compounds

Tin compounds, organic (n-Octyl-)

→ n-Octyltin compounds

Tin compounds, organic (Phenyl-) → Phenyltin compounds

**Titanium dioxide**[13463-67-7]  $\text{TiO}_2$   
(respirable fraction)

except for ultrafine particles; see Section Vh  
 see Section Vf

MAK[mg/m<sup>3</sup>]: 0,3 R  
 multiplied with the material density  
 Peak lim: II(8)  
 Preg gr: C  
 Carc cat: 4

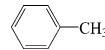
TMAD → Tetramethylol acetylenediurea

TNT → 2,4,6-Trinitrotoluene

o-Tolidine → 3,3'-Dimethylbenzidine

**Toluene**

[108-88-3]

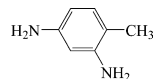


VP[hPa]: 37.9 at 25°C  
 see Section XII

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 190  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H

**2,4-Toluenediamine**

[95-80-7]



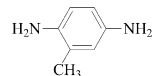
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $2.3 \times 10^{-4}$  at 25°C  
 see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3B

**2,5-Toluenediamine**

[95-70-5]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $4.5 \times 10^{-3}$  at 25°C  
 see Section IV

Sens: Sh

**Toluene diisocyanates**

The substance can occur simultaneously as vapour and aerosol.

see Section XII

MAK[ml/m<sup>3</sup>]: 0.001

MAK[mg/m<sup>3</sup>]: 0.007

Peak lim: I(1)

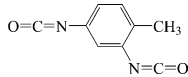
A momentary value of 0.005 ml/m<sup>3</sup> (0.035 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

Sens: Sah

**-2,4-Toluene diisocyanate**

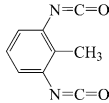
[584-84-9]



VP[hPa]: 0.011

**-2,6-Toluene diisocyanate**

[91-08-7]



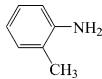
VP[hPa]: 0.028 at 25°C

**-Toluene diisocyanates, mixture**

[26471-62-5]

**o-Toluidine**

[95-53-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.18

see Section XII

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

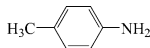
Perc abs: H

Carc cat: 1

Muta cat: 3A

**p-Toluidine**

[106-49-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.38 at 25°C

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

Perc abs: H

Sens: Sh

Carc cat: 3

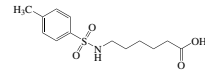
2,4-Toluylenediamine → 2,4-Toluenediamine

Tolyl diiodomethyl sulfone

→ 4-(Diiodomethylsulfonyl)-toluene

**★ N-Tosyl-6-aminocaproic acid**

[78521-39-8]



VP[hPa]: 3.98×10<sup>-9</sup>

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

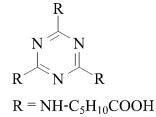
Peak lim: -

Preg gr: -

Tremolite (fibrous dust) → Asbestos

**Triazinetriyltriiminotrishexanoic acid**

[80584-91-4]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**Tribromomethane**

[75-25-2]

CHBr<sub>3</sub>

VP[hPa]: 7

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

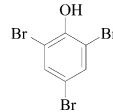
Peak lim: -

Preg gr: -

Carc cat: 3

**2,4,6-Tribromophenol**

[118-79-6]



The substance can occur simultaneously as vapour and aerosol.

see Section IIb

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -

**Tri-n-butylamine**

[102-82-9]

N(CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>3</sub>)<sub>3</sub>

The substance can occur simultaneously as vapour and aerosol. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodi-n-butylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 0.12 at 25°C

see Section IIb

MAK[ml/m<sup>3</sup>]: -

MAK[mg/m<sup>3</sup>]: -

Peak lim: -

Preg gr: -



**Tributyl phosphate**

[126-73-8]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.5 \times 10^{-3}$  at 25°C

MAK[ml/m <sup>3</sup> ]:	1
MAK[mg/m <sup>3</sup> ]:	11
Peak lim:	II(2)
Preg gr:	C
Perc abs:	H
Carc cat:	4

Tri-n-butyltin compounds → n-Butyltin compounds

**Trichloroacetic acid**

[76-03-9]



see also Sodium trichloroacetate

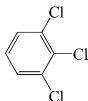
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.1

MAK[ml/m <sup>3</sup> ]:	0.2
MAK[mg/m <sup>3</sup> ]:	1.4
Peak lim:	I(1)
Preg gr:	C

**1,1,2-Trichlorobenzene**

[87-61-6]



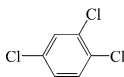
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.28 at 25°C

MAK[ml/m <sup>3</sup> ]:	0.5
MAK[mg/m <sup>3</sup> ]:	3.8
Peak lim:	II(2)
Preg gr:	C
Perc abs:	H
Sens:	Sh

**1,2,4-Trichlorobenzene**

[120-82-1]



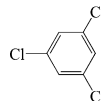
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.61 at 25°C

MAK[ml/m <sup>3</sup> ]:	0.5
MAK[mg/m <sup>3</sup> ]:	3.8
Peak lim:	II(2)
Preg gr:	C
Perc abs:	H

**1,3,5-Trichlorobenzene**

[108-70-3]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.32 at 25°C

MAK[ml/m <sup>3</sup> ]:	0.5
MAK[mg/m <sup>3</sup> ]:	3.8
Peak lim:	II(2)
Preg gr:	C
Perc abs:	H

1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane  
→ DDT (Dichlorodiphenyltrichloroethane)

**2,3,4-Trichloro-1-butene**

[2431-50-7]



MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	2

**1,1,1-Trichloroethane**

[71-55-6]



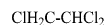
VP[hPa]: 133

see Section XII

MAK[ml/m <sup>3</sup> ]:	100
MAK[mg/m <sup>3</sup> ]:	550
Peak lim:	II(1)
Preg gr:	C
Perc abs:	H

**1,1,2-Trichloroethane**

[79-00-5]



VP[hPa]: 25

MAK[ml/m <sup>3</sup> ]:	1
MAK[mg/m <sup>3</sup> ]:	5.5
Peak lim:	I(2)
Preg gr:	D
Perc abs:	H
Carc cat:	3

**Trichloroethene**

[79-01-6]



VP[hPa]: 77

see Section XII

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Perc abs:	H
Carc cat:	1
Muta cat:	3B

Trichloroethylene → Trichloroethene

**Trichlorofluoromethane (FC-11)**

[75-69-4]

CCl<sub>3</sub>F

VP[hPa]: 889

MAK[ml/m<sup>3</sup>]: 1000MAK[mg/m<sup>3</sup>]: 5700

Peak lim: II(2)

Preg gr: C

Trichloromethane → Chloroform (Trichloromethane)

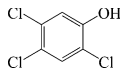
1-Trichloromethylbenzene → Benzyl trichloride

Trichloronaphthalenes → Chlorinated naphthalenes

Trichloronitromethane → Chloropicrin

**2,4,5-Trichlorophenol**

[95-95-4]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $8 \times 10^{-3}$  at 25°C

see Section IIb

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

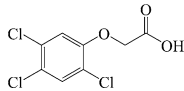
Peak lim: –

Preg gr: –

**2,4,5-Trichlorophenoxyacetic acid**

[93-76-5]

including salts and esters

MAK[mg/m<sup>3</sup>]: 2 I

Peak lim: II(2)

Preg gr: C

Perc abs: H

**1,2,3-Trichloropropane**

[96-18-4]

ClCH<sub>2</sub>-CHCl-CH<sub>2</sub>Cl

VP[hPa]: 4.5

MAK[ml/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

 $\alpha,\alpha$ -Trichlorotoluene → Benzyl trichloride**1,1,2-Trichloro-1,2,2-trifluoroethane (FC-113)**

[76-13-1]

ClF<sub>2</sub>C-CCl<sub>2</sub>F

VP[hPa]: 360

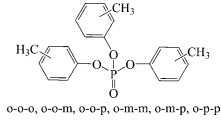
MAK[ml/m<sup>3</sup>]: 500MAK[mg/m<sup>3</sup>]: 3900

Peak lim: II(2)

Preg gr: D

**Tricresyl phosphate, sum of all o-isomers**

[78-30-8]



o-o-o, o-o-m, o-o-p, o-m-m, o-m-p, o-p-p

The substance can occur simultaneously as vapour and aerosol.

see Section XII

MAK[ml/m<sup>3</sup>]: 0.001MAK[mg/m<sup>3</sup>]: 0.015

Peak lim: II(8)

Preg gr: D

Perc abs: H

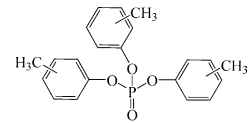
Carc cat: 3

**Tricresyl phosphate, isomers, “free of o-isomers”**

[1330-78-5;

563-04-2;

78-32-0]



m-m-m, m-m-p, m-p-p, p-p-p

see Section Xc

MAK[mg/m<sup>3</sup>]: 5 I

Peak lim: II(2)

Preg gr: C

Tridymite → Silica, crystalline

**Triethanolamine**

[102-71-6]

N(CH<sub>2</sub>-CH<sub>2</sub>OH)<sub>3</sub>VP[hPa]:  $4.8 \times 10^{-6}$  at 25°C

see Section Xc

MAK[mg/m<sup>3</sup>]: 1 I

Peak lim: I(1)

Preg gr: C

**★ Triethylamine**

[121-44-8]

(H<sub>3</sub>C-CH<sub>2</sub>)<sub>3</sub>N

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III “Amines which form carcinogenic nitrosamines on nitrosation”.

VP[hPa]: 72

MAK[ml/m<sup>3</sup>]: 1MAK[mg/m<sup>3</sup>]: 4.2

Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see

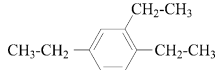
Section Ie

Peak lim: I(2)

Preg gr: D

**1,2,4-Triethylbenzene**

[877-44-1]

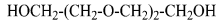


The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m <sup>3</sup> ]:	5
MAK[mg/m <sup>3</sup> ]:	34
Peak lim:	II(2)
Preg gr:	D
Perc abs:	H

**Triethylene glycol**

[112-27-6]



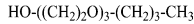
The substance can occur simultaneously as vapour and aerosol. Because formation of a mist is possible, exposure should be minimized for reasons of occupational safety and hygiene.

VP[hPa]: 0.003

MAK[mg/m <sup>3</sup> ]:	1000 I
Peak lim:	II(2)
Preg gr:	B

**Triethylene glycol n-butyl ether**

[143-22-6]



The substance can occur simultaneously as vapour and aerosol.

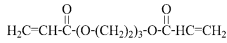
VP[hPa]:  $3.3 \times 10^{-3}$  at 25°C

see Section IIb and Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–

**Triethylene glycol diacrylate**

[1680-21-3]

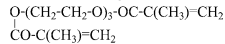


see Section IV

Sens: Sh

**Triethylene glycol dimethacrylate**

[109-16-0]

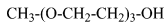


see Section IV

Sens: Sh

**Triethylene glycol monomethyl ether**

[112-35-6]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $4.7 \times 10^{-3}$  at 25°C (calculated value)

see Section Xc

MAK[mg/m <sup>3</sup> ]:	50 I
Peak lim:	II(2)
Preg gr:	C

**Triethylenetetramine**

[112-24-3]



The substance can occur simultaneously as vapour and aerosol.

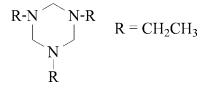
VP[hPa]:  $5.5 \times 10^{-4}$  at 25°C

see Section IV

Sens: Sh

**1,3,5-Triethylhexahydro-1,3,5-triazine**

[7779-27-3]



releases formaldehyde

see Section Xc

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Carc cat:	3

**Trifluoromonobromomethane**

→ Bromotrifluoromethane

**Trifluoromonochloromethane**

→ Chlorotrifluoromethane (FC-13)

**1,1,1-Trifluoro-2,2-dichloroethane**

→ 2,2-Dichloro-1,1,1-trifluoroethane (FC-123)

**Triglycerides**

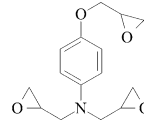
(lard oil, palm oil, rapeseed oil, soybean oil) see also coconut oil

see Section Xc

MAK[mg/m <sup>3</sup> ]:	5 R
Peak lim:	II(4)
Preg gr:	C

**Triglycidyl-p-aminophenol**

[5026-74-4]



see Section IV

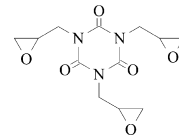
Sens: Sh

**1,3,5-Triglycidyl isocyanurate (mixture of isomers)**

[2451-62-9]

α-isomer [59653-73-5]

β-isomer [59653-74-6]

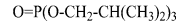


see Section IV

Sens: Sah

**Triisobutyl phosphate**

[126-71-6]



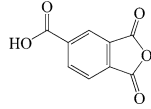
The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.02

see Section IIb

MAK[ml/m <sup>3</sup> ]:	–
MAK[mg/m <sup>3</sup> ]:	–
Peak lim:	–
Preg gr:	–
Sens:	Sh

Trimanganese tetroxide → Manganese

**Trimellitic anhydride**[552-30-7]  
(fume)MAK[mg/m<sup>3</sup>]: 0.04 R  
Peak lim: I(1)  
Sens: Sa★ **Trimethylamine**

[75-50-3]



Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

VP[hPa]: 1900

MAK[m<sup>3</sup>/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 4.9

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

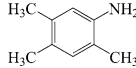
Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (12 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

**2,4,5-Trimethylaniline**

[137-17-7]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.057 at 25°C

MAK[m<sup>3</sup>/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

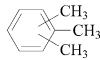
Perc abs: H

Carc cat: 2

N,N,4-Trimethylaniline → N,N-Dimethyl-p-toluidine

**Trimethylbenzene (all isomers)**

[25551-13-7]



VP[hPa]: 2-6

see Section XII

MAK[m<sup>3</sup>/m<sup>3</sup>]: 20MAK[mg/m<sup>3</sup>]: 100

Peak lim: II(2)

Preg gr: C

– **1,2,3-Trimethylbenzene**  
[526-73-8]– **1,2,4-Trimethylbenzene**  
[95-63-6]– **1,3,5-Trimethylbenzene**  
[108-67-8]

3,5,5-Trimethyl-2-cyclo-1-hexenone

→ Isophorone

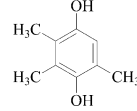
3,7,11-Trimethyl-2,6,10-dodecatrien-1-ol

→ Farnesol

3,5,5-Trimethylhexanoic acid → Isononanoic acid

**Trimethylhydroquinone**

[700-13-0]

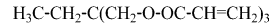


see Section IV

Sens: Sh

**Trimethylolpropane triacrylate**

[15625-89-5]

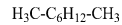


see Section IV

Sens: Sh

**Trimethylpentane (all isomers)**

[29222-48-8]

MAK[m<sup>3</sup>/m<sup>3</sup>]: 100MAK[mg/m<sup>3</sup>]: 470

Peak lim: II(2)

Preg gr: D

**Trimethyl phosphate**

[512-56-1]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.59

MAK[m<sup>3</sup>/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 3

Muta cat: 2

**Trimethylphosphite**

[121-45-9]



see Section IIb

MAK[m<sup>3</sup>/m<sup>3</sup>]: –MAK[mg/m<sup>3</sup>]: –

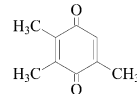
Peak lim: –

Preg gr: –

Perc abs: H

**Trimethylquinone**

[935-92-2]



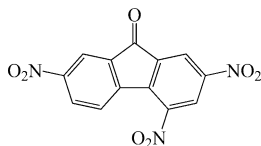
see Section IV

Sens: Sh

Trimethyltin compounds → Methyltin compounds

**2,4,7-Trinitrofluorenone**

[129-79-3]

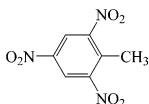


MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 3

2,4,6-Trinitrophenol → Picric acid

2,4,6-Trinitrophenylmethylnitramine  
→ N-Methyl-N,2,4,6-tetranitroaniline**2,4,6-Trinitrotoluene**

[118-96-7]

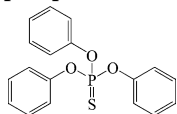


see Section XII

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: Sh  
 Carc cat: 2  
 Muta cat: 3B

**Triphenyl monothiophosphate**

[597-82-0]



VP[hPa]: &lt;0.00001

see Section Xc

MAK[mg/m<sup>3</sup>]: 20 I  
 Peak lim: II(2)  
 Preg gr: D

Triphenylphosphane → Triphenylphosphine

**Triphenyl phosphate**

[115-86-6]

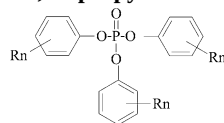
(C<sub>6</sub>H<sub>5</sub>O)<sub>3</sub>POVP[hPa]: 1×10<sup>-5</sup> at 25°C (calculated value)

see Section Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: 10 I  
 Peak lim: II(2)  
 Preg gr: C

**Triphenyl phosphate, isopropylated**

[68937-41-7]

VP[hPa]: 1×10<sup>-7</sup> at 25°C (calculated value)

see Section Xc

MAK[mg/m<sup>3</sup>]: 1 I  
 Peak lim: II(2)  
 Preg gr: C

**Triphenylphosphine**

[603-35-0]

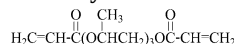
P(C<sub>6</sub>H<sub>5</sub>)<sub>3</sub>VP[hPa]: 1.2×10<sup>-6</sup> at 20°C (extrapolated)

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: II(2)  
 Preg gr: D  
 Sens: Sh

Triplochiton scleroxylon → Woods

**Tripropylene glycol diacrylate**

[42978-66-5]

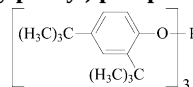


see Section IV

Sens: Sh

**Tris(2,4-ditert-butylphenyl) phosphite**

[31570-04-4]

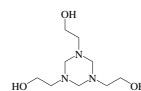


see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**★ N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine**

[4719-04-4]



releases formaldehyde

The substance can occur simultaneously as vapour and aerosol.

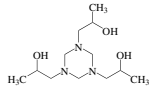
VP[hPa]: 5×10<sup>-8</sup> at 25°C (calculated value)

see Section Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Sens: Sh  
 Carc cat: 2  
 Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.  
 Muta cat: 3B

★ **N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine**

[25254-50-6]



releases formaldehyde

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]:  $1.7 \times 10^{-8}$  (calculated value)

see Section Xc

MAK[ml/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Sens: Sh

Carc cat: 2

Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.

Muta cat: 3B

**Tris[(2- or 4-)C<sub>9</sub>–C<sub>10</sub>-isoalkylphenyl]phosphorothioate**

[126019-82-7]

S=P(O-C<sub>6</sub>H<sub>4</sub>-C<sub>9-10</sub>H<sub>19,21</sub>)<sub>3</sub>

VP[hPa]:  $2.8 \times 10^{-10}$  at 25°C (extrapolated)

see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –

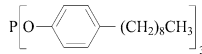
MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Tris(nonylphenyl) phosphite**

[26523-78-4]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

**Trypsin and Chymotrypsin**

[9002-07-7; 9004-07-3]

see Section IV

Sens: Sa

**Tungsten**

[7440-33-7]

W

and its compounds (as W)

see Section IIb

MAK[ml/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Tungsten carbide → Hard metal containing tungsten carbide and cobalt

**Turpentine**

[8006-64-2]

VP[hPa]: 6.6

MAK[ml/m<sup>3</sup>]: 5

MAK[mg/m<sup>3</sup>]: 28

Peak lim: II(2)

Preg gr: D

Perc abs: H

Sens: Sh

**Uranium**

[7440-61-1]

U

and its hardly soluble inorganic compounds

see Section XII

MAK[mg/m<sup>3</sup>]: –

The threshold value of the 'Strahlenschutzkommission' (Commission on Radiological Protection) of 20 mSv per year or 400 mSv per working lifetime corresponds to about 25 µg uranium/m<sup>3</sup> for poorly soluble uranium compounds and 250 µg uranium/m<sup>3</sup> for soluble compounds (MMAD of 5 µm). The value for soluble uranium compounds does not provide protection against nephrotoxicity.

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 2

Muta cat: 3A

**Uranium compounds, soluble inorganic**

see Section XII

MAK[mg/m<sup>3</sup>]: –

The threshold value of the 'Strahlenschutzkommission' (Commission on Radiological Protection) of 20 mSv per year or 400 mSv per working lifetime corresponds to about 25 µg uranium/m<sup>3</sup> for poorly soluble uranium compounds and 250 µg uranium/m<sup>3</sup> for soluble compounds (MMAD of 5 µm). The value for soluble uranium compounds does not provide protection against nephrotoxicity.

Peak lim: –

Preg gr: –

Perc abs: H

Carc cat: 3

Muta cat: 3A

Urethane → Carbamic acid ethyl ester

Utile (Entandrophragma utile) → Woods

★ **Vanadium**

[7440-62-2]

V

and its inorganic compounds (inhalable fraction)

see Section XII

MAK[mg/m<sup>3</sup>]: 0.005 I

Peak lim: II(2)

Preg gr: D

Carc cat: 4

Muta cat: 5

**Vinyl acetate**

[108-05-4]  $H_2C=CHOCH_2-CH_3$   
 VP[hPa]: 120  
 MAK[ml/m<sup>3</sup>]: 10  
 MAK[mg/m<sup>3</sup>]: 36  
 Peak lim: I(1)  
 A momentary value of 20 ml/m<sup>3</sup> (71 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

Vinylbutyrolactam → N-Vinyl-2-pyrrolidone

**Vinylcarbazole**


[1484-13-5]  


see Section IV  
 Sens: Sh

**Vinyl chloride**

[75-01-4]  $H_2C=CHCl$   
 see Section XII  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Carc cat: 1

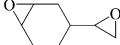
**4-Vinylcyclohexene**

[100-40-3]  
  
 (E)

VP[hPa]: 20  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

4-Vinyl-1,2-cyclohexene diepoxide  
 → 4-Vinyl-1-cyclohexene dioxide

**4-Vinyl-1-cyclohexene dioxide**

[106-87-6]  


The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.13  
 MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

Vinyl ethyl ether → Ethyl vinyl ether

**Vinylidene chloride**

[75-35-4]  $H_2C=CCl_2$   
 VP[hPa]: 667  
 MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 8.0  
 Peak lim: II(2)  
 Preg gr: C  
 Carc cat: 3

Vinylidene fluoride → 1,1-Difluoroethylene

Vinyl isobutyl ether → Isobutyl vinyl ether

Vinyl methyl ether → Methyl vinyl ether

**N-Vinyl-2-pyrrolidone**

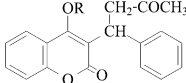
[88-12-0]  


The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.15 at 25°C  
 MAK[ml/m<sup>3</sup>]: 0.01  
 MAK[mg/m<sup>3</sup>]: 0.047  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Carc cat: 4

Vinyl toluene → Methyl styrene (all isomers)

**Warfarin**

[81-81-2]  
 and sodium warfarin  
 [129-06-6]  
  
 R = H, Na

The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.09  
 MAK[ml/m<sup>3</sup>]: 0.0016  
 MAK[mg/m<sup>3</sup>]: 0.02  
 MAK value for sodium warfarin 0.02 mg/m<sup>3</sup> I  
 Peak lim: II(8)  
 Preg gr: B  
 Perc abs: H

Western red cedar (*Thuja plicata*) → Woods

Wheat → Cereal flour dusts

**White mineral oil (pharmaceutical)**

[8042-47-5]  
 see Section Xc  
 MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: C

White spirit, dearomatised → Naphtha (petroleum)

**Wollastonite**

[13983-17-0] CaSiO<sub>3</sub>  
(fibrous dust)  
see Section IIb

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

Wood dust (beech) → Beech wood dust

Wood dust (oak) → Oak wood dust

**Wood dust (except beech and oak wood dust)**

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Carc cat: 3

Wood ether → Dimethyl ether

**Woods**

see Section IV

- **Acacia melanoxylon R.Br.**  
Australian blackwood  
Sens: Sh
- **Bowdichia nitida Bentham**  
sapupira, (black) sucupira  
Sens: –
- **Brya ebenus DC.**  
cocus wood  
Sens: Sh
- **Calocedrus decurrens (Torr.) Florin**  
incense cedar, pencil cedar  
Sens: –
- **Chlorophora excelsa (Welw.) Benth. & Hook**  
iroko, kambala  
Sens: Sh
- **Dalbergia latifolia Roxb.**  
East Indian rosewood, Bombay blackwood  
Sens: Sh
- **Dalbergia melanoxylon Guill. et Perr.**  
African blackwood  
Sens: Sh
- **Dalbergia nigra Allem.**  
Brazilian rosewood  
Sens: Sh
- **Dalbergia retusa Hemsl.**  
cocobolo, rosewood  
Sens: Sh
- **Dalbergia stevensonii Standley**  
Honduras rosewood  
Sens: Sh
- **Diospyros celebica Bakh.**  
Macassar ebony, coromandel  
Sens: –
- **Diospyros crassiflora Hiern.**  
African ebony  
Sens: –
- **Diospyros ebenum Koenig**  
Ceylon ebony, Indian ebony  
Sens: –
- **Diospyros melanoxylon Roxb.**  
ebony  
Sens: –
- **Distemonanthus benthamianus Baill.**  
ayan  
Sens: Sh
- **Entandrophragma angolense C.DC.**  
gedu nohor, edinam, tiama  
Sens: –
- **Entandrophragma candollei Harms**  
heavy sapele, omu  
Sens: –
- **Entandrophragma cylindricum Sprague**  
sapele  
Sens: –
- **Entandrophragma utile Sprague**  
utile  
Sens: –
- **Gonystylus bancanus (Miq.) Baill.**  
ramin  
Sens: –
- **Grevillea robusta A.Cunn.**  
Australian silky oak  
Sens: Sh
- **Khaya anthotheca C.DC.**  
African mahogany  
Sens: Sh
- **Khaya grandifoliola C.DC.**  
African mahogany, big leaf mahogany  
Sens: –
- **Khaya ivorensis A.Chev.**  
African mahogany, Grand Bassam mahogany  
Sens: –
- **Khaya senegalensis A.Juss.**  
African mahogany, Senegal mahogany  
Sens: –
- **Machaerium scleroxylon Tul.**  
pao ferro, Santos rosewood  
Sens: Sh
- **Mansonia altissima A.Chev.**  
mansonia, pruno, bété  
Sens: Sh
- **Paratecoma peroba (Record) Kuhlmann.**  
ipe peroba  
Sens: Sh
- **Quercus petraea (Matuschka) Liebl.**  
durmast oak, sessile oak  
Sens: –



- **Quercus robur L.**  
European oak, common oak, pedunculate oak  
Sens: –
- **Quercus rubra L.**  
American red oak  
Sens: –
- **Swietenia macrophylla King**  
American mahogany, mahogany, broadleaf mahogany  
Sens: –
- **Swietenia mahagoni (L.) Jacq.**  
Caribbean mahogany, Cuban mahogany  
Sens: –
- **Tabebuia avellanedae (Griseb.) Lor.**  
lapacho, ipe  
Sens: –
- **Tabebuia serratifolia Nichols**  
bethabara, ipe  
Sens: –
- **Tectona grandis L.f.**  
teak  
Sens: Sh
- **Terminalia ivorensis A.Chev.**  
framiré, idigbo  
Sens: –
- **Terminalia superba Engl. u. Diels**  
fraké, limba, afara, white afara  
Sens: Sa
- **Thuja occidentalis L.**  
arborvitae, eastern white cedar, northern white cedar  
Sens: –
- **Thuja plicata (D.Don.) Donn.**  
western red cedar, giant arborvitae, shinglewood  
Sens: Sah
- **Tieghemella africana A.Chev.**  
douka  
Sens: –
- **Tieghemella heckelii Pierre**  
makoré, “cherry mahogany”, African “cherry”  
Sens: –
- **Triplochiton scleroxylon K.Schum.**  
obeche, wawa, African whitewood  
Sens: Sah

**Xylanases**

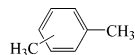
[37278-89-0]

see Section IV

Sens: Sa

**Xylene (all isomers)**

[1330-20-7]



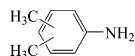
At high levels of physical activity the observance of the BAT value should be checked regularly by biological monitoring.

VP[hPa]: 8  
see Section XII

MAK[ml/m<sup>3</sup>]: 50  
MAK[mg/m<sup>3</sup>]: 220  
Peak lim: II(2)  
Preg gr: D  
Perc abs: H

**Xylidine**

(isomers)



The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 3  
Muta cat: 3B

– **2,3-Xylidine**

[87-59-2]

VP[hPa]: 0.1 at 25°C

– **2,5-Xylidine**

[95-78-3]

VP[hPa]: 0.2

– **3,4-Xylidine**

[95-64-7]

VP[hPa]: 0.04 at 25°C

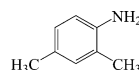
– **3,5-Xylidine**

[108-69-0]

VP[hPa]: 0.2 at 25°C

**2,4-Xylidine**

[95-68-1]



The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: –  
MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: H  
Carc cat: 2

**2,6-Xylidine**

[87-62-7]

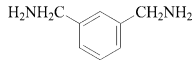


The substance can occur simultaneously as vapour and aerosol.

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Carc cat: 2

**m-Xylylenediamine**

[1477-55-0]



The substance can occur simultaneously as vapour and aerosol.

VP[hPa]: 0.04  
 see Section IV

Sens: Sh

**Yttrium**

[7440-65-5]

Y

and its compounds  
 see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

Zeolites (fibrous dust) → Erionite

**Zeolites, synthetic (non-fibrous)**

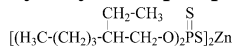
[1318-02-1]

see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Zinc, O,O'-di-2-ethylhexyl dithiophosphate**

[4259-15-8]



see Section IIb and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –

**Zinc**

[7440-66-6]

Zn

and its inorganic compounds  
 (inhalable fraction)

MAK[mg/m<sup>3</sup>]: 2 I  
 Peak lim: I(2)  
 Zinc chloride: Peak limitation category I(1)  
 Preg gr: C  
 Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

**Zinc**

[7440-66-6]

Zn

and its inorganic compounds  
 (respirable fraction)

MAK[mg/m<sup>3</sup>]: 0.1 R  
 Peak lim: I(4)  
 Preg gr: C

Classification in Pregnancy Risk Group C was re-evaluated in 2011 and confirmed.

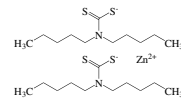
Zinc bis(dipentylthiocarbamate) → Zinc diamylthiocarbamate

Zinc chromate → Chromium(VI) compounds

**★ Zinc diamylthiocarbamate**

[15337-18-5]

(inhalable fraction)



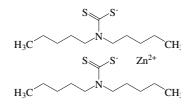
VP[hPa]: 6.3×10<sup>-13</sup> at 25°C  
 see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I  
 Peak lim: II(8)  
 Preg gr: D

**★ Zinc diamylthiocarbamate**

[15337-18-5]

(respirable fraction)



VP[hPa]: 6.3×10<sup>-13</sup> at 25°C  
 see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R  
 Peak lim: II(4)  
 Preg gr: D

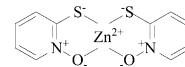
Zinc dimethylthiocarbamate → Ziram

Zinc N,N-dipentylcarbomodithioate → Zinc diamylthiocarbamate

Zinc molybdate → Molybdenum

**Zinc pyrrhione**

[13463-41-7]

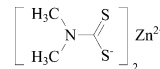


see Section IIb

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H

**Ziram**

[137-30-4]



MAK[mg/m<sup>3</sup>]: 0.01 I  
 Peak lim: I(2)  
 Preg gr: C  
 Sens: Sh

**Zirconium**

[7440-67-7]  
and its compounds (except  
zirconium dioxide)  
see Section IIb

Zr

MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –

**Zirconium dioxide**

[1314-23-4;  
12036-23-6]  
(respirable fraction)  
except for ultrafine particles; see Section Vh  
see Section Vf

ZrO<sub>2</sub>

MAK[mg/m<sup>3</sup>]: 0.3 R  
multiplied with the material density  
Peak lim: II(8)  
Preg gr: C  
Carc cat: 4

**b) Substances for which no MAK value can be established at present**

For a number of the substances examined by the Commission, studies of the effects in man or in experimental animals have yielded insufficient information for the establishment of MAK values. These substances are listed below. The toxicological documentation has been published by the Commission in the monograph collection "Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten". Some of these reviews are available in English (available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)).

Acetoacetic acid ethyl ester [141-97-9]

Acrylic acid hydroxypropyl ester (all isomers) [25584-83-2]

3-Aminomethyl-3,5,5-trimethyl-cyclohexylamine (Isophorone diamine) [2855-13-2]

2-Aminopyridine [504-29-0]

Ammonium sulfamate [7773-06-0]

Arsine [7784-42-1]

Benzaldehyde [100-52-7]

Benzalkonium chloride [8001-54-5]

Bisphenol A diglycidyl ether [1675-54-3]

Boron oxide [1303-86-2]

Boron trifluoride [7637-07-2]

Bromine [7726-95-6]

2-Butanol [78-92-2]

sec-Butyl acetate [105-46-4]

2-tert-Butyl-p-cresol [2409-55-4]

p-tert-Butyl toluene [98-51-1]

γ-Butyrolactone [96-48-0]

★ Calcium sulfate (respirable fraction)

Anhydrite [7778-18-9]

Hemihydrate [10034-76-1]

Dihydrate [10101-41-4]

Gypsum [13397-24-5]

Camphor [76-22-2]

Chlorinated biphenyl oxides several CAS Nos, e.g. [55720-99-5]

Chlorinated biphenyl oxides form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated biphenyl oxides with low chlorine content can occur as a particle-vapour mixture, whereas chlorinated biphenyl oxides with a large quantity of chlorine occur only as particles.

Chlorinated naphthalenes

Chlorinated naphthalenes form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated naphthalenes with low chlorine content can occur as a particle-vapour mixture, whereas chlorinated naphthalenes with a large quantity of chlorine occur only as particles.

Chlorine trifluoride [7790-91-2]

Chloroacetyl chloride [79-04-9]

o-Chloroaniline [95-51-2]

m-Chloroaniline [108-42-9]

Chlorobenzoic acid (all isomers)

4-Chloromethyl-biphenyl [1667-11-4]

m-Chloronitrobenzene [121-73-3]

1-Chloro-1-nitropropane [600-25-9]

Chromium carbonyl [13007-92-6]

## Chromium(III) compounds

Cyanogen chloride [506-77-4]

Cyclohexanol [108-93-0]

Cyclohexene [110-83-8]

Cyclopentadiene [542-92-7]

Demeton [8065-48-3]

see Section XII, Acetylcholinesterase inhibitors

Desflurane [57041-67-5]

Diallyl phthalate [131-17-9]

Diborane [19287-45-7]

Dibromodifluoromethane [75-61-6]

3,4-Dichloroaniline [95-76-1]

1,1-Dichloro-1-nitroethane [594-72-9]

2,2-Dichloropropionic acid [75-99-0]

2,2-Dichloropropionic acid, sodium salt [127-20-8]

Dicyanodiamide [461-58-5]

Dicyclohexylamine [101-83-7]

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodicyclohexylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Dicyclohexylamine nitrite [3129-91-7]

Diethylene glycol dinitrate [693-21-0]

Diisobutyl ketone [108-83-8]

Diketene [674-82-8]

see documentation "Ketene"

Dimethyl adipate [627-93-0] see also Dicarboxylic acid (C4-C6) dimethylester

Dimethylaminopropionitrile [1738-25-6]

Dimethyl glutarate [1119-40-0] see also Dicarboxylic acid (C4-C6) dimethylester

Dimethyl succinate [106-65-0] see also Dicarboxylic acid (C4-C6) dimethylester

Dimethyl sulfide [75-18-3]

4,6-Dinitro-o-cresol [534-52-1]

Dipentamethylenethiuram disulfide [94-37-1]

Diphenyl cresyl phosphate [26444-49-5]

Divinylbenzene (all isomers) [1321-74-0]

Ethyl 2-cyanoacrylate [7085-85-0]

Ethylenediamine [107-15-3]

Ethylenediaminetetraacetic acid (EDTA) [60-00-4]

Avoid exposure to mixtures with iron compounds (formation of FeEDTA).

2-Ethylhexanoic acid [149-57-5]

N-Ethylmorpholine [100-74-3]

Ethyltin compounds

Ethyl vinyl ether [109-92-2]

Ferbam [14484-64-1]

Ferrovanadium [12604-58-9]

Fluorine [7782-41-4]

Formamide [75-12-7]

Germanium tetrahydride [7782-65-2]

Gold [7440-57-5] and its inorganic compounds

Hafnium [7440-58-6] and its compounds

Hexachlorocyclopentadiene [77-47-4]

sec-Hexyl acetate [108-84-9]  
Hydroxyacetic acid butyl ester [7397-62-8]  
2-Hydroxyethyl methacrylate [868-77-9]  
3-Hydroxy-2-naphthalenecarboxylic acid [92-70-6]  
Imidazole [288-32-4]  
Iodine [7553-56-2] and inorganic iodides  
4-Isopropylphenyl isocyanate [31027-31-3]  
Ketene [463-51-4]  
D,L-Limonene [138-86-3] and similar mixtures  
L-Limonene [5989-54-8]  
Lithium [7439-93-2] and highly irritating lithium compounds (as lithium amide, hydride, hydroxide, nitride, oxide, tetrahydroaluminate, tetrahydroborate)  
Magnesium oxide fume [1309-48-4]  
3-Methoxy-n-butyl acetate [4435-53-4]  
Methyl acetylene [74-99-7]  
Methylcyclohexanol (all isomers) [25639-42-3]  
1-Methylcyclohexan-2-one [583-60-8]  
Methyl vinyl ketone [78-94-4]  
Molybdenum [7439-98-7] and its compounds apart from molybdenum trioxide  
Montmorillonite [1318-93-0] and Bentonite [1302-78-9]  
quartz content must be considered separately  
2-(4-Morpholinylmercapto)benzothiazole [102-77-2]  
Nickel titan yellow pigment [8007-18-9]  
Nicotine [54-11-5]  
Nitric acid [7697-37-2]  
Osmium tetroxide [20816-12-0]  
Palladium [7440-05-3] and palladium compounds  
2-Pentanone [107-87-9]  
Perchloromethyl mercaptan [594-42-3]  
1H,1H,2H-Perfluorohexene [19430-93-4]  
Phosphorus, red [7723-14-0]  
Phosphorus pentasulfide [1314-80-3]  
o-Phthalic acid [88-99-3]  
Phthalic anhydride [85-44-9]  
Platinum compounds (Chloroplatinates)  
A peak concentration of 2 µg/m<sup>3</sup> should not be exceeded.  
n-Propyl nitrate [627-13-4]  
Pyrethrum [8003-34-7]  
Resorcinol [108-46-3]  
Rotenone [83-79-4]  
Sevoflurane [28523-86-6]  
Silicon carbide [409-21-2] (without fibres)  
Sodium hydroxide [1310-73-2]  
Stibine [7803-52-3]  
Strontium [7440-24-6] and its inorganic compounds  
Strychnine [57-24-9]  
Sulfur monochloride [10025-67-9]  
Sulfur pentafluoride [5714-22-7]

Tellurium [13494-80-9] and its inorganic compounds  
 1,1,2,2-Tetrabromoethane [79-27-6]  
 Tetramethyl succinonitrile [3333-52-6]  
 Tetramethyl urea (TMU) [632-22-4]  
 Thallium, soluble compounds  
 Thioglycolic acid [68-11-1]  
 Tin [7440-31-5] and its inorganic compounds  
 2,4,6-Tribromophenol [118-79-6]  
 Tri-n-butylamine [102-82-9]  
 Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodi-n-butylamine, see Section III  
 "Amines which form carcinogenic nitrosamines on nitrosation".  
 2,4,5-Trichlorophenol [95-95-4]  
 Triisobutyl phosphate [126-71-6]  
 Trimethylphosphite [121-45-9]  
 Tungsten [7440-33-7] and its compounds (as W)  
 Wollastonite [13983-17-0] (fibrous dust)  
 Yttrium [7440-65-5] and its compounds  
 Zeolites, synthetic (non-fibrous) [1318-02-1]  
 Zinc pyrithione [13463-41-7]  
 Zirconium [7440-67-7] and its compounds (except zirconium dioxide)

### **Metal-working fluids, hydraulic fluids and other lubricants**

(see Section Xc)

Abietic acid [514-10-3]  
 also includes disproportionation and transposition products  
 Alkyl amines, C11 – 14-branched, monohexyl and dihexyl phosphates [80939-62-4]  
 Alkyl benzenesulfonates C10–C14, linear [69669-44-9; 85117-50-6]  
 Alkyl ether carboxylic acids  
 2-Amino-2-ethyl-1,3-propanediol [115-70-8]  
 1-Amino-2-propanol [78-96-6]  
 Aminotris(methylenephosphonic acid) [6419-19-8] and its sodium salts  
 Azelaic acid [123-99-9]  
 Behenic acid [112-85-6]  
 1,2-Benzisothiazol-3(2H)-one [2634-33-5]  
 Benzyl alcohol mono(poly)hemiformal [14548-60-8]  
 releases formaldehyde  
 Bis[O,O-bis(2-ethylhexyl) dithiophosphorato-S,S']dioxodi- $\mu$ -thioxodimolybdenum  
 [68958-92-9; 72030-25-2]  
 N,N-Bis(2-ethylhexyl)-(1,2,4-triazole-1-yl)methanamine [91273-04-0]  
 1,3-Bis(hydroxymethyl)urea [140-95-4]  
 releases formaldehyde  
 Bithionol [97-18-7]  
 2-Bromo-2-nitro-1,3-propanediol [52-51-7]  
 use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16  
 Absatz 2), Nr. 4"  
 2-Butyl-1,2-benzisothiazolin-3-one [4299-07-4]  
 Calcium bis(dinonylnaphthalenesulphonate) [57855-77-3]  
 5(or 6)-Carboxy-4-hexylcyclohex-2-ene-1-octanoic acid [53980-88-4]  
 2-Chloroacetamide [79-07-2]  
 p-Chloro-m-cresol [59-50-7]

- Chlorothalonil [1897-45-6]  
Citric acid alkali metal salts  
The MAK value for citric acid (2 mg/m<sup>3</sup>) protects from irritation, a higher value for alkali metal salts is not justifiable.  
Dibenzyl disulfide [150-60-7]  
2,2-Dibromo-2-cyanacetamide [10222-01-2]  
1,2-Dibromo-2,4-dicyanobutane [35691-65-7]  
3-(3,5-Di-tert-butyl-4-hydroxyphenyl)-N'-[3-(3,5-di-tert-butyl-4-hydroxyphenyl)prop-  
anoyl]propanehydrazide [32687-78-8]  
2,6-Di-tert-butylphenol [128-39-2]  
Di-n-butyl phosphonate [1809-19-4] see also Di-n-octyl phosphonate  
Diethylenetriaminepenta(methylenephosphonic acid) [15827-60-8] and its sodium salts  
[22042-96-2]  
1,2-Dihydro-2,2,4-trimethyl-quinoline polymer [26780-96-1]  
4-(Diiodomethylsulfonyl)-toluene [20018-09-1]  
1,3-Dimethylol-5,5-dimethyl hydantoin [6440-58-0]  
4,4'-Dioctyldiphenylamine [101-67-7]  
Di-n-octyl phosphonate [1809-14-9] see also Di-n-butyl phosphonate  
Diphenylamine, octylated (Benzenamine, N-phenyl-, reaction products with 2,4,4-tri-  
methylpentene) [68411-46-1]  
Diphenylamine, reaction products with styrene and 2,4,4-trimethylpentene  
[68921-45-9]  
2,2'-Dithiobis(N-methylbenzamide) [2527-58-4]  
Dodecanedioic acid [693-23-2]  
1-Dodecanol [112-53-8]  
5-Ethyl-3,7-dioxo-1-azabicyclo[3.3.0]octane (EDAO) [7747-35-5]  
releases formaldehyde  
2-Ethyl-1,3-hexanediol [94-96-2]  
★ Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8]  
Fatty alcohol ethoxylates, C16–18 and C18-unsaturated [68920-66-1]  
1-Hexadecanol [36653-82-4]  
Hexamethylenetetramine [100-97-0]  
releases formaldehyde  
1-Hexanol [111-27-3]  
2-Hexyl-1-decanol [2425-77-6]  
1-Hydroxyethyl-2-heptadecenyl-imidazoline [21652-27-7]  
1-Hydroxyethylidene-1,1-diphosphonic acid [2809-21-4] and its sodium and potassium  
salts  
2-Hydroxymethyl-2-nitro-1,3-propanediol [126-11-4]  
use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16  
Absatz 2), Nr. 4"  
12-Hydroxystearic acid [106-14-9]  
Isononanoic acid [3302-10-1] [26896-18-4]  
Isooctadecanol [27458-93-1]  
Isotridecanol [27458-92-0]  
Lithium-12-hydroxystearate [7620-77-1]  
Lithium stearate [4485-12-5]  
Methyl-1H-benzotriazole [29385-43-1]  
Methyldiethanolamine [105-59-9]  
4,4'-Methylenebis(2,6-di-tert-butylphenol) [118-82-1]



N,N'-Methylenebis(5-methyloxazolidine) [66204-44-2]

4,4'-Methylenedimorpholine [5625-90-1]

releases formaldehyde

2-Methyl-4-isothiazolin-3-one [2682-20-4]

Myristic acid [544-63-8]

3-Nitrobenzoic acid [121-92-6]

(4-Nonylphenoxy)acetic acid [3115-49-9]

1-Octadecanol [112-92-5]

2-Octyl-1-dodecanol [5333-42-6]

Oleic acid [112-80-1]

Oleyl alcohol [143-28-2]

Palmitic acid [57-10-3]

Petroleum sulfonates, sodium salts [68608-26-4]

Phenothiazine [92-84-2]

phototoxic effect

1-Phenoxy-2-propanol [770-35-4]

2-Phenyl-1-ethanol [60-12-8]

Piperazine [110-85-0]

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N,N'-dinitrosopiperazine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Polybutenes and Polyisobutenes

Polydimethyl siloxanes, linear [63148-62-9; 9006-65-9; 9016-00-6]

Polyethylene glycol (average molecular weight > 600) [25322-68-3]

Polyethylenepolypropylene glycol [9003-11-6]

Polyoxyethylene oleyl ether [9004-98-2]

Polypropylene glycol (PPG) [25322-69-4]

Poly(propylene glycol) n-butyl ether [9003-13-8]

Propylene glycol [57-55-6]

Pyrrolidine [123-75-1]

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosopyrrolidine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Sebacic acid [111-20-6]

Stearic acid [57-11-4]

Tall oil, distilled [8002-26-4]

1-Tetradecanol [112-72-1]

Tetrahydrobenzotriazole [6789-99-7]

★ N-Tosyl-6-aminocaproic acid [78521-39-8]

Triazinetriyltriiminotrihexanoic acid [80584-91-4]

Triethylene glycol n-butyl ether [143-22-6]

Tris(2,4-ditert-butylphenyl) phosphite [31570-04-4]

Tris[(2- or 4-)C9-C10-isoalkylphenyl]phosphorothioate [126019-82-7]

Tris(nonylphenyl) phosphite [26523-78-4]

Zinc, O,O'-di-2-ethylhexyl dithiophosphate [4259-15-8]

### ★ c) Substances for which the MAK value and classifications have been withdrawn

For the following substances the Commission has decided to withdraw the previous MAK values, designations and classifications because the earlier evaluation does not reflect the current data. A new evaluation has not yet been carried out and is not a priority.

