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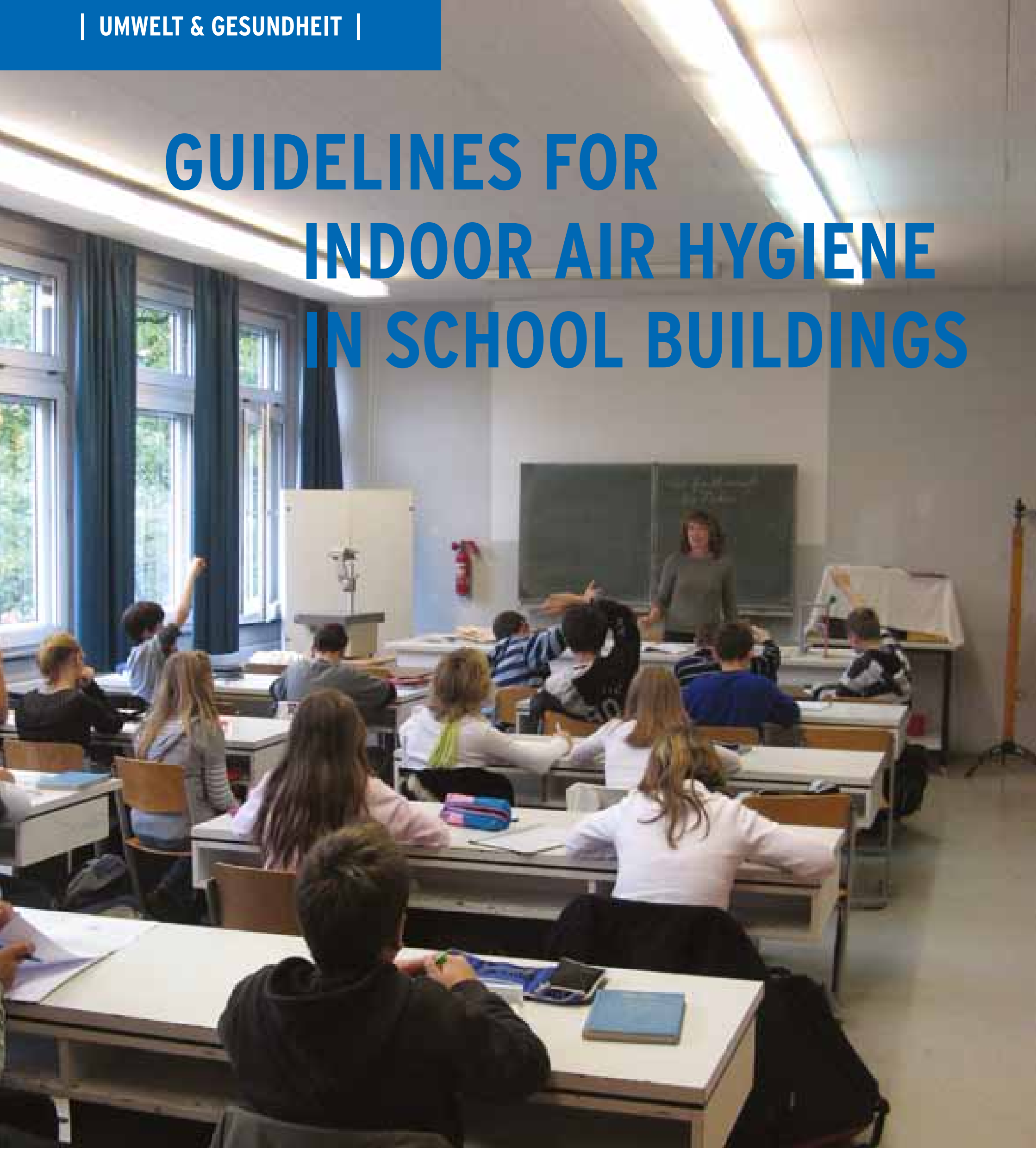
GUIDELINES FOR INDOOR AIR HYGIENE IN SCHOOL BUILDINGS



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Guidelines for Indoor Air Hygiene in School Buildings

Produced by the German Federal Environment Agency's Indoor Air Hygiene Commission

Berlin, August 2008

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GENERAL

I Introduction, objectives

I-1 The issue

Air pollutants inside schools present a hygiene problem. The indoor pollution observed inside school buildings can be traced back to a variety of causes, such as poor construction, failings in ventilation engineering, incorrect ventilation routines, and the use of particular building materials, fittings or cleaning products which release chemicals into the air. Microbial problems (mould growth) also play a significant part in school buildings.

In recent years there has been much discussion about healthy and hygienically acceptable indoor air quality in schools. Some schools have been extensively renovated in the last few years because of suspected asbestos, PCBs and other indoor pollutants. Nevertheless there are still very many schools whose buildings are in dire need of modernisation on account of inadequate building maintenance work and lack of finance at the local authority. The introduction of the Building Energy Conservation Ordinance [Energieeinsparverordnung, EnEV] in 2002 (amended in 2007) places new demands on all those involved in the modernisation of school buildings. The outer shell and the windows are intentionally made airtight in order to meet energy conservation regulations. The disadvantage can be an increase in chemical and biological substances in the air inside if there is inadequate ventilation. Therefore, if school buildings require upgrading for energy efficiency or other reasons, specific regulations must be observed so that indoor air hygiene problems do not arise later. These guidelines set out what should be taken into account from a hygiene perspective and should help to identify solutions.

In the 2000 "Guidelines for Indoor Air Hygiene in School Buildings" the Federal Environment Agency drew attention to hygiene problems and cleaning in schools. New challenges such as the problems of suspended particulate matter and carbon dioxide and the need to upgrade buildings to meet energy efficiency standards have however made updating necessary.

New chemical substances to be found in the air inside school buildings and their significance for hygiene are dealt with in the guidelines, as is the problem of suspended particulate matter in schools, the emission of ultrafine particles from printers, and the issue of mould growth. One chapter is devoted entirely to the important subject of ventilation. Here – in schools as elsewhere – a paradigm shift may possibly occur, since in some cases natural ventilation via windows is no longer an adequately practical and lasting way of achieving acceptable indoor air quality. This is especially the case with the concentration of