- ★ Aldrin [309-00-2]
- ★ Carbaryl (1-Naphthyl methylcarbamate) [63-25-2]
- ★ Chlordane [57-74-9]
- ★ Chloropicrin [76-06-2]
- ★ DDT (Dichlorodiphenyltrichloroethane) [50-29-3]
- ★ Demeton-methyl [8022-00-2]
- ★ Dieldrin [60-57-1]
- ★ EPN (O-Ethyl O-(4-nitrophenyl)phenylthiophosphonate) [2104-64-5]
- ★ Fenthion [55-38-9]
- ★ Malathion [121-75-5]
- ★ Mevinphos [7786-34-7]  
see documentation "Phosdrin"
- ★ Paraquat dichloride [1910-42-5]
- ★ Parathion [56-38-2]
- ★ Propoxur [114-26-1]
- ★ TEPP [107-49-3]

### III Carcinogenic Substances

Advances in our understanding of the modes of action and potency of carcinogens have made possible the improved differentiation of carcinogenic substances. Therefore, in 1998 an extended classification scheme was introduced<sup>24</sup>). The sections of the List of MAK and BAT Values previously called IIIA1, IIIA2 and III B were renamed as Categories 1, 2 and 3 of Section III and two new categories, 4 and 5, were added.

Substances which have been shown to be carcinogenic in man or in experimental animals are classified in the Categories 1 or 2 and are not assigned MAK or BAT values. Suspected carcinogens are classified in Category 3 and are assigned a MAK or BAT value only if neither the substance nor any of its metabolites is genotoxic or the genotoxic effect is not the main effect.

In the Categories 4 and 5 are classified substances with carcinogenic properties for which the available data are sufficient for assessment of the carcinogenic potency. For these substances an occupational exposure level (MAK or BAT value) is defined at which no or at most a very slight contribution to the cancer risk of the exposed persons is to be expected. The substances classified in Category 4 are known to act typically by non-genotoxic mechanisms. Category 5 contains genotoxic carcinogens of weak potency. For the monitoring of exposure to these substances, the establishment of BAT values is of particular importance.

**1. Substances that cause cancer in man and can be assumed to contribute to cancer risk. Epidemiological studies provide adequate evidence of a positive correlation between the exposure of humans and the occurrence of cancer. Limited epidemiological data can be substantiated by evidence that the substance causes cancer by a mode of action that is relevant to man.**

Aflatoxins [1402-68-2]

4-Aminobiphenyl [92-67-1]

Arsenic [7440-38-2] and inorganic arsenic compounds

Asbestos [1332-21-4] (fibrous dust)

Actinolite, Amosite, Anthophyllite, Chrysotile, Crocidolite and Tremolite

Cigarette smokers bear an increased risk of bronchial cancer.

Beech wood dust

Dusts have been shown epidemiologically to be unequivocally carcinogenic. The active carcinogenic principle has not been identified to date.

Benzene [71-43-2]

Benzidine [92-87-5] and its salts

Beryllium [7440-41-7] and its inorganic compounds

Bis( $\beta$ -chloroethyl)sulfide (mustard gas) [505-60-2]

Bischloromethyl ether (dichlorodimethylether) [542-88-1]

not to be confused with the asymmetric (Dichloromethyl) methyl ether

1,3-Butadiene [106-99-0]

Cadmium [7440-43-9] and its inorganic compounds (inhalable fraction)

<sup>24</sup>) For detailed documentation see "Änderung der Einstufung krebserzeugender Arbeitsstoffe" (1998, <https://doi.org/10.1002/3527600418.mb0ckatd0026>; 2000, <https://doi.org/10.1002/3527600418.mb0ckatd0030>; 2006, <https://doi.org/10.1002/3527600418.mb0ckatd0040>; 2021, [https://doi.org/10.34865/mb0ckat3dgt6\\_1ad](https://doi.org/10.34865/mb0ckat3dgt6_1ad)) and the English translation of the documentation from 1998: "Changes in the classification of carcinogenic chemicals in the work area" (1999, <https://doi.org/10.1002/3527600418.mb0ckate0012>)

$\alpha$ -Chlorinated toluenes:

- mixture of Benzoyl chloride [98-88-4],
- Benzyl chloride [100-44-7],
- Benzyl dichloride [98-87-3],
- Benzyl trichloride [98-07-7]

## 4-Chloro-o-toluidine [95-69-2]

## Chromium(VI) compounds (inhalable fraction)

## 1,2-Dichloropropane [78-87-5]

## Erionite [12510-42-8] (fibrous dust)

## Hard metal containing tungsten carbide and cobalt (inhalable fraction)

## Methylarsenic compounds

## N-Methyl-bis(2-chloroethyl)amine (nitrogen mustard) [51-75-2]

## Monochlorodimethyl ether [107-30-2]

The classification in Category 1 applies to technical monochlorodimethyl ether which can be contaminated with up to 7% bischloromethyl ether.

## 2-Naphthylamine [91-59-8]

## Nickel and nickel compounds (inhalable fraction)

Regarding compounds which have been found to be unequivocally carcinogenic in man, see documentation.

## Oak wood dust

Dusts have been shown epidemiologically to be unequivocally carcinogenic. The active carcinogenic principle has not been identified to date.

## N-Phenyl-2-naphthylamine [135-88-6]

## 1,3-Propane sultone [1120-71-4]

## Sidestream smoke (passive smoking at the workplace)

## Silica, crystalline (respirable fraction)

## o-Toluidine [95-53-4]

## Trichloroethene [79-01-6]

## Vinyl chloride [75-01-4]

**2. Substances that are considered to be carcinogenic for man because sufficient data from long-term animal studies or evidence from animal studies substantiated by evidence from epidemiological studies indicate that they can contribute to cancer risk. Limited data from animal studies can be supported by evidence that the substance causes cancer by a mode of action that is relevant to man and by results of in vitro tests and short-term animal studies.**

## Acrylamide [79-06-1]

## Acrylonitrile [107-13-1]

## Allyl glycidyl ether [106-92-3]

## Aluminium oxide [1344-28-1] (fibrous dust)

## Aluminium silicate fibres (RCF)

Cristobalite can develop from aluminium silicate fibres used in building materials under thermal load, see documentation.

## o-Aminoazotoluene [97-56-3]

## 6-Amino-2-ethoxynaphthalene [293733-21-8]

## o-Anisidine [90-04-0]

## Anthanthrene [191-26-4]

## Antimony [7440-36-0] and its inorganic compounds except for stibine

## Attapulgitite [12174-11-7] (fibrous dust)

## Auramine [492-80-8]

## Auramine hydrochloride [2465-27-2]

Benzo[a]anthracene [56-55-3]  
Benzo[b]fluoranthene [205-99-2]  
Benzo[j]fluoranthene [205-82-3]  
Benzo[k]fluoranthene [207-08-9]  
Benzo[b]naphtho[2,1-d]thiophene [239-35-0]  
Benzo[a]pyrene [50-32-8]  
Benzyl chloride [100-44-7] see also  $\alpha$ -Chlorinated toluenes  
Benzyl dichloride [98-87-3] see also  $\alpha$ -Chlorinated toluenes  
Benzyl trichloride [98-07-7] see also  $\alpha$ -Chlorinated toluenes  
Bitumen (high-temperature processing, vapours and aerosols) [64742-93-4] (bitumen, oxidized)  
Bromodichloromethane [75-27-4]  
Bromoethane [74-96-4]  
1-Bromopropane [106-94-5]  
2,4-Butane sultone [1121-03-5]  
Butanone oxime [96-29-7]  
1,2-Butylene oxide [106-88-7]  
Carbamic acid ethyl ester [51-79-6]  
Chlordecone [143-50-0]  
Chlorinated camphene [8001-35-2]  
p-Chloroaniline [106-47-8]  
p-Chlorobenzotrichloride [5216-25-1]  
1-Chloro-2,3-epoxypropane (Epichlorohydrin) [106-89-8]  
Chlorofluoromethane (FC-31) [593-70-4]  
N-Chloroformylmorpholine [15159-40-7]  
Chloroprene [126-99-8]  
Chrysene [218-01-9]  
Cobalt [7440-48-4] and cobalt compounds (inhalable fraction)  
Cyclopenta[cd]pyrene [27208-37-3]  
Dawsonite [12011-76-6] (fibrous dust)  
2,4-Diaminoanisole [615-05-4]  
4,4'-Diaminodiphenylmethane [101-77-9]  
1,5-Diaminonaphthalene [2243-62-1]  
Diazomethane [334-88-3]  
Dibenzo[a,h]anthracene [53-70-3]  
Dibenzo[a,e]pyrene [192-65-4]  
Dibenzo[a,h]pyrene [189-64-0]  
Dibenzo[a,i]pyrene [189-55-9]  
Dibenzo[a,l]pyrene [191-30-0]  
1,2-Dibromo-3-chloropropane [96-12-8]  
1,2-Dibromoethane [106-93-4]  
Dichloroacetylene [7572-29-4]  
3,3'-Dichlorobenzidine [91-94-1]  
1,4-Dichloro-2-butene [764-41-0]  
1,2-Dichloroethane [107-06-2]  
1,3-Dichloro-2-propanol [96-23-1]  
1,3-Dichloropropene (cis and trans) [542-75-6]

### Diesel engine emissions

Because of the new diesel engine technology the emissions have changed significantly in quality and quantity. Since it must be assumed that these new diesel engines were introduced at the end of the 1990s, all the available epidemiological studies which were evaluated in 2007 are based on exposures to emissions from older diesel engines. The emissions from the new diesel engines can not be evaluated until appropriate studies become available.

Diethyl sulfate [64-67-5]

Diglycidyl resorcinol ether [101-90-6]

3,3'-Dimethoxybenzidine [119-90-4]

3,3'-Dimethylbenzidine [119-93-7]

Dimethylcarbamoyl chloride [79-44-7]

1,1-Dimethylhydrazine [57-14-7]

1,2-Dimethylhydrazine [540-73-8]

N,N-Dimethyl-p-toluidine [99-97-8]

Dimethylsulfamoyl chloride [13360-57-1]

Dimethyl sulfate [77-78-1]

Dinitrotoluene (mixtures of isomers) [25321-14-6]

Ethylene oxide [75-21-8]

Ethylenimine [151-56-4]

Glass fibres (fibrous dust)

Glycidol [556-52-5]

Glycidyl trimethylammonium chloride [3033-77-0]

Hexamethylphosphoric acid triamide [680-31-9]

Hydrazine [302-01-2]

Hydrazobenzene [122-66-7]

Hydroquinone [123-31-9]

Indeno[1,2,3-cd]pyrene [193-39-5]

Indium phosphide [22398-80-7]

Iodomethane [74-88-4]

5-Methyl-o-anisidine [120-71-8]

4,4'-Methylenebis(2-chloroaniline) (MOCA) [101-14-4]

4,4'-Methylenebis(N,N-dimethylaniline) [101-61-1]

4,4'-Methylenebis(2-methylaniline) [838-88-0]

1-Methylpyrene [2381-21-7]

Michler's ketone [90-94-8]

Monomethylhydrazine [60-34-4]

Naphthalene [91-20-3]

5-Nitroacenaphthene [602-87-9]

2-Nitroanisole [91-23-6]

4-Nitrobiphenyl [92-93-3]

2-Nitronaphthalene [581-89-5]

2-Nitropropane [79-46-9]

N-Nitrosodi-n-butylamine [924-16-3]

N-Nitrosodiethanolamine [1116-54-7]

N-Nitrosodiethylamine [55-18-5]

N-Nitrosodiisopropylamine [601-77-4]

N-Nitrosodimethylamine [62-75-9]

N-Nitrosodi-n-propylamine [621-64-7]

N-Nitrosoethylphenylamine [612-64-6]

N-Nitrosomethylethylamine [10595-95-6]

- N-Nitrosomethylphenylamine [614-00-6]
- N-Nitrosomorpholine [59-89-2]
- N-Nitrosopiperidine [100-75-4]
- N-Nitrosopyrrolidine [930-55-2]
- 2-Nitrotoluene [88-72-2]
- 5-Nitro-o-toluidine [99-55-8]
- Ochratoxin A [303-47-9]
- 4,4'-Oxydianiline [101-80-4]
- Pentachlorophenol [87-86-5]
- Phenyl glycidyl ether (PGE) [122-60-1]
- Potassium titanates (fibrous dust) several CAS Nos and formulas
- β-Propiolactone [57-57-8]
- Propylene imine [75-55-8]
- Rock wool (fibrous dust)
- Silicon carbide [409-21-2] (fibrous dust)
- ★ Tetrabromobisphenol A [79-94-7]  
Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
- Tetrafluoroethene [116-14-3]
- Tetranitromethane [509-14-8]
- 4,4'-Thiodianiline [139-65-1]
- 2,4-Toluenediamine [95-80-7]
- 2,3,4-Trichloro-1-butene [2431-50-7]
- 1,2,3-Trichloropropane [96-18-4]
- 2,4,5-Trimethylaniline [137-17-7]
- 2,4,6-Trinitrotoluene [118-96-7]
- ★ N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4]  
Releases formaldehyde. Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
- ★ N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6]  
Releases formaldehyde. Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
- Uranium [7440-61-1] and its hardly soluble inorganic compounds
- 4-Vinylcyclohexene [100-40-3]
- 4-Vinyl-1-cyclohexene dioxide [106-87-6]
- 2,4-Xylidine [95-68-1]
- 2,6-Xylidine [87-62-7]

For substances in Categories 1 and 2, exposure to which is considered to involve a distinct cancer risk for man, no MAK value is listed in Section IIa since a safe concentration range cannot be given. For some of these substances, even uptake through the intact skin is very dangerous. Substances in Categories 1 or 2, for which, as a result of the mechanism of action, a dose or concentration without carcinogenic effects, a "No Adverse Effect Level" (NAEL), can be expected, but the database is not sufficient to be able to derive a MAK value and reclassify them in Categories 4 or 5, are designated in Sections II and III of the List of MAK and BAT Values with the footnote "*Prerequisite for Category 4 (or 5) in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value*".

Where it is necessary to employ such substances for industrial purposes, special measures are required for protection and monitoring. These include: 1. routine analysis of

the workplace air with analytical methods which are appropriate and sufficiently sensitive for the purpose; 2. special medical supervision of exposed individuals whereby, e.g., regular tests must be performed to determine whether the substance or its metabolites are detectable in the human body or whether appropriate effect parameters have been altered.

Continual technical improvements should make it possible to prevent these substances from occurring in the workplace air or from directly affecting the individual at work. Where this goal cannot presently be attained, additional protective measures are required (e.g., individual respirators and protective clothing, shorter periods in the area of danger, etc.) so that exposure is minimal. The kind of protective measures which are necessary also depends on the particular physical characteristics of the substance and on the nature and intensity of its carcinogenic effect.

**3. Substances that cause concern that they could be carcinogenic for man but cannot be assessed conclusively because of lack of data. The classification in Category 3 is provisional. Substances for which the available studies have yielded evidence of carcinogenic effects that is not sufficient for classification of the substance in one of the other categories. Further studies are required before a final decision can be made. A MAK or BAT value can be established, provided no genotoxic effects have been detected for the substance or its metabolites or the genotoxic effect is not the main effect.**

Acetamide [60-35-5]

Acrolein [107-02-8]

Allyl alcohol [107-18-6]

Allyl chloride [107-05-1]

4-Aminodiphenylamine [101-54-2]

3-Amino-9-ethylcarbazole [132-32-1]

p-Anisidine [104-94-9]

p-Aramid [26125-61-1] (fibrous dust)

Benzotriazole [95-14-7]

Benzoyl chloride [98-88-4] see also  $\alpha$ -Chlorinated toluenes

Biphenyl [92-52-4]

Bitumen (high-temperature processing, vapours and aerosols) [8052-42-4; 64741-56-6/64742-93-4] (straight-run bitumen/air-rectified bitumen)

Bromochloromethane [74-97-5]

1,4-Butane sultone [1633-83-6]

n-Butyl glycidyl ether (BGE) [2426-08-6]

tert-Butyl glycidyl ether [7665-72-7]

tert-Butyl-4-hydroxyanisole (BHA) [25013-16-5]

tert-Butyl methyl ether [1634-04-4]

Calcium sodium metaphosphate [23209-59-8] (fibrous dust)

Carbon black (inhalable fraction)

Chlorinated paraffins unbranched chains, several CAS Nos, e.g. [63449-39-8]

Chlorinated paraffins form a group of compounds with different degrees and positions of chlorine substitution. Chlorinated paraffins with low chlorine content and short chain length can occur as a particle-vapour mixture, whereas chlorinated paraffins with a large quantity of chlorine or with long alkyl chains occur only as particles.

Chloroacetaldehyde [107-20-0]

Chloroacetamide-N-methylol (CAM) [2832-19-1]

releases formaldehyde



2-Chloroacrylonitrile [920-37-6]  
 Chloroethane [75-00-3]  
 Chloroformic acid ethyl ester [541-41-3]  
 3-Chloro-2-methylpropene [563-47-3]  
 o-Chloronitrobenzene [88-73-3]  
 p-Chloronitrobenzene [100-00-5]  
 4-Chlorophenyl isocyanate [104-12-1]  
 3-Chloro-1,2-propanediol ( $\alpha$ -Chlorohydrin) [96-24-2]  
 5-Chloro-o-toluidine [95-79-4]  
 Coal mine dust (respirable fraction)  
 Cresyl glycidyl ethers mixture of isomers [26447-14-3] o-isomer [2210-79-9]  
 Crotonaldehyde [123-73-9; 4170-30-3]  
 Cyclohexanone [108-94-1]  
 Diacetyl [431-03-8]  
 3,3'-Diaminobenzidine and its tetrahydrochloride [91-95-2; 7411-49-6]  
 Di-n-butyl phosphate [107-66-4] and its technical mixtures  
 Di-n-butyl phthalate [84-74-2]  
 1,1-Dichloroethane [75-34-3]  
 1,2-Dichloromethoxyethane [41683-62-9]  
 3,4-Dichloronitrobenzene [99-54-7]  
 4-(2,4-Dichlorophenoxy)benzenamine [14861-17-7]  
 2,2-Dichloro-1,1,1-trifluoroethane (FC-123) [306-83-2]  
 Diethanolamine [111-42-2]  
 Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethanolamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".  
 Diethylcarbamoyl chloride [88-10-8]  
 1,1-Difluoroethylene [75-38-7]  
 Diglycidyl ether (DGE) [2238-07-5]  
 Diisodecyl phthalate [26761-40-0]  
 Diisotridecyl phthalate [27253-26-5]  
 2,5-Dimethoxy-4-chloroaniline [6358-64-1]  
 N,N-Dimethylaniline [121-69-7]  
 Dimethyl hydrogen phosphite [868-85-9]  
 Dinitrobenzene (all isomers) [25154-54-5]  
 Dinitronaphthalene (all isomers) [27478-34-8]  
 Diphenylamine [122-39-4]  
 Di(2-propylheptyl) phthalate (DPHP) [53306-54-0]  
 Distillates (petroleum) [64742-47-8] hydrotreated light (aerosol)  
 Distillates (petroleum) [64742-47-8] hydrotreated light (vapour)  
 Ditridecyl phthalate [119-06-2]  
 3,4-Epoxy cyclohexane carboxylic acid (3,4-epoxycyclohexylmethyl) ester [2386-87-0]  
 Ethidium bromide [1239-45-8]  
 Ethylene [74-85-1]  
 Ethylene thiourea (Imidazoline-2-thione) [96-45-7]  
 Furfural [98-01-1]  
 Furfuryl alcohol [98-00-0]  
 Glyoxal [107-22-2]  
 Halloysite [12298-43-0] (fibrous dust)

- Hexachloroethane [67-72-1]  
Hexahydrophthalic acid diglycidylester [5493-45-8]  
Hydrogen selenide [7783-07-5]  
Iron oxides (inhalable fraction) [1345-25-1; 1309-37-1; 1309-38-2; 1317-61-9]  
with the exception of iron oxides which are not biologically available  
Isophorone [78-59-1]  
Isopropylbenzene (cumene) [98-82-8]  
Isopropyl glycidyl ether (IGE) [4016-14-2]  
Isopropyl oil  
residue of isopropyl alcohol production  
Kaolinite [1332-58-7]  
quartz content must be considered separately  
Kerosine (petroleum) (aerosol) [8008-20-6]  
applies to skin contact  
Kerosine (petroleum) (vapour) [8008-20-6]  
applies to skin contact  
Magnesium oxide sulfate [12286-12-3] (fibrous dust)  
2-Mercaptobenzothiazole [149-30-4]  
Mercury [7439-97-6] and its inorganic compounds (as Hg)  
Mercury, organic compounds  
Metal-working fluids which contain nitrite or nitrite-forming compounds and substances which react with nitrite to yield nitrosamines  
N-Methylaniline [100-61-8]  
Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosomethylaniline, see Section III  
"Amines which form carcinogenic nitrosamines on nitrosation".  
Methyl bromide [74-83-9]  
N-Methyl-N,2,4,6-tetranitroaniline [479-45-8]  
Molybdenum trioxide [1313-27-5]  
Naphthenic acids and sodium, calcium, potassium naphthenates [1338-24-5; 61790-13-4;  
61789-36-4; 66072-08-0] (technical mixtures)  
1,5-Naphthylene diisocyanate [3173-72-6]  
1-Naphthylthiourea [86-88-4]  
Nemalite [1317-43-7] (fibrous dust)  
2-Nitro-4-aminophenol [119-34-6]  
4-Nitroaniline [100-01-6]  
4-Nitrobenzoic acid [62-23-7]  
Nitrogen dioxide [10102-44-0]  
Nitroglycerin [55-63-0]  
Nitromethane [75-52-5]  
1-Nitronaphthalene [86-57-7]  
2-Nitro-p-phenylenediamine [5307-14-2]  
Nitropyrenes (Mono-, Di-, Tri-, Tetra-) (isomers)  
N-Nitrosodiphenylamine [86-30-6]  
3-Nitrotoluene [99-08-1]  
4-Nitrotoluene [99-99-0]  
Olaquinox (N-(2-Hydroxyethyl)-3-methyl-2-quinoxalinecarboxamide 1,4-dioxide)  
[23696-28-8]  
Ozone [10028-15-6]  
Pentachloroethane [76-01-7]  
Perfluorooctanesulfonic acid (PFOS) [1763-23-1] and its salts

Phenol [108-95-2]  
 Phenyl arsenic compounds [637-03-6]  
 o-Phenylenediamine [95-54-5]  
 m-Phenylenediamine [108-45-2]  
 p-Phenylenediamine [106-50-3]  
 Phenylhydrazine [100-63-0]  
 Picric acid [88-89-1]  
 Portland cement dust [65997-15-1]  
 Cr(VI) content and quartz level to be assessed separately  
 Pyridine [110-86-1]  
 Quinone [106-51-4]  
 Rhodium [7440-16-6] and its inorganic compounds  
 Selenium [7782-49-2] and its inorganic compounds (as Se)  
 Sepiolite (fibrous dust) several CAS Nos and formulas  
 Slag wool (fibrous dust)  
 Talc [14807-96-6] (without asbestos fibres) (respirable fraction)  
 Tetrachloroethene [127-18-4]  
 Thiourea [62-56-6]  
 p-Toluidine [106-49-0]  
 Tribromomethane [75-25-2]  
 1,1,2-Trichloroethane [79-00-5]  
 Tricresyl phosphate, sum of all o-isomers [78-30-8]  
 1,3,5-Triethylhexahydro-1,3,5-triazine [7779-27-3]  
 releases formaldehyde  
 Trimethyl phosphate [512-56-1]  
 2,4,7-Trinitrofluorenone [129-79-3]  
 Uranium compounds, soluble inorganic  
 Vinylidene chloride [75-35-4]  
 Wood dust (except beech and oak wood dust)  
 Xylidine (isomers)

The monitoring of the health of employees using substances classified in Category 3 must be intensified. In addition, the branches of industry which produce and process such substances are requested – as are all relevantly involved research laboratories – to participate in the effort to shed light on the cancer-correlation question and, where necessary, to search for harmless alternative substances.

Category 3 will be re-evaluated annually to determine whether substances must be reassigned to Categories 1 or 2, whether the database permits their transfer to one of the Categories 4 or 5 or whether they require no classification and can be dismissed completely from Section III of this list.

**4. Substances that cause cancer in humans or animals or that are considered to be carcinogenic for humans and for which a MAK value can be derived. A non-genotoxic mode of action is of prime importance and genotoxic effects play no or at most a minor part, provided the MAK and BAT values are observed. Under these conditions no contribution to human cancer risk is expected. The classification is supported especially by evidence that, for example, increases in cellular proliferation, inhibition of apoptosis or disturbances in cellular differentiation are important in the mode of action. The classification and the MAK and BAT values take into consideration the manifold mechanisms contributing to carcinogenesis and their characteristic dose-time-response relationships.**

Acrylic acid polymer (neutralized, cross-linked)

$\alpha$ -Aluminium oxide [1302-74-5] (corundum)

except for aluminium oxide fibres and ultrafine particles; see Section Vh

Amitrole [61-82-5]

Aniline [62-53-3]

Barium sulfate [7727-43-7] (respirable fraction)

except for ultrafine particles; see Section Vh

Butylated hydroxytoluene (BHT) [128-37-0]

n-Butyltin compounds (as Sn [7440-31-5])

Chlorinated biphenyls [53469-21-9]

Chlorinated biphenyls form a group of compounds with different degrees and positions of chlorine substitution; often, more than one of these substances occur simultaneously at the workplace. Chlorinated biphenyls with low chlorine content (up to 5 chlorine atoms) can occur as a particle-vapour mixture, whereas chlorinated biphenyls with a large quantity of chlorine occur only as particles.

Chloroform (Trichloromethane) [67-66-3]

Dichloroacetic acid [79-43-6] and its salts

1,4-Dichlorobenzene [106-46-7]

Di(2-ethylhexyl)phthalate (DEHP) [117-81-7]

N,N-Dimethylformamide [68-12-2]

1,4-Dioxane [123-91-1]

Dust, general threshold limit value (respirable fraction) (biopersistent granular dusts)

except for ultrafine particles; see Section Vh

1,2-Epoxypropane [75-56-9]

Ethylbenzene [100-41-4]

Formaldehyde [50-00-0]

Furan [110-00-9]

Glutaraldehyde [111-30-8]

Graphite [7782-42-5] (respirable fraction)

except for ultrafine particles; see Section Vh

Heptachlor [76-44-8]

Hexachlorobenzene [118-74-1]

Hexachloro-1,3-butadiene [87-68-3]

$\alpha$ -Hexachlorocyclohexane [319-84-6]

$\beta$ -Hexachlorocyclohexane [319-85-7]

1,2,3,4,5,6-Hexachlorocyclohexane techn. mixture of  $\alpha$ -HCH [319-84-6] and  $\beta$ -HCH [319-85-7]

Hydrogen peroxide [7722-84-1]

Lead [7439-92-1] and its inorganic compounds (inhalable fraction)

except lead arsenate and lead chromate

Lindane ( $\gamma$ -1,2,3,4,5,6-Hexachlorocyclohexane) [58-89-9]

Magnesium oxide [1309-48-4] (respirable fraction)

except for ultrafine particles; see Section Vh

4,4'-Methylene diphenyl diisocyanate (MDI) [101-68-8] (inhalable fraction) see also "polymeric MDI"

Nitrilotriacetic acid [139-13-9] and its sodium salts

Avoid simultaneous exposure to iron compounds (formation of FeNTA).

Nitrobenzene [98-95-3]

n-Octyltin compounds (as Sn [7440-31-5])

Peracetic acid [79-21-0]

Perfluorooctanoic acid (PFOA) [335-67-1] and its salts

o-Phenylphenol [90-43-7] see also Sodium o-phenylphenol

Phenyltin compounds (as Sn [7440-31-5])

Pigment Yellow 12, Pigment Yellow 13, Pigment Yellow 83 [6358-85-6; 5102-83-0; 5567-15-7]

"polymeric MDI" [9016-87-9] (inhalable fraction) see also 4,4'-Methylene diphenyl diisocyanate (MDI)

"polymeric MDI" (pMDI) is a technical grade MDI, containing 30–80% w/w 4,4'-methylene diphenyl isocyanate (MDI); the remainder consists of MDI oligomers and MDI homologues.

Polytetrafluoroethene [9002-84-0] (respirable fraction)

except for ultrafine particles; see Section Vh

Polyvinyl chloride [9002-86-2]

except for ultrafine particles; see Section Vh

Sodium o-phenylphenol [132-27-4]

Sulfuric acid [7664-93-9]

Tantalum [7440-25-7] (respirable fraction)

except for ultrafine particles; see Section Vh

2,3,7,8-Tetrachlorodibenzo-p-dioxin [1746-01-6]

1,1,2,2-Tetrachloroethane [79-34-5]

Tetrachloromethane [56-23-5]

Tetrahydrofuran [109-99-9]

★ Tetramethylol acetylenediurea [5395-50-6]

releases formaldehyde

Titanium dioxide [13463-67-7] (respirable fraction)

except for ultrafine particles; see Section Vh

Tributyl phosphate [126-73-8]

★ Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction)

Vinyl acetate [108-05-4]

N-Vinyl-2-pyrrolidone [88-12-0]

Zirconium dioxide [1314-23-4; 12036-23-6] (respirable fraction)

except for ultrafine particles; see Section Vh

**5. Substances that cause cancer in humans or animals or that are considered to be carcinogenic for humans and for which a MAK value can be derived. A genotoxic mode of action is of prime importance but is considered to contribute only very slightly to human cancer risk, provided the MAK and BAT values are observed. The classification and the MAK and BAT values are supported by information on the mode of action, dose-dependence and toxicokinetic data.**

Acetaldehyde [75-07-0]

Dichloromethane [75-09-2]

Ethanol [64-17-5]

Isoprene (2-Methyl-1,3-butadiene) [78-79-5]

Styrene [100-42-5]

For these substances, exposure at the level of the MAK value makes only a small contribution to the cancer risk. The derivation of the MAK value is described in more detail in the documentation for each substance.

The monitoring of the health of employees using substances classified in Categories 4 and 5 must be intensified since after exposures at levels exceeding the MAK or BAT value an increase in the cancer risk is conceivable.

## **Groups of substances requiring special consideration**

### **Carcinogenic medicines<sup>25)</sup>**

Results from animal studies or experience of effects in man suggest that a number of medicines have carcinogenic effects. Exposure of employees to such substances can occur during the manufacturing process, therapeutic use and in research laboratories.

Substances with a genotoxic therapeutic mechanism are assumed to be carcinogenic. This assumption is supported by the development of novel tumours in patients undergoing treatment with alkylating cytostatics such as cyclophosphamide, ethylenimine or chlor-naphazine as well as with ointments containing arsenic or tar after use for long periods.

Consequently, it must be assumed that a hazard exists when these substances are handled occupationally. Suitable precautions must guarantee that exposure to such substances is prevented.

### **Amines which form carcinogenic nitrosamines on nitrosation**

Nitrosatable amines require particular attention because in the presence of nitrosating agents they may be transformed into potentially strongly carcinogenic nitroso compounds. A detailed account of "Nitrosation of volatile amines at the workplace" may be found online under <https://doi.org/10.1002/3527600418.mb0b03e0001>.

The formation of nitrosamines from such amines has not only been observed in model experiments but – at least for some of the compounds – has also been demonstrated at the workplace. The amine-containing substances and end products handled at work can themselves be contaminated to a considerable extent with the corresponding nitrosamines. Under conditions encountered in practice nitrosation is to be expected particularly with secondary amines, although in principle, primary and tertiary amines may also undergo nitrosation reactions. Nitrogen oxides are the most probable nitrosating agents. In addition, nitrosation of amines may be brought about by nitrosyl chloride, nitrite esters, metal nitrites and nitroso compounds.

The potential danger associated with any particular amine arises on the one hand from the readiness with which it undergoes nitrosation reactions, and on the other from the degree of carcinogenicity of the corresponding nitrosamine. For both parameters considerable differences are to be found between the various amines. In model studies several factors such as pH, temperature, catalysts and inhibitors are known to determine the extent of nitrosation. Nitrosation of amines can take place not only in acid milieu but also in alkaline. Because nitrogen oxides are effective nitrosating agents also in alkaline milieu,

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<sup>25)</sup> see "Carcinogenic Medicines" (1990). <https://doi.org/10.1002/3527600418.mb0200e0001>

when nitrosatable amines are present nitrogen oxides should be excluded. The reaction of nitrite with nitrosatable amines is accelerated by the presence of formaldehyde, which also causes extension towards the alkaline of the pH range in which significant levels of nitrosation are possible (see documentation of MAK values<sup>26</sup>) “Kühlschmierstoffe” (Metalworking fluids)). At present, however, it is not possible to make quantitative predictions as to the formation of nitrosamines under the complex conditions found at the workplace and in mixtures of substances found there. Two precautionary measures are therefore necessary when handling amines at the workplace:

1. Simultaneous exposure to nitrosating agents should be reduced to a minimum. This can be put into practice by eliminating nitrosating agents, or – if they play a role in the actual process – by replacing them with substances which do not lead to the formation of carcinogenic nitrosamines. In particular, the level of nitrogen oxides at the workplace should be monitored and reduced when necessary.
2. The level of nitrosamines in the workplace air and in substances containing amines should be monitored. This applies particularly when amines are used from which highly carcinogenic nitroso compounds, e.g., nitrosodimethylamine or nitrosodiethylamine, can be formed.

### **Monocyclic aromatic amino and nitro compounds**

The List of MAK and BAT Values includes more than 30 monocyclic aromatic amino and nitro compounds, most of which are classified in Categories 1 to 3 for carcinogenic substances, but there are also some with MAK values and others for which no MAK value could be established and which are therefore listed in Section IIb of the List of MAK and BAT Values. Comparison of these compounds (see “Toxikologisch-arbeitsmedizinische Begründungen von MAK-Werten”) reveals that their acute and chronic toxic effects are very similar. When they are tested with appropriate methods, they may be shown to have carcinogenic potential (Categories 1 or 2) or at least to be suspected carcinogens (Category 3). And the substances all cause very similar kinds of tumours. The substances are generally only weakly genotoxic. Therefore, it is considered that the acute toxic effects play an important role, a role in tumour promotion. The creation of the Categories 4 and 5 for carcinogenic substances made it necessary to review the contribution of genotoxic and non-genotoxic properties to the carcinogenicity of (especially) suspected carcinogens (substances in Category 3) and to decide whether they could be reclassified in one of the new categories. In addition, inconsistencies in the classification of these substances had become apparent. Because there is frequently insufficient information available for the classification of individual substances, it seems sensible to draw conclusions on the basis of analogy with structurally related compounds. The comparison reveals that this is possible within certain limits but that, in the absence of appropriate data, it is not possible to decide with any certainty where a substance belongs in the spectrum between weak and powerful carcinogens.

Practically all the monocyclic aromatic amino and nitro compounds reviewed here are methaemoglobin producers and most cause haemosiderosis. This suggests that the N-hydroxylamines formed from the compounds are responsible for the toxic effects in experimental animals and in man. It has, however, not yet been demonstrated whether the

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<sup>26</sup>) Available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019).

observed differences between sexes and species and in target organs may all be explained in terms of toxicokinetically induced differences in the bioavailability of the effective metabolites. It is also not clear whether the genotoxic or acute toxic effects are influenced by the release of iron during methaemoglobin formation or erythrocyte turnover and by the "oxidative stress" associated with these processes.

In any case, toxic tissue changes and fibrosis precede tumour development in the spleen, liver and kidneys.

Genotoxic effects have been demonstrated for many monocyclic aromatic amino and nitro compounds and are likely for others. Because of this (albeit weak) genotoxicity, a classification in Category 5 for carcinogenic substances could seem appropriate. However, there is considerable evidence that tissue damage is decisive for the tumour development and that the substances should be classified in Category 4. But such a classification requires that the causes and dose-dependence of the tissue damage are understood.

The comparison of these substances also indicates that the haematotoxic members of the group must generally be seen to be risk factors for cancer and should be re-examined to decide whether they should be classified in one of the categories for carcinogenic substances.

### **Azo colourants**

Azo colourants are characterised by the azo group  $\text{—N=N—}$ . They are made by the coupling of singly and multiply diazotized aryl amines. Of particular toxicological importance are colourants from doubly diazotized benzidine and benzidine derivatives (3,3'-dimethylbenzidine, 3,3'-dimethoxybenzidine, 3,3'-dichlorobenzidine). In addition, aminoazobenzene, aminonaphthalene and monocyclic aromatic amines are encountered. Reductive fission of the azo group, either by intestinal bacteria or by azo reductases of the liver and of extrahepatic tissues, can cause these compounds to be released. Such breakdown products have been detected in animal experiments as well as in man (urine). Mutagenicity, which has been observed with numerous azo colourants in *in vitro* test systems, and the carcinogenicity in animal experiments are attributed to the release of amines and their subsequent metabolic activation. There are now epidemiological indications that occupational exposure to benzidine-based azo colourants can increase the incidence of bladder carcinoma.

Thus all azo colourants whose metabolism can liberate a carcinogenic aryl amine are suspected of having carcinogenic potential. Due to the large number of such dyes (several hundred) it seems neither possible nor justifiable to substantiate this suspicion in each individual case by means of animal experimentation according to customary classification criteria. Instead, scientific models have to be relied on. Therefore, as a preventive measure to avoid putting exposed persons at risk, it is recommended that the substances be dealt with as if they were classified in the same categories as the corresponding carcinogenic or suspected carcinogenic amines (Categories 1, 2, 3). If there are indications that the colourant itself (e.g. a pigment) or any carcinogenic breakdown product is not biologically available, the absence of risk should be proved experimentally or substantiated by bio-monitoring. Suitable animal experiments can also rule out a suspected carcinogenic potential.



### **Pyrolysis products of organic materials**

If organic material is heated or combusted with a limited supply of oxygen, mixtures are produced whose compositions are dependent on the starting material and the reaction conditions. These mixtures contain, among numerous other substances, polycyclic aromatic hydrocarbons (PAH).

The extremely complex mixtures which have been examined to date contain, simultaneously and in widely differing proportions, carcinogenic components and substances which promote cancer development, as well as fractions which inhibit the carcinogenic effects of concurrently present components.

Many of the PAH which occur regularly in pyrolysis products are carcinogenic in animal studies. They are present at particularly high levels in

- brown coal tars (soft coal tars),
- coal tars (black coal tars),
- coal tar pitches,
- coal tar oils,
- coke oven emissions.

The carcinogenic effect after occupational exposures to these mixtures of aromatic compounds has been demonstrated in epidemiological studies. Therefore, they are classified in

#### **Category 1.**

Particularly the local carcinogenic effects of these mixtures are accounted for largely in terms of their content of PAH. Such effects are therefore also to be expected with other PAH-containing mixtures. The levels and significance of other carcinogenic components of these mixtures has not yet been studied in detail. Thus, although

#### **diesel engine emissions<sup>27)</sup>**

also contain PAH, in this case it is probably the soot particles which determine the carcinogenic effect. This has been demonstrated only in animal studies and therefore diesel engine emissions are classified in

#### **Category 2.**

The carcinogenic effects of other mixtures such as, e.g., petrol engine emissions, used motor oils, curing smoke, used cutting oils, have not yet been studied in as much detail. The composition of these mixtures also makes them difficult to define. If, however, exposure to PAH which have been shown in animal studies to be carcinogenic, e.g.,

- anthanthrene,
- benzo[a]anthracene,
- benzo[b]fluoranthene,
- benzo[j]fluoranthene,
- benzo[k]fluoranthene,

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<sup>27)</sup> Because of the new diesel engine technology the emissions have changed significantly in quality and quantity. Since it must be assumed that these new diesel engines were introduced at the end of the 1990s, all the available epidemiological studies which were evaluated in 2007 are based on exposures to emissions from older diesel engines. The emissions from the new diesel engines can not be evaluated until appropriate studies become available.

benzo[b]naphtho[2,1-d]thiophene,  
benzo[a]pyrene,  
chrysene,  
cyclopenta[cd]pyrene,  
dibenzo[a,h]anthracene,  
dibenzo[a,e]pyrene,  
dibenzo[a,h]pyrene,  
dibenzo[a,i]pyrene,  
dibenzo[a,l]pyrene,  
indeno[1,2,3-cd]pyrene,  
1-methylpyrene,  
naphthalene,

can be demonstrated during work with such pyrolysis products, the mixtures should be handled like the substances in Category 2, except for phenanthrene and pyrene, which are not classified in a Carcinogen category on the basis of the data (see documentation “Polycyclic aromatic hydrocarbons (PAH) 2012”).

It will be possible to establish a clearer, more quantitative relationship between exposure and an increase in cancer risk when more precise data for the compositions of specific mixtures and of their cancer-producing effects are available (see also documentation “Polycyclic aromatic hydrocarbons (PAH) 2012”). The Commission emphasizes the urgency of such investigations.

Polycyclic aromatic hydrocarbons (PAH) may be readily absorbed through the skin. Therefore, pyrolysis products and other mixtures containing PAH should be handled like substances designated with an “H” (see Section VII Percutaneous absorption; see also documentation “Polycyclic aromatic hydrocarbons (PAH) 2012”).

### **Fibrous dusts**

Not only certain kinds of asbestos but also the fibrous zeolite, erionite, is considered to produce tumours in man. In addition, a number of fibrous dusts have been shown to produce tumours in experimental animals after inhalation or after intratracheal instillation or direct local administration into the chest (intrapleural) or abdominal (intraperitoneal) cavity.

When all the information as to the effects of dust on man and the effects seen in studies with animals and cultured cells is taken into account, it must be concluded that, unlike the non-fibrous insoluble dusts of corresponding composition,

- the fibrous asbestos dust particles which are durable in the organism must be seen as the cause of the tumorigenic effects of asbestos
- and that, in principle, all kinds of elongated dust particles have the potential, like asbestos fibres, to cause tumours if they are sufficiently long, thin and durable in vivo.

Factors also suggested to play a role include other properties of fibres such as their surface characteristics.

The animal studies have also demonstrated that longer or more durable fibres have higher carcinogenic potency than shorter or less durable fibres.

## **Classification criteria**

### **a. Properties of carcinogenic fibres**

According to the internationally accepted convention established in the 1960s for measuring levels of asbestos dust at workplaces by counting the fibres under the light microscope, only particles with a ratio of length to diameter greater than 3:1 and which are longer than 5  $\mu\text{m}$  and have a diameter less than 3  $\mu\text{m}$  are counted. The term fibrous dust is used here for fibres of these dimensions. With such fibrous dusts in animal studies, the number of fibres has been shown to correlate positively with the tumour incidence.

The above definition, however, does not distinguish clearly between carcinogenic and non-carcinogenic fibres. The presently available data do not make it possible to state precisely from which fibre length or diameter or from which length to diameter ratio and from which durability fibres possess the biological activity resulting in tumour induction. Nevertheless, at present there is no other definition which has a better scientific basis.

The situation is made more difficult by the fact that, with the exception of a few inorganic and organic textile fibres, fibrous materials produce dusts in which the fibre lengths and diameters are spread over a wide range.

In addition, the diameter of fibres, e.g., asbestos fibres, can be reduced after incorporation by longitudinal splitting. Then fibres with diameters less than 3  $\mu\text{m}$  can be found in the lungs although, before splitting, the fibres in the inhaled air did not fit the definition of fibrous dust.

### **b. Effects in man**

Epidemiological studies of the inhabitants of three villages in central Anatolia together with mineralogical studies and analyses of the fibres in lung dust produced convincing evidence that erionite fibres cause mesothelioma and lung cancer.

In epidemiological studies carried out in factories producing glass fibre and glass wool, no convincing evidence of an increased risk of developing mesothelioma or lung cancer was found. An increased risk of developing lung cancer was found for persons exposed to rock and slag wool but could not be associated unequivocally with the exposure to these fibrous dusts.

The studies available to date neither confirm nor refute the proposal that man-made mineral fibres have carcinogenic effects but this was not to be expected since, even if the individual fibres were as carcinogenic as asbestos fibres, the tumorigenicity would not be detectable at the low exposure concentrations measured in these studies. At present there are no appropriate studies of workplaces where persons processing or using fibres are exposed to the much higher fibre concentrations necessary to examine with sufficient sensitivity the question of the carcinogenic effects in man.

### **c. Animal inhalation studies**

The results of inhalation studies with fibrous dusts are not always consistent so that positive results obtained in some studies could not be confirmed in others. The main reason for this inconsistency is that it is difficult to ensure that a sufficient dose of the carcinogenic fibre fraction reaches the target tissue. The fibres which are relevant for the effects in man, for example, penetrate the nasal filter of rodents either only poorly or not at all. For crocidolite, which has been shown to be carcinogenic in man, positive results have been obtained in only one adequately documented inhalation study with rats but negative results in several adequately documented studies.

Thus a negative result in an inhalation study does not exclude the possibility that the substance has carcinogenic effects. Positive results in the lung must be analysed to determine whether overloading has occurred.

#### **d. Animal studies with intratracheal instillation, intrapleural or intraperitoneal injection**

Many kinds of fibre have proved to be carcinogenic after administration by intratracheal instillation or by intrapleural or intraperitoneal injection. These administration routes are unphysiological but they guarantee a high dose of fibres immediately after application at the sites which are relevant for man (bronchial tract, pleura and peritoneum). Thus, in the studies with intratracheal, intraperitoneal or intrapleural administration, a longer time and higher dose is available for tumour production than in inhalation studies where the fibre concentration in the target organs builds up only slowly.

With these methods, dose-response relationships can be established; they have demonstrated that the carcinogenic effect is determined by the form of the fibre. Inhalation studies with selected ceramic fibres have confirmed positive results obtained in injection studies. Although the possibility of overloading the target tissue cannot be excluded with these administration routes, a positive result from such a study is considered to be good evidence that the fibre would be carcinogenic in man.

#### **e. Genotoxicity and cell transformation studies**

Genotoxicity and cell transformation studies with various fibres also demonstrate that fibre form largely determines the effects of fibres. Whereas numerical and structural chromosome changes were detected in a number of test systems, there was no conclusive evidence that fibres can induce point mutations.

#### **f. Durability**

From the results of animal studies with durable and non-durable fibres it is concluded that durability in the biological system has a considerable effect on the carcinogenicity of fibres. At present, however, it is not possible to define the degree of durability necessary for carcinogenic activity or to state to what extent the durability determines the carcinogenic potency of the fibres. Gypsum and wollastonite, e.g., dissolve in the organism within a period of some days to a few weeks and show no signs of carcinogenic effects even after intraperitoneal administration.

#### **g. Mechanism**

The mechanism of the toxicity and carcinogenicity of fibres is very complex and many aspects are unclear.

The formation of tumours in the lungs and on serous skin is mainly the result of inflammatory processes. Chronic inflammation and cell proliferation are caused by the impairment of fibre clearance; whereby inflammation-promoting cytokines, growth factors, reactive oxygen (ROS) and nitrogen species (RNS), and chlorine radicals are released from macrophages, alveolar cells and mesothelial cells. The generation of these radicals leads to indirect genotoxic effects.

Additional mechanistic aspects are:

- i) the formation of ROS and RNS caused by the fibres themselves,

- ii) the absorption of the fibres into the target cells by means of endocytosis, whereby ROS and RNS are released intracellularly causing genetic and epigenetic changes, and
- iii) the stimulation of cell receptors and inflammasomes, which in turn activate intracellular signal pathways and thus give the impulse for cell proliferation and the resistance to apoptosis.

### **Summary**

The fibre dust groups will be evaluated individually, and depending on the data available and taking into consideration the mechanism of action will be classified in one of the categories for carcinogens.

The results of the evaluation of the individual fibre groups are given in List II a “Substances with MAK values and substances listed in Sections II b and III to XII”<sup>28)</sup>.

### *Organic fibrous dusts*

Evaluation of the carcinogenicity of organic fibres in the critical dimension range is not possible. Studies are necessary, for example of carcinogenicity, surface characteristics, bioavailability and durability, to enable assessment of the carcinogenic effects of organic fibres.

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<sup>28)</sup> Detailed documentation is available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## IV Sensitizing substances

The allergies caused by substances at the workplace affect mostly the skin (contact eczema, contact urticaria), the respiratory passages (rhinitis, asthma, alveolitis) and the conjunctiva (blepharoconjunctivitis). The kind of allergy is determined by the route of uptake, the chemical properties of the substance and its aggregation state.

Contact allergies are generally manifested as contact eczema, the pathogenesis of which involves a T lymphocyte-mediated immune reaction of delayed type. Contact eczema is almost always caused by reactive substances of low molecular weight. Immunologically, these low molecular weight substances must be seen as haptens, prehaptenes or prohaptenes. They become complete allergens in the organism either by binding to peptides or proteins as such (haptenes), after activation *ex vivo* (prehaptenes) or after metabolism (prohaptenes).

The development of a contact allergy of delayed type is determined by several factors, by the sensitization potential resulting from the chemical properties of the substance or the metabolites produced from it in the organism, by the exposure concentration and the duration and manner of exposure, by the genetic disposition of the person and, not least, by the state of the tissue with which the substance makes contact. The release of (pro-) inflammatory cytokines (e.g. TNF- $\alpha$  or interleukin-1 $\beta$ ), which is triggered by existing inflammation of the skin or by irritation from a foreign substance, is necessary for the induction of sensitization. Thus, the irritating properties of a substance can increase its sensitization potential. Cytokine induction, which stimulates the immune response, can also be triggered by the additional contact with other irritating substances, e.g. detergents such as sodium dodecyl sulfate, which then provide the necessary (pro-)inflammatory stimulus. Furthermore, the irritating effect of these kinds of substances leads to increased penetration of the sensitizing substance. An effect which enhances (or decreases) penetration is also possible from non-irritating substances with suitable/adequate polarity (such as dimethyl sulfoxide). These types of cofactors and combinatorial effects, as well as particular factors relevant under conditions at the workplace and expressly pointed out in the documentation, are taken into account in the evaluation, as described in Chapter IV.c. The sensitization potency of a substance is not necessarily reflected in the incidence of sensitizations which it causes because the clinical significance of a contact allergen is not only determined by its sensitization potency but also by the distribution of the substance and the possibilities of exposure to it. Quantitatively, the sensitization potential of a substance can best be estimated in animal studies, in particular in the Local Lymph Node Assay (LLNA) in the mouse. At present, *in vitro* studies are not yet sufficiently validated for this purpose.

Other allergic skin reactions, e.g., urticaria, involve immune reactions mediated by specific antibodies. Similar symptoms can also be produced, however, by mechanisms not involving immune reactions (see below).

Most respiratory allergens are macromolecules, mainly peptides or proteins. But low molecular weight substances can also produce specific immunological reactions in the airways (see List of allergens). Some of the low molecular weight respiratory allergens are also contact allergens.

The allergic reactions of the airways and conjunctiva which take the form of bronchial asthma or rhinoconjunctivitis mostly involve reaction of the allergen with specific IgE antibodies and belong to the manifestations of immediate type. However, in the deeper airways they can also first appear after a delay of several hours. Exogenous allergic

alveolitis is induced generally by allergen-specific immune complexes of IgG type and by cell-mediated reactions. Allergic reactions of immediate type can also cause systemic reactions and even anaphylactic shock.

The development of allergies of the respiratory passages, like that of contact allergies, is dependent on a number of factors. In addition to the substance-specific potential for causing sensitization, the amount of the allergen, the exposure period and the genetically determined disposition of the exposed person play a decisive role. Factors which increase the sensitivity of the mucosa may play a role in predisposing a person to allergy; they may be genetically determined or acquired, for example, during infections or exposure to irritant substances. Particular attention should be drawn to atopic diathesis which is characterized by an increased susceptibility to atopic eczema (neurodermatitis) or to allergic rhinitis and allergic bronchial asthma and is often associated with increased IgE synthesis.

In addition, there are also a number of relatively rare disorders of quite different kinds which are immunologically induced and so belong with the allergic phenomena such as, for example, manifestations involving granuloma formation (e. g. berylliosis) and certain exanthematous skin disorders.

A number of substances only induce the formation of antigens and then contact sensitization when they have previously been put into an energetically excited state by the absorption of light (photocontact sensitization, "photoallergization"). Likewise, many other substances can cause a skin reaction after exposure to light but without proof of an immunological mechanism (phototoxicity). Differentiation between phototoxicity and immunological photocontact sensitization can be difficult, as the classical factors that distinguish between (photo)allergic and (photo)toxic effects are not always found. In Anglo-American usage the expression "photosensitization" is used for both mechanisms. Although photocontact sensitization and phototoxicity involve primarily the physical activation (photosensitization) of a chromophore, both types of reactions are in principle clinically and diagnostically distinguishable.

It is still not possible to determine (and document scientifically) generally applicable threshold concentrations either for the induction of an allergy (sensitization) or for triggering the allergic reaction in an already sensitized person. The likelihood of induction increases with the concentration of the allergen to which persons are exposed. The concentrations required for the triggering of acute symptoms are generally lower than those required for sensitization. Even when MAK values are observed, the induction or triggering of an allergic reaction cannot be excluded with any certainty.

Sensitizing substances are indicated in the List of MAK and BAT Values under the abbreviation "Sens" by "Sa" or "Sh". This designation refers only to the organ or organ system in which the allergic reaction is manifested. The pathological mechanism producing the symptoms is not taken into account. "Sh" designates substances which can cause allergic reactions of the skin and the mucosa close to the skin (skin-sensitizing substances). The designation "Sa" (substances causing airway sensitization) indicates that a sensitization can involve symptoms of the airways and also of the conjunctiva, and that other effects associated with reactions of immediate type are also possible. These include systemic effects (anaphylaxis) and local effects on the skin (urticaria). The latter reactions only result in the additional designation with "Sh" when the skin symptoms are relevant under workplace conditions. Substances which increase photosensitivity in exposed persons by mechanisms not involving immune reactions (e. g. furocoumarins) are not separately designated. On the other hand, substances which cause photocontact sensitization are designated with "SP" (e. g. bithionol). Separate criteria for their evaluation are not

necessary because, in essence, the criteria for the evaluation of substances causing contact sensitization may be applied. Some substances can cause local or systemic reactions the symptoms of which are entirely or largely identical to those of allergic reactions but which do not involve specific immunological mechanisms; they involve, e.g., the release of various mediators by mechanisms which are not immunological. These reactions are not a result of antigen-antibody interactions and can therefore also appear on the very first contact with the substance. Such reactions are induced, e.g., by sulfites, by benzoic acid and acetylsalicylic acid and their derivatives and by a variety of dyes such as tartrazine. Such substances are not designated with an "S". However, attention is drawn to their potential for producing such non-immunological reactions in the documentation and in some cases in the List of MAK and BAT Values as well.

The criteria which are used in the evaluation of substances causing contact and airway sensitization are described below.

### a. Criteria for the assessment of contact allergens

The allergological evaluation is based on a variety of information which must be seen as providing different qualities of evidence.

- 1) **Sufficient evidence** of an allergenic effect is provided by valid results from **either i) or ii)**:
  - i) effects in man
    - studies in which numerous clinically relevant cases of sensitization (i. e. association of symptoms and exposure) were observed in tests with large collectives of patients in at least two independent centres, or
    - epidemiological studies which reveal a relationship between sensitization and exposure, or
    - case reports of clinically relevant sensitization (association of symptoms and exposure) for more than one patient from at least two independent centres
  - or**
  - ii) results of experimental studies
    - at least one positive result in an animal study without adjuvant carried out according to accepted guidelines, or
    - positive results from at least two less well-documented animal studies carried out according to accepted guidelines, one of which did not use adjuvant.
    - at least two positive results from in vitro studies carried out according to test guidelines, in which different key events of contact sensitization were tested
- 2) An allergenic effect can be considered **probable** on the basis described in i) **and** ii) below:
  - i) effects in man
    - studies in which numerous clinically relevant cases of sensitization (association of symptoms and exposure) were observed in tests in just one centre, or
    - studies in which numerous cases of sensitization without details of clinical relevance were observed in tests with large collectives of patients in at least two independent centres
  - and**
  - ii) results of experimental studies



- a positive result in an animal study with adjuvant carried out according to accepted guidelines or
  - positive results from an in vitro study carried out according to test guidelines,
- or
- evidence from structural considerations based on sufficiently valid results for structurally closely related compounds.

- 3) An allergenic effect is **not sufficiently documented**, but also not excluded, when only the data listed below are available:
- insufficiently documented case reports, or
  - only one positive result in an animal study with adjuvant carried out according to accepted guidelines, or
  - positive results in animal studies which were not carried out according to accepted guidelines, or
  - evidence from studies of structure-effect-relationships or from in vitro studies not carried out according to test guidelines.

#### Commentary:

##### Effects in man

The data obtained in numerous clinics and allergy centres from serial patch tests give us a useful picture of the frequency of skin sensitization and of the practical importance of the individual contact allergens. In contrast, useful results of reliable epidemiological studies are available for only few allergens.

The allergens which are observed most frequently, e. g., nickel, are not always the most potent sensitizers. On the other hand, very strongly sensitizing substances such as 2,4-dinitrochlorobenzene play quantitatively only a small role because only a small number of persons have sufficiently intensive contact with them. A number of highly potent contact allergens have been identified from clinical observations obtained in only a few patients, often after the first and only exposure (sometimes even after the first patch test). Examples of such substances are chloromethylimidazoline, diphenylcyclopropenone, quadratic acid diethyl ester, p-nitrobenzoyl bromide. For such exceptional substances, given proper scientific data, the evidence could be considered as 'probable' (category a2) even when the data come from just one centre.

The results of use tests in man with substances found at the workplace – often internal studies of the producing company – are of considerable value when they are carried out properly. Nowadays, the use of experimental sensitization tests must be rejected for ethical reasons, but historical results can be of importance in the evaluation of a substance.

##### Results of experimental studies

Animal studies to determine the potential of a substance to cause allergic sensitization were carried out with guinea pigs with or without the use of Freund's complete adjuvant (FCA) and in the mouse. The most frequently used methods were the maximization test of Magnusson and Kligman (with FCA), and the Buehler test and LLNA (without FCA). The methods with FCA are generally more sensitive and their use can therefore occasionally result in overrating of the potential of sensitization. For this reason, a positive result in a test without adjuvant is considered in the test criteria to be better evidence than a positive result in one with adjuvant.

The tests with experimental animals generally yield useful data; that is, for most substances they have yielded results in agreement with the data obtained in man. One advantage of the experimental animal methods is that dose-response relationships can be studied.

The test systems used for *in vitro* studies refer to individual key events of the sensitization phase, such as the binding of the test substance to proteins, the activation of keratinocytes, the maturation and migration of dendritic cells or the activation and proliferation of T lymphocytes. The plausibility of positive findings from *in vitro* studies is examined. For this purpose, for example, the physico-chemical properties of the substances, existing knowledge of their reactivity with proteins or structure–effect relationships can be taken into consideration. An evaluation scheme in which merely a minimum number of positive findings is required is considered by the Commission to be too rigid an instrument for scientific evaluations.

Substances to which people have not yet been exposed or known to be exposed (e. g. because they have been newly synthesized or are newly available products) and for which, therefore, clinical data cannot be available (neither negative nor positive results of clinical observations can be applied as a criterion) can also be classified as probably sensitizing (category a2) simply on the basis of positive results from animal studies with adjuvant carried out according to accepted guidelines. Even plausible positive results from experimental studies not carried out according to accepted guidelines can be accepted, provided theoretical chemical structural considerations or well-founded mechanistic aspects indicate that the substance is so closely related to known allergens that it may be expected to have analogous properties. Theoretical considerations require practical confirmation; therefore, they are generally of less importance in the final evaluation and cannot be the only criterion for a potential sensitizing effect in the absence of other clinical or experimental data.

## **b. Criteria for the assessment of respiratory allergens**

The kinds of data which may be used in the evaluation of respiratory allergens are listed below; here too the different kinds of data provide different qualities of evidence.

- 1) Sufficient evidence of allergenic effects of a substance in the airways or the lungs is provided by valid data from:
  - studies or case reports of a specific hyperreactivity of the airways or the lungs which are indicative of an immunological mechanism from more than one patient and at least two independent testing centres. In addition, the (clinical) symptoms or adverse effects on the function of the upper or lower airways or the lungs must be shown to be associated with the exposure to the substance.
- 2) An allergenic effect can be considered probable on the basis of the results listed below:
  - one single case report of a specific hyperreactivity of the airways or the lungs

**and**

  - other indications of sensitizing effects, e. g., a close structure-effect relationship with known airway allergens.
- 3) An allergenic effect is not sufficiently documented, but also not excluded, when only the data listed below are available:

- epidemiological studies which demonstrate an increased incidence of symptoms or impaired function in exposed persons, or
- studies or case reports of a specific hyperreactivity of the airways or the lungs in only one patient, or
- studies or case reports of sensitization (e. g. detection of IgE) without accompanying symptoms or impairment of function causally associated with the exposure, or
- positive results of animal studies, or
- positive results of in vitro studies, or
- structure-effect relationships with known respiratory allergens.

Commentary:

Generally, the classification is based on the results of epidemiological studies. Case reports do not always withstand critical examination, not least because of the difficulty or impossibility of carrying out adequate control studies. This is particularly true of inhalation-provocation tests. In addition, it is not always possible to produce adequate exposure data.

Symptoms are usually not a sufficient criterion for the designation of a substance as a respiratory allergen; generally, it is necessary to demonstrate sensitization and record objective changes such as exposure-related impairment of lung function or bronchial hyperreactivity to specific stimuli. An immunological mechanism can generally be recognized on the basis of in vivo (e. g. prick test) or in vitro test results, ideally by detection of a specific antibody after proved exposure.

For many substances, an immunological mechanism has not yet been demonstrated directly. Therefore, indirect evidence of immunological mechanisms can also be taken into account in classification. These include:

- the existence of a latency period between the start of the exposure and the appearance of the first symptoms (sensitization period),
- the triggering of symptoms with low concentrations of the substance which do not cause symptoms in appropriate controls,
- occasional delayed reactions or sequential immediate and delayed reactions (dual reactions) in the inhalation-provocation test,
- associated cutaneous symptoms such as urticaria or Quincke's oedema.

An allergenic effect is not sufficiently documented, but also not excluded, when evidence of airway sensitization is available but the conditions described in the criteria are not fulfilled. In particular, epidemiological studies which demonstrate an increased incidence of symptoms or of impaired function in exposed persons (even with demonstrated dose-response relationships) do not provide sufficient evidence of sensitizing properties if no indications of a specific immunological mechanism are available. Likewise, studies or case reports which merely document workplace-related variations in lung function or bronchial hyperreactivity are not sufficient.

To date there is no thoroughly validated method to induce and detect respiratory allergies in an animal model.

In guinea pig models, sensitizing substances cause reactions like those seen in man. Sensitization can be induced by inhalation or by intradermal, subcutaneous injection or topical epidermal application. In these tests the respiratory hyperreactivity (respiration rate, tidal volume, respiratory minute volume, inhalation and exhalation times, exhalation rate) is measured. In the mouse IgE test, the potential of a substance to cause sensitization in BALB/c mice is determined as a function of the increase in the level of total IgE but not,

to date, as a function of substance-specific IgE. In studies in rats, effects are often investigated after topical induction and inhalation challenge treatment.

With these models no observed effect levels (NOEL) can be established but it is questionable whether they apply for man. Systematic comparative tests have not yet been carried out.

To date, sensitive and specific standardized in vitro methods for detecting low molecular weight respiratory allergens (and which can differentiate between respiratory and contact allergens) are not available. In addition, it is not possible to date to give a valid assessment of the sensitizing potential of the substance (with the exception of a few classes of substances such as e.g. the diisocyanates or the dicarboxylic acid anhydrides) on the airways on the basis of structural or mechanistic properties alone. These may, however, be useful when the data from experimental studies are ambiguous.

### c. Designation of a substance as an allergen

Whether or not it is necessary to designate a substance as an allergen in the List of MAK and BAT Values is determined on the basis of the available evidence of allergenic effects and, when possible, also on the basis of the expected levels of exposure.

- The substances characterized according to the criteria in Section IV a) or IV b) as belonging in Categories 1) or 2) are generally designated as allergens with “Sa”, “Sh”, “Sah” or “SP”.
  - Substances for which these criteria are fulfilled are also designated with an “S” when the observed sensitization is associated mainly with cofactors which are (only) relevant under workplace conditions (e.g. (previous) damage to the skin caused by chemical or physical agents).
- On the other hand, substances are not designated with an “S” when
  - in spite of extensive handling of the substance, very few (well-documented) cases of sensitization are observed, or
  - the observed cases of sensitization are mainly associated with cofactors which are not relevant under workplace conditions (e.g. the presence of eczema on the lower leg), or
  - the criteria of Section IV a) or IV b) resulted in classification of the substance in category 3). This also includes substances for which a positive result was obtained in a study with experimental animals using adjuvant (maximization test); at the same time, however, no case of contact sensitization in humans was observed despite relevant exposure. A substance is not designated with “Sa” if the reactions which occurred are caused by irritating or pharmacological effects, since these effects were taken into account in establishing a MAK value.
- Thus, in individual cases a designation which differs from the designation according to the EU regulations for hazardous substances is possible.

The criteria are to be seen as guidelines for an intelligible evaluation of the data but in certain special cases their strict application may not be obligatory.

**d. List of allergens**

The list below shows the substances in Section II a which are designated with Sa, Sh, Sah or SP. It does not claim to be a complete list of sensitizing substances and is subject to continual revision and extension.

Abietic acid [514-10-3] (Sh)

also includes disproportionation and transposition products An immunological genesis of the asthma often seen in persons working with materials containing abietic acid has not been proved.

Acrylamide [79-06-1] (Sh)

Acrylic acid 2-ethylhexyl ester [103-11-7] (Sh)

Acrylic acid 2-hydroxyethyl ester [818-61-1] (Sh)

Acrylic acid hydroxypropyl ester (all isomers) [25584-83-2] (Sh)

Acrylonitrile [107-13-1] (Sh)

Alkali persulfates (Sah)

Allyl glycidyl ether [106-92-3] (Sh)

p-Aminoazobenzene [60-09-3] (Sh)

o-Aminoazotoluene [97-56-3] (Sh)

4-Aminodiphenylamine [101-54-2] (Sh)

2-Aminoethanol [141-43-5] (Sh)

2-(2-Aminoethoxy)ethanol [929-06-6] (Sh)

3-Aminomethyl-3,5,5-trimethyl-cyclohexylamine (Isophorone diamine) [2855-13-2] (Sh)

3-Aminophenol [591-27-5] (Sh)

p-Aminophenol [123-30-8] (Sh)

Ammonium persulfate [7727-54-0] (Sah)

α-Amylase (Sa)

α-Amylcinnamaldehyde [122-40-7] (Sh)

Aniline [62-53-3] (Sh)

Animal hair, epithelia and other materials derived from animals (Sah)

Azinphos-methyl [86-50-0] (Sh)

Benomyl [17804-35-2] (Sh)

1,2-Benzisothiazol-3(2H)-one [2634-33-5] (Sh)

Benzyl alcohol mono(poly)hemiformal [14548-60-8] (Sh)

releases formaldehyde

Beryllium [7440-41-7] and its inorganic compounds (Sah)

N,N-Bis(2-ethylhexyl)-(1,2,4-triazole-1-yl)methanamine [91273-04-0] (Sh)

Bisphenol A (4,4'-Isopropylidenediphenol) [80-05-7] (SP)

Bisphenol A diglycidyl ether [1675-54-3] (Sh)

Bisphenol A diglycidyl methacrylate [1565-94-2] (Sh)

Bisphenol A ethoxylate dimethacrylate [24448-20-2] (Sh)

Bisphenol A glycerolate [4687-94-9] (Sh)

Bisphenol F diglycidyl ether (Sh)

Bithionol [97-18-7] (SP)

Bromelain [9001-00-7] (Sa)

2-Bromo-2-nitro-1,3-propanediol [52-51-7] (Sh)

use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4"

1,4-Butanediol diacrylate [1070-70-8] (Sh)

1,4-Butanediol diglycidyl ether [2425-79-8] (Sh)

- 1,4-Butanediol dimethacrylate [2082-81-7] (Sh)  
1-Butanethiol [109-79-5] (Sh)  
Butanone oxime [96-29-7] (Sh)  
n-Butyl acrylate [141-32-2] (Sh)  
tert-Butyl acrylate [1663-39-4] (Sh)  
2-Butyl-1,2-benzisothiazolin-3-one [4299-07-4] (Sh)  
p-tert-Butylcatechol [98-29-3; 27213-78-1] (Sh)  
n-Butyl glycidyl ether (BGE) [2426-08-6] (Sh)  
tert-Butyl glycidyl ether [7665-72-7] (Sh)  
n-Butyl methacrylate [97-88-1] (Sh)  
p-tert-Butylphenol [98-54-4] (Sh)  
p-tert-Butylphenyl glycidyl ether [3101-60-8] (Sh)  
Butynediol [110-65-6] (Sh)  
N-Carboxyanthranilic anhydride [118-48-9] (Sh)  
Cellulases (Sa)  
Cereal flour dusts Rye, Wheat (Sa)  
2-Chloroacetamide [79-07-2] (Sh)  
Chloroacetamide-N-methylol (CAM) [2832-19-1] (Sh)  
releases formaldehyde  
Chloroacetic acid methyl ester [96-34-4] (Sh)  
m-Chloroaniline [108-42-9] (Sh)  
p-Chloroaniline [106-47-8] (Sh)  
p-Chloro-m-cresol [59-50-7] (Sh)  
1-Chloro-2,4-dinitrobenzene [97-00-7] (Sh)  
1-Chloro-2,3-epoxypropane (Epichlorohydrin) [106-89-8] (Sh)  
5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one [26172-55-4; 2682-20-4] mixture in ratio 3:1 (Sh)  
Chlorothalonil [1897-45-6] (Sh)  
Chlorpromazine (2-Chloro-10-(3-dimethylaminopropyl)phenothiazine) [50-53-3] (SP)  
Chromium(III) compounds (Sh)  
does not apply for chromium(III) oxide and similar poorly soluble chromium(III) compounds  
Chromium(VI) compounds (inhalable fraction) (Sh)  
barium chromate and lead chromate are not designated with "Sh"  
Cinnamaldehyde [104-55-2] (Sh)  
Cinnamyl alcohol [104-54-1] (Sh)  
Cobalt [7440-48-4] and cobalt compounds (inhalable fraction) (Sh)  
Cresyl glycidyl ethers mixture of isomers [26447-14-3], o-isomer [2210-79-9] (Sh)  
Cyanamide [420-04-2] (Sh)  
Cyanuric chloride [108-77-0] (Sh)  
N-Cyclohexyl-2-benzothiazolesulfenamide [95-33-0] (Sh)  
N-Cyclohexyl-N'-phenyl-p-phenyldiamine [101-87-1] (Sh)  
Diacetyl [431-03-8] (Sh)  
4,4'-Diaminodiphenylmethane [101-77-9] (Sh)  
1,5-Diaminonaphthalene [2243-62-1] (Sh)  
2,2'-Dibenzothiazyl disulfide [120-78-5] (Sh)  
2,2-Dibromo-2-cyanacetamide [10222-01-2] (Sh)  
1,2-Dibromo-2,4-dicyanobutane [35691-65-7] (Sh)  
3,4-Dichloroaniline [95-76-1] (Sh)  
1,3-Dichloropropene (cis and trans) [542-75-6] (Sh)

- Dicyclohexylcarbodiimide [538-75-0] (Sh)
- Dicyclohexyl methane 4,4'-diisocyanate [5124-30-1] (Sh)
- Diethanolamine [111-42-2] (Sh)  
 Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethanolamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".
- Diethylene glycol diacrylate [4074-88-8] (Sh)
- Diethylene glycol dimethacrylate [2358-84-1] (Sh)
- Diethylenetriamine [111-40-0] (Sh)
- Diglycidyl hexanediol [16096-31-4] (Sh)
- Diglycidyl resorcinol ether [101-90-6] (Sh)
- N,N'-(Dimethylamino)ethyl methacrylate [2867-47-2] (Sh)
- N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine [793-24-8] (Sh)
- 1,1-Dimethylhydrazine [57-14-7] (Sh)
- 1,2-Dimethylhydrazine [540-73-8] (Sh)
- Dimethylol dihydroxyethyleneurea [1854-26-8] (Sh)
- 1,3-Dimethylol-5,5-dimethyl hydantoin [6440-58-0] (Sh)
- Dipentamethylenethiuram disulfide [94-37-1] (Sh)
- N,N-Diphenyl-p-phenylenediamine [74-31-7] (Sh)
- Disperse blue 106/124 [68516-81-4; 15141-18-1] (Sh)
- Disperse Orange 3 [730-40-5] (Sh)
- Disperse Red 1 [2872-52-8] (Sh)
- Disperse Red 17 [3179-89-3] (Sh)
- Disperse Yellow 3 [2832-40-8] (Sh)
- Disulfiram [97-77-8] (Sh)  
 Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".
- 2,2'-Dithiobis(N-methylbenzamide) [2527-58-4] (Sh)
- 3,4-Epoxy cyclohexane carboxylic acid (3,4-epoxycyclohexylmethyl) ester [2386-87-0] (Sh)
- 1,2-Epoxypropane [75-56-9] (Sh)
- Ethyl acrylate [140-88-5] (Sh)
- 5-Ethyl-3,7-dioxo-1-azabicyclo[3.3.0]octane (EDAO) [7747-35-5] (Sh)  
 releases formaldehyde
- Ethylenediamine [107-15-3] (Sah)
- Ethylene glycol dimethacrylate [97-90-5] (Sh)
- 2-Ethylhexyl mercaptoacetate [7659-86-1] (Sh)
- Eugenol [97-53-0] (Sh)
- Farnesol [4602-84-0] (Sh)
- Formaldehyde [50-00-0] (Sh)
- Formaldehyde condensation products with p-tert-butylphenol (low molecular) (Sh)
- Formaldehyde condensation products with phenol (low-molecular) (Sh)
- Geraniol [106-24-1] (Sh)
- Glutaraldehyde [111-30-8] (Sah)
- Glyceryl monothioglycolate [30618-84-9] (Sh)
- Glycidyl methacrylate [106-91-2] (Sh)
- Glycidyl trimethylammonium chloride [3033-77-0] (Sh)
- Glyoxal [107-22-2] (Sh)
- Gold [7440-57-5] and its inorganic compounds (Sh)  
 only soluble gold compounds
- Hard metal containing tungsten carbide and cobalt (inhalable fraction) (Sah)

Hexahydrophthalic acid diglycidylester [5493-45-8] (Sh)  
Hexahydrophthalic anhydride [85-42-7] (Sa)  
1,6-Hexamethylene diisocyanate [822-06-0] (Sah)  
Hexamethylenetetramine [100-97-0] (Sh)  
releases formaldehyde  
1,6-Hexanediol diacrylate [13048-33-4] (Sh)  
Hydrazine [302-01-2] (Sh)  
Hydrazine hydrate [7803-57-8] and hydrazine salts (Sh)  
Hydroquinone [123-31-9] (Sh)  
Hydroxycitronellal [107-75-5] (Sh)  
2-Hydroxyethyl methacrylate [868-77-9] (Sh)  
N-(2-Hydroxyethyl)piperidine [3040-44-6] (Sh)  
Hydroxylamine [7803-49-8] and its salts (Sh)  
4-(4-Hydroxy-4-methyl pentyl)-3-cyclohexene-1-carboxaldehyde (Lyrall) [31906-04-4]  
(Sh)  
3-Iodo-2-propynyl butylcarbamate [55406-53-6] (Sh)  
Isobornyl acrylate [5888-33-5] (Sh)  
Isoeugenol [97-54-1] (Sh)  
Isophorone diisocyanate [4098-71-9] (Sah)  
4-Isopropylphenyl isocyanate [31027-31-3] (Sh)  
N-Isopropyl-N'-phenyl-p-phenylenediamine [101-72-4] (Sh)  
D-Limonene [5989-27-5] (Sh)  
D,L-Limonene [138-86-3] and similar mixtures (Sh)  
L-Limonene [5989-54-8] (Sh)  
Maleic anhydride [108-31-6] (Sah)  
Manganese ethylenebis(dithiocarbamate) (Maneb) [12427-38-2] (Sh)  
Merbromin [129-16-8] (Sh)  
2-Mercaptobenzothiazole [149-30-4] (Sh)  
Mercury [7439-97-6] and its inorganic compounds (as Hg) (Sh)  
Mercury, organic compounds (Sh)  
Methacrylic acid ethyl ester [97-63-2] (Sh)  
Methacrylic acid 2-hydroxypropyl ester [923-26-2] (Sh)  
Methacrylic acid methyl ester [80-62-6] (Sh)  
Methenamine 3-chloroallylchloride [4080-31-3] (Sh)  
releases formaldehyde  
Methyl acrylate [96-33-3] (Sh)  
N-Methyl-bis(2-chloroethyl)amine (nitrogen mustard) [51-75-2] (Sh)  
N,N'-Methylenebis(5-methyloxazolidine) [66204-44-2] (Sh)  
4,4'-Methylenedimorpholine [5625-90-1] (Sh)  
releases formaldehyde  
4,4'-Methylene diphenyl diisocyanate (MDI) [101-68-8] (inhalable fraction) see also  
"polymeric MDI" (Sah)  
2-Methyl-4-isothiazolin-3-one [2682-20-4] (Sh)  
2-Methyl-2-propanethiol [75-66-1] (Sh)  
Methyltetrahydrophthalic anhydride [11070-44-3] (Sa)  
N-Methyl-N,2,4,6-tetranitroaniline [479-45-8] (Sh)  
Methyl vinyl ketone [78-94-4] (Sh)  
Microbial rennets: endothiapsin and mucorpepsin (Sa)  
Monomethylhydrazine [60-34-4] (Sh)



2-(4-Morpholinylmercapto)benzothiazole [102-77-2] (Sh)

Naled [300-76-5] (Sh)

1,8-Naphthalic anhydride [81-84-5] (Sh)

1,5-Naphthylene diisocyanate [3173-72-6] (Sa)

Natural rubber latex [9006-04-6] (Sah)

Nickel and nickel compounds (inhalable fraction) (Sah)

Regarding compounds which have been found to be unequivocally carcinogenic in man, see documentation.

4-Nitro-4'-aminodiphenylamine-2-sulfonic acid [91-29-2] (Sh)

4-(2-Nitrobutyl)morpholine (70 % w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-propandiy)bis-morpholin (20 % w/w) [2224-44-4; 1854-23-5] (mixture) (Sh)

In this mixture formaldehyde can be released and nitrosamines formed. Use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4".

p-Nitrocumene [1817-47-6] (Sh)

2-Nitro-p-phenylenediamine [5307-14-2] (Sh)

Oakmoss extracts (Sh)

2-Octyl-4-isothiazolin-3-one [26530-20-1] (Sh)

Olaquinox (N-(2-Hydroxyethyl)-3-methyl-2-quinoxalinecarboxamide 1,4-dioxide) [23696-28-8] (SP)

Palladium [7440-05-3] and palladium compounds

Palladium chloride [7647-10-1] (Sh)

bioavailable palladium(II) compounds (Sh)

Papain [9001-73-4] (Sa)

Pentaerythritol triacrylate [3524-68-3] (Sh)

2,3-Pentanedione [600-14-6] (Sh)

Pepsin [9001-75-6] (Sa)

o-Phenylenediamine [95-54-5] (Sh)

m-Phenylenediamine [108-45-2] (Sh)

p-Phenylenediamine [106-50-3] (Sh)

The "Ursol-Asthma" which used to be observed frequently, especially in persons dyeing furs with p-phenylenediamine, has not been demonstrated unequivocally to involve respiratory allergy to p-phenylenediamine; see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (18th issue, 1992) and in English translation in Occupational Toxicants Volume 6, VCH-Verlagsgesellschaft mbH, Weinheim 1994

Phenyl glycidyl ether (PGE) [122-60-1] (Sh)

Phenylhydrazine [100-63-0] (Sh)

Phenyl isocyanate [103-71-9] (Sah)

N-Phenyl-1-naphthylamine [90-30-2] (Sh)

N-Phenyl-2-naphthylamine [135-88-6] (Sh)

Phthalic anhydride [85-44-9] (Sa)

Phytases (Sa)

Picric acid [88-89-1] (Sh)

Picryl chloride [88-88-0] (Sh)

Piperazine [110-85-0] (Sah)

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N,N'-dinitrosopiperazine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Platinum compounds (Chloroplatinates) (Sah)

A peak concentration of 2 µg/m<sup>3</sup> should not be exceeded.

"polymeric MDI" [9016-87-9] (inhalable fraction) see also 4,4'-Methylene diphenyl diisocyanate (MDI) (Sah)

"polymeric MDI" (pMDI) is a technical grade MDI, containing 30–80 % w/w 4,4'-methylene diphenyl isocyanate (MDI); the remainder consists of MDI oligomers and MDI homologues.

**Pyrethrum [8003-34-7] (Sh)**

does not apply for the constituents of insecticides (pyrethrins and cinerins) or for synthetic derivatives (pyrethroids) but only for the constituents of the plant drug and its crude extracts, including  $\alpha$ -methylene sesquiterpene lactones (e. g. pyrethrosin)

**Quinone [106-51-4] (Sh)****Resorcinol [108-46-3] (Sh)****Ricinus protein (Sa)****Rosin (colophony) [8050-09-7] (Sh)**

An immunological genesis of the asthma often seen in persons working with materials containing rosin has not been proved.

**Rubber components**

## Dithiocarbamates (Sh)

## Thiazoles (Sh)

## p-Phenylenediamine compounds (Sh)

## Thiurams (Sh)

**Sesquiterpene lactones (Sh)****Sodium diethyldithiocarbamate [148-18-5] (Sh)**

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

**Soya bean constituents (Sa)****Subtilisins (Sa)****Tall oil, distilled [8002-26-4] (Sh)**

only applies to tall oil distillates containing abietic acid, see also Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (34th issue 2002)

**Tetraethylene glycol diacrylate [17831-71-9] (Sh)****Tetraethylene glycol dimethacrylate [109-17-1] (Sh)****Tetraglycidyl-4,4'-methylenedianiline [28768-32-3] (Sh)****Tetrahydrofurfuryl methacrylate [2455-24-5] (Sh)**★ **Tetramethylol acetylenediurea [5395-50-6] (Sh)**

releases formaldehyde

**Thimerosal [54-64-8] (Sh)****Thioglycolates (Sh)****Thioglycolic acid [68-11-1] (Sh)****Thiourea [62-56-6] (Sh SP)****Thiram [137-26-8] (Sh)**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

**2,4-Toluenediamine [95-80-7] (Sh)****2,5-Toluenediamine [95-70-5] (Sh)****Toluene diisocyanates (Sah)****p-Toluidine [106-49-0] (Sh)****1,2,3-Trichlorobenzene [87-61-6] (Sh)****Triethylene glycol diacrylate [1680-21-3] (Sh)****Triethylene glycol dimethacrylate [109-16-0] (Sh)****Triethylenetetramine [112-24-3] (Sh)****Triglycidyl-p-aminophenol [5026-74-4] (Sh)****1,3,5-Triglycidyl isocyanurate (mixture of isomers) [2451-62-9]  $\alpha$ -isomer [59653-73-5]** **$\beta$ -isomer [59653-74-6] (Sah)****Triisobutyl phosphate [126-71-6] (Sh)****Trimellitic anhydride [552-30-7] (fume) (Sa)****Trimethylhydroquinone [700-13-0] (Sh)****Trimethylolpropane triacrylate [15625-89-5] (Sh)**

Trimethylquinone [935-92-2] (Sh)  
 2,4,6-Trinitrotoluene [118-96-7] (Sh)  
 Triphenylphosphine [603-35-0] (Sh)  
 Tripropylene glycol diacrylate [42978-66-5] (Sh)

★ N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] (Sh)  
 releases formaldehyde

★ N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] (Sh)  
 releases formaldehyde

Trypsin and Chymotrypsin [9002-07-7; 9004-07-3] (Sa)

Turpentine [8006-64-2] (Sh)

Vinylcarbazole [1484-13-5] (Sh)

Woods

Acacia melanoxylon R.Br., Australian blackwood (Sh)

Brya ebenus DC., cocus wood (Sh)

Chlorophora excelsa (Welw.) Benth. & Hook, iroko, kambala (Sh)

Dalbergia latifolia Roxb., East Indian rosewood, Bombay blackwood (Sh)

Dalbergia melanoxylon Guill. et Perr., African blackwood (Sh)

Dalbergia nigra Allem., Brazilian rosewood (Sh)

Dalbergia retusa Hemsl., cocobolo, rosewood (Sh)

Dalbergia stevensonii Standley, Honduras rosewood (Sh)

Distemonanthus benthamianus Baill., ayan (Sh)

Grevillea robusta A.Cunn., Australian silky oak (Sh)

Khaya anthotheca C.DC., African mahogany (Sh)

Machaerium scleroxylon Tul., pao ferro, Santos rosewood (Sh)

Mansonia altissima A.Chev., mansonia, pruno, bété (Sh)

Paratecoma peroba (Record) Kuhlm., ipe peroba (Sh)

Tectona grandis L.f., teak (Sh)

Terminalia superba Engl. u. Diels, fraké, limba, afara, white afara (Sa)

Thuja plicata (D.Don.) Donn., western red cedar, giant arborvitae, shinglewood (Sah)

Triplochiton scleroxylon K.Schum., obeche, wawa, African whitewood (Sah)

Xylanases [37278-89-0] (Sa)

m-Xylylenediamine [1477-55-0] (Sh)

Ziram [137-30-4] (Sh)

## e. Evaluation of members of specific groups of substances

For numerous substances, a reliable evaluation of the sensitizing effects according to the criteria described above is not possible. Often the substance of interest is one of the many members of a specific group of substances. Valid data for man are generally available only for individual members of such groups of substances, those considered to be typical of the group and commercially available as test substances because they are used for this purpose. With other less frequently used substances or substances for which no reliable data as to the extent of their use is available, patch tests are carried out relatively rarely, with some substances – because of the danger of sensitization – only in special cases. The effects in man are made even more difficult to assess because these substances are often used in mixtures with other members of the same group of substances and so can be involved in concomitant sensitizations and in cross-reactions. Mixtures containing members of other groups of allergenic substances are also often used and then too it is not readily possible to

determine the causality of the observed disorder. In addition, it is not always possible to establish all the components of the mixture involved and so an allergologically relevant component can be missed. Therefore, substances which are not listed in the List of MAK and BAT Values and which belong to groups of substances known to be able to cause sensitization should be handled with appropriate care.

It is emphasized that in general there is no danger of sensitization from fully polymerized plastics. A danger of sensitization, but only little, can result from release of residual monomer, e. g. during mechanical processing.

The groups of substances of which numerous members have sensitizing effects on the skin or airways include:

- acrylates and methacrylates
- dicarboxylic acid anhydrides
- diisocyanates
- glycidyl compounds (epoxides)
- dusts containing enzymes
- certain plant or animal proteins

In current usage, the general expression “**isocyanate**” is used for both *mono-isocyanates* and *di- or polyisocyanates*. These classes of compounds must be strictly differentiated with regard to the areas of use as well as the toxicological and allergological properties: *monoisocyanates* such as methyl isocyanate or phenyl isocyanate are used practically almost exclusively during syntheses as precursors or intermediate products, for example in the production of insecticides or pesticides. On the other hand, *diisocyanates* in particular are used in the production of polyurethanes, which are processed to adhesives, insulating foams, lacquers, and foams. Findings of a sensitizing effect on the respiratory tract in humans are available almost only for *diisocyanates* because of the widespread use. Also *monoisocyanates* can have a marked irritating effect on the airways and a sensitizing effect on the respiratory tract cannot be excluded. However, data for the *diisocyanates*, which are assessed as potent respiratory allergens, does not justify classifying *monoisocyanates* as substances causing airway sensitization solely in analogy; an evaluation of the individual case is necessary.

The **antibiotics** are a group of substances which are very heterogeneous in chemical structure and in sensitizing effects. Persons may be exposed to these substances at work during isolation or production of the active principles, during preparation and packing of the medicines, and during their medical use in man and animals. Sensitization of the skin can result in the development of a systemic allergic reaction – including anaphylaxis – or haematogenic contact dermatitis after later parenteral use. Sensitization of the airways and allergic contact dermatitis have often been reported in persons exposed occupationally to  $\beta$ -lactam antibiotics (especially *penicillins* and *cephalosporins*). Allergic reactions after medicinal use of these antibiotics (enteral or parenteral), on the other hand, generally take the form of IgE-mediated reactions of immediate type. However, other immunological reactions such as medicinal skin eruptions and, in serious cases, also erythema exsudativum multiforme, Stevens-Johnson syndrome or Lyell’s syndrome can also develop. Some of the *amino-glycoside antibiotics* are also conspicuous for the relatively high rates of sensitization which they produce, especially as a result of application of medicaments to (chronically) eroded skin. Sensitization of the skin resulting from occupational contact with *aminoglycosides* has been reported more rarely. Individual *macrolide antibiotics*, especially those used in veterinary medicine, can cause immunological reactions

in the airways and also (inhalation-mediated) contact dermatitis. Only rare individual cases of contact allergy or allergic airway reactions to most other macrolide antibiotics and to polyene or peptide antibiotics and tetracyclines have been reported.

**Components of fragrance mixtures**, another group of substances which differ widely in their structures, allergenic potencies and clinical significance, must also be evaluated individually. This becomes clear even on consideration of the components of the standard fragrance test mixtures. For many other fragrance components the clinical findings are inadequate because the substances are never or only very rarely used in patch tests. Non-occupational exposure to these practically ubiquitous fragrance mixtures can rarely be excluded and this makes the demonstration that sensitization was occupational more difficult.

## V Aerosols

### a) General definitions

**Aerosols** are multiphase systems of particulate solids or liquids dispersed in gases, in particular in air. Aerosols which occur at the workplace include dusts, fumes and mists.

**Dusts** consist of particles of solid matter which have been produced mostly in mechanical processes or have been stirred up and dispersed in gases, in particular in air.

Airborne particles can be composed of compact fine particles and free ultrafine primary particles but can also consist of their aggregates or agglomerates. The following nomenclature will be used:

- **Primary particles** are compact single particles which are recognizable as such under the electron microscope, even when they are associated with other aggregates or agglomerates.
- **Aggregates**<sup>29) 30)</sup> are groups of primary particles which are firmly bound with each other.
- **Agglomerates**<sup>29) 30)</sup> are groups of particles (primary particles or aggregates), which are held together by weak forces (in particular van der Waals forces). They can be broken apart again into smaller units by input of a low level of energy (e. g. by treatment of an aqueous suspension with ultrasound).

**Fibrous dusts** consist of inorganic or organic fibres of certain dimensions dispersed in gases, in particular in air (see Section III Carcinogenic substances, Fibrous dust). Inorganic fibrous dusts arise during mechanical processing especially of fibrous minerals and of products made from or containing natural or man-made fibres. Fibre-shaped fragments of non-fibrous minerals and of non-fibrous products also count as fibrous dust. Fibres can also be released by erosion processes.

**Fumes** are dispersions of very finely divided solid matter in gases, in particular in air. They arise in thermal processes (e. g., welding fumes, metal oxide fumes, soot and flue ash) or chemical processes (e. g., the reaction of ammonia with hydrogen chloride).

**Mists** are dispersions of particulate liquids (droplets) in gases, in particular in air. They arise during nebulization of liquids, during condensation from the vapour phase and during chemical processes (e. g., oil mist, hydrogen chloride in damp air).

**Ultrafine particles and their aggregates and agglomerates** see Section Vh.

**Ultrafine particles** as components of dusts and fumes are identified by a mobility-equivalent diameter ( $D_M$ ) < 100 nm (corresponds to a diffusion-equivalent diameter ( $D_{ae}$ ))

<sup>29)</sup> The terms “aggregates” and “agglomerates” are not used uniformly on the international level. See, for example, the definitions of ISO 14887, NIST, BSI, IUPAC, etc.

<sup>30)</sup> Measurement of the shape and size of airborne particles in an aerosol cannot distinguish between compact particles and aggregates and agglomerates of similar size. Nor is differentiation between liquid droplets and solid particles possible. Since air analyses even with the electron microscope cannot distinguish whether aggregates or agglomerates are involved in the aggregated groups of ultrafine primary particles observed, such groups of particles are in practice often combined with the designation of “aggregates and agglomerates (A + A)”.

< 100 nm) (see Section Vh and “Aerosole” in *Toxikologisch-arbeitsmedizinische Begründungen von MAK-Werten*, 25th issue, 1997, in English translation in *Occupational Toxicants Volume 12*).

The **respirable dust fraction (R)** which can enter the alveoli and **the inhalable fraction (I)** of the dust are the fractions which are relevant for health (according to DIN/EN 481) and for these there are threshold values (see Section Vd).

## **b) Properties of aerosols which determine their effects**

Particulate substances encountered at the workplace can cause various disorders of the respiratory organs. These are mostly a result of overloading of the lung, or of carcinogenic, fibrotic (fibrogenic) or allergenic effects, or of chemical irritation or toxicity. The effects are determined in part by the site of deposition of inhaled particles or droplets in the respiratory tract. The deposition pattern of the particles or droplets and the intensity and rapidity of appearance of the effects are determined essentially by the size, mass, specific density, shape, surface area, chemical composition, biopersistence, solubility, and hygroscopic properties of the particles.

These parameters can act independently of one another as well as in combination. The effects of coarser particles are largely proportional to the mass or the volume.

With all **aerosols of ultrafine particles** as compared with coarser particles, an important role is played by the large specific surface area, the low density of the agglomerate compared with the material density of ultrafine particles, the slight solubility and the uptake into the cells. These properties of ultrafine particles can result in other toxicologically relevant effects. When aggregates or agglomerates of ultrafine particles are deposited, their effects also depend on whether they disaggregate or not in the fluid environment of the lung.

In the milieu of the lung fluids, particulate substances have as a rule a bioavailability other than indicated by the physicochemical solubilities reported in the literature, which are mostly determined in water, or where appropriate also in other solvents. Thus, the poor solubility suggested by the reported data for a substance is not directly applicable to the lung tissue. With the diversity of particles deposited in the lung fluids, also changes in toxicity can occur in individual cases through masking and demasking, e. g., in the presence of particles with adsorbing surfaces.

In lung fluids, not only the dissolution of particles (such as metal particles) and the absorption of dissolved substances are observed, but also changes in the crystalline structure. For example, certain glass fibres become jellylike (that is, they lose their rigidity and become rubberlike), or chrysotile fibres are split into their individual fibrils, which in this case causes an increase in the number of particularly fine fibres. Such processes of splitting have now been identified for other fibrous substances. The properties of ultrafine fibres (such as nanotubes) have not yet been adequately investigated.

## **c) Inhalation, deposition and clearance of aerosols in the respiratory tract**

### **Uptake**

The uptake of dusts and fumes into the body takes place mostly via the airways. Mists can also be taken up in relevant amounts through the skin.

Transport and deposition of particulate solids and droplets in the airways are determined by the size, shape and specific density of the particles or droplets.

The distribution of the inhaled aerosol within the various parts of the airways is affected not only by the properties of the particles but also markedly by:

1. individual differences in the anatomy of the airways,
2. individual breathing habits, especially the different transition from nasal to oral breathing during physical activity and differences in respiration rate, respiratory flow and thus respiratory volumes,
3. pathophysiological changes in the respiratory organs (e. g. obstructive airway disease).

The critical dimension for aerosol particles with a diameter  $> 0.5 \mu\text{m}$  is the **aerodynamic diameter** ( $D_{ae}$ ). The aerodynamic diameter of a particle whatever its shape and density is defined as the geometric diameter of a sphere with the density  $1 \text{ g/cm}^3$  which sediments at the same rate as the particle in still or laminarly flowing air. This definition also applies for fibrous particles. The aerodynamic diameter of a fibre is determined essentially by the diameter of the fibre and less by its length. For long fibres ( $l \gg d$ ) the aerodynamic diameter is about three times the fibre diameter.

For isometric particles with diameters less than  $0.5 \mu\text{m}$ , the **diffusion-equivalent diameter** ( $D_d$ ) determines the site of deposition in the airways. The diffusion-equivalent diameter of a particle is defined as the geometric diameter of a sphere which diffuses at the same rate as the particle in the same dispersion medium (at the workplace, in air).

On principle, it is necessary to distinguish between the aerosol fractions which enter the various regions of the airways during inhalation and exhalation and the parts of these fractions which are deposited in these airway regions.

Deposition can take place during inhalation or during exhalation. Some of the inhaled particles are not deposited in the airways but are exhaled.

Of particular importance for occupational health are the aerosol fractions which penetrate into the respirator organs and are deposited there; they are described below (Figure 1).

Only a fraction of the total particles present in the breathing zone (the part designated as the **inhaled fraction**) is inhaled. It is determined by the flow rates into the mouth and nose as well as the conditions of air flow around the head. Whereas almost all the smaller particles ( $D_{ae} < 5 \mu\text{m}$ ) are inhaled, the fraction of particles which can be inhaled decreases with increasing particle size.

Of the particles in the inhaled fraction, larger solid particles and droplets ( $D_{ae} > 15 \mu\text{m}$ ) are deposited almost exclusively in the extrathoracic region, i. e., in the region of the nose, pharynx and larynx.

Of the **fraction which enters the thorax (thoracic fraction)** some of the smaller solid particles and droplets are deposited in the tracheobronchial region or in the alveolar region.

The **fraction which enters the alveolar region (respirable fraction)** contains those particles which can penetrate into the airway regions which are not ciliated, i. e., the alveoli, the terminal non-ciliated bronchioles and the alveolar ducts; some of this fraction is deposited there.

## Deposition and Clearance

### Fraction deposited in the nose-pharynx-larynx region (extrathoracic fraction)

This is the aerosol fraction which is deposited after inhalation in the region of the nose, the mouth, the throat and the larynx; part of this fraction can be swallowed and so enter the



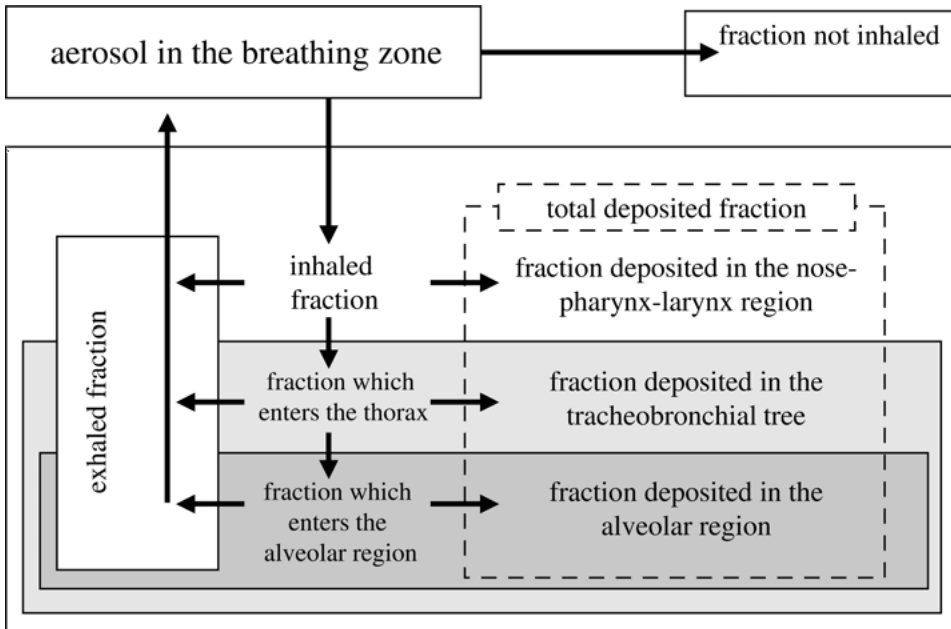


Figure 1. Subdivision of the aerosol in the breathing zone according to occupational medical criteria and deposition behaviour of the fractions.

The transfer of the inhaled fraction of the aerosol in the breathing zone into the thorax and the alveolar region, i. e., the alveoli, the non-ciliated bronchioles and the alveolar ducts, is represented by arrows. The arrows pointing to the right show the fractions deposited in the three regions of the respiratory tract, those pointing to the left show the contribution from these regions to the exhaled fraction.

digestive tract. The clearance from this region of the respiratory tract is complete within a few hours at most.

### Fraction deposited in the tracheobronchial region

This is that part of the fraction which enters the thorax which is deposited in the region of the tracheobronchial tree in which the mucociliary clearance mechanism operates.

Isometric particles with diameters  $> 7 \mu\text{m}$  are completely eliminated from the tracheobronchial region of a healthy person within one day. There is evidence that some of the smaller particles and especially ultrafine particles may persist for several weeks in the tracheobronchial region. The rate of transport out of this region decreases with decreasing particle size.

### Fraction deposited in the alveolar region

This is the fraction of the aerosol which is deposited in the alveolar region including the non-ciliated bronchioles (bronchioli respiratorii) and the alveolar ducts (ductuli alveolares). In this region there is no mucociliary clearance. This aerosol fraction can be transferred via the pulmonary interstitial tissue (interstitium) into the lymphatic system and especially ultrafine particles can also enter the blood capillaries. Alveolar macrophages can take in particles by phagocytosis and transport these through the tracheobronchial tree; swallowing then transfers them into the digestive tract. The half-times for the elimination from the lung of insoluble particles deposited in the alveolar region are of the order of months or years.

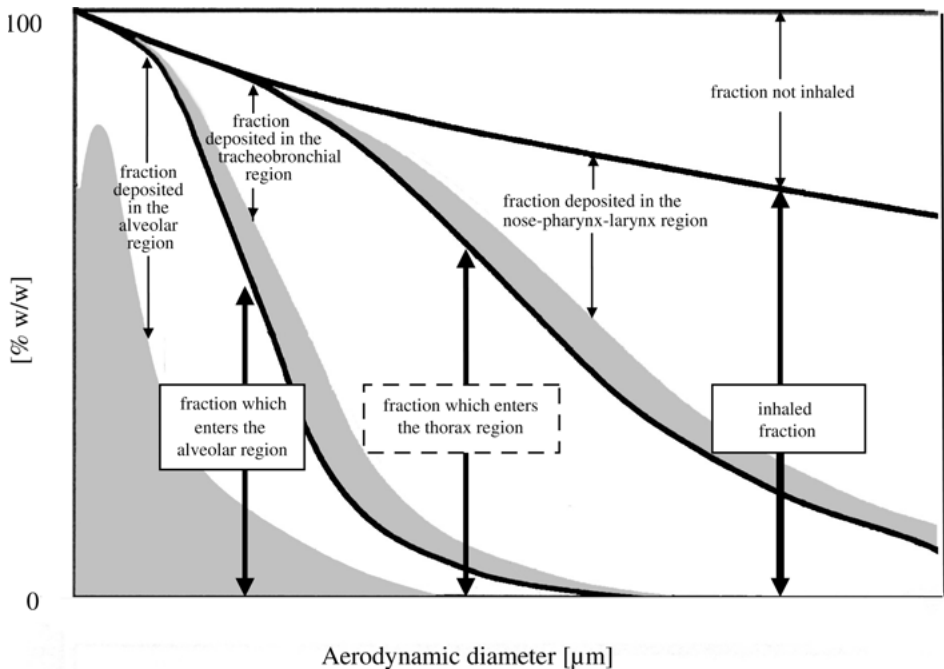


Figure 2. Diagram showing the fractions of the aerosol in the respiratory organs which are relevant for occupational health. Alongside the curves for the fractions deposited in the various regions, the fractions exhaled from those regions are shown as shaded areas. The two fractions in solid boxes are those corresponding to the conventions for measuring particle concentrations for checking the observance of MAK values.

### Total deposited fraction

The total deposited fraction is that aerosol fraction which is inhaled but then not exhaled. This fraction includes the particles and droplets deposited in the nose, pharynx and larynx, the tracheobronchial tree and the non-ciliated deeper airways, and thus the entire range of the inhalable dust fraction.

It should be remembered that deposited droplets and soluble particles spread on the surfaces of the respiratory organs and lose their droplet or particulate form. Soluble components can be absorbed, which means that the constituents of the dissolved particles may be distributed and their cellular effects may no longer be only localized. They can enter the circulation and the lymphatic system and have systemic effects.

The insoluble fraction can be phagocytised by macrophages or, with certain limitations, be taken in by lung epithelial cells and transported from the alveolar region into the interstitial tissue. Especially ultrafine particles can enter the bloodstream by this route. Components which are neither dissolved nor absorbed can be transported from the tracheobronchial tree towards the larynx by mucociliary clearance, as can particles deposited in the nose-pharynx-larynx region. From there, they are swallowed, enter the digestive system and perhaps have effects there, or they are removed from the breathing zone or the body by coughing up and spitting out or by blowing of the nose.

#### d) Conventions for measuring concentrations of particles: definition of fractions

Measured particle concentrations should reflect the concentrations of those particles responsible for the pathogenic effects in the respiratory organs, as described in Section c. This requires that in sampling and assay devices the particles from the air are fractionated according to their aerodynamic diameters in a way which reflects the deposition pattern of the particles in the airways during breathing.

However, for measuring and sampling devices for the determination of various particle fractions in the workplace air, international conventions have been established for only three deposition curves (see DIN/EN 481, 1993)<sup>31)</sup>. They are based on average analytical values obtained under defined experimental conditions, values for the aerosol fractions which enter the various regions of the respiratory organs.

Thus the analytical methods yield data for the three fractions which may be deposited, in each case including the fraction which is exhaled. That means that the aerosol fractions determined are those which enter the regions of the lung which are relevant for occupational health (see Figures 1 and 2).

1. **Inhalable fraction (I):** the deposition curve expresses, as a function of aerodynamic diameter, the mean probability that particles and droplets will be inhaled (inhaled fraction).
2. **Thoracic fraction:** the curve for this part of the inhalable fraction expresses, as a function of aerodynamic diameter, the mean probability that particles and droplets will enter the tracheobronchial tree and the alveolar region (fraction which enters the thorax).
3. **Respirable fraction (R):** the curve for this part of the thoracic fraction expresses, as a function of aerodynamic diameter, the mean probability that particles and droplets will enter the alveolar region (fraction which enters the alveolar region).
4. **Extrathoracic fraction:** this fraction is obtained by subtracting the thoracic fraction from the inhalable fraction.
5. **Tracheobronchial fraction:** this fraction is obtained by subtracting the alveolar fraction from the thoracic fraction.

The use of this analytical procedure for hygroscopic particles is justified by the fact that their aerodynamic diameters increase during transport into the respiratory organs as a result of uptake of water and that therefore the sites of deposition and proportion of particles deposited cannot be predicted.

The definitions of the “inhalable fraction” (I)<sup>32)</sup> and “respirable fraction” (R)<sup>33)</sup> correspond to the definitions of “total dust” (G) and “fine dust” (F) used until 1996 in the establishment of MAK values<sup>34)</sup>. Since 1996 the internationally accepted definitions have been used.

<sup>31)</sup> European Committee for Standardization (CEN): EN 481 Workplace atmospheres – Size fraction definitions for measurement of airborne particles. Brussels 1993, Beuth Verlag, Berlin 1993

<sup>32)</sup> German: “E” for “Einatembare Fraktion”

<sup>33)</sup> German: “A” for “Alveolengängige Fraktion”

<sup>34)</sup> DFG (1995): List of MAK and BAT Values 1995, Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Report No. 31, page 132, VCH Weinheim, BIA-Arbeitsmappe: Messung von Gefahrstoffen. Expositionsermittlung bei chemischen und biologischen Einwirkungen. Berufsgenossenschaftliches Institut für Arbeitssicherheit (BIA) (Ed.), Erich Schmidt Verlag, Health and Safety Executive, Health and Safety Laboratory, Project Report: Pilot study of CEN Protocols for the Performance Testing of Workplace Aerosol Sampling Instruments by L.C. Kenny. Sheffield, September 1995

### e) Fibrogenic aerosols

As **fibrogenic dusts** are designated aerosols, including droplet aerosols, which contain insoluble particles which can cause dust lung diseases (e. g. silicosis) involving formation of connective tissue. Prerequisite for the development of such disorders is the deposition of the aerosol in the alveolar region. Therefore, the effective levels of fibrogenic aerosols are determined after sampling the respirable fraction (R) (previously “fine dust”, (F)).

### f) General threshold limit value for dust

The “general threshold value for dust” is established as a concentration of the respirable fraction (R) of biopersistent granular dusts<sup>35)</sup> of 0.3 mg/m<sup>3</sup><sup>36)</sup> for dusts with a density of 1 g/cm<sup>3</sup> and a concentration of the inhalable fraction (I) of 4 mg/m<sup>3</sup>.

Excursions above the threshold as described in Section Vg are permitted for the inhalable fraction. The permitted excursions may not exceed the “general threshold value for dust” by a factor of more than two (see Toxikologisch-arbeitsmedizinische Begründungen von MAK-Werten, 25th issue, 1997, in English translation in Occupational Toxicants Volume 12).

Observance of the general threshold value for dust should prevent unspecific effects of dust (e. g. overloading effects) on the respiratory organs. The threshold applies for poorly soluble and insoluble dusts which are not subject to other regulations and for mixtures of dusts even when for individual components of a dust specific MAK values exist and are observed. The threshold value does not apply for soluble particles, especially not for salts from rock salt and potash deposits, or for ultrafine (see Section Vh) or dispersed coarse particle fractions.

**Even when the general threshold value for dust is observed, a health hazard may be ruled out only if it has been demonstrated that other substance-specific effects of the dust are not to be expected.**

### g) Exposures exceeding the MAK value

MAK values for aerosols which are designated with a reference to Section Vg have been derived from average long-term exposure levels without detectable effects (no observed adverse effect levels, NOAEL).

Impairment of respiratory organ function by these dusts is a result of long-term effects which are determined largely by the aerosol concentration to which the person is exposed over long periods of time. The MAK values correspond to the average long-term exposure levels without detectable effects (NOAEL) but apply to the concentration values averaged over a single shift. As the long-term exposure level is an average of variously high shift average levels, the occasional exceeding of the MAK value by single shift average levels can be tolerated. The permitted frequency and extent of the excursions above the MAK value are established on the basis of occupational medical and toxicological findings (see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten, 23rd issue, 1996 and in English in Occupational Toxicants Volume 11). In these cases the peak limitation categories do not apply.

<sup>35)</sup> with the exception of ultrafine particles; see Section Vh

<sup>36)</sup> for dusts with a density of 1 g/cm<sup>3</sup>

For all other aerosols the peak limitation categories must be observed (see Section VI Limitation of exposure peaks).

### **h) Ultrafine particles, their aggregates and agglomerates**

Ultrafine primary particles are measured according to their mobility-equivalent diameter ( $D_M$ ) < 100 nm (corresponds to a diffusion-equivalent diameter ( $D_{ae}$ ) < 100 nm). They can occur as single particles in the workplace air or more often as basic units of aggregates and agglomerates. In these forms they can be seen under an electron microscope.

For the characterization of the potential danger associated with ultrafine primary particles and their aggregates and agglomerates, the following aspects are of significance.

- The particles are formed mostly in combustion processes and gas phase reactions.
- The mechanisms of deposition in the respiratory tract involve the Brownian motion of the particles.
- The effects of the particles in the respiratory tract increase not so much in proportion to the weight as in proportion to the surface area or number of particles per air volume.
- The probability of aggregate or agglomerate formation depends also on the concentration of primary particles in the workplace air.

#### *Notes:*

Depending on the definition of the threshold value, for **dusts and fumes** either the inhalable fraction “I” or the respirable fraction “R” is determined. For **mists**, the inhalable fraction “I” is determined.

Sampling devices which sample fine dust according to the Johannesburg convention, which used to be used in Germany, fulfil the requirements of DIN/EN 481 for the sampling of respirable dust.

When sampling devices are used which collect fractions for assay according to deposition functions which differ from those described above, the results must be corrected using a correction factor which is dependent on the particle size distribution. The validity of the procedure must be documented.

It must be emphasized that the total dust fraction (G) which used to be determined in Germany and also the inhalable dust fraction (I) used today may not be automatically assumed to be equivalent to “**total dust**”, a term which is still widely found in the international literature. The term “total dust” does not describe a standardized dimension. Sampling devices which collect “total dust” must be validated.

The fractions  $PM_{10}$  and  $PM_{2.5}$  collected during sampling of environmental air outdoors are defined by ISO 7708.  $PM_{10}$  corresponds to the thoracic fraction (function with 50% deposition at 10  $\mu m$ ) whereas  $PM_{2.5}$  is described by a curve with 50% deposition at 2.5  $\mu m$ . The respirable dust fraction (R) would therefore correspond to  $PM_4$ .

For the determination of **fibrous dusts**, fractions are not defined according to aerodynamic criteria. Instead the fibre lengths and diameters must be determined microscopically (see Section III Carcinogenic substances, Fibrous dusts).

## VI Limitation of exposure peaks

MAK values are conceived and applied as 8-hour time-weighted average values. The actual concentrations of substances in the workplace air are, however, frequently subject to considerable variation. Excursions above the average value must be limited in order to prevent local irritation, unreasonable annoyance and adverse systemic effects.

The effects on health of exceeding the MAK value for brief periods depend decisively on the mode of action of the substance in question. Since the year 2000, substances have been assessed individually and substance-specific excursion factors (ratio of permitted short-term peak value to the MAK value) have been established. For substances in Category I, the MAK value may generally not be exceeded (excursion factor = 1 is the default value) unless the available data permit the establishment of a different excursion factor. For some substances excursion factors > 1 have been derived. For substances in Category II, the default value is 2. In this category too, in appropriate cases, other excursion factors have been established. For reasons of analytical practicability, peak values for the substances in these two categories have now been established for a sampling period of 15 minutes. For a discussion of the use of longer sampling periods see “Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten”. The permitted frequency per shift of excursions above the MAK value, the minimum period between individual exposure peaks, and the total permitted duration of excursions above the MAK value are to be seen as a convention. For all substances, however, the 8-hour time-weighted average value must be observed<sup>37)</sup>.

This concept takes into account both the toxicological situation and the analytical practicability.

Thus the two categories shown in the table below have been established for the limitation of peak concentrations at the workplace; see also “Spitzenbegrenzung” in “Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten”<sup>38)</sup>.

Excursion factors, maximum duration of peaks, maximum number per shift and minimum interval between the peaks

Category	Excursion factor	Duration	Number per shift	Interval ***
I Substances for which local irritant effects determine the MAK value, also respiratory allergens	1*	15 min, average value**	4	1 h
II Substances with systemic effects	2*	15 min, average value	4	1 h

\* default value, or a substance-specific value (maximum 8)

\*\* In certain cases, a momentary value (concentration which should not be exceeded at any time) can also be established.

\*\*\* only for excursion factors > 1

In Section IIa of the List of MAK and BAT Values, the Peak limitation category for each substance is listed and in brackets also the appropriate excursion factor. Carcinogenic substances without a MAK value have no entry (–).

A description of analytical methods for monitoring workplaces (Analytische Methoden zur Prüfung gesundheitsschädlicher Arbeitsstoffe – Luftanalysen and in English

<sup>37)</sup> but see Section Vg

<sup>38)</sup> available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

translation as Analyses of Hazardous Substances in Air)<sup>38</sup>) has been published. Data for the individual substances may be found in the documentation of the MAK values<sup>39</sup>).

## VII Percutaneous absorption

At the workplace the absorption of substances through the skin can make a significant contribution to the systemic exposure of the employee or can even be the main exposure route.

The only relevant barrier to absorption of substances at work is the horny layer (stratum corneum) of the skin. The ability of a substance to penetrate this barrier is determined by its physicochemical properties. The rate of dermal penetration is also affected by workplace conditions and by individual factors. Solid, liquid and gaseous substances can be taken up percutaneously. For many substances the skin acts as a depot from which absorption continues even after the end of exposure. Normal working clothes do not generally provide any protection against percutaneous absorption. Quantification of the amount of a substance absorbed through the skin can only be realized by biological monitoring (see Section XI Significance and Use of BAT Values – Surveillance).

Substances are designated with an “H” if through dermal exposure the observance of the MAK value on its own no longer guarantees the prevention of important adverse effects on health which were considered for establishment of the threshold value. In addition to systemic effects these can also include the sensitization of the respiratory tract if it has been demonstrated to be induced by skin contact. Substances are not designated with an “H” if toxic effects are not to be expected under workplace conditions, independent of the ability of the substance to penetrate the skin. It may not be assumed that the absence of a designation with “H” means that wearing inhalation protection is sufficient to adequately protect an employee from the substance if the MAK value can not be observed. Under these conditions, considerable absorption from the gas phase was detected, especially for amphiphilic substances. Substances in section II b are dealt with in analogy to substances with MAK values and designated with “H” when a toxicologically relevant uptake can be assumed and one of the criteria for designation is fulfilled. Carcinogenic substances in Categories 1 and 2 and suspected carcinogens without a MAK value in Category 3 are designated with an “H” whenever it appears that dermal absorption can make a significant contribution to a person’s body burden. For an assessment of the measures necessary for adequate occupational hygiene, the reader is referred to the documentation for the substance in question.

A substance is designated with an “H” when one of the criteria listed below is fulfilled.

### 1. Designation with “H” on the basis of workplace studies

Field studies or scientifically documented casuistics demonstrate that percutaneous absorption is significant in practice in persons handling the substance:

The percutaneous absorption is certainly responsible for part of the systemic dose and can contribute to toxic effects.

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<sup>39</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## 2. Designation with “H” on the basis of animal studies

Percutaneous absorption can be demonstrated in animal studies and the exposure can contribute to toxic effects.

## 3. Designation with “H” on the basis of in vitro studies

A relevant level of percutaneous absorption which can contribute to toxic effects has been quantified with recognized methods. The flux through the skin has been determined and the permeability constant has been or may be calculated, or details of percentage absorption of the applied dose (percentage absorbed per unit of time and skin surface area) are available.

## 4. Designation with “H” on the basis of theoretical models

On the basis of data for analogous substances or calculations with mathematical models, a relevant level of percutaneous absorption may be expected.

The criteria 1 to 4 are arranged in order of decreasing significance; data obtained with exposed persons are most important. The quantitative criteria are described in detail in “Kriterien für die Vergabe der “H”-Markierung” in *Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten*<sup>40</sup>).

The designation “H” is shown in the List of MAK and BAT Values and does not indicate that the substance can cause skin irritation.

## VIII MAK values and pregnancy

Observance of the MAK values and BAT values does not guarantee, in every case, that the unborn child is reliably protected because numerous substances have not yet been investigated or have been only partially tested for prenatal toxicity.

### Definition

The expression “prenatal toxicity” or developmental toxicity is taken in its broadest sense by the Commission; it includes any effect of the substance which elicits an alteration from the physiological norm in the development of the organism and leads to prenatal or postnatal death of the offspring or to permanent morphological or functional damage.

### Effects in humans

Epidemiological studies that yield evidence of toxic effects of substances on the human embryo or foetus are of particular importance for the assessment. Because of the limitations of such studies, e.g. inadequate methods, low statistical power, exposures to mixtures of substances, personal factors and life styles, a clear statement as to substance-specific effects and effect thresholds is usually not possible.

### ★ Animal Studies

The evaluation of the developmental toxicity of substances is based mainly on animal studies. Studies which have been carried out according to internationally recognized

<sup>40</sup>) criteria for designation with an “H” (2017), <https://doi.org/10.1002/3527600418.mb0hmrkkrie5617>



testing guidelines such as OECD or similar test guidelines (e. g. EU, Japan) play a decisive role. The OECD Test Guideline 414 in particular is appropriate for the determination of prenatal toxicity. Testing for perinatal and postnatal toxicity, to a limited extent also for prenatal toxicity, is carried out in one-generation studies according to OECD Test Guideline 415 (valid until 27.12.2019), in extended one-generation studies according to OECD Test Guideline 443, in two-generation studies according to OECD Test Guideline 416 or in screening tests according to OECD Test Guidelines 421 and 422. If studies are available that were not conducted according to these guidelines, their validity is to be determined individually. The most important criteria are a sufficiently large number of animals, the use of different dose groups with derivation of a NOAEL (no observed adverse effect level), in-depth studies (external, skeletal and visceral examinations of the foetuses in the developmental toxicity studies) and adequate documentation of the results.

Inhalation studies are of particular importance in assessment of the prenatal toxicity of substances present at the workplace. Also studies with oral administration or dermal application can be taken into consideration if the available data do not present evidence against extrapolation to inhalative administration (e. g. by a pronounced “first pass” effect). Studies carried out with routes of administration which are not relevant in humans (e. g. intraperitoneal) are not included in the evaluation as a rule.

In studies with an oral route of administration, higher doses than those with inhalative or dermal application are usually possible. For this reason, effects are also reported which occur only in the high dose range. Therefore, the test guidelines mentioned consider 1000 mg/kg body weight to be the maximum dose to be tested (limit dose). Such high dose effects are mostly irrelevant for assessing prenatal toxicity at concentrations near the MAK value. Prenatal toxic effects which are observed in the presence of marked maternal toxicity are of low relevance for the situation at the workplace as they are prevented by observance of the MAK value. Findings at doses or concentrations at which no or only slight maternal toxicity is observed are of particular relevance.

The preferred animal species usually recommended in the test guidelines for prenatal developmental toxicity (OECD 414) are female rats and rabbits. The generation studies (e. g. OECD 415, 416 and 443) including the screening tests (e. g. OECD 421 and 422) are usually carried out only with rats of both sexes.

In order to take into consideration the different stage of maturity of organs at birth in rodents compared with in humans (e. g. brain and kidneys), in studies with rodents the evaluation of developmental toxicity may include exposure extending into the postnatal period.

To consider the factor of uncertainty in assessing animal studies, the margin between the NOAEL for developmental toxicity in animal studies and the resulting exposure level or body burden if the MAK or BAT value is observed must be adequate. The necessary margin depends on a number of very different factors:

- comparative toxicokinetic data for humans and animals
- toxicokinetic data for a substance in the dams and embryos or foetuses to evaluate differences in level of exposure between maternal and foetal organs/tissues
- If such data are not available, the evaluation of specific substance properties such as molecular size, lipid solubility and protein binding plays an important role; such data determine the transplacental transfer of the substance from the mother animal and the internal exposure of the embryos or foetuses.

- The kind and severity of the results observed are important factors. Serious effects such as the increased occurrence of specific malformations at doses not causing simultaneous maternal toxicity should receive more emphasis than rather transient unspecific or less severe foetotoxic effects such as slightly decreased foetal body weight or delayed skeletal maturation.

Thus, determination of an adequate margin is a substance-specific process which will result in documentations based on different justifications.

- ★ For substances whose MAK or BAT value is derived from a neurotoxic effect, information on developmental neurotoxicity has been included since 2016. Developmental neurotoxicity is taken into consideration also in the following cases: if the critical effect for the derivation of the MAK or BAT value is not neurotoxicity, but a substance has neurotoxic effects and neonatal or juvenile animals have been found to be more sensitive than adult animals for the substance-induced neurotoxic effects. The most suitable means of evaluating developmental neurotoxicity are studies with prenatal exposure and investigations of neurotoxic end points in developing or adult offspring which take into consideration the effects observed in adult animals, such as studies carried out according to test guidelines for developmental neurotoxicity (OECD Test Guideline 426) or extended one-generation studies (OECD Test Guideline 443) and other suitable studies of developmental neurotoxicity. In addition, relevant information on the toxicokinetics and mechanism of action are included. Possible developmental neurotoxicity is taken into consideration in the classification of the substance in a pregnancy risk group.

### Pregnancy risk groups

Based on the criteria mentioned, the Commission is evaluating substances with MAK or BAT values as to whether prenatal toxic effects are unlikely when the MAK value or the BAT value is observed (Group C), whether, according to the currently available information, such effects cannot be excluded (Group B) or whether they have been unequivocally demonstrated (Group A). For a number of substances, however, it is not yet possible to make a statement as to prenatal toxicity (Group D). This is described in detail in the respective documentation.

The following pregnancy risk groups are defined:

**Group A:** Damage to the embryo or foetus in humans has been unequivocally demonstrated and is to be expected even when MAK and BAT values are observed.

**Group B:** According to currently available information damage to the embryo or foetus cannot be excluded after exposure to concentrations at the level of the MAK and BAT values. The documentation indicates, when the Commission's assessment of the data makes it possible, which concentration would correspond to the classification in Pregnancy Risk Group C. Substances with this indication have the footnote "*prerequisite for Group C, see documentation*".

**Group C:** Damage to the embryo or foetus is unlikely when the MAK value or the BAT value is observed.

- ★ **Group D:** Either there are no data for an assessment of damage to the embryo or foetus, including developmental neurotoxicity, or the currently available data are not sufficient for classification in one of the groups A – C.

Substances without a MAK or BAT value (carcinogenic substances or substances included in Section IIb) have no entry (-).

## IX Germ cell mutagens

Germ cell mutagens produce heritable gene mutations and heritable structural and numerical chromosome aberrations in germ cells. The consequences of germ cell mutations in subsequent generations include genetically determined phenotypic alterations without signs of illness, reduction in fertility, embryonic or perinatal death, more or less severe congenital malformations, and genetic diseases with various degrees of health impairment. The term “germ cell mutagenicity” refers specifically to mutagenicity in male and female germ cells and is distinguished from mutagenicity in somatic cells which can initiate cancer.

Epidemiological studies, however, have been unable to provide any evidence as yet that exposure to chemicals or to radiation results in hereditary diseases in man. Although structural changes have been demonstrated in the chromosomes of the germ cells of men exposed to radiation, even this finding can only provide indirect evidence that such exposures could lead to hereditary disorders in the offspring. The proof that an increased frequency of hereditary diseases is related to a particular exposure would be associated with great methodological difficulties. In the human population there are a large number of hereditary diseases of unknown origin with frequencies which differ widely in different subpopulations. Since mutational events occur largely randomly in the genome, it is not to be expected that one particular substance would induce one characteristic genetic disease. Therefore, it is most unlikely that proof of a causal relationship between exposure to a chemical and occurrence of heritable diseases will become available in the foreseeable future.

In this situation, for the identification of germ cell mutagens the results of animal experiments must be given particular attention. The mutagenic effect of chemicals on the germ cells of exposed parent animals can be demonstrated by observing an increased mutant frequency among the progeny. In addition, the demonstration of genotoxic effects of a substance in germ cells or somatic cells provides evidence of a potential hazard for subsequent generations.

The categories for classification of germ cell mutagens have been established in analogy to the categories for carcinogenic chemicals at the workplace.

1. Germ cell mutagens which have been shown to increase the mutant frequency in the progeny of exposed humans
2. Germ cell mutagens which have been shown to increase the mutant frequency in the progeny of exposed mammals
- 3A. Substances which have been shown to induce genetic damage in germ cells of humans or animals, or which produce mutagenic effects in somatic cells of mammals in vivo and have been shown to reach the germ cells in an active form
- 3B. Substances which are suspected of being germ cell mutagens because of their genotoxic effects in mammalian somatic cells in vivo; in exceptional cases, substances for which there are no in vivo data but which are clearly mutagenic in vitro and structurally related to known in vivo mutagens
4. not applicable (\*)
5. Germ cell mutagens or suspected substances (according to the definition of Category 3 A and 3B), the potency of which is considered to be so low that, provided the MAK and BAT values are observed, their contribution to genetic risk for man is considered to be very slight

(\*) Category 4 carcinogenic substances are those with non-genotoxic mechanisms of action. By definition, germ cell mutagens are genotoxic. Therefore, a Category 4 for germ cell mutagens cannot apply. At some time in the future it is conceivable that a Category 4 could be established for genotoxic substances with primary targets other than the DNA (e. g. purely aneugenic substances) if research results make this seem sensible.

## X Substances requiring special consideration

### a) Organic peroxides

The inflammatory and caustic effects of organic peroxides on the skin and mucous membranes vary considerably. For some of these compounds, even very small amounts of very dilute solutions produce severe necrosis of the skin or the cornea, resulting in loss of eyesight. Inhalation of the vapours causes various degrees of irritation in the respiratory passages. In practice, the danger of systemic effects is low. Sensitizations of the immediate type have been observed after inhalation of these substances. With hydroperoxides and with certain peroxides contact sensitization may be expected as well.

A number of organic peroxides have produced mutagenic effects in *in vitro* tests. In addition, tumours have been produced in animal experiments with, e. g., diacetyl peroxide, *tert*-butyl peroxide, dilauroyl peroxide and  $\alpha,\alpha$ -dimethylbenzyl hydroperoxide.

Negligible or very weak effects on skin	{	Di- <i>tert</i> -butyl peroxide	
		Dibenzoyl peroxide	(50%)
		Dilauroyl peroxide	(50%)
Moderate effects on skin:	{	<i>tert</i> -Butylhydroperoxide	
		<i>tert</i> -Butyl peracetate	(50%)
Very severe effects on skin:	{	$\alpha,\alpha$ -Dimethylbenzyl hydroperoxide (Cumene hydroperoxide)	
		Methyl ethyl ketone peroxide (2-Butanone peroxide)	(40%)
		Cyclohexanone peroxide mixtures	(50%)
		Dicyclohexyl peroxide	(50%)
		Diacetyl peroxide	(30%)
		Peroxyacetic acid	(40%)

### b) Gasolines

The Commission could not agree to assign a MAK value to “gasolines” because this term describes a number of very different mixtures such as motor gasolines (petrol), special boiling point gasolines, white spirits and pyrolysis gasolines. The toxicity of gasolines depends primarily on their content of aromatic compounds (benzene, toluene, xylenes, ethyl benzene, cumene), which varies markedly with the production method.

Procedures suggested for establishing MAK values by the mathematical evaluation of the composition of such mixtures of liquid solvents must be rejected on principle because such calculations cannot provide information as to the actual concentrations in the workplace air. Only when results are available from studies with defined gasoline-vapour mixtures (see Section I) can the Commission make any concrete statements.

Levels of additives such as 1,2-dibromoethane and 1,2-dichloroethane must be evaluated independently (see these listings).

### c) Metal-working fluids, hydraulic fluids and other lubricants

#### Definition

Lubricants are lubricating media based on mineral oils, natural oils or synthetic liquids. Lubricants in liquid form are to be viewed like metal-working fluids (DIN 51385) and lubricating greases of varying consistencies (DIN 51825). Hydraulic fluids are also included (DIN 51524), which are used for power transmission in hydrostatic/hydrodynamic systems and at the same time may enter the metal-working process, for example due to contamination.

When lubricants are defined according to type or field of application, automotive lubricants (motor oils, transmission oils) are differentiated from industrial lubricants, such as metal-working fluids and hydraulic fluids.

Chemically, lubricants are a heterogeneous group and have a complex composition. Metal-working fluids contain various substances which are also found in other lubricants. Therefore the substances which before 2013 had been listed separately in the List of MAK and BAT Values and in “Toxikologisch-arbeitsmedizinische Begründungen von MAK-Werten”<sup>41)</sup> are now combined. Hydraulic fluids have numerous components in common with both groups and are therefore also discussed here.

#### Metal-working fluids

Metal-working fluids are used to cool metallic workpieces and to increase the quality and speed of the cutting process (for example, turning, drilling, milling and cutting) and the service life of the tools.

During the shaping treatment and processing of workpieces (includes rolling and forming, for example), the fluids decrease friction and protect surfaces. They are subdivided into non-water miscible (earlier synonyms: honing oils, cutting oils, grinding oils and rolling oils) and water-miscible metal-working fluids. When used diluted with water, they are called water-mixed metal-working fluids, in practice also drilling fluid or emulsion and grinding water.

The modern non-water miscible metal-working fluids are generally multicomponent mixtures whose composition may vary considerably according to the intended use. They consist predominantly of base oils. These are either mineral oils (natural hydrocarbons, paraffinic or naphthenic), natural oils (such as rapeseed oils) or chemically synthesized oils such as synthetic ester oils (e. g. trimethyl propane esters and polyglycol ethers). Important technically desirable properties, such as load-carrying capacity, adjustment of the viscosity index and pour point are only achieved by including additives.

Essential additives are used for protection against wear, corrosion and ageing, as defoamers and as antimist additives and may also be surface-active substances (surfactants). Antioxidants prevent the degradation of lubricants, for example, while metal deactivators inhibit the catalytic activity and corrosion of non-ferrous metals.

Water-miscible metal-working fluids, which are typically used as water-mixed metal-working fluids at concentrations of 1–20%, also contain additives such as emulsifiers,

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<sup>41)</sup> see: “Komponenten von Kühlschmierstoffen, Hydraulikflüssigkeiten und anderen Schmierstoffen” (2018), <https://doi.org/10.1002/3527600418.mb0215khsd0065>

solubilisers, odour maskers and dyes. Biocides are used for the control of bacteria (preservation) in aqueous systems. As part of inspection/maintenance/care of water-mixed metal-working fluids, individual components may be added which do not always correspond to the original formulation of the manufacturer. For example, if there is increased bacterial growth, biocides might be added. Therefore, the composition may constantly vary in the course of time or during prolonged service lives.

The toxicological assessment of metal-working fluids is dependent on their composition and properties of their components, which differ greatly in number and proportion according to the intended use. The mineral oil component alone is therefore not representative of the potential effect. As a result, the MAK value of 5 mg/m<sup>3</sup> previously established for pure mineral oil is not applicable to present-day metal-working fluids since these are generally mixtures whose composition may vary considerably according to the intended use. For this reason, it is not possible to establish a single MAK value for all types of metal-working fluids. It is a substantial disadvantage that there is no regulation requiring declaration of components of metal-working fluids. Therefore, it is virtually impossible to make a systematic evaluation. New components and compositions are to be expected with advancing technology. Disclosure of the composition is an absolute requirement for an adequate assessment by the Commission.

### **Hydraulic fluids and other lubricants such as greases**

Hydraulic fluids are operating liquids for hydrostatic/hydrodynamic power transmissions. They consist mainly of oils such as mineral oils, natural oils or synthetic fluids of varying structure and viscosity with additives (DIN 51524). The use of hydraulic fluids and other lubricants such as greases may involve intensive skin contact. Skin contact with components of hydraulic fluids results mainly when they are added to water-mixed metal-working fluids during metal working.

There are numerous applications for which liquid lubricants are not suitable (for example, plain and rolling bearings in machine tools). In these cases, greases covering a wide range of viscosity are used. From a physical point of view, greases are colloidal suspensions of thickeners in oils. Mainly metal soaps are used as thickeners, but also mineral substances and polymers.

### **Hazards**

Following skin contact, the effects on health expected most frequently are sensitizing and irritant effects on the skin in the sense of toxic irritant reactions or type IV sensitization (see Section IV "Sensitizing substances" and TRGS 401<sup>42</sup>). Systemic toxicity as a result of skin absorption is, however, of minor importance.

When metal-working fluids are in use, it is possible for vapours resulting from high temperatures at the cutting edge and aerosols due to high rotation speeds to pass into the workplace atmosphere. To date, hardly any animal studies or epidemiological data are available for long-term effects following uptake in the lungs under working conditions. However, the toxic profiles of individual components which are absorbed in the lungs or dermally suggest evidence of a systemic toxic reaction. There may be irritant or toxic reactions in the respiratory tract and lungs following inhalation. It can be assumed that

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<sup>42</sup>) Ausschuss für Gefahrstoffe (2011) Gefährdung durch Hautkontakt – Ermittlungen, Beurteilung, Maßnahmen (TRGS 401) Gemeinsames Ministerblatt 2011, page 175. <https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-401.html>

systemic toxicity and local effects on the skin and respiratory tract are mainly due to the additives.

Carcinogenic nitrosamines resulting from nitrosatable secondary amines such as diethanolamine and morpholine (see Section III “Amines which form carcinogenic nitrosamines on nitrosation”; see TRGS 552<sup>43</sup>) and 611<sup>44</sup>), may be of potential toxicological relevance in water-mixed metal-working fluids, particularly if the fluids contain no inhibitors against their formation.

Both the nitrite concentration and the pH of the water-mixed metal-working fluid have substantial influence on formation of nitrosamines and the rate of their formation. Bacterial nitrite formation can be avoided by the addition of biocides.

Since the nitrosamine concentration does not always correlate with the nitrite concentration, it is more reliable to determine nitrosamine rather than nitrite levels in metal-working fluids containing secondary amines (these do not comply with TRGS 611, unless the provision in Paragraph 2.4 applies). In particular, the absence of nitrite at a particular sampling time does not rule out the possibility that nitrosamines are present. The use of non-water miscible metal-working fluids leads to the formation of polycyclic aromatic hydrocarbons (PAH; reference substance: benzo[a]pyrene). They form at non-critical concentrations if their mineral base oils are sufficiently refined or hydrogenated. According to TRGS 905<sup>45</sup>), the mass content of benzo[a]pyrene in the base oils of non-water miscible metal-working fluids should be lower than 0.005 % (50 ppm).

For systemically hardly toxic components of metal-working fluids which were assessed as non-irritating to mucous membranes and for which no MAK value can be established, it is pointed out that no adverse effects on health are expected at a concentration of up to 10 mg metal-working fluid/m<sup>3</sup>, which corresponds to the technical exposure limit of the German BGR/GUV-R 143, 2011<sup>46</sup>).

The Commission prepares toxicological/occupational-medical reviews of individual components with the aim of publishing practicable assessments in the form of MAK values, if possible. The list, which is subject to constant revision, should assist in the assessment of the effects of metal-working fluids, hydraulic fluids and other lubricants on a case by case basis and in taking any necessary action for health protection.

Documentation has been published for the following substances:

Abietic acid [514-10-3]

also includes disproportionation and transposition products

Adipic acid [124-04-9]

Alkyl amines, C11–14-branched, monohexyl and dihexyl phosphates [80939-62-4]

Alkyl benzenesulfonates C10–C14, linear [69669-44-9; 85117-50-6]

Alkyl ether carboxylic acids

1-(2-Allyloxy)-2-(2,4-dichlorophenyl)ethyl)-1H-imidazole [35554-44-0]

<sup>43</sup>) Ausschuss für Gefahrstoffe (2018) Krebserzeugende N-Nitrosamine der Kat 1 A und 1B (TRGS 552). <https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-552.html>

<sup>44</sup>) Ausschuss für Gefahrstoffe (2007) Verwendungsbeschränkungen für wassermischbare bzw. wassergemischte Kühlschmierstoffe, bei deren Einsatz N-Nitrosamine auftreten können (TRGS 611). <https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-611.html>

<sup>45</sup>) Ausschuss für Gefahrstoffe (2020) Verzeichnis krebserzeugender, erbgutverändernder oder fortpflanzungsgefährdender Stoffe (TRGS 905). <https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-905.html>

<sup>46</sup>) Deutsche Gesetzliche Unfallversicherung (2011) Regel 109003 “Tätigkeiten mit Kühlschmierstoffen”. <https://publikationen.dguv.de/regelwerk/regeln/1006/taetigkeiten-mit-kuehlschmierstoffen>

- 2-Aminobutanol [96-20-8]  
 2-(2-Aminoethoxy)ethanol [929-06-6]  
 2-Amino-2-ethyl-1,3-propanediol [115-70-8]  
 2-Amino-2-methyl-1-propanol [124-68-5]  
 1-Amino-2-propanol [78-96-6]  
 N-(3-Aminopropyl)-N-dodecylpropane-1,3-diamine [2372-82-9]  
 Aminotris(methylenephosphonic acid) [6419-19-8] and its sodium salts  
 Azelaic acid [123-99-9]  
 Behenic acid [112-85-6]  
 1,2-Benzisothiazol-3(2H)-one [2634-33-5]  
 ★ Benzoic acid [65-85-0] (inhalable fraction)  
   see also Benzoic acid alkali salts  
   Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995).  
 Benzoic acid [65-85-0] (respirable fraction)  
   see also Benzoic acid alkali salts  
   Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995).  
 Benzotriazole [95-14-7]  
 Benzyl alcohol [100-51-6]  
 Benzyl alcohol mono(poly)hemiformal [14548-60-8]  
   releases formaldehyde  
 Bis(O,O-bis(2-ethylhexyl) dithiophosphorato-S,S')dioxodi- $\mu$ -thioxodimolybdenum  
   [68958-92-9; 72030-25-2]  
 N,N-Bis(2-ethylhexyl)-(1,2,4-triazole-1-yl)methanamine [91273-04-0]  
 1,3-Bis(hydroxymethyl)urea [140-95-4]  
   releases formaldehyde  
 Bithionol [97-18-7]  
 Boric acid [10043-35-3] and tetraborates  
   Boric acid [10043-35-3]  
 2-Bromo-2-nitro-1,3-propanediol [52-51-7]  
   use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4"  
 Butylated hydroxytoluene (BHT) [128-37-0]  
 2-Butyl-1,2-benzisothiazolin-3-one [4299-07-4]  
 p-tert-Butylbenzoic acid [98-73-7]  
 tert-Butyl-4-hydroxyanisole (BHA) [25013-16-5]  
 Calcium bis(dinonylnaphthalenesulphonate) [57855-77-3]  
 Calcium hydroxide [1305-62-0]  
 5(or 6)-Carboxy-4-hexylcyclohex-2-ene-1-octanoic acid [53980-88-4]  
 2-Chloroacetamide [79-07-2]  
 Chloroacetamide-N-methylol (CAM) [2832-19-1]  
   releases formaldehyde  
 p-Chloro-m-cresol [59-50-7]  
 5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one [26172-55-4; 2682-20-4] mixture in ratio 3:1  
 Chlorothalonil [1897-45-6]  
 Citric acid [77-92-9]  
 Citric acid alkali metal salts  
 Coconut oil [8001-31-8]  
 Cyclohexylhydroxydiazene-1-oxide, potassium salt [66603-10-9]  
 N-Cyclohexylhydroxy-diazen-1-oxide, copper salt [15627-09-5]



- 1-Decanol [112-30-1]
- n-Decyl oleate [3687-46-5]
- Dibenzyl disulfide [150-60-7]
- 2,2-Dibromo-2-cyanacetamide [10222-01-2]
- 1,2-Dibromo-2,4-dicyanobutane [35691-65-7]
- 3-(3,5-Di-tert-butyl-4-hydroxyphenyl)-N'-[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionyl]propanehydrazide [32687-78-8]
- 3,5-Di-tert-butyl-4-hydroxyphenyl propionic acid octadecyl ester [2082-79-3]
- 2,6-Di-tert-butylphenol [128-39-2]
- Di-n-butyl phosphate [107-66-4] and its technical mixtures
- Di-n-butyl phosphonate [1809-19-4] see also Di-n-octyl phosphonate
- Di-n-butyl phthalate [84-74-2]
- Di-tert-dodecyl pentasulfide and Di-tert-dodecyl polysulfide [31565-23-8; 68583-56-2; 68425-15-0]
- Diethylenetriaminepenta(methylenephosphonic acid) [15827-60-8] and its sodium salts [22042-96-2]
- 1,2-Dihydro-2,2,4-trimethyl-quinoline polymer [26780-96-1]
- 4-(Diiodomethylsulfonyl)-toluene [20018-09-1]
- Diisodecyl phthalate [26761-40-0]
- Diisotridecyl phthalate [27253-26-5]
- 1,3-Dimethylol-5,5-dimethyl hydantoin [6440-58-0]
- 4,4'-Dioctyldiphenylamine [101-67-7]
- Di-n-octyl phosphonate [1809-14-9] see also Di-n-butyl phosphonate
- Diphenylamine [122-39-4]
- Diphenylamine, octylated (Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene) [68411-46-1]
- Diphenylamine, reaction products with styrene and 2,4,4-trimethylpentene [68921-45-9]
- Dipropylene glycol [25265-71-8]
- Distillates (petroleum) [64742-47-8] hydrotreated light (aerosol)
- Distillates (petroleum) [64742-47-8] hydrotreated light (vapour)
- 2,2'-Dithiobis(N-methylbenzamide) [2527-58-4]
- Diridecyl phthalate [119-06-2]
- Dodecanedioic acid [693-23-2]
- 1-Dodecanol [112-53-8]
- 5-Ethyl-3,7-dioxo-1-azabicyclo[3.3.0]octane (EDAO) [7747-35-5]  
releases formaldehyde
- 2-Ethyl-1,3-hexanediol [94-96-2]
- 2-Ethylhexyl oleate [26399-02-0]
- ★ Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8]
- Fatty alcohol ethoxylates, C16–18 and C18-unsaturated [68920-66-1]
- Glycerol [56-81-5]
- 1-Hexadecanol [36653-82-4]
- Hexamethylene bis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate) [35074-77-2]
- Hexamethylenetetramine [100-97-0]  
releases formaldehyde
- 1-Hexanol [111-27-3]
- 2-Hexyl-1-decanol [2425-77-6]

Hexylene glycol [107-41-5]

1-Hydroxyethyl-2-heptadecenyl-imidazoline [21652-27-7]

1-Hydroxyethylidene-1,1-diphosphonic acid [2809-21-4] and its sodium and potassium salts

N-(2-Hydroxyethyl)piperidine [3040-44-6]

2-Hydroxymethyl-2-nitro-1,3-propanediol [126-11-4]

use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4"

12-Hydroxystearic acid [106-14-9]

3-Iodo-2-propynyl butylcarbamate [55406-53-6]

Isodecyl oleate [59231-34-4]

Isononanoic acid [3302-10-1] [26896-18-4]

Isooctadecanol [27458-93-1]

Isotridecanol [27458-92-0]

Kerosine (petroleum) (aerosol) [8008-20-6]

Kerosine (petroleum) (vapour) [8008-20-6]

Lauric acid [143-07-7]

Lithium-12-hydroxystearate [7620-77-1]

Lithium stearate [4485-12-5]

2-Mercaptobenzothiazole [149-30-4]

Methenamine 3-chloroallylchloride [4080-31-3]

releases formaldehyde

Methyl-1H-benzotriazole [29385-43-1]

Methyldiethanolamine [105-59-9]

4-Methyl-1,3-dioxolan-2-one [108-32-7]

Methylenebis(dibutyldithiocarbamate) [10254-57-6] (inhalable fraction)

Methylenebis(dibutyldithiocarbamate) [10254-57-6] (respirable fraction)

4,4'-Methylenebis(2,6-di-tert-butylphenol) [118-82-1]

N,N'-Methylenebis(5-methyloxazolidine) [66204-44-2]

4,4'-Methylenedimorpholine [5625-90-1]

releases formaldehyde

2-Methyl-4-isothiazolin-3-one [2682-20-4]

Myristic acid [544-63-8]

Naphtha (petroleum) hydrotreated, heavy [64742-48-9]

Naphthenic acids and sodium, calcium, potassium naphthenates [1338-24-5; 61790-13-4; 61789-36-4; 66072-08-0] (technical mixtures)

3-Nitrobenzoic acid [121-92-6]

4-(2-Nitrobutyl)morpholine (70% w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-propandiyl)bis-morpholin (20% w/w) [2224-44-4; 1854-23-5] (mixture)

In this mixture formaldehyde can be released and nitrosamines formed. Use forbidden as component of metal-working fluids and corrosion inhibitors: see "GefStoffV 2010, Anhang II (zu §16 Absatz 2), Nr. 4".

(4-Nonylphenoxy)acetic acid [3115-49-9]

1-Octadecanol [112-92-5]

1-Octanol [111-87-5]

2-Octyl-1-dodecanol [5333-42-6]

2-Octyl-4-isothiazolin-3-one [26530-20-1]

4-tert-Octylphenol [140-66-9]

Oleic acid [112-80-1]

Oleyl alcohol [143-28-2]

Oleyl sarcosine [110-25-8]

Palmitic acid [57-10-3]

Petroleum sulfonates, calcium salts (technical mixture in mineral oil) [61789-86-4]

Petroleum sulfonates, sodium salts [68608-26-4]

Phenothiazine [92-84-2]

phototoxic effect

2-Phenoxyethanol [122-99-6]

1-Phenoxy-2-propanol [770-35-4]

2-Phenyl-1-ethanol [60-12-8]

N-Phenyl-1-naphthylamine [90-30-2]

o-Phenylphenol [90-43-7] see also Sodium o-phenylphenol

Piperazine [110-85-0]

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N,N'-dinitrosopiperazine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Polyalphaolefins, several CAS Nos, e. g. [68649-11-6]

Polybutenes and Polyisobutenes

Polybutenes [9003-29-6]

Polyisobutenes [9003-27-4]

Polydimethyl siloxanes, linear [63148-62-9; 9006-65-9; 9016-00-6]

Polyethylene glycol (average molecular weight 200–600) [25322-68-3]

Because formation of a mist is possible, exposure should be minimized for reasons of occupational safety and hygiene.

Polyethylene glycol (average molecular weight > 600) [25322-68-3]

Polyethylenepolypropylene glycol [9003-11-6]

Polyoxyethylene oleyl ether [9004-98-2]

Polypropylene glycol (PPG) [25322-69-4]

Poly(propylene glycol) n-butyl ether [9003-13-8]

Polytetrafluoroethene [9002-84-0] (inhalable fraction)

Polytetrafluoroethene [9002-84-0] (respirable fraction)

except for ultrafine particles; see Section Vh

Propylene glycol [57-55-6]

Pyrrrolidine [123-75-1]

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosopyrrolidine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Sebacic acid [111-20-6]

Sodium diethyldithiocarbamate [148-18-5]

Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

Sodium o-phenylphenol [132-27-4]

Sodium pyrithione [3811-73-2; 15922-78-8]

Stearic acid [57-11-4]

Succinic acid [110-15-6]

Tall oil, distilled [8002-26-4]

Tartaric acid [87-69-4]

1-Tetradecanol [112-72-1]

Tetrahydrobenzotriazole [6789-99-7]

★ Tetramethylol acetylenediurea [5395-50-6]

releases formaldehyde

Thiabendazole [148-79-8]

2,2'-Thiobis(4-methyl-6-tert-butylphenol) [90-66-4]

2,2'-Thiodiethylene Bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]  
[41484-35-9]

★ N-Tosyl-6-aminocaproic acid [78521-39-8]

- Triazinetriyltriiminotrihexanoic acid [80584-91-4]  
 Tricresyl phosphate, isomers, "free of o-isomers" [1330-78-5; 563-04-2; 78-32-0]  
 Triethanolamine [102-71-6]  
 Triethylene glycol n-butyl ether [143-22-6]  
 Triethylene glycol monomethyl ether [112-35-6]  
 1,3,5-Triethylhexahydro-1,3,5-triazine [7779-27-3]  
 releases formaldehyde  
 Triglycerides (lard oil, palm oil, rapeseed oil, soybean oil) see also coconut oil  
 Triphenyl monothiophosphate [597-82-0]  
 Triphenyl phosphate [115-86-6]  
 Triphenyl phosphate, isopropylated [68937-41-7]  
 Tris(2,4-ditert-butylphenyl) phosphite [31570-04-4]  
 ★ N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4]  
 releases formaldehyde  
 ★ N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6]  
 releases formaldehyde  
 Tris[(2- or 4-)C9–C10-isoalkylphenyl]phosphorothioate [126019-82-7]  
 Tris(nonylphenyl) phosphite [26523-78-4]  
 White mineral oil (pharmaceutical) [8042-47-5]  
 Zinc, O,O'-di-2-ethylhexyl dithiophosphate [4259-15-8]  
 ★ Zinc diamyldithiocarbamate [15337-18-5] (inhalable fraction)  
 ★ Zinc diamyldithiocarbamate [15337-18-5] (respirable fraction)

#### d) Metals and metal compounds

In the List of MAK and BAT Values, metals are listed as the element "and its inorganic compounds"; the threshold value is then expressed consistently in terms of the metal content. For the individual compounds of most metals, the data available from animal studies or from known effects on man are insufficient for evaluation. Whenever analogy of various compounds of a metal and the element itself seems plausible, these substances should be put in a single category. Therefore, it is necessary that the individual metal compounds be specified as exactly as possible. Generally organic metal compounds should be evaluated separately from the inorganic compounds with respect to the establishment of a MAK value and of carcinogenic potential.

And since the type and extent of metal-related damage depends markedly on the nature of the chemical bond, differences in water solubility of metal compounds can influence their acute and chronic toxicity. On principle, therefore, every metal compound should be tested individually and then categorized according to its toxicity and any carcinogenic potential. At present, sufficient data for such a classification is available for only a few metal compounds.

#### e) Radioactive materials

For procedures in handling radionuclides, reference is made to the special regulations of the "Strahlenschutzverordnung" (radiation protection guidelines). The current version of the guideline may be found in the relevant issue of the Bundesgesetzblatt.

# Assessment Values in Biological Material

## ★ XI Significance and use of assessment values in biological material

### Definition

The Commission derives **assessment values in biological material** to enable the occupational-medical and toxicological evaluation of the individual body burden which results from exposure to a substance at the workplace.

The **BAT value** (**B**iologischer **A**rbeitsstoff-**T**oleranz-**W**ert, “biological tolerance value”) describes the occupational-medical and toxicological derived concentration for a substance, its metabolites, reaction products with endogenous macromolecules (adducts as special metabolites) or an effect parameter in the corresponding biological material at which the health of an employee generally is not adversely affected even when the person is repeatedly exposed during long periods (see Section XIII).

In addition, the Commission examines all hazardous substances at the workplace with a BAT value with respect to whether prenatal toxicity occurs when the BAT value is observed and classifies them in the appropriate pregnancy risk groups (see Section XIII).

The **BLW** (**B**iologischer **L**eit-**W**ert, “biological guidance value”) is the concentration of a chemical substance or its metabolites or the deviation from the norm of biological parameters induced by the substance in exposed humans which serves as an indicator for necessary protective measures (see Section XIV).

The **BAR** (**B**iologischer **A**rbeitsstoff-**R**eferenzwert “biological reference value”) describes the background level of a substance which is present concurrently at a particular time in a reference population of persons of working age who are not occupationally exposed to this substance (see Section XV).

**EKA** (**E**xpositionsäquivalente für **k**rebserzeugende **A**rbeitsstoffe, “exposure equivalents for carcinogenic substances”) are established by the Commission for carcinogenic substances in the form of relationships between the concentration of the carcinogen in the workplace air and that of the substance or its metabolites in biological material (see Section XVI).

### Prerequisites

Assessment values in biological material can be established only for such substances which can be taken up via the respiratory tract, skin and gastrointestinal tract during occupational exposure. Another prerequisite for the establishment of assessment values is that sufficient occupational-medical and toxicological data are available for the substance and that these data are supported primarily by observations in man. The data must have been obtained with scientific methods. For the establishment of new assessment values and the annual review of the list, the submission of suggestions and reports of experience with such substances in man is requested.

## Documentation of the scientific evaluations

The reasons why assessment values in biological material were established at a particular level are documented by the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area in scientific evaluations which are published online in “The MAK-Collection for Occupational Health and Safety”<sup>47)</sup>.

As a rule, the Commission makes its decisions regarding the establishment of assessment values on the basis of scientific texts which have undergone a peer review procedure. When necessary, after detailed discussion, other sources such as unpublished internal company reports are cited and are then identified as such in the reference list at the end of the documentation. The unabridged reports are made available to the Commission and are filed at the Commission’s scientific central office. Information required by a third party about the company reports cited in the Commission’s documentation is supplied in writing by the chair of the Commission at own discretion. Access to company reports is not made available to third parties.

## Purpose

In the context of specific occupational-medical check-ups, BAT values are intended to protect employees from impairment of health at work. They enable an occupational medical toxicological assessment of occupational exposure. For substances that can be absorbed through the skin, individual exposures can be determined only by biological monitoring.

## Evaluation of the health risk

The protection of the health of the individual, which is the reason for establishing assessment values in biological material, can be monitored by periodic quantitative determination of the chemical compounds or their metabolites in biological material or of biological parameters. The methods used must be diagnostically specific and sensitive enough for the purpose, acceptable to the employee and practicable for the physician. The assessment values in biological material are only valid, if the specified sampling time and other requirements named in the evaluation texts are adhered to during sampling.

Whole blood, serum and urine samples are used as assay materials, occasionally and under certain conditions, also samples of alveolar air. The analyses should be carried out under the conditions of statistical quality control according to the requirements of the guidelines of the German Medical Association for quality assurance of medical laboratory analyses (Richtlinien der Bundesärztekammer zur Qualitätssicherung laboratoriumsmedizinischer Untersuchungen (RiLiBÄK)) and the occupational medical rule (Arbeitsmedizinische Regel, AMR) 6.2 Biomonitoring. The Commission’s working group “Analyses in Biological Materials” has compiled a series of valid and recognised methods<sup>47)</sup>.

For workers who come into direct skin contact with substances which are designated with an “H”, it is particularly necessary to check that the assessment values have not been exceeded or, in the case of carcinogenic substances, to assess the systemic dose in terms of the EKA.

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<sup>47)</sup> Available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## **Evaluation of analytical data**

Results from analyses of substances in biological material can only be interpreted with occupational-medical and toxicological knowledge and in Germany are subject to medical discretion.

In occupational-medical health practice analyses of urine specimens for the purpose of biological monitoring are carried out using spontaneously voided urine samples (spot urine samples). These are not suitable for an analysis if they have been highly concentrated or highly diluted through diuresis. In occupational-medical practice the creatinine content of the urine specimen is used as a criterion for the specimen's acceptance while the specific weight or the osmolality is of little importance as a basis for evaluation. Creatinine concentrations  $< 0.3 \text{ g/l}$  or  $> 3.0 \text{ g/l}$  are criteria which would exclude the usability of the spot urine sample (see Addendum to creatinine as reference parameter for the concentration of substances in urine 1999 and 2016 in "The MAK-Collection for Occupational Health and Safety"<sup>48</sup>).

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<sup>48</sup>) Available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## XII List of substances

For interpretation of the occupational-medical and experimental toxicological data, reference should also be made to the “The MAK-Collection for Occupational Health and Safety”<sup>49</sup>).

### Abbreviations

BV	= assessment values in biological material (BAT/EKA/BLW/BAR)
BAT	= biological tolerance value (“Biologischer Arbeitsstoff-Toleranz-Wert”, see Section XIII)
BLW	= biological guidance value (“Biologischer Leit-Wert”, see Section XIV)
BAR	= biological reference value (“Biologischer Arbeitsstoff-Referenzwert”, see Section XV)
EKA	= exposure equivalents for carcinogenic substances (“Expositions-äquivalente für krebserzeugende Arbeitsstoffe”, see Section XVI)

In the table under Substance:

Perc abs: H	= danger from percutaneous absorption (see Sections VII and XI)
Carc cat	= Carcinogen category (see Section III)
Preg(BAT)	= Pregnancy Risk Group for BAT value (see Section XIII)

Assay material:

B	= whole blood
B <sub>E</sub>	= erythrocyte fraction of whole blood
U	= urine
P/S	= plasma/serum

Sampling time:

a	= not fixed
b	= end of exposure or end of shift
c	= end of shift, for long-term exposures after several previous shifts
d	= at the beginning of the next shift
e	= time after end of exposure: ... hours
f	= after exposure for at least 3 months
g	= immediately after exposure

<sup>49</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)



1 Substances which have been examined for possible biological monitoring and for which there is documentation in “The MAK-Collection for Occupational Health and Safety”<sup>50</sup>).

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Acetone [67-64-1]</b>				
			<b>Preg(BAT): B</b> Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum	
Acetone	BAT	50 mg/l see Section XIII.1	U	b
	BAR	2.5 mg/l see Section XV.1	U	b
<b>Acetylcholine esterase inhibitors</b>				
Acetylcholine esterase	BAT	Reduction of activity to 70% of reference value see Section XIII.1 BAT value derived as ceiling value because of acute toxic effects.	B <sub>E</sub>	b, c
<b>Acrolein (2-Propenal) [107-02-8]</b>				
<b>Carc cat: 3</b>				
S-(3-Hydroxypropyl)mercapturic acid N-Acetyl-S-(3-hydroxypropyl)cysteine	BAR	600 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
<b>Acrylamide [79-06-1]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
N-(2-Carbonamideethyl)valine	EKA	see Section XVI.1	B <sub>E</sub>	f
	BLW	550 pmol/g globin see Section XIV.1	B <sub>E</sub>	f
	BAR	50 pmol/g globin see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
S-(2-Carbamoyl)mercapturic acid N-Acetyl-S-(2-carbamoyl)ethyl)cysteine	BAR	100 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b
<b>Acrylonitrile [107-13-1]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
S-(2-Cyanoethyl)mercapturic acid N-Acetyl-S-(2-cyanoethyl)cysteine	BAR	15 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
	N-(2-Cyanoethyl)valine	EKA	see Section XVI.1	B <sub>E</sub>
BAR		12 pmol/g globin see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
<b>Alkali chromates (Cr(VI))</b>				
<b>Perc abs: H</b> the chromates of barium, lead, strontium and zinc are not designated with “H”				
<b>Carc cat: 1</b>				
Chromium	EKA	see Section XVI.1	B <sub>E</sub> , U	b, c
<b>Aluminium [7429-90-5]</b>				
Aluminium	BAT	50 µg/g creatinine see Section XIII.1	U	c
	BAR	15 µg/g creatinine see Section XV.1	U	c

<sup>50</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>4-Aminobiphenyl [92-67-1]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 1</b>				
4-Aminobiphenyl (released from haemoglobin conjugate)	EKA	not established see Section XVI.2	B	b
	BLW	not established see Section XIV.2	B <sub>E</sub>	f
	BAR	15 ng/l see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
<b>Aniline [62-53-3]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 4</b>				
Aniline (after hydrolysis)	BAT	500 µg/l see Section XIII.1 BAT value derived as ceiling value because of acute toxic effects.	U	b
Aniline (released from haemoglobin conjugate)	BLW	100 µg/l see Section XIV.1	B <sub>E</sub>	f
<b>Antimony [7440-36-0] and its inorganic compounds including stibine [7803-52-3]</b>				
<b>Carc cat: 2</b>				
does not apply for stibine				
Antimony	EKA	not established see Section XVI.2 for antimony trioxide	U	b, c
	BAR	0.2 µg/l see Section XV.1 for antimony and stibine	U	b, c
<b>★ Arsenic [7440-38-2] and inorganic arsenic compounds apart from arsine</b>				
<b>Perc abs: H</b>				
with the exception of metallic arsenic and gallium arsenide				
<b>Carc cat: 1</b>				
∑ Arsenic(+III), arsenic(+V) and monomethylarsonic acid	BLW	10 µg/l see Section XIV.1	U	b, c
	EKA	see Section XVI.1	U	b, c
Arsenic(+III)	BAR	0.5 µg/l see Section XV.1	U	b, c
Arsenic(+V)	BAR	0.5 µg/l see Section XV.1	U	b, c
Monomethylarsonic acid	BAR	2 µg/l see Section XV.1	U	b, c
Dimethylarsinic acid	BAR	10 µg/l see Section XV.1	U	b, c
<b>Barium compounds (soluble) (as Ba [7440-39-3])</b>				
Barium	BAR	10 µg/l see Section XV.1	U	b, c
<b>Benzene [71-43-2]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 1</b>				
Benzene	EKA	see Section XVI.1	U	b
	BAR	0.3 µg/l see Section XV.1 evaluated for non-smokers	U	b
S-Phenylmercapturic acid	EKA	see Section XVI.1	U	b
N-Acetyl-S-phenylcysteine	BAR	0.3 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b
trans, trans-Muconic acid	EKA	see Section XVI.1	U	b
	BAR	150 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Benzidine [92-87-5]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 1</b>				
Benzidine	EKA	not established see Section XVI.2	U	b, c
	BAR	not established see Section XV.2	U	b, c
Benzidine adducts	EKA	not established see Section XVI.2	P/S, B <sub>E</sub>	f
	BAR	not established see Section XV.2	P/S, B <sub>E</sub>	f
<b>Beryllium [7440-41-7] and its inorganic compounds</b>				
<b>Carc cat: 1</b>				
Beryllium	EKA	not established see Section XVI.2	U	b, c
	BAR	0.05 µg/l see Section XV.1	U	b, c
<b>Bisphenol A (4,4'-Isopropylidenediphenol) [80-05-7]</b>				
Bisphenol A (after hydrolysis)	BLW	80 mg/l see Section XIV.1	U	b
<b>Bisphenol S [80-09-1]</b>				
Bisphenol S (after hydrolysis)	BAR	1 µg/l see Section XV.1	U	b
<b>Boric acid [10043-35-3] and tetraborates</b>				
Boron	BAT	not established see Section XIII.2	U	difference between pre-shift and post- shift urine
<b>1-Bromopropane [106-94-5]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
S-(n-Propyl)mercapturic acid N-Acetyl-S-n-propylcysteine	EKA	see Section XVI.1	U	c
<b>1,3-Butadiene [106-99-0]</b>				
<b>Carc cat: 1</b>				
S-(3,4-Dihydroxybutyl)mercapturic acid	EKA	see Section XVI.1	U	b, c
N-Acetyl-S-(3,4-dihydroxybutyl)cysteine	BAR	400 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
S-(2-Hydroxy-3-butenyl)mercapturic acid	EKA	see Section XVI.1	U	b, c
N-Acetyl-S-(2-hydroxy-3-butenyl)cysteine	BAR	< 2 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
<b>1-Butanol [71-36-3]</b>				
1-Butanol	BAT	2 mg/g creatinine see Section XIII.1	U	d
	BAT	10 mg/g creatinine see Section XIII.1	U	b
<b>2-Butanone (Methyl ethyl ketone) [78-93-3]</b>				
<b>Perc abs: H</b>				
2-Butanone	BAT	2 mg/l see Section XIII.1	U	b
<b>2-Butoxyethanol [111-76-2]</b>				
<b>Perc abs: H</b>				
Butoxyacetic acid (after hydrolysis)	BAT	150 mg/g creatinine see Section XIII.1	U	b, c
<b>2-Butoxyethyl acetate [112-07-2]</b>				
<b>Perc abs: H</b>				
Butoxyacetic acid (after hydrolysis)	BAT	150 mg/g creatinine see Section XIII.1	U	b, c

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>★ Butylated hydroxytoluene (BHT) [128-37-0]</b>				
<b>Carc cat: 4</b>				
Butylhydroxytoluene acid (after hydrolysis)	BAR	7 µg/l see Section XV.1	U	b
<b>tert-Butyl methyl ether [1634-04-4]</b>				
<b>Carc cat: 3</b>				
tert-Butyl methyl ether	BAT	not established see Section XIII.2	B, U	b
tert-Butyl alcohol	BAT	not established see Section XIII.2	B, U	-
<b>p-tert-Butylphenol [98-54-4]</b>				
<b>Perc abs: H</b>				
p-tert-Butylphenol (after hydrolysis)	BAT	2 mg/l see Section XIII.1	U	b
<b>Cadmium [7440-43-9] and its inorganic compounds</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 1</b>				
Cadmium	BLW	not established see Section XIV.2	U	a
	BAR	1 µg/l see Section XV.1 evaluated for non-smokers	B	a
	BAR	0.8 µg/l see Section XV.1 evaluated for non-smokers	U	a
<b>Carbon disulfide [75-15-0]</b>				
<b>Perc abs: H</b>				
2-Thiothiazolidine-4-carboxylic acid (TTCA)	BAT	2 mg/g creatinine see Section XIII.1	U	b
<b>Carbon monoxide [630-08-0]</b>				
<b>Preg(BAT): B</b>				
CO-Hb	BAT	5% see Section XIII.1 BAT value derived as ceiling value because of acute toxic effects. Evaluated for non-smokers.	B	b
<b>Chlorinated biphenyls [53469-21-9]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 4</b>				
<b>Preg(BAT): B</b> Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum				
∑ PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180	BAT	15 µg/l see Section XIII.1	P	a
PCB 28	BAR	0.02 µg/l see Section XV.1	P	a
PCB 52	BAR	< 0.01 µg/l see Section XV.1	P	a
PCB 101	BAR	< 0.01 µg/l see Section XV.1	P	a
<b>Chlorobenzene [108-90-7]</b>				
<b>Preg(BAT): C</b>				
4-Chlorocatechol (after hydrolysis)	BAT	80 mg/g creatinine see Section XIII.1	U	b
<b>1-Chloro-2,3-epoxypropane (Epichlorohydrin) [106-89-8]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
S-(3-Chloro-2-hydroxypropyl)mercapturic acid N-Acetyl-S-(3-chloro-2-hydroxypropyl)-cysteine	EKA	see Section XVI.1	U	b, c



Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>★ Dichloromethane [75-09-2]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 5</b>		<b>Preg(BAT): B</b>	
Dichloromethane	BAT	500 µg/l see Section XIII.1	B	g
	EKA	see Section XVI.1	B	g
<b>1,2-Dichloropropane [78-87-5]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 1</b>			
S-(2-Hydroxypropyl)mercapturic acid N-Acetyl-S-(2-hydroxypropyl)cysteine	BAR	not established see Section XV.2	U	b, c
<b>Diethylene glycol dimethyl ether [111-96-6]</b>				
<b>Perc abs: H</b>				
Methoxyacetic acid	BAT	15 mg/g creatinine see Section XIII.1	U	b, c
<b>Di(2-ethylhexyl)phthalate (DEHP) [117-81-7]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 4</b>			
∑ (MEHP + 5-OH-MEHP + 5-oxo- MEHP + 5-cx-MEPP) (after hydrolysis)	BLW	4 mg/g creatinine see Section XIV.1	U	c
<b>N,N-Dimethylacetamide [127-19-5]</b>				
<b>Perc abs: H</b>			<b>Preg(BAT): C</b>	
N-Methylacetamide plus N-hydroxy- methyl-N-methylacetamide	BAT	25 mg/l see Section XIII.1	U	b, c
<b>N,N-Dimethylformamide [68-12-2]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 4</b>		<b>Preg(BAT): B</b> Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum	
N-Methylformamide plus N-Hydroxy- methyl-N-methylformamide	BAT	20 mg/l see Section XIII.1	U	b
S-(Methylcarbamoyl)mercapturic acid N-Acetyl-S-(N-methylcarbamoyl)cysteine	BAT	25 mg/g creatinine see Section XIII.1	U	b, c
<b>Dimethyl sulfate [77-78-1]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 2</b>			
N-Methylvaline	EKA	see Section XVI.1	B <sub>E</sub>	f
<b>1,4-Dioxane [123-91-1]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 4</b>		<b>Preg(BAT): C</b>	
2-Hydroxyethoxyacetic acid	BAT	200 mg/g creatinine see Section XIII.1	U	b
<b>★ 1,2-Epoxypropane (1,2-Propylene oxide) [75-56-9]</b>				
	<b>Carc cat: 4</b>		<b>Preg(BAT): C</b>	
N-(2-Hydroxypropyl)valine	BAT	2500 pmol/g globin see Section XIII.1	B <sub>E</sub>	f
	EKA	see Section XVI.1	B <sub>E</sub>	f
	BAR	10 pmol/g globin see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
S-(2-Hydroxypropyl)mercapturic acid N-Acetyl-S-(2-hydroxypropyl)cysteine	BAR	25 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
<b>2-Ethoxyethanol [110-80-5]</b>				
<b>Perc abs: H</b>				
Ethoxyacetic acid	BAT	50 mg/l see Section XIII.1	U	c
<b>2-Ethoxyethyl acetate [111-15-9]</b>				
<b>Perc abs: H</b>				
Ethoxyacetic acid	BAT	50 mg/l see Section XIII.1	U	c

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>1-Ethoxy-2-propanol [1569-02-4]</b>				
<b>Perc abs: H</b>				
1-Ethoxy-2-propanol	BAT	not established see Section XIII.2	U	b
<b>1-Ethoxy-2-propyl acetate [54839-24-6]</b>				
<b>Perc abs: H</b>				
1-Ethoxy-2-propanol	BAT	not established see Section XIII.2	U	b
<b>★ Ethylbenzene [100-41-8]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 4</b>	<b>Preg(BAT): C</b>	
Mandelic acid plus phenyl glyoxylic acid	BAT	250 mg/g creatinine see Section XIII.1	U	b
	EKA	see Section XVI.1	U	b
<b>Ethylene [74-85-1]</b>				
<b>Carc cat: 3</b>				
N-(2-Hydroxyethyl)valine	EKA	not established see Section XVI.2	B <sub>E</sub>	f
<b>Ethylene glycol dinitrate [628-96-6]</b>				
<b>Perc abs: H</b>				
Ethylene glycol dinitrate	BAT	not established see Section XIII.2	B	–
<b>Ethylene oxide [75-21-8]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 2</b>		
N-(2-Hydroxyethyl)valine	EKA	see Section XVI.1	B <sub>E</sub>	f
	BAR	60 pmol/g globin see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
S-(2-Hydroxyethyl)mercapturic acid N-Acetyl-S-(2-hydroxyethyl)cysteine	BAR	5 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
<b>Formic acid methyl ester [107-31-3]</b>				
<b>Perc abs: H</b>				
Methanol	BAT	not established see Section XIII.2	U	c
Formic acid	BAT	not established see Section XIII.2	U	–
<b>Gadolinium [7440-54-2]</b>				
Gadolinium	BAR	not established see Section XV.2	U	–
<b>Glycidol [556-52-5]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 2</b>		
N-(2,3-Dihydroxypropyl)valine	BAR	15 pmol/g globin see Section XV.1 evaluated for non-smokers	B <sub>E</sub>	f
<b>Halothane (2-Bromo-2-chloro-1,1,1-trifluoroethane) [151-67-7]</b>				
Trifluoroacetic acid	BAT	2.5 mg/l see Section XIII.1	B	b, c
<b>n-Heptane [142-82-5]</b>				
Heptane-2,5-dione	BAT	250 µg/l see Section XIII.1	U	b
<b>Hexachlorobenzene [118-74-1]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 4</b>		
Hexachlorobenzene	BAT	150 µg/l see Section XIII.1	P/S	a

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>1,6-Hexamethylene diisocyanate [822-06-0]</b>				
Hexamethylenediamine (after hydrolysis)	BAT	15 µg/g creatinine see Section XIII.1	U	b
<b>n-Hexane [110-54-3]</b>				
2,5-Hexanedione plus 4,5-dihydroxy-2-hexanone (after hydrolysis)	BAT	5 mg/l see Section XIII.1	U	b, c
<b>2-Hexanone [591-78-6]</b>				
<b>Perc abs: H</b>				
2,5-Hexanedione plus 4,5-dihydroxy-2-hexanone (after hydrolysis)	BAT	5 mg/l see Section XIII.1	U	b, c
<b>Hydrazine [302-01-2]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
Hydrazine	EKA	see Section XVI.1	U, P	b
<b>★ Hydrogen fluoride [7664-39-3] and inorganic fluorine compounds (fluorides)</b>				
<b>Perc abs: H</b>				
<b>Preg(BAT): C</b>				
Hydrogen fluoride is not designated with "H"				
Fluoride	BAT	4 mg/l see Section XIII.1	U	b
<b>★ Indium [7440-74-6] and its inorganic compounds</b>				
<b>Indiumphosphide Carc cat: 2</b>				
Indium	BLW	not established see Section XIV.2	P/S	a
	BAR	not established see Section XV.2	P/S	a
<b>Iodine [7553-56-2] and inorganic iodides</b>				
<b>Perc abs: H</b>				
Iodine	BAR	not established see Section XV.2	U	–
<b>★ Isoflurane [26675-46-7]</b>				
<b>Preg(BAT): D</b>				
Isoflurane	BAT	4 µg/l see Section XIII.1	U	b
<b>★ Isopropylbenzene (cumene) [98-82-8]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 3</b>				
<b>Preg(BAT): C</b>				
2-Phenyl-2-propanol (after hydrolysis)	BAT	10 mg/g creatinine see Section XIII.1	U	b
<b>Lead [7439-92-1] and its inorganic compounds (except lead arsenate and lead chromate)</b>				
<b>Carc cat: 4</b>				
<b>Preg(BAT): A</b>				
Lead	BAT	150 µg/l see Section XIII.1	B	a
	BAR	30 µg/l see Section XV.1 for women	B	a
	BAR	40 µg/l see Section XV.1 for men	B	a
<b>Lindane (γ-1,2,3,4,5,6-Hexachlorocyclohexane) [58-89-9]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 4</b>				
<b>Preg(BAT): C</b>				
Lindane	BAT	25 µg/l see Section XIII.1	P/S	b
<b>Lithium [7439-93-2]</b>				
Lithium	BAR	50 µg/l see Section XV.1	U	a



Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Manganese [7439-96-5] and its inorganic compounds</b>				
Manganese	BAT	not established see Section XIII.2	B	b, c
	BAR	15 µg/l see Section XV.1	B	b, c
<b>Mercury [7439-97-6] and its inorganic compounds</b>				
<b>Perc abs: H</b>		<b>Carc cat: 3</b>		
Mercury	BAT	25 µg/g creatinine see Section XIII.1 30 µg/l urine	U	a
<b>Mercury, organic compounds</b>				
<b>Perc abs: H</b>		<b>Carc cat: 3</b>		
Mercury	BAT	not established see Section XIII.2	B	a
	EKA	not established see Section XVI.2	B	a
<b>Methanol [67-56-1]</b>				
<b>Perc abs: H</b>		<b>Preg(BAT): C</b>		
Methanol	BAT	15 mg/l see Section XIII.1	U	b, c
<b>Methaemoglobin-forming substances</b>				
Methaemoglobin-forming substances	BAT	not established see Section XIII.2 Values of 1.5% methaemoglobin or more indicate exposure to methaemoglobin inducers. The causative substance should be used to evaluate the toxicity.	B	b
<b>★ Methoxyacetic acid [625-45-6]</b>				
<b>Perc abs: H</b>				
Methoxyacetic acid	BAT	15 mg/g creatinine see Section XIII.1	U	b, c
<b>2-Methoxyethanol [109-86-4]</b>				
<b>Perc abs: H</b>				
Methoxyacetic acid	BAT	15 mg/g creatinine see Section XIII.1	U	b, c
<b>2-Methoxyethyl acetate [110-49-6]</b>				
<b>Perc abs: H</b>				
Methoxyacetic acid	BAT	15 mg/g creatinine see Section XIII.1	U	b, c
<b>1-Methoxy-2-propanol [107-98-2]</b>				
Propylene glycol 1-methyl ether	BAT	15 mg/l see Section XIII.1	U	b
<b>Methyl bromide [74-83-9]</b>				
		<b>Carc cat: 3</b>		
Bromide	BLW	12 mg/l see Section XIV.1	P/S	c
S-Methylcysteine albumin	EKA	not established see Section XVI.2	S	a
<b>4,4'-Methylenebis(2-chloroaniline) (MOCA) [101-14-4]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 2</b>		
4,4'-Methylenebis(2-chloroaniline) (MOCA) (after hydrolysis)	BAR	< 1 µg/l see Section XV.1	U	b
<b>4,4'-Methylene diphenyl diisocyanate (MDI) [101-68-8] (inhalable fraction)</b>				
<b>Perc abs: H</b>		<b>Carc cat: 4</b>		
4,4'-Diaminodiphenylmethane (after hydrolysis)	BLW	10 µg/l see Section XIV.1	U	b

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>4-Methyl-2-pentanone (Methyl isobutyl ketone) [108-10-1]</b>				
<b>Perc abs: H</b>				
4-Methyl-2-pentanone	BAT	0.7 mg/l see Section XIII.1	U	b
<b>N-Methyl-2-pyrrolidone [872-50-4]</b>				
<b>Perc abs: H</b>				
5-Hydroxy-N-methyl-2-pyrrolidone	BAT	150 mg/l see Section XIII.1	U	b
<b>Molybdenum [7439-98-7] and its compounds</b>				
Molybdenum	BAT	not established see Section XIII.2	U, P	–
	BAR	150 µg/l see Section XV.1	U	–
<b>Naphthalene [91-20-3]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
1-Naphthol plus 2-naphthol (after hydrolysis)	EKA	see Section XVI.1	U	b, c
	BAR	35 µg/l see Section XV.1 evaluated for non-smokers	U	b, c
1,2-Dihydroxynaphthalene (after hydrolysis)	EKA	see Section XVI.1	U	b, c
S-(1-Naphthyl)mercapturic acid N-Acetyl-S-(1-naphthyl)cysteine	EKA	see Section XVI.1	U	b, c
<b>2-Naphthylamine [91-59-8]</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 1</b>				
2-Naphthylamine	EKA	not established see Section XVI.2	U	b
	BAR	not established see Section XV.2	U	b
2-Naphthylamine adducts	EKA	not established see Section XVI.2	B <sub>E</sub>	f
	BAR	not established see Section XV.2	B <sub>E</sub>	f
<b>1,5-Naphthylene diisocyanate [3173-72-6]</b>				
<b>Carc cat: 3</b>				
1,5-Diaminonaphthalene	BLW	not established see Section XIV.2	U	b
<b>Neuropathy target esterase inhibitors</b>				
Reduction of activity of neuropathy target esterase in lymphocytes	BAT	not established see Section XIII.2	B	b, c Determination of individual pre-exposure values
<b>Nickel [7440-02-0] and its compounds</b>				
<b>Carc cat: 1</b>				
Nickel	BAR	3 µg/l see Section XV.1	U	c
<b>Nickel [7440-02-0] (nickel metal, nickel oxide, nickel carbonate, nickel sulfide, sulfidic ores)</b>				
<b>Carc cat: 1</b>				
Nickel	EKA	see Section XVI.1	U	c
<b>Nickel (easily soluble nickel compounds, e. g. nickel acetate and similar soluble salts, nickel chloride, nickel sulfate)</b>				
<b>Carc cat: 1</b>				
Nickel	EKA	not established see Section XVI.2	U	c

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Nitrobenzene [98-95-3]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 4</b>			
Aniline (released from haemoglobin conjugate)	BLW	100 µg/l see Section XIV.1	B <sub>E</sub>	f
<b>Nitroglycerin [55-63-0]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 3</b>			
1,2-Glyceryl dinitrate	BLW	not established see Section XIV.2	P/S	b
1,3-Glyceryl dinitrate	BLW	not established see Section XIV.2	P/S	b
<b>Parathion [56-38-2]</b>				
<b>Perc abs: suspended</b>				
p-Nitrophenol (after hydrolysis)	BAT	500 µg/l see Section XIII.1	U	c
Acetylcholine esterase	BAT	Reduction of activity to 70% of reference value see Section XIII.1 BAT value derived as ceiling value because of acute toxic effects.	B <sub>E</sub>	c
<b>Pentachlorophenol [87-86-5]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 2</b>			
Pentachlorophenol	EKA	not established see Section XVI.2	P/S	a
Pentachlorophenol (after hydrolysis)	EKA	not established see Section XVI.2	U	a
<b>Perfluorooctanesulfonic acid (PFOS) [1763-23-1] and its salts</b>				
<b>Perc abs: H</b>	<b>Carc cat: 3</b>			
Perfluorooctanesulfonic acid	BAT	15 mg/l see Section XIII.1	S	a
<b>Perfluorooctanoic acid (PFOA) [335-67-1] and its salts</b>				
<b>Perc abs: H</b>	<b>Carc cat: 4</b>			
Perfluorooctanoic acid	BAT	5 mg/l see Section XIII.1	S	a
<b>Phenol [108-95-2]</b>				
<b>Perc abs: H</b>	<b>Carc cat: 3</b>			
Phenol (after hydrolysis)	BLW	200 mg/l see Section XIV.1	U	b
<b>Polychlorinated biphenyls (PCB)</b>				
see Chlorinated biphenyls				
<b>Polycyclic aromatic hydrocarbons (PAH)</b>				
<b>Perc abs: H</b>	<b>see Section III "pyrolysis products of organic materials"</b>			
3-Hydroxybenzo[a]pyrene (after hydrolysis)	EKA	see Section XVI.1	U	d
1-Hydroxypyrene (after hydrolysis)	BAR	0.3 µg/g creatinine see Section XV.1 evaluated for non-smokers	U	b, c
<b>★ 2-Propanol [67-63-0]</b>				
<b>Preg(BAT): C</b>				
Acetone	BAT	25 mg/l see Section XIII.1	B	b
	BAT	25 mg/l see Section XIII.1	U	b

Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Pyrethrum [8003-34-7] and Pyrethroids (e. g. allethrin, cyfluthrin, cypermethrin, deltamethrin, permethrin, phenothrin, resmethrin, tetramethrin)</b>				
trans-Chrysanthemumdicarboxylic acid, 4-fluoro-3-phenoxybenzoic acid, cis- and trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid or cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylic acid (all parameters after hydrolysis)	BAT	not established see Section XIII.2	U	b
<b>Selenium [7782-49-2] and its inorganic compounds</b>				
<b>Perc abs: H</b>		<b>Carc cat: 3</b>		
Selenium	BAT	150 µg/l see Section XIII.1	S	a
	BAR	100 µg/l see Section XV.1	P/S	a
	BAR	30 µg/g creatinine see Section XV.1	U	c
<b>Styrene [100-42-5]</b>				
		<b>Carc cat: 5</b>		
Mandelic acid plus phenyl glyoxylic acid	BAT	600 mg/g creatinine see Section XIII.1	U	b, c
<b>Tetrachloroethene [127-18-4]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 3</b>		
Tetrachloroethene	BAT	200 µg/l see Section XIII.1	B	e 16 hours after end of exposure
	EKA	see Section XVI.1	B	e 16 hours after end of exposure
<b>Tetrachloromethane [56-23-5]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 4</b>		
Tetrachloromethane	BAT	3.5 µg/l see Section XIII.1	B	c
<b>Tetraethyllead [78-00-2]</b>				
<b>Perc abs: H</b>				
Diethyllead	BAT	25 µg/l, as Pb see Section XIII.1	U	b
Total lead (also applies for mixtures of tetraethyllead with tetramethyllead)	BAT	50 µg/l see Section XIII.1	U	b
<b>Tetrahydrofuran [109-99-9]</b>				
<b>Perc abs: H</b>		<b>Carc cat: 4</b>		
Tetrahydrofuran	BAT	2 mg/l see Section XIII.1	U	b
<b>Tetramethyllead [75-74-1]</b>				
<b>Perc abs: H</b>				
Total lead	BAT	50 µg/l see Section XIII.1	U	b
<b>Toluene [108-88-3]</b>				
<b>Perc abs: H</b>		<b>Preg(BAT): C</b>		
Toluene	BAT	600 µg/l see Section XIII.1	B	g
	BAT	75 µg/l see Section XIII.1	U	b
o-Cresol (after hydrolysis)	BAT	1.5 mg/l see Section XIII.1	U	b, c



Substance Parameter	BV	Value or correlation	Assay material	Sampling time
<b>Uranium [7440-61-1] and its hardly soluble inorganic compounds</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 2</b>				
Uranium	BAR	not established see Section XV.2	U	a
<b>Uranium compounds, soluble inorganic</b>				
<b>Perc abs: H</b>				
<b>Carc cat: 3</b>				
Uranium	BAR	not established see Section XV.2	U	a
<b>★ Vanadium [7440-62-2] and its inorganic compounds</b>				
<b>Carc cat: 4</b>				
Vanadium	BAT	not established see Section XIII.2	U	b, c
	EKA	not established see Section XVI.2	U	b, c
	BAR	0.15 µg/l see Section XV.1	U	b, c
<b>★ Vinyl chloride [75-01-4]</b>				
<b>Carc cat: 1</b>				
Thiodiglycolic acid	EKA	not established see Section XVI.2	U	c
	BAR	1.5 mg/l see Section XV.1 This BAR is not suitable for the assessment of vinyl chloride monomer exposures < 5 ppm.	U	d
<b>Vitamin K antagonists</b>				
Quick value	BAT	Reduction to no less than 70% see Section XIII.1 BAT value derived as ceiling value because of acute toxic effects.	B	a
<b>★ Xylene (all isomers) [1330-20-7]</b>				
<b>Perc abs: H</b>			<b>Preg(BAT): D</b>	
Methylhippuric acid (toluric acid) (all isomers)	BAT	2000 mg/l see Section XIII.1	U	b

## ★ XIII Biological Tolerance Values (BAT values)

The Commission establishes **BAT** values (“**Biologische Arbeitsstoff-Toleranzwerte**”: biological tolerance values) to enable the occupational-medical and toxicological evaluation of the risk to an individual’s health which results from exposure to a substance at the workplace. The BAT value describes the average occupational-medical and toxicological derived concentration for a substance, its metabolites or an effect parameter in the corresponding biological material at which the health of an employee generally is not adversely affected even when the person is repeatedly exposed during long periods. As a rule, exposure to the substance is assumed for the whole of working life. BAT values are based on a relationship between external and systemic exposure or between the systemic exposure and the resulting effect of the substance.

The BAT value is exceeded when, following several individual examinations, the average concentration of the parameter is greater than the BAT value; individual measured values greater than the BAT value must be evaluated in relation to occupational-medical and toxicological data. Adverse effects on health can not necessarily be deduced from one single excursion above the BAT value. This is not valid for acute toxicity, which must not be permitted at any time. The individual evaluations of substances include evidence of acute toxic effects. Substances with a BAT value which targets an acute toxic effect are marked accordingly in the List of MAK and BAT Values (“derivation of the BAT value as ceiling value because of acute toxic effects”).

### Derivation of BAT values

The derivation of a BAT value can be based on various constellations of scientific data.

- Studies in humans which reveal a direct relationship between concentrations of a substance or metabolites in biological material (internal exposure) and adverse effects on health are preferred, or
- studies in humans which reveal a relationship between a biological indicator (effect parameter) and adverse effects on health.
- If such information is not available, studies are preferred which reveal a quantitative relationship between exposure concentration and internal exposure and therefore permit the linking of MAK and BAT values.
- In individual cases, the assessment value is derived from a NOAEL from experiments with animals by means of a human toxicokinetic model.

The following considerations of sex-specific factors apply for the establishment of BAT-values:

1. The range of the variation in toxicokinetics and the anatomical and physiological characteristics in humans is very wide even for a single sex; the ranges for the two sexes overlap.
2. The resulting sex-specific differences in toxicokinetics generally vary in a range which is insignificant compared with the uncertainty involved in establishing threshold values.
3. During pregnancy and breast-feeding, certain changes in the toxicokinetics of xenobiotics can occur. In practice, however, the effects of these changes are limited so that for health protection at the workplace the effects on the unborn child and the breast-fed baby are of particular importance (see Section VIII “MAK values and pregnancy”).

BAT values are not suitable for the derivation of biological assessment values for exposures from the general environment by means of fixed conversion factors.

### **Correlations between BAT and MAK values**

When a substance is inhaled under steady state conditions in controlled laboratory experiments, the relationship between the external exposure and the internal exposure can be expressed in terms of toxicokinetics. As a result of the conditions at the workplace, it is not necessarily possible to deduce the internal exposure from the concentration of certain substances in the air, and vice versa. In addition to inhalation of the substance, a series of other factors can determine the extent of exposure of the organism. These factors include for example the level of physical activity (respiratory minute volume), absorption through the skin and individual variations in metabolic or excretory patterns.

In general, for substances with low vapour pressure which are readily absorbed through the skin, there is no correlation between the external and internal exposure. For these substances a BAT value can therefore be established only on the basis of a relationship between the internal exposure and effect.

The concentrations of substances in the workplace air may vary with time and the biological parameters may not vary to the same extent. Therefore, the levels in the air cannot always be deduced from the results of investigations in biological material.

In spite of all these influencing factors and the consequent differences in the definitions of MAK and BAT values, the two thresholds are based on equivalent effects of substances on the organism. Exceptions are substances for which the MAK value was not established on the basis of systemic effects but because of local irritation of skin and mucous membranes. In these cases the BAT value can still be based on “critical toxicity” resulting from systemic exposure, so that the MAK and BAT values may then be based on different end points.

### **BAT values and pregnancy**

Observance of the BAT values does not guarantee the protection of the unborn child in every case, as for numerous hazardous substances at the workplace there are no or no adequate studies of their prenatal toxicity. On the basis of the prerequisites named in Section VIII “MAK values and pregnancy”, the Commission examines all hazardous substances at the workplace with MAK or BAT values with respect to whether prenatal toxicity occurs when the MAK or BAT value is observed.

If there is a correlation between the MAK and BAT values, the pregnancy risk group for the MAK value usually applies also for the correlating BAT value.

If the BAT value was not derived in correlation with the MAK value, a procedure like that described in Section VIII “MAK values and pregnancy” is followed for the pregnancy risk group for the BAT value.

### **Allergenic substances**

Depending on individual disposition, allergic reactions can be induced by various kinds of substances, more or less rapidly and in differing degrees of severity after sensitization of, for example, the skin or respiratory passages. The observance of BAT values cannot provide a guarantee that such reactions will not occur.



**Mixtures of substances**

BAT values apply as a rule for exposure to pure substances. They are not necessarily applicable for persons exposed to preparations containing more than one toxic substance (blends, mixtures, solutions). For mixtures of components with similar effects, a BAT value based on a biological parameter can be helpful in the assessment of health risks, as long as it provides a measure of critical clinical-functional effects of the components. The Commission makes every effort to define and publish such criteria for the biological effects of interfering components of mixtures.

**1 Substances for which BAT values can be derived:**

- Acetone [67-64-1]
- Acetylcholine esterase inhibitors
- Aluminium [7429-90-5]
- Aniline [62-53-3]
- 1-Butanol [71-36-3]
- 2-Butanone (Methyl ethyl ketone) [78-93-3]
- 2-Butoxyethanol [111-76-2]
- 2-Butoxyethyl acetate [112-07-2]
- p-tert-Butylphenol [98-54-4]
- Carbon disulfide [75-15-0]
- Carbon monoxide [630-08-0]
- Chlorinated biphenyls [53469-21-9]
- Chlorobenzene [108-90-7]
- Cyclohexane [110-82-7]
- 1,2-Dichlorobenzene [95-50-1]
- 1,4-Dichlorobenzene [106-46-7]
- Dichloromethane [75-09-2]
- Diethylene glycol dimethyl ether [111-96-6]
- N,N-Dimethylacetamide [127-19-5]
- N,N-Dimethylformamide [68-12-2]
- 1,4-Dioxane [123-91-1]
- 1,2-Epoxypropane (1,2-Propylene oxide) [75-56-9]
- 2-Ethoxyethanol [110-80-5]
- 2-Ethoxyethyl acetate [111-15-9]
- Ethylbenzene [100-41-4]
- Halothane (2-Bromo-2-chloro-1,1,1-trifluoroethane) [151-67-7]
- n-Heptane [142-82-5]
- Hexachlorobenzene [118-74-1]
- 1,6-Hexamethylene diisocyanate [822-06-0]
- n-Hexane [110-54-3]
- 2-Hexanone [591-78-6]
- Hydrogen fluoride [7664-39-3] and inorganic fluorine compounds (fluorides)
- ★ Isoflurane [26675-46-7]
- Isopropylbenzene (cumene) [98-82-8]
- Lead [7439-92-1] and its inorganic compounds (except lead arsenate and lead chromate)
- Lindane ( $\gamma$ -1,2,3,4,5,6-Hexachlorocyclohexane) [58-89-9]

- Mercury [7439-97-6] and its inorganic compounds  
 Methanol [67-56-1]  
 ★ Methoxyacetic acid [625-45-6]  
 2-Methoxyethanol [109-86-4]  
 2-Methoxyethyl acetate [110-49-6]  
 1-Methoxy-2-propanol [107-98-2]  
 4-Methyl-2-pentanone (Methyl isobutyl ketone) [108-10-1]  
 N-Methyl-2-pyrrolidone [872-50-4]  
 Parathion [56-38-2]  
 Perfluorooctanesulfonic acid (PFOS) [1763-23-1] and its salts  
 Perfluorooctanoic acid (PFOA) [335-67-1] and its salts  
 2-Propanol [67-63-0]  
 Selenium [7782-49-2] and its inorganic compounds  
 Styrene [100-42-5]  
 Tetrachloroethene [127-18-4]  
 Tetrachloromethane [56-23-5]  
 Tetraethyllead [78-00-2]  
 Tetrahydrofuran [109-99-9]  
 Tetramethyllead [75-74-1]  
 Toluene [108-88-3]  
 2,4-Toluene diisocyanate [584-84-9]  
 2,6-Toluene diisocyanate [91-08-7]  
 Toluene diisocyanates, mixture [26471-62-5]  
 1,1,1-Trichloroethane (Methyl chloroform) [71-55-6]  
 Trimethylbenzene (all isomers) [25551-13-7]: 1,2,3-Trimethylbenzene [526-73-8],  
 1,2,4-Trimethylbenzene [95-63-6], 1,3,5-Trimethylbenzene [108-67-8]  
 Vitamin K antagonists  
 Xylene (all isomers) [1330-20-7]

2 For the substances listed below, there is at present insufficient data for the derivation of a BAT value; however, documentation for these substances has been published in “The MAK-Collection for Occupational Health and Safety”<sup>51)</sup>:

- Boric acid [10043-35-3] and tetraborates  
 tert-Butyl methyl ether [1634-04-4]  
 Copper [7440-50-8] and its inorganic compounds  
 Cresol (all isomers) [1319-77-3]: o-cresol [95-48-7], m-cresol [108-39-4], p-cresol [106-44-5]  
 1-Ethoxy-2-propanol [1569-02-4]  
 1-Ethoxy-2-propyl acetate [54839-24-6]  
 Ethylene glycol dinitrate [628-96-6]  
 Formic acid methyl ester [107-31-3]  
 Manganese [7439-96-5] and its inorganic compounds  
 Mercury, organic compounds  
 Methaemoglobin-forming substances

<sup>51)</sup> Available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019).

- Molybdenum [7439-98-7] and its compounds
- Neuropathy target esterase inhibitors
- Pyrethrum [8003-34-7] and Pyrethroids (e. g. allethrin, cyfluthrin, cypermethrin, deltamethrin, permethrin, phenothrin, resmethrin, tetramethrin)
- Tricresyl phosphate, sum of all o-isomers [78-30-8]
- ★ Vanadium [7440-62-2] and its inorganic compounds

3 BAT values examined with regard to their pregnancy risk group:

3.1 Substances at the workplace **with** a correlation between MAK and BAT value

Acetone [67-64-1]	Group B
<small>Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum</small>	
Chlorobenzene [108-90-7]	Group C
1,4-Dichlorobenzene [106-46-7]	Group C
★ Dichloromethane [75-09-2]	Group B
N,N-Dimethylacetamide [127-19-5]	Group C
N,N-Dimethylformamide [68-12-2]	Group B
<small>Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum</small>	
1,4-Dioxane [123-91-1]	Group C
★ 1,2-Epoxypropane (1,2-Propylene oxide) [75-56-9]	Group C
★ Ethylbenzene [100-41-4]	Group C
★ Isoflurane [26675-46-7]	Group D
★ Isopropylbenzene (cumene) [98-82-8]	Group C
Lead [7439-92-1] and its inorganic compounds (except lead arsenate and lead chromate)	Group A
Kohlenmonoxid [630-08-0]	Group B
Methanol [67-56-1]	Group C
★ 2-Propanol [67-63-0]	Group C
Toluene [108-88-3]	Group C
2,4-Toluene diisocyanate [584-84-9]	Group C
2,6-Toluene diisocyanate [91-08-7]	Group C
Toluene diisocyanates, mixture [26471-62-5]	Group C
1,1,1-Trichloroethane (Methyl chloroform) [71-55-6]	Group C
★ Xylene (all isomers) [1330-20-7]	Group D

3.2 Substances at the workplace **with no** correlation between MAK and BAT value

Chlorinated biphenyls [53469-21-9]	Group B
<small>Note regarding prerequisites for Pregnancy Risk Group C see BAT addendum</small>	
★ Hydrogen fluoride [7664-39-3] and inorganic fluorine compounds (fluorides)	Group C
Lindane ( $\gamma$ -1,2,3,4,5,6-Hexachlorocyclohexane) [58-89-9]	Group C

## ★ XIV Biological Guidance Values (BLW)

The BLW (“biological guidance value”) is the average concentration of a chemical substance or its metabolites or the deviation from the norm of biological parameters induced by the substance in exposed humans which serves as an indicator for necessary protective measures. BLWs are assigned only for hazardous substances for which the available toxicological or occupational-medical data are insufficient for the establishment of BAT values (i. e. for carcinogenic substances and suspected carcinogens). BLW values are established on the assumption that persons are exposed for their entire working lives.

The BLW is based on occupational-medical information as to the effects of handling the hazardous material together with toxicological data. Since observance of the BLW does not exclude a risk of adverse effects on health, it is necessary to extend our knowledge of the relationships between exposure to the substance, the systemic dose and the resulting risks for health, so that BAT values may be derived.

The BLW is exceeded if, in several examinations of one person, the mean concentration of the parameter is above the BLW. Individual measured values above the BLW must be assessed from the point of view of occupational medicine and toxicology.

### 1 Substances for which BLW can be derived:

- Acrylamide [79-06-1]
- Aniline [62-53-3]
- ★ Arsenic [7440-38-2] and inorganic arsenic compounds apart from arsine
- Bisphenol A (4,4'-Isopropylidenediphenol) [80-05-7]
- Cobalt [7440-48-4] and cobalt compounds
- Di(2-ethylhexyl)phthalate (DEHP) [117-81-7]
- Methyl bromide [74-83-9]
- 4,4'-Methylene diphenyl diisocyanate (MDI) [101-68-8] (inhalable fraction)
- Nitrobenzene [98-95-3]
- Phenol [108-95-2]

### 2 For the substances listed below, there is at present insufficient data for the derivation of a BLW; however, documentation for these substances has been published in “The MAK-Collection for Occupational Health and Safety”<sup>52)</sup>:

- 4-Aminobiphenyl [92-67-1]
- Cadmium [7440-43-9] and its inorganic compounds
- Cresol (all isomers) [1319-77-3]: o-cresol [95-48-7], m-cresol [108-39-4], p-cresol [106-44-5]
- 4,4'-Diaminodiphenylmethane [101-77-9]
- ★ Indium [7440-74-6] and its inorganic compounds
- 1,5-Naphthylene diisocyanate [3173-72-6]
- Nitroglycerin [55-63-0]

<sup>52)</sup> available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## ★ XV Biological Reference Values (BAR)

The BAR (“biological reference value”) represents the internal exposure to a substance at a particular time of a reference population of persons of working age who are not occupationally exposed to this substance (background exposure). This background exposure may (also) have an endogenous cause.

The reference level for a substance or its metabolite in biological material is derived with the help of the measured level in a random sample from a defined population group. The BAR is based on the 95<sup>th</sup> percentile without regarding effects on health. It must be taken into account that the reference level of the background exposure can be influenced by such factors as age, sex, social status, residential environment, life style and geographical region. For substances which occur also in tobacco smoke, the BAR is generally derived only for non-smokers.

Occupational exposure can be assessed by comparing biomonitoring values in occupationally exposed persons with the BAR, provided the sampling time is observed.

### 1 Substances for which a BAR can be derived:

Acetone [67-64-1]

Acrolein (2-Propenal) [107-02-8]

Acrylamide [79-06-1]

Acrylonitrile [107-13-1]

Aluminium [7429-90-5]

4-Aminobiphenyl [92-67-1]

Antimony [7440-36-0] and its inorganic compounds including stibine [7803-52-3]

Arsenic [7440-38-2] and inorganic arsenic compounds apart from arsine

Barium compounds (soluble) (as Ba [7440-39-3])

Benzene [71-43-2]

Beryllium [7440-41-7] and its inorganic compounds

Bisphenol S [80-09-1]

1,3-Butadiene [106-99-0]

### ★ Butylated hydroxytoluene (BHT) [128-37-0]

Cadmium [7440-43-9] and its inorganic compounds

Chlorinated biphenyls [53469-21-9]

Chloroprene (2-Chloro-1,3-butadiene) [126-99-8]

Chromium [7440-47-3] and its compounds

Cobalt [7440-48-4] and cobalt compounds

4,4'-Diaminodiphenylmethane [101-77-9]

1,4-Dichlorobenzene [106-46-7]

1,2-Epoxypropane (1,2-Propylene oxide) [75-56-9]

Ethylene oxide [75-21-8]

Glycidol [556-52-5]

Lead [7439-92-1] and its inorganic compounds (except lead arsenate and lead chromate)

Lithium [7439-93-2]

Manganese [7439-96-5] and its inorganic compounds

4,4'-Methylenebis(2-chloroaniline) (MOCA) [101-14-4]

Molybdenum [7439-98-7] and its compounds

Naphthalene [91-20-3]

- Nickel [7440-02-0] and its compounds
- Polycyclic aromatic hydrocarbons (PAH)
- Selenium [7782-49-2] and its inorganic compounds
- o-Toluidine [95-53-4]
- Tributyl phosphate [126-73-8]
- Trichloroethene [79-01-6]
- 2,4,6-Trinitrotoluene [118-96-7] (and isomers in technical mixtures)
- ★ Vanadium [7440-62-2] and its inorganic compounds
- ★ Vinyl chloride [75-01-4]

2 For the substances listed below, there is at present insufficient data for the derivation of a BAR; however, documentation for these substances has been published in “The MAK-Collection for Occupational Health and Safety”<sup>53</sup>):

- Benzidine [92-87-5]
- Copper [7440-50-8] and its inorganic compounds
- 1,2-Dichloropropane [78-87-5]
- Gadolinium [7440-54-2]
- ★ Indium [7440-74-6] and its inorganic compounds
- Iodine [7553-56-2] and inorganic iodides
- 2-Naphthylamine [91-59-8]
- 2,4-Toluenediamine (2,4-TDA) [95-80-7]
- 2,4-Toluene diisocyanate [584-84-9]
- Tricresyl phosphate, sum of all o-isomers [78-30-8]
- Uranium [7440-61-1] and its hardly soluble inorganic compounds
- Uranium compounds, soluble inorganic

<sup>53</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

★ XVI Carcinogenic substances

For chemical substances which, by their own action or by that of their reactive intermediates or metabolites, are known to cause cancer in man or for which there is good evidence of a human cancer risk (Carcinogen categories 1 and 2) or which cause concern because they are or could be carcinogenic (Carcinogen category 3) and for which no MAK value can be derived, also no BAT values are derived. Therefore, the handling of such substances must take place under the conditions described in Section III of the List of MAK and BAT Values. For substances in Carcinogen categories 3, 4 and 5, BAT values are derived, if there are sufficient data. For carcinogenic substances and suspected carcinogens for which there are insufficient data for the derivation of a BAT value or the conditions for deriving a BAT value are not fulfilled, a BLW can be established.

In order to be able to evaluate internal exposure in the case of carcinogenic substances, the Commission investigates the relationships between the concentration of the carcinogen in the workplace air and that of the substance or its metabolites in biological material (“Expositionsäquivalente für krebserzeugende Arbeitsstoffe”, EKA: exposure equivalents for carcinogenic substances). From these relationships, the expected internal exposure which results from uptake of the substance exclusively by inhalation may be determined.

1 Carcinogenic substances and suspected carcinogens for which correlations (“exposure equivalents for carcinogenic substances”, EKA) can be evaluated:

*(printed in italics: Equivalent Values according to ERB (=exposure-risk relationships as defined in “Risk-related concept of measures for activities involving carcinogenic hazardous substances (TRGS 910)”)*

**Acrylamide [79-06-1] H**

Air Acrylamide [mg/m <sup>3</sup> ]	Sampling time: after exposure for at least 3 months  Erythrocyte fraction of whole blood N-(2-Carbonamideethyl)valine [pmol/g globin]
0.035	200
<i>0.07</i>	<i>400</i>
0.10	550
<i>0.15</i>	<i>800</i>
0.30	1600

**Acrylonitrile [107-13-1] H**

Air Acrylonitrile [ml/m <sup>3</sup> ]      [mg/m <sup>3</sup> ]		Sampling time: after exposure for at least 3 months  Erythrocyte fraction of whole blood N-(2-Cyanoethyl)valine [pmol/g globin]
0.12	0.26	650
0.23	0.5	1400
0.45	1	2450
1.2	2.6	6500
3	7	17000

**Alkali chromates (Cr(VI))**

**H** (the chromates of barium, lead, strontium and zinc are not designated with “H”)

Air CrO <sub>3</sub> [mg/m <sup>3</sup> ]	Sampling time: end of shift, for long-term exposures after several previous shifts  Erythrocyte fraction of whole blood <sup>a)</sup> Chromium [µg/l whole blood]	Sampling time: end of exposure or end of shift  Urine <sup>b)</sup> Chromium [µg/l]
0.03	9	12
0.05	17	20
0.08	25	30
0.10	35	40

<sup>a)</sup> not applicable for exposure to welding fumes  
<sup>b)</sup> also applicable for exposure to welding fumes

**★ Arsenic [7440-38-2] and inorganic arsenic compounds (apart from arsine)**

**H** (metallic arsenic and gallium arsenide are not designated with “H”)

Air Arsenic and inorganic arsenic compounds (apart from arsine) [µg/m <sup>3</sup> ] <sup>a)</sup>	Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts  Urine Σ Arsenic(+III), arsenic(+V), monomethylarsonic acid  [µg/l]
0.5	2.0
0.8	2.5
1	3.0
5	8.0
8.3	11.0
10	13.0
50	36.0
100	57.0

<sup>a)</sup> determined in the inhalable fraction



**Benzene [71-43-2] H**

Air Benzene		Sampling time: end of exposure or end of shift		
		S-Phenyl- mercapturic acid <sup>a)</sup> [µg/g creatinine]	Urine trans, trans- Muconic acid [µg/g creatinine]	Benzene [µg/l]
[ml/m <sup>3</sup> ]	[mg/m <sup>3</sup> ]			
0.03	0.1	1.5 <sup>b)</sup>	–	0.5 <sup>b)</sup>
0.06	0.2	3 <sup>b)</sup>	–	0.8 <sup>b)</sup>
0.15	0.5	5	–	1.5
0.3	1.0	12	300	2.75
0.6	2.0	25	500	5.0
1.0	3.3	45	750	7.5
2.0	6.5	90	1200	12.5

a) N-Acetyl-S-phenylcysteine  
b) evaluated for non-smokers

**1-Bromopropane [106-94-5] H**

Air 1-Bromopropane		Sampling time: end of shift, for long-term exposures after several previous shifts	
		Urine S-(n-Propyl)mercapturic acid <sup>a)</sup> [mg/g creatinine]	
[ml/m <sup>3</sup> ]	[mg/m <sup>3</sup> ]		
1	5	2.0	
2	10	3.4	
5	25	7.0	
10	50	12.0	
20	101	20.0	

a) N-Acetyl-S-n-propylcysteine

**1,3-Butadiene [106-99-0]**

Air 1,3-Butadiene		Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts	
		S-(3,4-Dihydroxybutyl)- mercapturic acid <sup>a)</sup> [µg/g creatinine]	Urine S-(2-Hydroxy-3-butenyl)- mercapturic acid <sup>b)</sup> [µg/g creatinine]
[ml/m <sup>3</sup> ]	[mg/m <sup>3</sup> ]		
0.2	0.45	600	10
0.5	1.1	1000	20
1	2.3	1600	40
2	4.5	2900	80
3	6.8	4200	120

a) N-Acetyl-S-(3,4-dihydroxybutyl)cysteine  
b) N-Acetyl-S-(2-hydroxy-3-butenyl)cysteine

**1-Chloro-2,3-epoxypropane (Epichlorohydrin) [106-89-8] H**

Air 1-Chloro-2,3-epoxypropane [ml/m <sup>3</sup> ]		[mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts	Urine S-(3-Chloro-2-hydroxypropyl)mercapturic acid <sup>a)</sup> [mg/g creatinine]
0.06	0.23				0.80
0.13	0.5				1.75
0.26	1				3.5
0.6	2.3				8
2	8				28

<sup>a)</sup> N-Acetyl-S-(3-chloro-2-hydroxypropyl)cysteine

**Cobalt [7440-48-4] and cobalt compounds H**

Air Cobalt [mg/m <sup>3</sup> ]	Sampling time: end of shift, for long-term exposures after several previous shifts	Urine Cobalt [µg/l]
0.005		3
0.010		6
0.025		15
0.050		30
0.100		60
0.500		300

**Cyclohexanone [108-94-1] H**

Air Cyclohexanone [ml/m <sup>3</sup> ]		[mg/m <sup>3</sup> ]		Sampling time: end of shift, for long-term exposures after several previous shifts	Urine 1,2-Cyclohexanediol (after hydrolysis) [mg/l]	Sampling time: end of exposure or end of shift	Urine Cyclohexanol (after hydrolysis) [mg/l]
10	40				50		6
20	80				100		12
50	200				250		30

**1,4-Dichlorobenzene [106-46-7] H**

Air 1,4-Dichlorobenzene [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts  Urine 2,5-Dichlorophenol (after hydrolysis) [mg/l]
2	12	10
5	30.5	20
10	61	30
20	122	60
30	183	90

**Dichloromethane [75-09-2] H**

Air Dichloromethane [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]		Sampling time: during exposure, at least 2 hours after beginning of exposure  Whole blood Dichloromethane [mg/l]
10	35	0.1
20	70	0.2
50	175	0.5
100	350	1

**Dimethyl sulfate [77-78-1] H**

Air Dimethyl sulfate [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]		Sampling time: after exposure for at least 3 months  Erythrocyte fraction of whole blood N-Methylvaline [µg/l whole blood]
0.002	0.01	10
0.006	0.03	13
0.01	0.05	17
0.04	0.20	40

**1,2-Epoxypropane [75-56-9]**

Air 1,2-Epoxypropane [ml/m <sup>3</sup> ]      [mg/m <sup>3</sup> ]		Sampling time: after exposure for at least 3 months  Erythrocyte fraction of whole blood N-(2-Hydroxypropyl)valine [pmol/g globin]
0.5	1.2	600
1.0	2.4	1300
2.0	4.8	2600
2.5	6.0	3200

**Ethylbenzene [100-41-4] H**

Air Ethylbenzene [ml/m <sup>3</sup> ]      [mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift  Urine Mandelic acid plus phenyl glyoxylic acid [mg/g creatinine]
10	44	130
20	88	250
25	110	330
50	220	670
100	440	1300

**Ethylene oxide [75-21-8] H**

Air Ethylene oxide [ml/m <sup>3</sup> ]      [mg/m <sup>3</sup> ]		Sampling time: after exposure for at least 3 months  Erythrocyte fraction of whole blood Hydroxyethylvaline [µg/l]
0.5	0.92	45
1	1.83	90
2	3.66	180

**Hydrazine [302-01-2] H**

Air Hydrazine [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift	
		Urine Hydrazine [µg/g creatinine]	Plasma Hydrazine [µg/l]
0.01	0.013	35	27
0.017	0.022	62	47
0.02	0.026	70	55
0.025	0.033	95	77
0.05	0.065	200	160
0.08	0.104	300	270
0.10	0.130	380	340

**Naphthalene [91-20-3] H**

Air Naphthalene [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts		
		1,2-Dihydroxy- naphthalene (after hydrolysis) [µg/l]	Urine S-(1-Naphthyl)- mercapturic acid <sup>a)</sup> [µg/l]	(1+2)-Naphthol (after hydrolysis) [µg/l]
0.2	1	— <sup>b)</sup>	30	220
0.4	2	4000	60	500
0.9	5	13500	175	1500
1.4	7.5	23300	280	2300
1.9	10	34200	390	3300

<sup>a)</sup> N-Acetyl-S-(1-naphthyl)cysteine  
<sup>b)</sup> Extrapolation is not possible due to the high variation of individual values in this concentration range.

**Nickel [7440-02-0] (nickel metal, nickel oxide, nickel carbonate, nickel sulfide, sulfidic ores)**

Air Nickel [mg/m <sup>3</sup> ]	Sampling time: end of shift, for long-term exposures after several previous shifts
	Urine Nickel [µg/l]
0.10	15
0.30	30
0.50	45

**Polycyclic aromatic hydrocarbons (PAH) H**

Air Benzo[a]pyrene [ $\mu\text{g}/\text{m}^3$ ]	Sampling time: at the beginning of the next shift  Urine 3-Hydroxybenzo[a]pyrene (after hydrolysis) [ng/g creatinine]
0.07	0.7
0.35	2
0.7	3.5
1.0	5
1.5	7

**Tetrachloroethylene [127-18-4] H**

Air Tetrachloroethylene [ml/m <sup>3</sup> ] [mg/m <sup>3</sup> ]	Sampling time: 16 hours after end of exposure  Whole blood Tetrachloroethylene [ $\mu\text{g}/\text{l}$ ]
3      21	60
10     69	200
20     138	400
30     206	600
50     344	1000

**Toluene-2,4-diamine [95-80-7] H**

Air Toluene-2,4-diamine [mg/m <sup>3</sup> ]	Sampling time: end of exposure or end of shift  Urine Toluene-2,4-diamine (after hydrolysis) [ $\mu\text{g}/\text{g}$ creatinine]
0.0025	6
0.01	13
0.017	20
0.035	37
0.100 <sup>a)</sup>	100 <sup>a)</sup>

<sup>a)</sup> values obtained by extrapolation

**Trichloroethylene [79-01-6] H**

Air Trichloroethylene [ml/m <sup>3</sup> ]      [mg/m <sup>3</sup> ]		Sampling time: end of exposure or end of shift; end of shift, for long-term exposures after several previous shifts	Urine Trichloroacetic acid [mg/l]
0.6	3.3		1.2
6	33		12
10	55		20
11	60		22
15	82		30
20	109		40
25	137		50

2 Carcinogenic substances and suspected carcinogens for which correlations (“exposure equivalents for carcinogenic materials”, EKA) cannot be evaluated, or only evaluated incompletely, but which are documented in “The MAK-Collection for Occupational Health and Safety”<sup>54</sup>):

4-Aminobiphenyl [92-67-1]

Antimony [7440-36-0] and its inorganic compounds including stibine [7803-52-3]

Benzidine [92-87-5]

Beryllium [7440-41-7] and its inorganic compounds

Ethylene [74-85-1]

Mercury, organic compounds

Methyl bromide [74-83-9]

2-Naphthylamine [91-59-8]

Nickel (easily soluble nickel compounds, e. g. nickel acetate and similar soluble salts, nickel chloride, nickel sulfate)

Pentachlorophenol [87-86-5]

★ Vanadium [7440-62-2] and its inorganic compounds

Vinyl chloride [75-01-4]

<sup>54</sup>) available online under <https://mak-dfg.publisso.de> or <https://onlinelibrary.wiley.com/doi/book/10.1002/3527600418> (up to 2019)

## CAS Number Index

CAS numbers of the substances listed in Sections II to XVI and on the announcement list

CAS number	Substance
50-00-0	Formaldehyde
50-29-3	DDT (Dichlorodiphenyltrichloroethane)
50-32-8	Benzo[a]pyrene
50-53-3	Chlorpromazine (2-Chloro-10-(3-dimethylaminopropyl)phenothiazine)
51-75-2	N-Methyl-bis(2-chloroethyl)amine (nitrogen mustard)
51-79-6	Carbamic acid ethyl ester
52-51-7	2-Bromo-2-nitro-1,3-propanediol
53-70-3	Dibenzo[a,h]anthracene
54-11-5	Nicotine
54-64-8	Thimerosal
55-18-5	N-Nitrosodiethylamine
55-38-9	Fenthion
55-63-0	Nitroglycerin
56-23-5	Tetrachloromethane
56-38-2	Parathion
56-55-3	Benzo[a]anthracene
56-81-5	Glycerol
57-10-3	Palmitic acid
57-11-4	Stearic acid
57-12-5	Cyanides
57-14-7	1,1-Dimethylhydrazine
57-24-9	Strychnine
57-55-6	Propylene glycol
57-57-8	$\beta$ -Propiolactone
57-74-9	Chlordane
58-89-9	Lindane ( $\gamma$ -1,2,3,4,5,6-Hexachlorocyclohexane)
59-50-7	p-Chloro-m-cresol
59-89-2	N-Nitrosomorpholine
60-00-4	Ethylenediaminetetraacetic acid (EDTA)
60-09-3	p-Aminoazobenzene
60-12-8	2-Phenyl-1-ethanol
60-29-7	Ethyl ether
60-34-4	Monomethylhydrazine
60-35-5	Acetamide
60-57-1	Dieldrin
61-82-5	Amitrole
62-23-7	4-Nitrobenzoic acid
62-53-3	Aniline
62-56-6	Thiourea
62-73-7	Dichlorvos
62-74-8	Sodium fluoroacetate
62-75-9	N-Nitrosodimethylamine
63-25-2	Carbaryl (1-Naphthyl methylcarbamate)
64-17-5	Ethanol
64-18-6	Formic acid
64-19-7	Acetic acid
64-67-5	Diethyl sulfate
65-85-0	Benzoic acid
67-56-1	Methanol
67-63-0	2-Propanol
67-64-1	Acetone



CAS number	Substance
67-66-3	Chloroform (Trichloromethane)
67-68-5	Dimethyl sulfoxide
67-72-1	Hexachloroethane
68-11-1	Thioglycolic acid
68-12-2	N,N-Dimethylformamide
71-36-3	1-Butanol
71-41-0	Pentanol (isomers): 1-Pentanol
71-43-2	Benzene
71-55-6	1,1,1-Trichloroethane
72-20-8	Endrin
72-43-5	Methoxychlor (DMDT)
74-11-3	Chlorobenzoic acid (all isomers): p-Chlorobenzoic acid
74-31-7	N,N-Diphenyl-p-phenylenediamine
74-83-9	Methyl bromide
74-85-1	Ethylene
74-87-3	Chloromethane
74-88-4	Iodomethane
74-89-5	Methylamine
74-90-8	Hydrogen cyanide
74-93-1	Methanethiol
74-96-4	Bromoethane
74-97-5	Bromochloromethane
74-98-6	Propane
74-99-7	Methyl acetylene
75-00-3	Chloroethane
75-01-4	Vinyl chloride
75-04-7	Ethylamine
75-05-8	Acetonitrile
75-07-0	Acetaldehyde
75-08-1	Ethanethiol
75-09-2	Dichloromethane
75-12-7	Formamide
75-15-0	Carbon disulfide
75-18-3	Dimethyl sulfide
75-21-8	Ethylene oxide
75-25-2	Tribromomethane
75-27-4	Bromodichloromethane
75-28-5	Butane (both isomers): Isobutane
75-31-0	Isopropylamine
75-34-3	1,1-Dichloroethane
75-35-4	Vinylidene chloride
75-38-7	1,1-Difluoroethylene
75-43-4	Dichlorofluoromethane (FC-21)
75-44-5	Phosgene
75-45-6	Chlorodifluoromethane (FC-22)
75-50-3	Trimethylamine
75-52-5	Nitromethane
75-55-8	Propylene imine
75-56-9	1,2-Epoxypropane
75-61-6	Dibromodifluoromethane
75-63-8	Bromotrifluoromethane
75-64-9	tert-Butylamine
75-65-0	tert-Butanol
75-66-1	2-Methyl-2-propanethiol
75-68-3	1-Chloro-1,1-difluoroethane (FC-142b)
75-69-4	Trichlorofluoromethane (FC-11)

CAS number	Substance
75-71-8	Dichlorodifluoromethane (FC-12)
75-72-9	Chlorotrifluoromethane (FC-13)
75-74-1	Tetramethyllead
75-83-2	Hexane (all isomers except n-Hexane) and Methylcyclopentane: 2,2-Dimethylbutane
75-84-3	Pentanol (isomers): 2,2-Dimethyl-1-propanol
75-85-4	Pentanol (isomers): 2-Methyl-2-butanol
75-91-2	tert-Butyl hydroperoxide
75-99-0	2,2-Dichloropropionic acid
76-01-7	Pentachloroethane
76-03-9	Trichloroacetic acid
76-06-2	Chloropicrin
76-11-9	1,1,1,2-Tetrachloro-2,2-difluoroethane (FC-112a)
76-12-0	1,1,2,2-Tetrachloro-1,2-difluoroethane (FC-112)
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane (FC-113)
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (FC-114)
76-22-2	Camphor
76-44-8	Heptachlor
77-47-4	Hexachlorocyclopentadiene
77-73-6	Dicyclopentadiene
77-78-1	Dimethyl sulfate
77-92-9	Citric acid
78-00-2	Tetraethyllead
78-10-4	Silicic acid tetraethyl ester
78-18-2	1-Hydroxy-1'-hydroperoxydicyclohexyl peroxide
78-30-8	Tricresyl phosphate, sum of all o-isomers
78-32-0	Tricresyl phosphate, isomers, "free of o-isomers"
78-59-1	Isophorone
78-78-4	Pentane (all isomers): Isopentane
78-79-5	Isoprene (2-Methyl-1,3-butadiene)
78-81-9	Isobutylamine
78-83-1	Isobutanol
78-87-5	1,2-Dichloropropane
78-92-2	2-Butanol
78-93-3	2-Butanone
78-94-4	Methyl vinyl ketone
78-96-6	1-Amino-2-propanol
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethene
79-04-9	Chloroacetyl chloride
79-06-1	Acrylamide
79-07-2	2-Chloroacetamide
79-09-4	Propionic acid
79-10-7	Acrylic acid
79-11-8	Monochloroacetic acid
79-20-9	Methyl acetate
79-21-0	Peracetic acid
79-22-1	Chloroformic acid methyl ester
79-24-3	Nitroethane
79-27-6	1,1,2,2-Tetrabromoethane
79-29-8	Hexane (all isomers except n-Hexane) and Methylcyclopentane: 2,3-Dimethylbutane
79-34-5	1,1,2,2-Tetrachloroethane
79-41-4	Methacrylic acid
79-43-6	Dichloroacetic acid
79-44-7	Dimethylcarbamoyl chloride
79-46-9	2-Nitropropane
79-94-7	Tetrabromobisphenol A

CAS number	Substance
80-05-7	Bisphenol A
80-09-1	Bisphenol S
80-15-9	$\alpha,\alpha$ -Dimethylbenzyl hydroperoxide
80-62-6	Methacrylic acid methyl ester
81-81-2	Warfarin
81-84-5	1,8-Naphthalic anhydride
83-79-4	Rotenone
84-74-2	Di-n-butyl phthalate
85-01-8	Phenanthrene
85-42-7	Hexahydrophthalic anhydride
85-44-9	Phthalic anhydride
85-68-7	Benzylbutyl phthalate
86-30-6	N-Nitrosodiphenylamine
86-50-0	Azinphos-methyl
86-57-7	1-Nitronaphthalene
86-88-4	1-Naphthylthiourea
87-59-2	Xylidine: 2,3-Xylidine
87-61-6	1,2,3-Trichlorobenzene
87-62-7	2,6-Xylidine
87-68-3	Hexachloro-1,3-butadiene
87-69-4	Tartaric acid
87-86-5	Pentachlorophenol
88-10-8	Diethylcarbamoyl chloride
88-12-0	N-Vinyl-2-pyrrolidone
88-72-2	2-Nitrotoluene
88-73-3	o-Chloronitrobenzene
88-88-0	Picryl chloride
88-89-1	Picric acid
88-99-3	o-Phthalic acid
90-04-0	o-Anisidine
90-30-2	N-Phenyl-1-naphthylamine
90-43-7	o-Phenylphenol
90-66-4	2,2'-Thiobis(4-methyl-6-tert-butylphenol)
90-94-8	Michler's ketone
91-08-7	Toluene diisocyanates: 2,6-Toluene diisocyanate
91-17-8	Decahydronaphthalene
91-20-3	Naphthalene
91-23-6	2-Nitroanisole
91-29-2	4-Nitro-4'-aminodiphenylamine-2-sulfonic acid
91-59-8	2-Naphthylamine
91-94-1	3,3'-Dichlorobenzidine
91-95-2	3,3'-Diaminobenzidine and its tetrahydrochloride
92-52-4	Biphenyl
92-67-1	4-Aminobiphenyl
92-70-6	3-Hydroxy-2-naphthalenecarboxylic acid
92-84-2	Phenothiazine
92-87-5	Benzidine
92-93-3	4-Nitrobiphenyl
93-76-5	2,4,5-Trichlorophenoxyacetic acid
94-36-0	Dibenzoyl peroxide
94-37-1	Dipentamethylenethiuram disulfide
94-75-7	2,4-Dichlorophenoxyacetic acid
94-96-2	2-Ethyl-1,3-hexanediol
95-14-7	Benzotriazole
95-33-0	N-Cyclohexyl-2-benzothiazolesulfenamide
95-48-7	Cresol (all isomers): o-Cresol

CAS number	Substance
95-50-1	1,2-Dichlorobenzene
95-51-2	o-Chloroaniline
95-53-4	o-Toluidine
95-54-5	o-Phenylenediamine
95-63-6	Trimethylbenzene (all isomers): 1,2,4-Trimethylbenzene
95-64-7	Xylidine: 3,4-Xylidine
95-68-1	2,4-Xylidine
95-69-2	4-Chloro-o-toluidine
95-70-5	2,5-Toluenediamine
95-76-1	3,4-Dichloroaniline
95-78-3	Xylidine: 2,5-Xylidine
95-79-4	5-Chloro-o-toluidine
95-80-7	2,4-Toluenediamine
95-95-4	2,4,5-Trichlorophenol
96-12-8	1,2-Dibromo-3-chloropropane
96-14-0	Hexane (all isomers except n-Hexane) and Methylcyclopentane: 3-Methylpentane
96-18-4	1,2,3-Trichloropropane
96-20-8	2-Aminobutanol
96-23-1	1,3-Dichloro-2-propanol
96-24-2	3-Chloro-1,2-propanediol ( $\alpha$ -Chlorohydrin)
96-29-7	Butanone oxime
96-33-3	Methyl acrylate
96-34-4	Chloroacetic acid methyl ester
96-37-7	Hexane (all isomers except n-Hexane) and Methylcyclopentane: Methylcyclopentane
96-45-7	Ethylene thiourea (Imidazoline-2-thione)
96-48-0	$\gamma$ -Butyrolactone
97-00-7	1-Chloro-2,4-dinitrobenzene
97-18-7	Bithionol
97-53-0	Eugenol
97-54-1	Isoeugenol
97-56-3	o-Aminoazotoluene
97-63-2	Methacrylic acid ethyl ester
97-77-8	Disulfiram
97-88-1	n-Butyl methacrylate
97-90-5	Ethylene glycol dimethacrylate
98-00-0	Furfuryl alcohol
98-01-1	Furfural
98-07-7	Benzyl trichloride
98-29-3	p-tert-Butylcatechol
98-51-1	p-tert-Butyl toluene
98-54-4	p-tert-Butylphenol
98-73-7	p-tert-Butylbenzoic acid
98-82-8	Isopropylbenzene (cumene)
98-83-9	$\alpha$ -Methyl styrene
98-87-3	Benzyl dichloride
98-88-4	Benzoyl chloride
98-95-3	Nitrobenzene
99-08-1	3-Nitrotoluene
99-54-7	3,4-Dichloronitrobenzene
99-55-8	5-Nitro-o-toluidine
99-65-0	Dinitrobenzene (all isomers): 1,3-Dinitrobenzene
99-97-8	N,N-Dimethyl-p-toluidine
99-99-0	4-Nitrotoluene
100-00-5	p-Chloronitrobenzene
100-01-6	4-Nitroaniline
100-21-0	p-Phthalic acid

CAS number	Substance
100-25-4	Dinitrobenzene (all isomers): 1,4-Dinitrobenzene
100-37-8	2-Diethylaminoethanol
100-40-3	4-Vinylcyclohexene
100-41-4	Ethylbenzene
100-42-5	Styrene
100-44-7	Benzyl chloride
100-51-6	Benzyl alcohol
100-52-7	Benzaldehyde
100-61-8	N-Methylaniline
100-63-0	Phenylhydrazine
100-74-3	N-Ethylmorpholine
100-75-4	N-Nitrosopiperidine
100-97-0	Hexamethylenetetramine
101-14-4	4,4'-Methylenebis(2-chloroaniline) (MOCA)
101-54-2	4-Aminodiphenylamine
101-61-1	4,4'-Methylenebis(N,N-dimethylaniline)
101-67-7	4,4'-Dioctyldiphenylamine
101-68-8	4,4'-Methylene diphenyl diisocyanate (MDI)
101-72-4	N-Isopropyl-N'-phenyl-p-phenylenediamine
101-77-9	4,4'-Diaminodiphenylmethane
101-80-4	4,4'-Oxydianiline
101-83-7	Dicyclohexylamine
101-84-8	Diphenyl ether
101-87-1	N-Cyclohexyl-N'-phenyl-p-phenylenediamine
101-90-6	Diglycidyl resorcinol ether
102-71-6	Triethanolamine
102-77-2	2-(4-Morpholinylmercapto)benzothiazole
102-82-9	Tri-n-butylamine
103-09-3	2-Ethylhexyl acetate
103-11-7	Acrylic acid 2-ethylhexyl ester
103-71-9	Phenyl isocyanate
104-12-1	4-Chlorophenyl isocyanate
104-51-8	n-Butylbenzene
104-54-1	Cinnamyl alcohol
104-55-2	Cinnamaldehyde
104-76-7	2-Ethylhexanol
104-91-6	4-Nitrosophenol
104-94-9	p-Anisidine
105-46-4	sec-Butyl acetate
105-59-9	Methyldiethanolamine
105-60-2	$\epsilon$ -Caprolactam
105-74-8	Dilauroyl peroxide
106-14-9	12-Hydroxystearic acid
106-24-1	Geraniol
106-35-4	3-Heptanone
106-44-5	Cresol (all isomers): p-Cresol
106-46-7	1,4-Dichlorobenzene
106-47-8	p-Chloroaniline
106-49-0	p-Toluidine
106-50-3	p-Phenylenediamine
106-51-4	Quinone
106-65-0	Dimethyl succinate
106-87-6	4-Vinyl-1-cyclohexene dioxide
106-88-7	1,2-Butylene oxide
106-89-8	1-Chloro-2,3-epoxypropane
106-91-2	Glycidyl methacrylate

CAS number	Substance
106-92-3	Allyl glycidyl ether
106-93-4	1,2-Dibromoethane
106-94-5	1-Bromopropane
106-97-8	Butane (both isomers): n-Butane
106-99-0	1,3-Butadiene
107-02-8	Acrolein
107-05-1	Allyl chloride
107-06-2	1,2-Dichloroethane
107-07-3	2-Chloroethanol
107-13-1	Acrylonitrile
107-15-3	Ethylenediamine
107-18-6	Allyl alcohol
107-19-7	Propargyl alcohol
107-20-0	Chloroacetaldehyde
107-21-1	Ethylene glycol
107-22-2	Glyoxal
107-25-5	Methyl vinyl ether
107-30-2	Monochlorodimethyl ether
107-31-3	Formic acid methyl ester
107-41-5	Hexylene glycol
107-49-3	TEPP
107-66-4	Di-n-butyl phosphate
107-71-1	tert-Butyl peracetate
107-75-5	Hydroxycitronellal
107-83-5	Hexane (all isomers except n-Hexane) and Methylcyclopentane: 2-Methylpentane
107-87-9	2-Pentanone
107-98-2	1-Methoxy-2-propanol
108-03-2	1-Nitropropane
108-05-4	Vinyl acetate
108-10-1	4-Methyl-2-pentanone
108-11-2	4-Methyl-2-pentanol
108-20-3	Isopropyl ether
108-21-4	Propylacetate: Isopropyl acetate
108-22-5	Isopropenyl acetate
108-24-7	Acetic anhydride
108-31-6	Maleic anhydride
108-32-7	4-Methyl-1,3-dioxolan-2-one
108-39-4	Cresol (all isomers): m-Cresol
108-42-9	m-Chloroaniline
108-45-2	m-Phenylenediamine
108-46-3	Resorcinol
108-65-6	1-Methoxypropyl-2-acetate
108-67-8	Trimethylbenzene (all isomers): 1,3,5-Trimethylbenzene
108-69-0	Xylidine: 3,5-Xylidine
108-70-3	1,3,5-Trichlorobenzene
108-77-0	Cyanuric chloride
108-83-8	Diisobutyl ketone
108-84-9	sec-Hexyl acetate
108-87-2	Methylcyclohexane
108-88-3	Toluene
108-90-7	Chlorobenzene
108-91-8	Cyclohexylamine
108-93-0	Cyclohexanol
108-94-1	Cyclohexanone
108-95-2	Phenol
109-16-0	Triethylene glycol dimethacrylate

CAS number	Substance
109-17-1	Tetraethylene glycol dimethacrylate
109-53-5	Isobutyl vinyl ether
109-59-1	2-Isopropoxyethanol
109-60-4	Propylacetate: n-Propyl acetate
109-66-0	Pentane (all isomers): n-Pentane
109-73-9	n-Butylamine
109-79-5	1-Butanethiol
109-86-4	2-Methoxyethanol
109-87-5	Dimethoxymethane
109-89-7	Diethylamine
109-92-2	Ethyl vinyl ether
109-94-4	Formic acid ethyl ester
109-99-9	Tetrahydrofuran
110-00-9	Furan
110-01-0	Tetrahydrothiophene (THT)
110-05-4	Di-tert-butyl peroxide
110-12-3	Methyl-2-hexanone
110-15-6	Succinic acid
110-19-0	Isobutyl acetate
110-22-5	Diacetyl peroxide
110-25-8	Oleyl sarcosine
110-49-6	2-Methoxyethyl acetate
110-54-3	n-Hexane
110-65-6	Butynediol
110-80-5	2-Ethoxyethanol
110-82-7	Cyclohexane
110-83-8	Cyclohexene
110-85-0	Piperazine
110-86-1	Pyridine
110-91-8	Morpholine
110-94-1	Glutaric acid
111-15-9	2-Ethoxyethyl acetate
111-20-6	Sebacic acid
111-27-3	1-Hexanol
111-30-8	Glutaraldehyde
111-40-0	Diethylenetriamine
111-42-2	Diethanolamine
111-44-4	2,2'-Dichlorodiethyl ether
111-46-6	Diethylene glycol
111-76-2	2-Butoxyethanol
111-77-3	Diethylene glycol monomethyl ether (Announcement list)
111-87-5	1-Octanol
111-90-0	Diethylene glycol monoethyl ether
111-96-6	Diethylene glycol dimethyl ether
112-07-2	2-Butoxyethyl acetate
112-24-3	Triethylenetetramine
112-27-6	Triethylene glycol
112-30-1	1-Decanol
112-34-5	Diethylene glycol monobutyl ether
112-35-6	Triethylene glycol monomethyl ether
112-53-8	1-Dodecanol
112-72-1	1-Tetradecanol
112-80-1	Oleic acid
112-85-6	Behenic acid
112-92-5	1-Octadecanol
114-26-1	Propoxur

CAS number	Substance
115-10-6	Dimethyl ether
115-70-8	2-Amino-2-ethyl-1,3-propanediol
115-86-6	Triphenyl phosphate
116-14-3	Tetrafluoroethene
117-81-7	Di(2-ethylhexyl)phthalate (DEHP)
118-48-9	N-Carboxyanthranilic anhydride
118-74-1	Hexachlorobenzene
118-79-6	2,4,6-Tribromophenol
118-82-1	4,4'-Methylenebis(2,6-di-tert-butylphenol)
118-91-2	Chlorobenzoic acid (all isomers): o-Chlorobenzoic acid
118-96-7	2,4,6-Trinitrotoluene
119-06-2	Ditridecyl phthalate
119-34-6	2-Nitro-4-aminophenol
119-61-9	Benzophenone (Announcement list)
119-64-2	Tetrahydronaphthalene
119-90-4	3,3'-Dimethoxybenzidine
119-93-7	3,3'-Dimethylbenzidine
120-71-8	5-Methyl-o-anisidine
120-78-5	2,2'-Dibenzothiazyl disulfide
120-82-1	1,2,4-Trichlorobenzene
121-44-8	Triethylamine
121-45-9	Trimethylphosphite
121-69-7	N,N-Dimethylaniline
121-73-3	m-Chloronitrobenzene
121-75-5	Malathion
121-91-5	m-Phthalic acid
121-92-6	3-Nitrobenzoic acid
122-39-4	Diphenylamine
122-40-7	$\alpha$ -Amylcinnamaldehyde
122-60-1	Phenyl glycidyl ether (PGE)
122-66-7	Hydrazobenzene
122-99-6	2-Phenoxyethanol
123-30-8	p-Aminophenol
123-31-9	Hydroquinone
123-42-2	Diacetone alcohol
123-51-3	Pentanol (isomers): 3-Methyl-1-butanol
123-54-6	2,4-Pentanedione
123-73-9	Crotonaldehyde
123-75-1	Pyrrolidine
123-77-3	Azodicarbonamide
123-86-4	n-Butyl acetate
123-91-1	1,4-Dioxane
123-92-2	Amyl acetate (all isomers): 3-Methylbutyl acetate
123-99-9	Azelaic acid
124-04-9	Adipic acid
124-17-4	Diethylene glycol monobutyl ether acetate
124-38-9	Carbon dioxide
124-40-3	Dimethylamine
124-68-5	2-Amino-2-methyl-1-propanol
126-11-4	2-Hydroxymethyl-2-nitro-1,3-propanediol
126-71-6	Triisobutyl phosphate
126-73-8	Tributyl phosphate
126-99-8	Chloroprene
127-18-4	Tetrachloroethene
127-19-5	N,N-Dimethylacetamide
127-20-8	2,2-Dichloropropionic acid, sodium salt



CAS number	Substance
128-37-0	Butylated hydroxytoluene (BHT)
128-39-2	2,6-Di-tert-butylphenol
129-00-0	Pyrene
129-16-8	Merbromin
129-79-3	2,4,7-Trinitrofluorenone
131-17-9	Diallyl phthalate
132-27-4	Sodium o-phenylphenol
132-32-1	3-Amino-9-ethylcarbazole
135-01-3	Diethylbenzene: 1,2-Diethylbenzene
135-88-6	N-Phenyl-2-naphthylamine
137-05-3	Methyl 2-cyanoacrylate
137-17-7	2,4,5-Trimethylaniline
137-26-8	Thiram
137-30-4	Ziram
137-32-6	Pentanol (isomers): 2-Methyl-1-butanol
138-86-3	D,L-Limonene
139-13-9	Nitrilotriacetic acid
139-65-1	4,4'-Thiodianiline
140-66-9	4-tert-Octylphenol
140-88-5	Ethyl acrylate
140-95-4	1,3-Bis(hydroxymethyl)urea
141-32-2	n-Butyl acrylate
141-43-5	2-Aminoethanol
141-78-6	Ethyl acetate
141-79-7	4-Methyl-3-penten-2-one
141-97-9	Acetoacetic acid ethyl ester
142-82-5	n-Heptane
143-07-7	Lauric acid
143-22-6	Triethylene glycol n-butyl ether
143-28-2	Oleyl alcohol
143-33-9	Sodium cyanide
143-50-0	Chlordecone
148-18-5	Sodium diethyldithiocarbamate
148-79-8	Thiabendazole
149-30-4	2-Mercaptobenzothiazole
149-57-5	2-Ethylhexanoic acid
150-60-7	Dibenzyl disulfide
151-50-8	Potassium cyanide
151-56-4	Ethylenimine
151-67-7	Halothane
156-62-7	Calcium cyanamide
189-55-9	Dibenzo[a,i]pyrene
189-64-0	Dibenzo[a,h]pyrene
191-26-4	Anthanthrene
191-30-0	Dibenzo[a,l]pyrene
192-65-4	Dibenzo[a,e]pyrene
193-39-5	Indeno[1,2,3-cd]pyrene
205-82-3	Benzo[j]fluoranthene
205-99-2	Benzo[b]fluoranthene
207-08-9	Benzo[k]fluoranthene
218-01-9	Chrysene
239-35-0	Benzo[b]naphtho[2,1-d]thiophene
288-32-4	Imidazole
300-76-5	Naled
302-01-2	Hydrazine
303-47-9	Ochratoxin A

CAS number	Substance
306-83-2	2,2-Dichloro-1,1,1-trifluoroethane (FC-123)
309-00-2	Aldrin
319-84-6	$\alpha$ -Hexachlorocyclohexane
319-85-7	$\beta$ -Hexachlorocyclohexane
333-41-5	Diazinon
334-88-3	Diazomethane
335-67-1	Perfluorooctanoic acid (PFOA)
373-02-4	Nickel and nickel compounds: Nickel acetate
382-21-8	Perfluoroisobutene (Announcement list)
409-21-2	Silicon carbide
420-04-2	Cyanamide
431-03-8	Diacetyl
460-19-5	Oxalonnitrile
461-58-5	Dicyanodiamide
463-51-4	Ketene
463-82-1	Pentane (all isomers): tert-Pentane
470-17-7	Sesquiterpene lactones: Isoalantolactone
477-43-0	Sesquiterpene lactones: Dehydrocostus lactone
479-45-8	N-Methyl-N,2,4,6-tetranitroaniline
492-80-8	Auramine
504-29-0	2-Aminopyridine
505-60-2	Bis( $\beta$ -chloroethyl)sulfide (mustard gas)
506-77-4	Cyanogen chloride
508-59-8	Sesquiterpene lactones: Parthenin
509-14-8	Tetranitromethane
512-56-1	Trimethyl phosphate
513-53-1	2-Butanethiol
513-79-1	Cobalt: Cobalt(II) carbonate
514-10-3	Abietic acid
526-73-8	Trimethylbenzene (all isomers): 1,2,3-Trimethylbenzene
528-29-0	Dinitrobenzene (all isomers): 1,2-Dinitrobenzene
534-52-1	4,6-Dinitro-o-cresol
535-80-8	Chlorobenzoic acid (all isomers): m-Chlorobenzoic acid
538-75-0	Dicyclohexylcarbodiimide
540-59-0	1,2-Dichloroethylene sym
540-73-8	1,2-Dimethylhydrazine
540-88-5	tert-Butyl acetate
541-41-3	Chloroformic acid ethyl ester
541-73-1	1,3-Dichlorobenzene
541-85-5	5-Methyl-3-heptanone
542-75-6	1,3-Dichloropropene
542-88-1	Bischloromethyl ether
542-92-7	Cyclopentadiene
543-27-1	Chloroformic acid butyl ester
544-63-8	Myristic acid
546-43-0	Sesquiterpene lactones: Alantolactone
552-30-7	Trimellitic anhydride
553-21-9	Sesquiterpene lactones: Costunolide
556-52-5	Glycidol
563-04-2	Tricresyl phosphate, isomers, "free of o-isomers"
563-47-3	3-Chloro-2-methylpropene
581-89-5	2-Nitronaphthalene
583-60-8	1-Methylcyclohexan-2-one
584-02-1	Pentanol (isomers): 3-Pentanol
584-84-9	Toluene diisocyanates: 2,4-Toluene diisocyanate
591-27-5	3-Aminophenol

CAS number	Substance
591-78-6	2-Hexanone
592-34-7	Chloroformic acid butyl ester
593-70-4	Chlorofluoromethane (FC-31)
594-27-4	Methyltin compounds: Tetramethyltin
594-42-3	Perchloromethyl mercaptan
594-72-9	1,1-Dichloro-1-nitroethane
597-82-0	Triphenyl monothio phosphate
598-56-1	N,N-Dimethylethylamine
598-75-4	Pentanol (isomers): 3-Methyl-2-butanol
600-14-6	2,3-Pentanedione
600-25-9	1-Chloro-1-nitropropane
601-77-4	N-Nitrosodiisopropylamine
602-87-9	5-Nitroacenaphthene
603-35-0	Triphenylphosphine
612-64-6	N-Nitrosoethylphenylamine
614-00-6	N-Nitrosomethylphenylamine
615-05-4	2,4-Diaminoanisole
620-11-1	Amyl acetate (all isomers): 3-Pentyl acetate
621-64-7	N-Nitrosodi-n-propylamine
624-41-9	Amyl acetate (all isomers): 2-Methylbutyl acetate
624-83-9	Methyl isocyanate
625-16-1	Amyl acetate (all isomers): 1,1-Dimethylpropyl acetate
625-45-6	Methoxyacetic acid
626-38-0	Amyl acetate (all isomers): 1-Methylbutyl acetate
627-13-4	n-Propyl nitrate
627-93-0	Dimethyl adipate
628-63-7	Amyl acetate (all isomers): 1-Pentyl acetate
628-96-6	Ethylene glycol dinitrate
630-08-0	Carbon monoxide
632-22-4	Tetramethyl urea (TMU)
637-03-6	Phenyl arsenic compounds
646-06-0	1,3-Dioxolane (Dioxacyclopentane)
650-51-1	Sodium trichloroacetate
674-82-8	Diketene
680-31-9	Hexamethylphosphoric acid triamide
693-21-0	Diethylene glycol dinitrate
693-23-2	Dodecanedioic acid
700-13-0	Trimethylhydroquinone
730-40-5	Disperse Orange 3
754-12-1	2,3,3,3-Tetrafluoropropene
763-69-9	Ethyl-3-ethoxypropionate
764-41-0	1,4-Dichloro-2-butene
770-35-4	1-Phenoxy-2-propanol
793-24-8	N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine
811-97-2	1,1,1,2-Tetrafluoroethane
818-61-1	Acrylic acid 2-hydroxyethyl ester
822-06-0	1,6-Hexamethylene diisocyanate
838-88-0	4,4'-Methylenebis(2-methylaniline)
868-77-9	2-Hydroxyethyl methacrylate
868-85-9	Dimethyl hydrogen phosphite
872-50-4	N-Methyl-2-pyrrolidone
877-44-1	1,2,4-Triethylbenzene
920-37-6	2-Chloroacrylonitrile
923-26-2	Methacrylic acid 2-hydroxypropyl ester
924-16-3	N-Nitrosodi-n-butylamine
929-06-6	2-(2-Aminoethoxy)ethanol

CAS number	Substance
930-55-2	N-Nitrosopyrrolidine
935-92-2	Trimethylquinone
996-35-0	N,N-Dimethylisopropylamine
1070-70-8	1,4-Butanediol diacrylate
1116-54-7	N-Nitrosodiethanolamine
1119-40-0	Dimethyl glutarate
1120-71-4	1,3-Propane sultone
1121-03-5	2,4-Butane sultone
1239-45-8	Ethidium bromide
1302-74-5	Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts $\alpha$ -Aluminium oxide
1302-78-9	Bentonite
1303-00-0	Arsenic: Gallium arsenide
1303-28-2	Arsenic: Arsenic pentoxide
1303-86-2	Boron oxide
1305-62-0	Calcium hydroxide
1305-78-8	Calcium oxide
1306-38-3	Cerium dioxide (Announcement list)
1307-96-6	Cobalt: Cobalt(II) oxide
1308-06-1	Cobalt: Cobalt(II,III) oxide
1309-37-1	Iron oxides
1309-38-2	Iron oxides
1309-48-4	Magnesium oxide fume Magnesium oxide
1310-73-2	Sodium hydroxide
1313-27-5	Molybdenum trioxide
1313-99-1	Nickel and nickel compounds: Nickel monoxide
1314-06-3	Nickel and nickel compounds: Nickel sesquioxide
1314-23-4	Zirconium dioxide
1314-56-3	Phosphorus pentoxide
1314-80-3	Phosphorus pentasulfide
1317-33-5	Molybdenum disulfide (Announcement list)
1317-42-6	Cobalt: Cobalt(II) sulfide
1317-43-7	Nemalite
1317-61-9	Iron oxides
1318-02-1	Zeolites, synthetic (non-fibrous)
1318-93-0	Montmorillonite
1319-77-3	Cresol (all isomers)
1321-74-0	Divinylbenzene (all isomers)
1327-41-9	Aluminium chlorohydrate (Announcement list)
1327-53-3	Arsenic: Arsenic trioxide
1330-20-7	Xylene (all isomers)
1330-78-5	Tricresyl phosphate, isomers, "free of o-isomers"
1332-21-4	Asbestos
1332-58-7	Kaolinite
1333-86-4	Carbon black
1338-23-4	Methyl ethyl ketone peroxide
1338-24-5	Naphthenic acids and sodium, calcium, potassium naphthenates
1344-28-1	Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts Aluminium oxide
1345-25-1	Iron oxides
1402-68-2	Aflatoxins
1461-25-2	n-Butyltin compounds: Tetra-n-butyltin
1464-53-5	Diepoxybutane
1477-55-0	m-Xylylenediamine
1484-13-5	Vinylcarbazole

CAS number	Substance
1565-94-2	Bisphenol A diglycidyl methacrylate
1569-02-4	1-Ethoxy-2-propanol
1589-47-5	2-Methoxypropanol-1
1633-83-6	1,4-Butane sultone
1634-04-4	tert-Butyl methyl ether
1663-39-4	tert-Butyl acrylate
1667-11-4	4-Chloromethyl-biphenyl
1675-54-3	Bisphenol A diglycidyl ether
1680-21-3	Triethylene glycol diacrylate
1738-25-6	Dimethylaminopropionitrile
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin
1748-81-8	Sesquiterpene lactones: Carabrone
1758-61-8	Dicyclohexyl peroxide
1763-23-1	Perfluorooctanesulfonic acid (PFOS)
1809-14-9	Di-n-octyl phosphonate
1809-19-4	Di-n-butyl phosphonate
1817-47-6	p-Nitrocumene
1854-23-5	4-(2-Nitrobutyl)morpholine (70% w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-propandiyl)bis-morpholin (20% w/w)
1854-26-8	Dimethylol dihydroxyethyleneurea
1891-29-8	Sesquiterpene lactones: Lactucin
1897-45-6	Chlorothalonil
1910-42-5	Paraquat dichloride
1912-24-9	Atrazine
2082-79-3	3,5-Di-tert-butyl-4-hydroxyphenyl propionic acid octadecyl ester
2082-81-7	1,4-Butanediol dimethacrylate
2095-03-6	Bisphenol F diglycidyl ether: p,p'-Bisphenol F diglycidyl ether
2104-64-5	EPN (O-Ethyl O-(4-nitrophenyl)phenylthiophosphate)
2179-59-1	Allyl propyl disulfide
2224-44-4	4-(2-Nitrobutyl)morpholine (70% w/w) and 4,4'-(2-Ethyl-2-nitro-1,3-propandiyl)bis-morpholin (20% w/w)
2238-07-5	Diglycidyl ether (DGE)
2243-62-1	1,5-Diaminonaphthalene
2358-84-1	Diethylene glycol dimethacrylate
2372-82-9	N-(3-Aminopropyl)-N-dodecylpropane-1,3-diamine
2381-21-7	1-Methylpyrene
2386-87-0	3,4-Epoxy-cyclohexane carboxylic acid (3,4-epoxycyclohexylmethyl) ester
2406-68-0	Phenyltin compounds
2409-55-4	2-tert-Butyl-p-cresol
2425-77-6	2-Hexyl-1-decanol
2425-79-8	1,4-Butanediol diglycidyl ether
2426-08-6	n-Butyl glycidyl ether (BGE)
2431-50-7	2,3,4-Trichloro-1-butene
2451-62-9	1,3,5-Triglycidyl isocyanurate (mixture of isomers)
2455-24-5	Tetrahydrofurfuryl methacrylate
2465-27-2	Auramine hydrochloride
2527-58-4	2,2'-Dithiobis(N-methylbenzamide)
2551-62-4	Sulfur hexafluoride
2634-33-5	1,2-Benzisothiazol-3(2H)-one
2682-20-4	2-Methyl-4-isothiazolin-3-one 5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one
2687-91-4	N-Ethyl-2-pyrrolidone
2807-30-9	2-Propoxyethanol
2809-21-4	1-Hydroxyethylidene-1,1-diphosphonic acid
2832-19-1	Chloroacetamide-N-methylol (CAM)

CAS number	Substance
2832-40-8	Disperse Yellow 3
2855-13-2	3-Aminomethyl-3,5,5-trimethyl-cyclohexylamine (Isophorone diamine)
2867-47-2	N,N'-(Dimethylamino)ethyl methacrylate
2872-52-8	Disperse Red 1
3033-77-0	Glycidyl trimethylammonium chloride
3040-44-6	N-(2-Hydroxyethyl)piperidine
3101-60-8	p-tert-Butylphenyl glycidyl ether
3115-49-9	(4-Nonylphenoxy)acetic acid
3129-91-7	Dicyclohexylamine nitrite
3173-72-6	1,5-Naphthylene diisocyanate
3179-89-3	Disperse Red 17
3302-10-1	Isononanoic acid
3333-52-6	Tetramethyl succinonitrile
3333-67-3	Nickel and nickel compounds: Nickel carbonate
3524-68-3	Pentaerythritol triacrylate
3687-31-8	Arsenic: Lead arsenate
3687-46-5	n-Decyl oleate
3689-24-5	TEDP
3811-73-2	Sodium pyrrithione
3926-62-3	Sodium monochloroacetate
4016-14-2	Isopropyl glycidyl ether (IGE)
4074-88-8	Diethylene glycol diacrylate
4080-31-3	Methenamine 3-chloroallylchloride
4098-71-9	Isophorone diisocyanate
4170-30-3	Crotonaldehyde
4259-15-8	Zinc, O,O'-di-2-ethylhexyl dithiophosphate
4299-07-4	2-Butyl-1,2-benzisothiazolin-3-one
4435-53-4	3-Methoxy-n-butyl acetate
4485-12-5	Lithium stearate
4602-84-0	Farnesol
4687-94-9	Bisphenol A glycerolate
4719-04-4	N,N',N''-Tris( $\beta$ -hydroxyethyl)hexahydro-1,3,5-triazine
5026-74-4	Triglycidyl-p-aminophenol
5064-31-3	Nitriлотriacetic acid: Trisodium nitriлотriacetate
5102-83-0	Pigment Yellow 12, Pigment Yellow 13, Pigment Yellow 83
5124-30-1	Dicyclohexyl methane 4,4'-diisocyanate
5216-25-1	p-Chlorobenzotrìchloride
5307-14-2	2-Nitro-p-phenylenediamine
5333-42-6	2-Octyl-1-dodecanol
5395-50-6	1,3,4,6-Tetrakis(hydroxymethyl)-3a,6a-dihydroimidazo[4,5-d]imidazole-2,5-dione Tetramethylol acetylenediurea
5493-45-8	Hexahydrophthalic acid diglycidylester
5567-15-7	Pigment Yellow 12, Pigment Yellow 13, Pigment Yellow 83
5625-90-1	4,4'-Methylenedimorpholine
5714-22-7	Sulfur pentafluoride
5888-33-5	Isobornyl acrylate
5912-86-7	Isoeugenol: cis-Isoeugenol
5932-68-3	Isoeugenol: trans-Isoeugenol
5989-27-5	D-Limonene
5989-54-8	L-Limonene
6032-29-7	Pentanol (isomers): 2-Pentanol
6358-64-1	2,5-Dimethoxy-4-chloroaniline
6358-85-6	Pigment Yellow 12, Pigment Yellow 13, Pigment Yellow 83
6419-19-8	Aminotris(methylenephosphonic acid)
6423-43-4	Propylene glycol dinitrate
6440-58-0	1,3-Dimethylol-5,5-dimethyl hydantoin

CAS number	Substance
6754-13-8	Sesquiterpene lactones: Helenalin
6789-99-7	Tetrahydrobenzotriazole
7085-85-0	Ethyl 2-cyanoacrylate
7397-62-8	Hydroxyacetic acid butyl ester
7411-49-6	3,3'-Diaminobenzidine and its tetrahydrochloride
7429-90-5	Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts Aluminium (Announcement list)
7439-92-1	Lead
7439-93-2	Lithium
7439-96-5	Manganese
7439-97-6	Mercury
7439-98-7	Molybdenum
7440-02-0	Nickel and nickel compounds: Metallic nickel Nickel
7440-05-3	Palladium: Metallic palladium Palladium
7440-06-4	Platinum compounds (Chloroplatinates)
7440-16-6	Rhodium
7440-22-4	Silver
7440-24-6	Strontium
7440-25-7	Tantalum
7440-28-0	Thallium, soluble compounds
7440-31-5	Tin
7440-33-7	Tungsten
7440-36-0	Antimony
7440-38-2	Arsenic: Metallic arsenic Arsenic
7440-39-3	Barium compounds (soluble)
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7440-48-4	Cobalt alloys Cobalt: Metallic cobalt Cobalt
7440-50-8	Copper
7440-54-2	Gadolinium
7440-57-5	Gold
7440-58-6	Hafnium
7440-61-1	Uranium
7440-62-2	Vanadium
7440-65-5	Yttrium
7440-66-6	Zinc
7440-67-7	Zirconium
7440-74-6	Indium (Announcement list)
7446-09-5	Sulfur dioxide
7553-56-2	Iodine
7572-29-4	Dichloroacetylene
7620-77-1	Lithium-12-hydroxystearate
7631-86-9	Silica, amorphous a) synthetic colloidal amorphous silica
7637-07-2	Boron trifluoride
7647-01-0	Hydrogen chloride
7647-10-1	Palladium: Palladium chloride
7659-86-1	2-Ethylhexyl mercaptoacetate
7664-38-2	Phosphoric acid
7664-39-3	Hydrogen fluoride
7664-41-7	Ammonia

CAS number	Substance
7664-93-9	Sulfuric acid
7665-72-7	tert-Butyl glycidyl ether
7697-37-2	Nitric acid
7718-54-9	Nickel and nickel compounds: Nickel chloride
7719-12-2	Phosphorus trichloride
7722-84-1	Hydrogen peroxide
7723-14-0	Phosphorus, red Phosphorus, white/yellow
7726-95-6	Bromine
7727-43-7	Barium sulfate
7727-54-0	Ammonium persulfate
7747-35-5	5-Ethyl-3,7-dioxo-1-azabicyclo[3.3.0]octane (EDAO)
7773-06-0	Ammonium sulfamate
7778-18-9	Calcium sulfate
7778-39-4	Arsenic: Arsenic acid
7778-44-1	Arsenic: Calcium arsenate
7779-27-3	1,3,5-Triethylhexahydro-1,3,5-triazine
7782-41-4	Fluorine
7782-42-5	Graphite
7782-49-2	Selenium
7782-50-5	Chlorine
7782-65-2	Germanium tetrahydride
7782-79-8	Hydrazoic acid
7783-06-4	Hydrogen sulfide
7783-07-5	Hydrogen selenide
7784-42-1	Arsine
7784-46-5	Arsenic: Sodium arsenite
7786-34-7	Mevinphos
7786-81-4	Nickel and nickel compounds: Nickel sulfate
7790-91-2	Chlorine trifluoride
7803-49-8	Hydroxylamine
7803-51-2	Phosphine
7803-52-3	Stibine
7803-57-8	Hydrazine hydrate
8001-31-8	Coconut oil
8001-35-2	Chlorinated camphene
8001-54-5	Benzalkonium chloride
8002-26-4	Tall oil, distilled
8003-34-7	Pyrethrum
8006-64-2	Turpentine
8007-18-9	Nickel titan yellow pigment
8008-20-6	Kerosine (petroleum)
8022-00-2	Demeton-methyl
8042-47-5	White mineral oil (pharmaceutical)
8050-09-7	Rosin (colophony)
8052-42-4	Bitumen (high-temperature processing, vapours and aerosols)
8065-48-3	Demeton
9000-50-4	Oakmoss extracts
9001-00-7	Bromelain
9001-73-4	Papain
9001-75-6	Pepsin
9002-07-7	Trypsin and Chymotrypsin
9002-84-0	Polytetrafluoroethene
9002-86-2	Polyvinyl chloride
9003-01-4	Acrylic acid polymer (neutralized, cross-linked): Sodium polyacrylate
9003-11-6	Polyethylenepolypropylene glycol



CAS number	Substance
9003-13-8	Poly(propylene glycol) n-butyl ether
9003-27-4	Polybutenes and Polyisobutenes: Polyisobutenes
9003-29-6	Polybutenes and Polyisobutenes: Polybutenes
9004-07-3	Trypsin and Chymotrypsin
9004-98-2	Polyoxyethylene oleyl ether
9006-04-6	Natural rubber latex
9006-65-9	Polydimethyl siloxanes, linear
9014-01-1	Subtilisins
9016-00-6	Polydimethyl siloxanes, linear
9016-87-9	“polymeric MDI”
10024-97-2	Nitrous oxide
10025-67-9	Sulfur monochloride
10025-87-3	Phosphorus oxychloride
10026-13-8	Phosphorus pentachloride
10026-24-1	Cobalt: Cobalt(II) sulfate·7 H <sub>2</sub> O
10028-15-6	Ozone
10035-10-6	Hydrogen bromide
10043-35-3	Boric acid
10049-04-4	Chlorine dioxide
10102-43-9	Nitrogen monoxide
10102-44-0	Nitrogen dioxide
10222-01-2	2,2-Dibromo-2-cyanacetamide
10254-57-6	Methylenebis(dibutylthiocarbamate)
10595-95-6	N-Nitrosomethylethylamine
10605-21-7	Carbendazim
11070-44-3	Methyltetrahydrophthalic anhydride
11097-68-0	Aluminium chlorohydrate (Announcement list)
12011-76-6	Dawsonite
12030-97-6	Potassium titanates (fibrous dust): Potassium titanate
12035-36-8	Nickel and nickel compounds: Nickel dioxide
12035-72-2	Nickel and nickel compounds: Nickel subsulfide
12036-23-6	Zirconium dioxide
12054-48-7	Nickel and nickel compounds: Nickel hydroxide
12056-46-1	Potassium titanates (fibrous dust): Potassium titanate
12056-49-4	Potassium titanates (fibrous dust): Potassium titanate
12056-51-8	Potassium titanates (fibrous dust): Potassium titanate
12174-11-7	Attapulgit
12179-04-3	Boric acid: Sodium tetraborate pentahydrate
12185-10-3	Phosphorus, white/yellow
12286-12-3	Magnesium oxide sulfate
12298-43-0	Halloysite
12427-38-2	Manganese ethylenebis(dithiocarbamate) (Maneb)
12510-42-8	Erionite
12604-58-9	Ferrovandium
13007-92-6	Chromium carbonyl
13048-33-4	1,6-Hexanediol diacrylate
13360-57-1	Dimethylsulfamoyl chloride
13463-39-3	Nickel carbonyl (Announcement list)
13463-40-6	Iron pentacarbonyl
13463-41-7	Zinc pyrithione
13463-67-7	Titanium dioxide
13464-58-9	Arsenic: Arsenous acid
13494-80-9	Tellurium
13838-16-9	Enflurane
13952-84-6	sec-Butylamine
13983-17-0	Wollastonite

CAS number	Substance
14265-45-3	Sulfites
14464-46-1	Silica, crystalline: Cristobalite
14484-64-1	Ferbam
14548-60-8	Benzyl alcohol mono(poly)hemiformal
14807-96-6	Talc
14808-60-7	Silica, crystalline: Quartz
14861-17-7	4-(2,4-Dichlorophenoxy)benzenamine
15141-18-1	Disperse blue 106/124
15159-40-7	N-Chloroformylmorpholine
15337-18-5	Zinc diamyldithiocarbamate
15467-20-6	Nitrilotriacetic acid: Disodium nitrilotriacetate
15468-32-3	Silica, crystalline: Tridymite
15501-74-3	Sepiolite (fibrous dust): Sepiolite
15625-89-5	Trimethylolpropane triacrylate
15627-09-5	N-Cyclohexylhydroxy-diazen-1-oxide, copper salt
15827-60-8	Diethylenetriaminepenta(methylenephosphonic acid)
15922-78-8	Sodium pyrrhione
16065-83-1	Chromium(III) compounds
16096-31-4	Diglycidyl hexanediol
16812-54-7	Nickel and nickel compounds: Nickel sulfide
16984-48-8	Fluorides
17702-41-9	Decaborane
17804-35-2	Benomyl
17831-71-9	Tetraethylene glycol diacrylate
18307-23-8	Sepiolite (fibrous dust): Sepiolite
18540-29-9	Chromium(VI) compounds
18662-53-8	Nitrilotriacetic acid: Trisodium nitrilotriacetate monohydrate
18994-66-6	Nitrilotriacetic acid: Monosodium nitrilotriacetate
19287-45-7	Diborane
19430-93-4	1H,1H,2H-Perfluorohexene
19624-22-7	Pentaborane
20018-09-1	4-(Diiodomethylsulfonyl)-toluene
20554-84-1	Sesquiterpene lactones: Parthenolide
20706-25-6	2-Propoxyethyl acetate
20816-12-0	Osmium tetroxide
21645-51-2	Aluminium-, Aluminium oxide- and Aluminium hydroxide-containing dusts
21652-27-7	1-Hydroxyethyl-2-heptadecenyl-imidazoline
22398-80-7	Indium phosphide
23209-59-8	Calcium sodium metaphosphate
23255-03-0	Nitrilotriacetic acid: Disodium nitrilotriacetate monohydrate
23696-28-8	Olaquinox (N-(2-Hydroxyethyl)-3-methyl-2-quinoxalinecarboxamide 1,4-dioxide)
23971-84-8	Sesquiterpene lactones: Anthecotulide
24448-20-2	Bisphenol A ethoxylate dimethacrylate
25013-15-4	Methyl styrene (all isomers)
25013-16-5	tert-Butyl-4-hydroxyanisole (BHA)
25154-54-5	Dinitrobenzene (all isomers)
25254-50-6	N,N',N''-Tris( $\beta$ -hydroxypropyl)hexahydro-1,3,5-triazine
25265-71-8	Dipropylene glycol
25321-14-6	Dinitrotoluene (mixtures of isomers)
25322-68-3	Polyethylene glycol (average molecular weight > 600)
	Polyethylene glycol (average molecular weight 200–600)
25322-69-4	Polypropylene glycol (PPG)
25340-17-4	Diethylbenzene: Diethylbenzene, Mixture [25340-17-4]
	1,3-Diethylbenzene [141-93-5]
	1,4-Diethylbenzene [105-05-5]
25551-13-7	Trimethylbenzene (all isomers)

CAS number	Substance
25584-83-2	Acrylic acid hydroxypropyl ester (all isomers)
25639-42-3	Methylcyclohexanol (all isomers)
26125-61-1	p-Aramid
26172-55-4	5-Chloro-2-methyl-2,3-dihydroisothiazol-3-one and 2-Methyl-2,3-dihydroisothiazol-3-one
26399-02-0	2-Ethylhexyl oleate
26444-49-5	Diphenyl cresyl phosphate
26447-14-3	Cresyl glycidyl ethers
26471-62-5	Toluene diisocyanates: Toluene diisocyanates, mixture
26523-78-4	Tris(nonylphenyl) phosphite
26530-20-1	2-Octyl-4-isothiazolin-3-one
26628-22-8	Sodium azide
26636-01-1	Methyltin compounds: Dimethyltin bis(isooctylmercaptoacetate) (DMT(IOMA) <sub>2</sub> )
26675-46-7	Isoflurane
26761-40-0	Diisodecyl phthalate
26780-96-1	1,2-Dihydro-2,2,4-trimethyl-quinoline polymer
27208-37-3	Cyclopenta[cd]pyrene
27213-78-1	p-tert-Butylcatechol
27253-26-5	Diisotridecyl phthalate
27458-92-0	Isotridecanol
27458-93-1	Isooctadecanol
27478-34-8	Dinitronaphthalene (all isomers)
27579-97-1	Sesquiterpene lactones: (+)-Frullanolide and (-)-Frullanolide
28272-18-6	Sesquiterpene lactones: Pyrethrosin
28523-86-6	Sevoflurane
28553-12-0	Diisononyl phthalate (Announcement list)
28768-32-3	Tetraglycidyl-4,4'-methylenedianiline
29118-24-9	trans-1,3,3,3-Tetrafluoropropene
29222-48-8	Trimethylpentane (all isomers)
29385-43-1	Methyl-1H-benzotriazole
30618-84-9	Glyceryl monothioglycolate
30899-19-5	Pentanol (isomers): Mixture of isomers, Pentanol
31027-31-3	4-Isopropylphenyl isocyanate
31565-23-8	Di-tert-dodecyl pentasulfide and Di-tert-dodecyl polysulfide
31570-04-4	Tris(2,4-ditert-butylphenyl) phosphite
31906-04-4	4-(4-Hydroxy-4-methyl pentyl)-3-cyclohexene-1-carboxaldehyde (Lyal)
32687-78-8	3-(3,5-Di-tert-butyl-4-hydroxyphenyl)-N'-[3-(3,5-di-tert-butyl-4-hydroxyphenyl)prop- anoyl]propanehydrazide
33204-39-6	Sesquiterpene lactones: Arteglasin A
34590-94-8	Dipropylene glycol monomethyl ether
35001-25-3	Sesquiterpene lactones: Laurenobiolide
35074-77-2	Hexamethylene bis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate)
35554-44-0	1-(2-Allyloxy)-2-(2,4-dichlorophenyl)ethyl)-1H-imidazole
35691-65-7	1,2-Dibromo-2,4-dicyanobutane
36653-82-4	1-Hexadecanol
37278-89-0	Xylanases
40776-40-7	Sesquiterpene lactones: (+)-Frullanolide and (-)-Frullanolide
41484-35-9	2,2'-Thiodiethylene Bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]
41683-62-9	1,2-Dichloromethoxyethane
42978-66-5	Tripropylene glycol diacrylate
53306-54-0	Di(2-propylheptyl) phthalate (DPPH)
53469-21-9	Chlorinated biphenyls
53980-88-4	5(or 6)-Carboxy-4-hexylcyclohex-2-ene-1-octanoic acid
54208-63-8	Bisphenol F diglycidyl ether: o,o'-Bisphenol F diglycidylether
54839-24-6	1-Ethoxy-2-propyl acetate
54849-38-6	Methyltin compounds: Methyltin tris(isooctylmercaptoacetate) (MMT(IOMA) <sub>3</sub> )

CAS number	Substance
55406-53-6	3-Iodo-2-propynyl butylcarbamate
55720-99-5	Chlorinated biphenyl oxides
57041-67-5	Desflurane
57469-07-5	Bisphenol F diglycidyl ether: o,p'-Bisphenol F diglycidylether
57583-35-4	Methyltin compounds: Dimethyltin bis(2-ethylhexylmercaptoacetate) (DMT(2-EH-MA) <sub>2</sub> )
57855-77-3	Calcium bis(dinonylnaphthalenesulphonate)
59118-99-9	Methyltin compounds: Bis[methyltin di(2-mercaptoethylolate)]sulfide
59231-34-4	Isodecyl oleate
59766-31-3	Potassium titanates (fibrous dust): Potassium titanate
61789-36-4	Naphthenic acids and sodium, calcium, potassium naphthenates
61789-86-4	Petroleum sulfonates, calcium salts (technical mixture in mineral oil)
61790-13-4	Naphthenic acids and sodium, calcium, potassium naphthenates
63148-62-9	Polydimethyl siloxanes, linear
63449-39-8	Chlorinated paraffins
64741-56-6	Bitumen (high-temperature processing, vapours and aerosols)
64742-47-8	Distillates (petroleum)
64742-48-9	Naphtha (petroleum)
64742-93-4	Bitumen (high-temperature processing, vapours and aerosols)
65997-15-1	Portland cement dust
66072-08-0	Naphthenic acids and sodium, calcium, potassium naphthenates
66204-44-2	N,N'-Methylenebis(5-methyloxazolidine)
66603-10-9	Cyclohexylhydroxydiazene-1-oxide, potassium salt
67701-06-8	Fatty acids, C14–18 and C16–18-unsaturated
68359-37-5	Cyfluthrin
68411-46-1	Diphenylamine, octylated (Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene)
68425-15-0	Di-tert-dodecyl pentasulfide and Di-tert-dodecyl polysulfide
68516-81-4	Disperse blue 106/124
68583-56-2	Di-tert-dodecyl pentasulfide and Di-tert-dodecyl polysulfide
68608-26-4	Petroleum sulfonates, sodium salts
68649-11-6	Polyalphaolefins, several CAS Nos, e.g.
68920-66-1	Fatty alcohol ethoxylates, C16–18 and C18-unsaturated
68921-45-9	Diphenylamine, reaction products with styrene and 2,4,4-trimethylpentene
68937-41-7	Triphenyl phosphate, isopropylated
68958-92-9	Bis[O,O-bis(2-ethylhexyl) dithiophosphorato-S,S']dioxodi-μ-thioxodimolybdenum
69669-44-9	Alkyl benzenesulfonates C10–C14, linear
70657-70-4	2-Methoxypropylacetate-1
72030-25-2	Bis[O,O-bis(2-ethylhexyl) dithiophosphorato-S,S']dioxodi-μ-thioxodimolybdenum
72623-83-7	Mineral oils (petroleum), severely refined
78521-39-8	N-Tosyl-6-aminocaproic acid
80584-91-4	Triazinetriyltriiminotrishexanoic acid
80939-62-4	Alkyl amines, C11–14-branched, monohexyl and dihexyl phosphates
84861-98-3	Aluminium chlorohydrate (Announcement list)
85117-50-6	Alkyl benzenesulfonates C10–C14, linear
91273-04-0	N,N-Bis(2-ethylhexyl)-(1,2,4-triazole-1-yl)methanamine
92045-44-8	Mineral oils (petroleum), severely refined
92045-45-9	Mineral oils (petroleum), severely refined
92062-35-6	Mineral oils (petroleum), severely refined
94624-12-1	Pentanol (isomers): Mixture of isomers, Pentanol
95481-62-2	Dicarboxylic acid (C4–C6) dimethylester, mixture
126019-82-7	Tris[(2- or 4-)C9–C10-isoalkylphenyl]phosphorothioate
134954-21-5	Sesquiterpene lactones: α-Peroxyachifolide
293733-21-8	6-Amino-2-ethoxynaphthalene

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A current list of members, permanent guests and other guests is available at: [https://www.dfg.de/dfg\\_profil/gremien/senat/arbeitsstoffe/index.html](https://www.dfg.de/dfg_profil/gremien/senat/arbeitsstoffe/index.html)

## **Constitution and Procedures of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area**

### **I.**

The activity of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area is based on the following regulations of the statutes of the Deutsche Forschungsgemeinschaft.

#### § 1

##### Purpose of the Association

The Deutsche Forschungsgemeinschaft (German Research Foundation, DFG) serves all branches of science and the humanities by funding research projects and facilitating national and international cooperation among researchers. It devotes particular attention to the education and advancement of young researchers. It promotes equality between men and women in the scientific and academic communities. It advises parliaments and public authorities on scientific matters and fosters relations with the private sector and between scientists and academics.

#### § 11

##### Senate

1. The Senate is the central scientific body of the DFG. It shall deliberate and resolve, within the principles adopted by the General Assembly, all major matters of the DFG, unless they are reserved for the Joint Committee.
2. The Senate shall determine which review boards shall be formed and how they shall be structured. It shall ensure that the full range of fields in science and the humanities is covered by the review boards and that the review boards take their disciplinary research interests and interdisciplinary relationships duly into account.
3. The Senate shall consist of 39 members. The president of the German Rectors' Conference, the president of the Union of the German Academies of Sciences and Humanities and the president of the Max Planck Society shall be ex officio members of the Senate. The remaining 36 members shall be elected by the General Assembly in a staggered rotation system. Researchers who work at institutions of higher education or other research institutions are eligible for election. The General Assembly may also elect other persons, in consideration of certain expertise relevant to the DFG. Voting shall be based on the person; elected members of the Senate shall not act as representatives of institutions. Adequate representation of the entire spectrum of research disciplines shall be sought in the composition of the elected membership.
4. For the elections, the Senate, upon recommendation by the Executive Committee and in consideration of proposals from the members of the DFG, shall prepare slates of nominations, which as a rule shall comprise three names for each vacant seat. Details shall be governed by rules of procedure.
5. If a member of the Senate leaves during his or her term of office, the Senate may coopt a replacement member from the previous slates of nominations to complete the departing member's term of office.
6. Meetings of the Senate shall be convened and chaired by the President. The President shall convene the Senate at the request of at least one-third of its members. As a rule, the resolutions of the Senate shall be passed in the meetings. In individual cases, resolutions may also be passed by circulation (in writing, by fax or electronically) upon decision by the Executive Committee.
7. Within its mandate, the Senate may establish committees and commissions whose members need not be members of the Senate.



## II.

The following principles apply for the Constitution and Procedure of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area:

1. The Senate has assigned to the Deutsche Forschungsgemeinschaft's Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area the responsibility of investigating the scientific foundations for the protection of workers' health from the effects of toxic chemicals at the workplace. The most important practical results of the Commission's work are scientific recommendations for the establishment of MAK and BAT values, for the classification of carcinogenic substances and for the evaluation of embryotoxic and/or foetotoxic effects and of germ cell mutagens as well as the investigation and evaluation of analytical methods for controlling exposure and for examining observance of threshold values for health protection at the workplace. In addition, the Commission investigates further current problems of hazards to health caused by occupational exposures and proposes possible appropriate solutions.

A two-step procedure appears to be the best solution for the realization of health protection measures at the workplace which are in line with the current state of the science: The results of the Commission's work already mentioned above are annually reviewed and published by the Deutsche Forschungsgemeinschaft. At the same time they are handed to the Bundesminister für Arbeit und Soziales who examines the recommendations, also taking nonscientific viewpoints into account, and who then makes them legally binding in an appropriate form – altered or unaltered – as a basis for health protection.

2. The Commission works in scientific freedom and independence. It is not subject to instructions regarding selection or priority setting for the examination of substances and other matters to be investigated. It is the Commission's duty, however, to take up suggestions, in so far as they are of scientific significance, from industrial users and as far as possible to treat with precedence suggestions from the Bundesminister für Arbeit und Soziales who is responsible for health protection at the workplace.
3. The complete transparency of the Commission's work programme is guaranteed by means of the advance announcement of planned changes and additions on the homepage of the Commission at the DFG. A most comprehensive information basis for the Commission's recommendations is ensured by the request to supply the Commission with information and commentaries and the associated possibility of involving appropriate scientific experts in the decision-making process.

The derivation of MAK and BAT values and the classification of carcinogenic substances or substances suspected of having carcinogenic potential and the evaluation of embryotoxic and/or foetotoxic effects and germ cell mutagens are published in the form of detailed scientific documentations ("Begründungen").

4. The sole object of the Commission's work is to protect, as far as possible and necessary, and in line with the most up to date scientific information, the health of workers and of their offspring. The Commission regards health as the highest value which it does not weigh up against other factors. Therefore, only scientific arguments regarding health at the workplace are considered in discussions and decision-making. Other aspects such as sociopolitical, economic, technological and other non-substance-related considerations are excluded.
5. For the reasons stated in 4., requests for participation of experts, other than those concerned with health aspects of protection at work, in the Commission's discussions cannot be complied with.
6. At the same time the Commission does not undervalue the necessity for political decisions in the process of realizing protection at work. It does, however, reject mixing political with scientific judgements in its own work.
7. By publishing its recommendations, the Commission contributes to fulfilling the constitutional obligation of the Deutsche Forschungsgemeinschaft to provide advice on scientific matters to parliaments and public authorities. Should the Bundesministerium für Arbeit und Soziales (see 1. above) deviate in any particular case from the recommendations, the Commission considers it essential that it makes the reasons known.

8. The presidency and governing body of the Deutsche Forschungsgemeinschaft can check observance of the rules of procedure, but ensure unchanged and immediate publication of the Commission's results, in so far as there are no imperative opposing reasons.

### III.

Newly appointed Members and Permanent Guest Contributors of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area receive written notice from the President of the Deutsche Forschungsgemeinschaft in which the following fundamentals of the Commission's work are laid down:

In order to fulfil the statutory functions of the Deutsche Forschungsgemeinschaft as advisers to the legislative and executive organs, the Senate has set up Commissions for various fields of knowledge, for example, for protection at work, protection of health and protection of the environment. The Commission in which you have been appointed is one of these.

The Commissions have the responsibility of ascertaining the current state of scientific data available in the respective field and of formulating it in such a way that the government authorities to be advised are in a position to reach competent decisions on their own responsibility. To this end it is desirable that in the individual Commissions the scientific position is elaborated so that it can be upheld by all members. Such a consensus is then represented in public as the standpoint of the Deutsche Forschungsgemeinschaft.

In view of this responsibility of the Commission, scientists are appointed members *ad personam* in their capacity as authoritative experts and not as representatives of the institutions or companies in which they work.

As well as these members there are also permanent guest contributors working in the Commissions. Scientists and other experts from public authorities are appointed permanent guest contributors with advisory function and may take on research assignments as well as official responsibilities. As they belong to institutes potentially affected by the Commission's advice they have no voting rights. In this way a possible conflict of interests should be avoided from the outset.

The Senate appoints the Commissions for periods of office lasting 3 years each. Members and permanent guest contributors are also appointed for three years and can be reappointed once. A further extension of a personal mandate is only possible in justified exceptional cases.

The strict division aimed at between recognition of a scientific standpoint and its "application" in the broadest sense, be it from the political, legal, economic or other social point of view, presupposes that extra-scientific problems of the government bodies the Commission is required to advise do not find admittance into the vote of the Commission. Political consequences of scientific facts, problems of realization, decisions about the reasonableness of particular risks, economic aspects, etc. do not belong within the responsibility of the Deutsche Forschungsgemeinschaft nor its Commissions.

For the procedure of the Commissions, discussions as well as data and facts referred to in the discussions are dealt with in strict confidentiality up until their publication by the Deutsche Forschungsgemeinschaft as a Report from the Commission concerned. Nobody, through appointment in a Commission, may gain a competitive advantage by exploiting advance information.

### IV.

Procedure of the Commission for prospective new entries and changes to MAK values and Assessment Values in Biological Material

1. Prospective changes and new entries are announced one year in advance in the List of MAK and BAT Values, usually on 1st July. In addition, the new entries are published on the homepage of the Commission at the DFG ([https://www.dfg.de/download/pdf/dfg\\_im\\_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf](https://www.dfg.de/download/pdf/dfg_im_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf)). If necessary, in addition to the regular updates each year in July, further

announcements of prospective changes and new entries can be made there at any time. In the case of changes, the type of prospective change is reported and the reason for it. On announcement of the changes the Commission requests that relevant information and comments be received.

2. Completed substance evaluations in the Sections MAK Values and Assessment Values in Biological Material are listed in detail in the “Changes and New entries” of the List of MAK and BAT Values (Appendix page I) and published on the homepage of the Commission at the DFG (List of changes and new entries in German; [https://www.dfg.de/download/pdf/dfg\\_im\\_profil/gremien/senat/arbeitsstoffe/aenderungen\\_neuaufnahmen.pdf](https://www.dfg.de/download/pdf/dfg_im_profil/gremien/senat/arbeitsstoffe/aenderungen_neuaufnahmen.pdf)). The Commission has approved these suggestions, but presents them for discussion for the period of six months. Until this date new data or scientific comments can be sent to the secretarial office of the Commission; these will be examined by the Commission and as far as is necessary taken into account for the final ratification.

# Substances in the lists of MAK values and assessment values in biological material reviewed in 2021/2022

## MAK Values

### a) alphabetical sorting:

#### **Aldrin [309-00-2]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: suspended  
 Carc cat: –  
 Muta cat: –

#### **change**

previous MAK[mg/m<sup>3</sup>]: 0.25 I  
 previous Peak lim: II(8)

previous Perc abs: H  
 previous Sens: –

#### **Benzoic acid [65-85-0] (inhalable fraction)**

see also Benzoic acid alkali salts

The substance can occur simultaneously as vapour and aerosol.

Causes pseudoallergic reactions, see

Toxikologisch-arbeitsmedizinische Begründung von

MAK-Werten (21st issue 1995).

see Section Xc

MAK[ml/m<sup>3</sup>]: 0.39  
 MAK[mg/m<sup>3</sup>]: 2.1  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H

#### **new entry**

#### **1-Butanethiol [109-79-5]**

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 3.7  
 Even if the MAK value is observed, “odour-associated”  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: II(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh  
 Carc cat: –  
 Muta cat: –

#### **change**

previous MAK[mg/m<sup>3</sup>]: 3.7

#### **n-Butyl acrylate [141-32-2]**

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 11  
 Even if the MAK value is observed, “odour-associated”  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh  
 Carc cat: –  
 Muta cat: –

#### **change**

previous MAK[mg/m<sup>3</sup>]: 11

**n-Butylamine [109-73-9]**MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 6.1**sec-Butylamine [13952-84-6]**MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 6.1**tert-Butylamine [75-64-9]**MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 6.1**Calcium sulfate (respirable fraction)**

Anhydrite [7778-18-9]

Hemihydrate [10034-76-1]

Dihydrate [10101-41-4]

Gypsum [13397-24-5]

see Section IIb

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 1.5 R

previous Preg gr: C

**Carbaryl (1-Naphthyl methylcarbamate)****[63-25-2]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: –

Perc abs: suspended

Sens: suspended

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 5 I

previous Peak lim: II(4)

previous Perc abs: H

previous Sens: –

**Chlordane [57-74-9]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: suspended  
 Carc cat: suspended  
 Muta cat: –

**Chloropicrin [76-06-2]**

see Section IIc

MAK[l/m<sup>3</sup>]: suspended  
 MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**DDT (Dichlorodiphenyltrichloroethane)****[50-29-3]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**Demeton-methyl [8022-00-2]**

see Section IIc

MAK[l/m<sup>3</sup>]: suspended  
 MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**2,2'-Dichlorodiethyl ether [111-44-4]**

MAK[l/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 3.0  
 Peak lim: II(2)  
 Preg gr: D  
 Perc abs: H  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**Dieldrin [60-57-1]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.5 I  
 previous Peak lim: II(8)

previous Perc abs: H  
 previous Sens: –  
 previous Carc cat: 3

**change**

previous MAK[l/m<sup>3</sup>]: 0.1  
 previous MAK[mg/m<sup>3</sup>]: 0.68  
 previous Peak lim: I(1)

**change**

previous MAK[mg/m<sup>3</sup>]: 1 I  
 previous Peak lim: II(8)

previous Perc abs: H

**change**

previous MAK[l/m<sup>3</sup>]: 0.5  
 previous MAK[mg/m<sup>3</sup>]: 4.8  
 previous Peak lim: II(2)

previous Perc abs: H

**change**

previous MAK[l/m<sup>3</sup>]: 10  
 previous MAK[mg/m<sup>3</sup>]: 59  
 previous Peak lim: I(1)  
 previous Preg gr: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.25 I  
 previous Peak lim: II(8)

previous Perc abs: H

**Diethylamine [109-89-7]**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 2

MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D

Perc abs: H

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 6.1

**2-Diethylaminoethanol [100-37-8]**

MAK[ml/m<sup>3</sup>]: 2

MAK[mg/m<sup>3</sup>]: 9.7

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(1)

A momentary value of 5 ml/m<sup>3</sup> (24 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 9.7

**Dimethylamine [124-40-3]**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 2

MAK[mg/m<sup>3</sup>]: 3.7

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(2)

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 3.7

**N,N-Dimethylethylamine [598-56-1]**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine and N-nitrosomethylethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 2

MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 6.1

**EPN (O-Ethyl O-(4-nitrophenyl)  
phenylthiophosphonate) [2104-64-5]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended  
Peak lim: suspended  
Preg gr: –  
Perc abs: suspended  
Sens: suspended  
Carc cat: –  
Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.5 I  
previous Peak lim: II(2)

previous Perc abs: H  
previous Sens: –

**Ethanethiol [75-08-1]**

MAK[ml/m<sup>3</sup>]: 0.5  
MAK[mg/m<sup>3</sup>]: 1.3  
Even if the MAK value is observed, “odour-associated”  
symptoms cannot be ruled out in individual cases, see  
Section Ie  
Peak lim: II(2)  
Preg gr: D  
Perc abs: H  
Sens: –  
Carc cat: –  
Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 1.3

**Ethyl acrylate [140-88-5]**

MAK[ml/m<sup>3</sup>]: 2  
MAK[mg/m<sup>3</sup>]: 8.3  
Even if the MAK value is observed, “odour-associated”  
symptoms cannot be ruled out in individual cases, see  
Section Ie  
Peak lim: I(2)  
Preg gr: C  
Perc abs: H  
Sens: Sh  
Carc cat: –  
Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 8.3

**Ethylamine [75-04-7]**

MAK[ml/m<sup>3</sup>]: 5  
MAK[mg/m<sup>3</sup>]: 9.4  
Even if the MAK value is observed, “odour-associated”  
symptoms cannot be ruled out in individual cases, see  
Section Ie  
Peak lim: I(2)  
A momentary value of 10 ml/m<sup>3</sup> (19 mg/m<sup>3</sup>) should not  
be exceeded.  
Preg gr: D  
Perc abs: –  
Sens: –  
Carc cat: –  
Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 9.4

**Fatty acids, C14–18 and C16–18-unsaturated  
[67701-06-8]**

see Section IIb and Xc

MAK[mg/m<sup>3</sup>]: –  
Peak lim: –  
Preg gr: –  
Perc abs: –  
Sens: –  
Carc cat: –  
Muta cat: –

**new entry**



**Fenthion [55-38-9]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: –

Perc abs: suspended

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 0.2 I

previous Peak lim: II(2)

previous Perc abs: H

**Hydrogen selenide [7783-07-5]**MAK[ml/m<sup>3</sup>]: 0.006MAK[mg/m<sup>3</sup>]: 0.02

Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: II(8)

Preg gr: C

Perc abs: –

Sens: –

Carc cat: 3

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 0.02**Isobutylamine [78-81-9]**MAK[ml/m<sup>3</sup>]: 2MAK[mg/m<sup>3</sup>]: 6.1

Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(2)

A momentary value of 5 ml/m<sup>3</sup> (15 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 6.1**Isopropylamine [75-31-0]**MAK[ml/m<sup>3</sup>]: 5MAK[mg/m<sup>3</sup>]: 12

Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(2)

A momentary value of 10 ml/m<sup>3</sup> (25 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 12**Malathion [121-75-5]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: suspended

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**previous MAK[mg/m<sup>3</sup>]: 15 I

previous Peak lim: II(4)

previous Preg gr: D

**Methacrylic acid methyl ester [80-62-6]**

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 210  
 Even if the MAK value is observed, "odour-associated"  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: –  
 Sens: Sh  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 210

**Methanethiol [74-93-1]**

MAK[ml/m<sup>3</sup>]: 0.5  
 MAK[mg/m<sup>3</sup>]: 1.0  
 Even if the MAK value is observed, "odour-associated"  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: I(1)  
 Preg gr: D  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 1.0

**Methyl acrylate [96-33-3]**

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 7.1  
 Even if the MAK value is observed, "odour-associated"  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: H  
 Sens: Sh  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 7.1

**Methylamine [74-89-5]**

MAK[ml/m<sup>3</sup>]: 5  
 MAK[mg/m<sup>3</sup>]: 6.4  
 Even if the MAK value is observed, "odour-associated"  
 symptoms cannot be ruled out in individual cases, see  
 Section Ie  
 Peak lim: I(2)  
 A momentary value of 10 ml/m<sup>3</sup> (13 mg/m<sup>3</sup>) should not  
 be exceeded.  
 Preg gr: C  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 6.4

**Mevinphos [7786-34-7]**

see documentation "Phosdrin". The substance can occur  
 simultaneously as vapour and aerosol.  
 see Section IIc

MAK[ml/m<sup>3</sup>]: suspended  
 MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: suspended  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[ml/m<sup>3</sup>]: 0.01  
 previous MAK[mg/m<sup>3</sup>]: 0.093  
 previous Peak lim: II(2)

previous Perc abs: H  
 previous Sens: –

**Morpholine [110-91-8]**

Use in metal-working fluids is not permitted: see TRGS 611.  
Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosomorpholine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 5

MAK[mg/m<sup>3</sup>]: 18

Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see

Section Ie

Peak lim: I(1)

A momentary value of 10 ml/m<sup>3</sup> (36 mg/m<sup>3</sup>) should not be exceeded.

Preg gr: C

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 18

**Paraquat dichloride [1910-42-5]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: –

Perc abs: suspended

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.1 I

previous Peak lim: I(1)

previous Perc abs: H

**Parathion [56-38-2]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: suspended

Perc abs: suspended

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.1 I

previous Peak lim: II(8)

previous Preg gr: D

previous Perc abs: H

**Propoxur [114-26-1]**

see Section IIc

MAK[mg/m<sup>3</sup>]: suspended

Peak lim: suspended

Preg gr: –

Perc abs: –

Sens: suspended

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 2 I

previous Peak lim: II(8)

previous Sens: –

**Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2]**

changed after review period

see Section V

MAK[mg/m<sup>3</sup>]: 0.02 R

Peak lim: II(8)

Preg gr: C

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 0.5 R

**Sulfur hexafluoride [2551-62-4]**

The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.

MAK[ml/m<sup>3</sup>]: 5000  
 MAK[mg/m<sup>3</sup>]: 30000  
 Peak lim: II(8)  
 Preg gr: C  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[ml/m<sup>3</sup>]: 1000  
 previous MAK[mg/m<sup>3</sup>]: 6100  
 previous Preg gr: D

**TEPP [107-49-3]**

The substance can occur simultaneously as vapour and aerosol. see Section IIc

MAK[ml/m<sup>3</sup>]: suspended  
 MAK[mg/m<sup>3</sup>]: suspended  
 Peak lim: suspended  
 Preg gr: –  
 Perc abs: suspended  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[ml/m<sup>3</sup>]: 0.005  
 previous MAK[mg/m<sup>3</sup>]: 0.060  
 previous Peak lim: II(2)  
 previous Perc abs: H

**Tetrabromobisphenol A [79-94-7]**

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: H  
 Sens: –  
 Carc cat: 2  
 Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.  
 Muta cat: –

**new entry****Tetrahydrothiophene (THT) [110-01-0]**

MAK[ml/m<sup>3</sup>]: 50  
 MAK[mg/m<sup>3</sup>]: 183  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(1)  
 Preg gr: C  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**change**

previous MAK[mg/m<sup>3</sup>]: 183

**Tetramethylol acetylenediurea [5395-50-6]**

releases formaldehyde

The substance can occur simultaneously as vapour and aerosol. see Section Xc

MAK[ml/m<sup>3</sup>]: 0.046  
 MAK[mg/m<sup>3</sup>]: 0.5 l  
 Peak lim: I(2)  
 Preg gr: C  
 Perc abs: –  
 Sens: Sh  
 Carc cat: 4  
 Muta cat: 5

**new entry**

**N-Tosyl-6-aminocaproic acid [78521-39-8]****new entry**

see Section Ib and Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

**Triethylamine [121-44-8]****change**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 1  
 MAK[mg/m<sup>3</sup>]: 4.2  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 Preg gr: D  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

previous MAK[mg/m<sup>3</sup>]: 4.2**Trimethylamine [75-50-3]****change**

Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".

MAK[ml/m<sup>3</sup>]: 2  
 MAK[mg/m<sup>3</sup>]: 4.9  
 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie  
 Peak lim: I(2)  
 A momentary value of 5 ml/m<sup>3</sup> (12 mg/m<sup>3</sup>) should not be exceeded.  
 Preg gr: C  
 Perc abs: –  
 Sens: –  
 Carc cat: –  
 Muta cat: –

previous MAK[mg/m<sup>3</sup>]: 4.9**N,N',N''-Tris(β-hydroxyethyl)****change****hexahydro-1,3,5-triazine [4719-04-4]**

releases formaldehyde

The substance can occur simultaneously as vapour and aerosol.

see Section Xc

MAK[ml/m<sup>3</sup>]: –  
 MAK[mg/m<sup>3</sup>]: –  
 Peak lim: –  
 Preg gr: –  
 Perc abs: –  
 Sens: Sh  
 Carc cat: 2  
 Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.  
 Muta cat: 3B

previous Carc cat: –

previous Muta cat: –

**N,N',N''-Tris(β-hydroxypropyl)**

**new entry**

**hexahydro-1,3,5-triazine [25254-50-6]**

releases formaldehyde

The substance can occur simultaneously as vapour and aerosol.

see Section Xc

MAK[m<sup>3</sup>/m<sup>3</sup>]: –

MAK[mg/m<sup>3</sup>]: –

Peak lim: –

Preg gr: –

Perc abs: –

Sens: Sh

Carc cat: 2

Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.

Muta cat: 3B

**Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction)**

**change**

see Section XII

MAK[mg/m<sup>3</sup>]: 0.005 I

Peak lim: II(2)

Preg gr: D

Perc abs: –

Sens: –

Carc cat: 4

Muta cat: 5

previous MAK[mg/m<sup>3</sup>]: –  
previous Peak lim: –  
previous Preg gr: –

previous Carc cat: 2  
previous Muta cat: 2

**Zinc diamyldithiocarbamate [15337-18-5] (inhalable fraction)**

**new entry**

see Section Xc

MAK[mg/m<sup>3</sup>]: 10 I

Peak lim: II(8)

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

**Zinc diamyldithiocarbamate [15337-18-5] (respirable fraction)**

**new entry**

see Section Xc

MAK[mg/m<sup>3</sup>]: 5 R

Peak lim: II(4)

Preg gr: D

Perc abs: –

Sens: –

Carc cat: –

Muta cat: –

## b) sorting by MAK values and classifications:

A. MAK value [mg/m <sup>3</sup> ]	previous	new
<b>1. change</b>		
1-Butanethiol [109-79-5]	3.7	3.7 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
n-Butyl acrylate [141-32-2]	11	11 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
n-Butylamine [109-73-9]	6.1	6.1 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
sec-Butylamine [13952-84-6]	6.1	6.1 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
tert-Butylamine [75-64-9]	6.1	6.1 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
2,2'-Dichlorodiethyl ether [111-44-4]	59	3.0
Diethylamine [109-89-7]	6.1	6.1 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
2-Diethylaminoethanol [100-37-8]	9.7	9.7 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
Dimethylamine [124-40-3]	3.7	3.7 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
N,N-Dimethylethylamine [598-56-1]	6.1	6.1 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
Ethanethiol [75-08-1]	1.3	1.3 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
Ethyl acrylate [140-88-5]	8.3	8.3 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
Ethylamine [75-04-7]	9.4	9.4 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie
Hydrogen selenide [7783-07-5]	0.02	0.02 Even if the MAK value is observed, “odour-associated” symptoms cannot be ruled out in individual cases, see Section Ie

Isobutylamine [78-81-9]	6.1	6.1 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Isopropylamine [75-31-0]	12	12 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Methacrylic acid methyl ester [80-62-6]	210	210 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Methanethiol [74-93-1]	1.0	1.0 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Methyl acrylate [96-33-3]	7.1	7.1 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Methylamine [74-89-5]	6.4	6.4 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Morpholine [110-91-8] Use in metal-working fluids is not permitted: see TRGS 611. Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosomorpholine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation"	18	18 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	0.5 R	0.02 R
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	6100	30000
Tetrahydrothiophene (THT) [110-01-0]	183	183 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Triethylamine [121-44-8] Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodiethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".	4.2	4.2 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Trimethylamine [75-50-3] Reaction with nitrosating agents can result in the formation of carcinogenic N-nitrosodimethylamine, see Section III "Amines which form carcinogenic nitrosamines on nitrosation".	4.9	4.9 Even if the MAK value is observed, "odour-associated" symptoms cannot be ruled out in individual cases, see Section Ie
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	–	0.005 I



<b>A. MAK value [mg/m<sup>3</sup>]</b>	<b>previous</b>	<b>new</b>
<b>2. new entry</b>		
Benzoic acid [65-85-0] (inhalable fraction) see also Benzoic acid alkali salts The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995)		2 I
Tetrabromobisphenol A [79-94-7]		–
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		0.5 I
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		–
Zinc diamyldithiocarbamate [15337-18-5] (inhalable fraction) see Section Xc		10 I
Zinc diamyldithiocarbamate [15337-18-5] (respirable fraction) see Section Xc		5 R

<b>A. MAK value [mg/m<sup>3</sup>]</b>	<b>previous</b>	<b>new</b>
<b>3. Review of classification: no change</b>		
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	–

<b>B. Peak limitation</b>	<b>previous</b>	<b>new</b>
<b>1. change</b>		
2,2'-Dichlorodiethyl ether [111-44-4]	I(1)	II(2)
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	–	II(2)

<b>B. Peak limitation</b>	<b>previous</b>	<b>new</b>
<b>2. new entry</b>		
Benzoic acid [65-85-0] (inhalable fraction) see also Benzoic acid alkali salts The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995)		I(2)
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc		–
Tetrabromobisphenol A [79-94-7]		–
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		I(2)
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc		–
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		–
Zinc diamyldithiocarbamate [15337-18-5] (inhalable fraction) see Section Xc		II(8)
Zinc diamyldithiocarbamate [15337-18-5] (respirable fraction) see Section Xc		II(4)

<b>B. Peak limitation</b>	<b>previous</b>	<b>new</b>
<b>3. Review of classification: no change</b>		
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	II(8)	II(8)
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	II(8)	II(8)
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	–
 <b>C. Pregnancy risk group</b>		
<b>1. change</b>	<b>previous</b>	<b>new</b>
Calcium sulfate (respirable fraction) Anhydrite [7778-18-9] Hemihydrate [10034-76-1] Dihydrate [10101-41-4] Gypsum [13397-24-5] see Section IIb	C	–
2,2'-Dichlorodiethyl ether [111-44-4]	–	D
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	D	C
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	–	D
 <b>C. Pregnancy risk group</b>		
<b>2. new entry</b>	<b>previous</b>	<b>new</b>
Benzoic acid [65-85-0] (inhalable fraction) see also Benzoic acid alkali salts The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995)		C
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc		–
Tetrabromobisphenol A [79-94-7]		–
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		C
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc		–
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		–
Zinc diamyldithiocarbamate [15337-18-5] (inhalable fraction) see Section Xc		D
Zinc diamyldithiocarbamate [15337-18-5] (respirable fraction) see Section Xc		D

### C. Pregnancy risk group previous new

#### 3. Review of classification: no change

Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	C	C
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	–

### D. Percutaneous absorption previous new

#### 2. new entry

Benzoic acid [65-85-0] (inhalable fraction) see also Benzoic acid alkali salts The substance can occur simultaneously as vapour and aerosol. Causes pseudoallergic reactions, see Toxikologisch-arbeitsmedizinische Begründung von MAK-Werten (21st issue 1995)		H
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc		–
Tetrabromobisphenol A [79-94-7]		H
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		–
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc		–
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc		–
Zinc diamylthiocarbamate [15337-18-5] (inhalable fraction) see Section Xc		–
Zinc diamylthiocarbamate [15337-18-5] (respirable fraction) see Section Xc		–

### D. Percutaneous absorption previous new

#### 3. Review of classification: no change

2,2'-Dichlorodiethyl ether [111-44-4]	H	H
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	–	–
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	–	–
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	–
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	–	–

<b>E. Sensitization</b>	<b>previous</b>	<b>new</b>
<b>2. new entry</b>		
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc	–	
Tetrabromobisphenol A [79-94-7]	–	
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	Sh	
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc	–	
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	Sh	
Zinc diamylidithiocarbamate [15337-18-5] (inhalable fraction) see Section Xc	–	
Zinc diamylidithiocarbamate [15337-18-5] (respirable fraction) see Section Xc	–	

<b>E. Sensitization</b>	<b>previous</b>	<b>new</b>
<b>3. Review of classification: no change</b>		
2,2'-Dichlorodiethyl ether [111-44-4]	–	–
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	–	–
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	–	–
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	Sh	Sh
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	–	–

<b>F. Carcinogenicity</b>	<b>previous</b>	<b>new</b>
<b>1. change</b>		
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	2 Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	2	4

**F. Carcinogenicity****2. new entry**

	previous	new
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc	–	–
Tetrabromobisphenol A [79-94-7]	2	Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	4	4
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc	–	–
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	2	Prerequisite for Category 4 in principle fulfilled, but insufficient data available for the establishment of a MAK or BAT value.
Zinc diamylthiocarbamate [15337-18-5] (inhalable fraction) see Section Xc	–	–
Zinc diamylthiocarbamate [15337-18-5] (respirable fraction) see Section Xc	–	–

**F. Carcinogenicity****3. Review of classification: no change**

	previous	new
2,2'-Dichlorodiethyl ether [111-44-4]	–	–
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	–	–
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	–	–

**G. Germ cell mutagenicity****1. change**

	previous	new
N,N',N''-Tris(β-hydroxyethyl)hexahydro-1,3,5-triazine [4719-04-4] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	–	3B
Vanadium [7440-62-2] and its inorganic compounds (inhalable fraction) see Section XII	2	5

**G. Germ cell mutagenicity****2. new entry**

	previous	new
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc	–	–
Tetrabromobisphenol A [79-94-7]	–	–
Tetramethylol acetylenediurea [5395-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	5	5
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc	–	–
N,N',N''-Tris(β-hydroxypropyl)hexahydro-1,3,5-triazine [25254-50-6] releases formaldehyde The substance can occur simultaneously as vapour and aerosol. see Section Xc	3B	3B
Zinc diamylthiocarbamate [15337-18-5] (inhalable fraction) see Section Xc	–	–
Zinc diamylthiocarbamate [15337-18-5] (respirable fraction) see Section Xc	–	–

<b>G. Germ cell mutagenicity</b>	<b>previous</b>	<b>new</b>
<b>3. Review of classification: no change</b>		
2,2'-Dichlorodiethyl ether [111-44-4]	–	–
Silica, amorphous a) synthetic colloidal amorphous silica [7631-86-9] including pyrogenic [112945-52-5] and wet process synthetic silica (precipitated silica, silica gel) [112926-00-8] and diatomaceous earth (uncalcined) [61790-53-2] changed after review	–	–
Sulfur hexafluoride [2551-62-4] The evaluation refers to the pure substance; with very high energy input (e.g. electrical discharges or temperatures above 500°C), very toxic decomposition and reaction products can form from sulfur hexafluoride.	–	–
 <b>H. Substances in section IIb</b>	 <b>previous</b>	 <b>new</b>
<b>1. change</b>		
Calcium sulfate (respirable fraction) Anhydrite [7778-18-9] Hemihydrate [10034-76-1] Dihydrate [10101-41-4] Gypsum [13397-24-5] see Section IIb	1.5 R	–
 <b>H. Substances in section IIb</b>	 <b>previous</b>	 <b>new</b>
<b>2. new entry</b>		
Fatty acids, C14–18 and C16–18-unsaturated [67701-06-8] see Section IIb and Xc		–
N-Tosyl-6-aminocaproic acid [78521-39-8] see Section IIb and Xc		–
 <b>I. Substances in section IIc</b>	 <b>previous</b>	 <b>new</b>
Aldrin [309-00-2] see Section IIc		
Carbaryl (1-Naphthyl methylcarbamate) [63-25-2] see Section IIc		
Chlordane [57-74-9] see Section IIc		
Chloropicrin [76-06-2] see Section IIc		
DDT (Dichlorodiphenyltrichloroethane) [50-29-3] see Section IIc		
Demeton-methyl [8022-00-2] see Section IIc		
Dieldrin [60-57-1] see Section IIc		
EPN (O-Ethyl O-(4-nitrophenyl)phenylthiophosphonate) [2104-64-5] see Section IIc		
Fenthion [55-38-9] see Section IIc		
Malathion [121-75-5] see Section IIc		
Mevinphos [7786-34-7] see documentation "Phosdrin". The substance can occur simultaneously as vapour and aerosol. see Section IIc		
Paraquat dichloride [1910-42-5] see Section IIc		
Parathion [56-38-2] see Section IIc		
Propoxur [114-26-1] see Section IIc		
TEPP [107-49-3] The substance can occur simultaneously as vapour and aerosol. see Section IIc		

## Part Assessment Values in Biological Material

### Biological Tolerance Values (BAT values)

- ★ Isoflurane [26675-46-7]  
4 µg/l urine, parameter isoflurane no previous BAT value
- ★ Methoxyacetic acid [625-45-6]  
15 mg/g creatinine, parameter methoxyacetic acid no previous BAT value
- 2-Methoxyethanol [109-86-4]  
15 mg/g creatinine, parameter methoxyacetic acid BAT value confirmed
- 2-Methoxyethyl acetate [110-49-6]  
15 mg/g creatinine, parameter methoxyacetic acid BAT value confirmed
- ★ Vanadium [7440-62-2] and its inorganic compounds  
not established, parameter vanadium in urine no previous BAT value

### Exposure Equivalents for Carcinogenic Substances (EKA)

- ★ Arsenic [7440-38-2] and inorganic arsenic compounds apart from arsine  
parameter  $\Sigma$ arsenic(+III), arsenic(+V) and monomethylarsonic acid in urine previous for parameter  $\Sigma$ arsenic(+III), arsenic(+V), monomethylarsonic acid and dimethylarsinic acid in urine
- ★ Vanadium [7440-62-2] and its inorganic compounds  
not established, parameter vanadium in urine previous EKA

### Biological Guidance Values (BLW)

- ★ Arsenic [7440-38-2] and inorganic arsenic compounds apart from arsine  
10 µg/l urine, parameter  $\Sigma$ arsenic(+III), arsenic(+V) and monomethylarsonic acid previous 50 µg/l urine, parameter inorganic arsenic and methylated metabolites
- ★ Indium [7440-74-6] and its inorganic compounds  
not established, parameter indium in plasma/serum no previous BLW

### Biological Reference Values (BAR)

- ★ Butylated hydroxytoluene (BHT) [128-37-0]  
7 µg/l urine, parameter BHT acid (after hydrolysis) no previous BAR
- ★ Indium [7440-74-6] and its inorganic compounds  
not established, parameter indium in plasma/serum no previous BAR
- ★ Vanadium [7440-62-2] and its inorganic compounds  
0.15 µg/l urine, parameter vanadium no previous BAR
- ★ Vinyl chloride [75-01-4]  
1.5 mg/l urine\*, parameter thiodiglycolic acid BAR confirmed
- \*The BAR for thiodiglycolic acid is not suitable as a marker of exposure to vinyl chloride in an exposure range < 5 ppm. no previous footnote

### Pregnancy Risk Groups at BAT value

- ★ Dichloromethane [75-09-2] Group B
- ★ 1,2-Epoxypropane [75-56-9] Group C
- ★ Ethylbenzene [100-41-4] Group C
- ★ Hydrogen fluoride [7664-39-3] and anorganic fluorine compounds (fluorides) Group C
- ★ Isoflurane [26675-46-7] Group D
- ★ Isopropylbenzene [98-82-8] Group C
- ★ 2-Propanol [67-63-0] Group C
- ★ Xylene (all isomers) [1330-20-7] Group D

## Substances being Examined for the Establishment of MAK Values and Assessment Values in Biological Material

The “Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area” of the Deutsche Forschungsgemeinschaft is discussing changes of, or additions to, the MAK values and BAT values and other classifications of the following substances for the 2023 list (Report 59) and future subsequent lists:

### Announcement list

Substance	Point of discussion	Reason
Acrylamide [79-06-1]	Re-evaluation of EKA	Suggestion from the Commission
Acrylates (monomers and oligomers)	Sensitizing effect	Suggestion from the Commission
Aluminium [7429-90-5] and its inorganic compounds	MAK value, new entry	Suggestion from the Commission
Aluminium chlorohydrate [1327-41-9; 11097-68-0; 84861-98-3]	Percutaneous absorption, new entry	Suggestion from the Commission
Aniline [62-53-3]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
Benzidine [92-87-5] and its salts	Carcinogenic effect	Suggestion from the Commission
Benzophenone [119-61-9]	MAK value, new entry	Suggestion from the Commission
Benzyl formate [104-57-4]	MAK value, new entry	Suggestion from the Commission
Bisphenol A (4,4'-Iso-propylidenediphenol) [80-05-7]	MAK value	Suggestion from the Commission
	Re-evaluation of BLW	Suggestion from the Commission
1-Butanol [71-36-3]	Re-evaluation of BAT value	Suggestion from the Commission
2-Butoxyethanol [111-76-2]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
p-tert-Butylbenzoic acid [98-73-7]	MAK value	Suggestion from the Commission
tert-Butyl hydroperoxide [75-91-2]	MAK value	Suggestion from the Commission
p-tert-Butylphenol [98-54-4]	MAK value	Suggestion from the Commission
Cadmium [7440-43-9] and its inorganic compounds (inhalable fraction)	Carcinogenic effect	Suggestion from the Commission
	Re-evaluation of assessment values in biological material	Suggestion from the Commission
Calcium sulfate (inhalable fraction) Anhydrite [7778-18-9]	MAK value	Suggestion from the Commission
Hemihydrate [10034-76-1]		
Dihydrate [10101-41-4]		
Gypsum [13397-24-5]		
ε-Caprolactam [105-60-2] (vapour and dust)	MAK value	Suggestion from the Commission
Carbon dioxide [124-38-9]	MAK value	Suggestion from the Commission
Cerium dioxide [1306-38-3]	MAK value, new entry	Suggestion from the Commission
Chlorpromazine (2-Chloro-10-(3-dimethylaminopropyl)phenothiazine) [50-53-3]	MAK value	Suggestion from the Commission



<b>Substance</b>	<b>Point of discussion</b>	<b>Reason</b>
Chromium(III) compounds	MAK value	Suggestion from the Commission
Copper [7440-50-8] and its inorganic compounds	MAK value	Suggestion from the Commission
Dibenzoyl peroxide [94-36-0]	MAK value	Suggestion from the Commission
1,2-Dichloroethylene sym [540-59-0] (cis [156-59-2] and trans [156-60-5])	MAK value	Suggestion from the Commission
Dichloromethane [75-09-2]	MAK value	Suggestion from the Commission
2,2-Dichloropropionic acid [75-99-0]	MAK value	Suggestion from the Commission
Diethylene glycol dimethyl ether [111-96-6]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
Diethylene glycol monomethyl ether [111-77-3]	MAK value, new entry	Suggestion from the Commission
	Evaluation of assessment values in biological material	Suggestion from the Commission
Diisononyl phthalate [28553-12-0]	MAK value, new entry	Suggestion from the Commission
N,N-Dimethylpropylamine [926-63-6]	MAK value, new entry	Suggestion from users
Dinitrotoluene (mixtures of isomers) [25321-14-6]	Carcinogenic effect	Suggestion from the Commission
Dipropylene glycol monomethyl ether [34590-94-8] (mixture of isomers)	MAK value	Suggestion from the Commission
Dust, general threshold limit value (inhalable fraction)	MAK value	Suggestion from the Commission
Ethylene [74-85-1]	Re-evaluation of EKA	Suggestion from the Commission
(Ethylenedioxy)dimethanol [3586-55-8]	MAK value, new entry	Suggestion from the Commission
Ethylene oxide [75-21-8]	Re-evaluation of EKA	Suggestion from the Commission
N-Ethyl-2-pyrrolidone [2687-91-4] (vapour)	Evaluation of a BLW	Suggestion from the Commission
Fatty alcohols, C12–C18 [67762-25-8]	MAK value, new entry	Suggestion from the Commission
Fluranes (desflurane, enflurane, iso-flurane, sevoflurane)	MAK value	Suggestion from the Commission
	Evaluation of assessment values in biological material	Suggestion from the Commission
Formic acid ethyl ester [109-94-4]	MAK value	Suggestion from the UAIII
Glass wool fibres	Carcinogenic effect	Suggestion from the Commission
Graphene [1034343-98-0]	MAK value, new entry	Suggestion from the Commission
	Carcinogenic effect, new entry	Suggestion from the Commission
Halothane [151-67-7]	MAK value	Suggestion from the Commission
n-Hexane [110-54-3]	Re-evaluation of BAT value	Suggestion from the Commission
2-Hexanone [591-78-6]	MAK value	Suggestion from the Commission
Hydrazine [302-01-2]	Re-evaluation of EKA	Suggestion from the Commission
Indium [7440-74-6] and its inorganic compounds	MAK value, new entry	Suggestion from the Commission
Iodomethane [74-88-4]	Carcinogenic effect	Suggestion from the Commission

<b>Substance</b>	<b>Point of discussion</b>	<b>Reason</b>
Isophorone diisocyanate [4098-71-9]	MAK value	Suggestion from the Commission
Manganese [7439-96-5] and its inorganic compounds (inhalable fraction)	MAK value	Suggestion from AGS
Manganese [7439-96-5] and its inorganic compounds (respirable fraction)	MAK value	Suggestion from AGS
2-Mercaptobenzothiazole [149-30-4]	Evaluation of assessment values in biological material	Suggestion from the Commission
Mercury, organic compounds	Carcinogenic effect	Suggestion from the Commission
Metal-working fluids	Toxicity and carcinogenic effect	see Section Xc
Methoxyacetic acid [625-45-6]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
2-Methoxyethanol [109-86-4]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
2-Methoxyethyl acetate [110-49-6]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
Methyldiethanolamine [105-59-9]	MAK value	Suggestion from the Commission
5-Methyl-3-heptanone [541-85-5]	MAK value	Suggestion from the UAIII
N-Methyl-2-pyrrolidone [872-50-4] (vapour)	Re-evaluation of BAT value	Suggestion from the Commission
Molybdenum disulfide [1317-33-5]	MAK value, new entry	Suggestion from the Commission
Naphtha (petroleum) hydrotreated, heavy [64742-48-9]	MAK value	Suggestion from the Commission
1,5-Naphthylene diisocyanate [3173-72-6]	MAK value	Suggestion from the Commission
Nickel carbonyl [13463-39-3]	MAK value, new entry	Suggestion from the Commission
Pentachlorophenol [87-86-5]	Carcinogenic effect	Suggestion from the Commission
Perfluoroisobutene [382-21-8]	MAK value, new entry	Suggestion from the Commission
Perfluorooctanesulfonic acid (PFOS) [1763-23-1] and its salts	Re-evaluation of BAT value	Suggestion from the Commission
Perfluorooctanoic acid (PFOA) [335-67-1] and its salts	Re-evaluation of BAT value	Suggestion from the Commission
Phenol [108-95-2]	MAK value	Suggestion from the UAIII
	Re-evaluation of BLW	Suggestion from the Commission
p-Phenylenediamine [106-50-3]	MAK value	Suggestion from the Commission
2-Propoxyethyl acetate [20706-25-6]	MAK value	Suggestion from the Commission
Quartz [14808-60-7]	MAK value	Suggestion from the Commission
Selenium [7782-49-2] and its inorganic compounds (as Se)	MAK value	Suggestion from the UAIII
	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
Silica, amorphous b) quartz glass [60676-86-0], fused silica [60676-86-0], silica fume (calcined) [69012-64-2], diatomaceous earth [68855-54-9]	MAK value	Suggestion from the Commission
	Carcinogenic effect	Suggestion from the Commission

<b>Substance</b>	<b>Point of discussion</b>	<b>Reason</b>
Soya bean constituents	MAK value	Suggestion from the Commission
Styrene [100-42-5]	Re-evaluation of the Pregnancy Risk Group at BAT value	Suggestion from the Commission
Tetraethyllead [78-00-2] (as Pb)	MAK value	Suggestion from the Commission
Tetrahydrofuran [109-99-9]	MAK value	Suggestion from the UAIH
Tetramethyllead [75-74-1] (as Pb)	MAK value	Suggestion from the Commission
Tributyl phosphate [126-73-8]	Percutaneous absorption	Suggestion from the Commission
Trimellitic anhydride [552-30-7] (fume)	MAK value	Suggestion from the Commission
Vinylidene chloride [75-35-4]	MAK value	Suggestion from the UAIH
	Carcinogenic effect	Suggestion from the UAIH
Xylene (all isomers) [1330-20-7]	Re-evaluation of BAT value	Suggestion from the Commission
Zinc [7440-66-6] and its inorganic compounds (inhalable fraction)	MAK value	Suggestion from AGS

This announcement list is also published in German language on the homepage of the Commission at the DFG; [https://www.dfg.de/download/pdf/dfg\\_im\\_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf](https://www.dfg.de/download/pdf/dfg_im_profil/gremien/senat/arbeitsstoffe/ankuendigungsliste.pdf). If necessary, in addition to the regular updates each year in July, further announcements of prospective changes and new entries can be made there at any time.

The Commission requests that company physicians, the manufacturers and users of industrial chemicals, research institutes dealing with these compounds, as well as boards of control and other governmental institutions, submit the names of any additional substances which occur at the workplace and have not as yet been considered.

Scientific and technical data and information applying to the compounds listed above should be submitted by

1st February 2023

to the

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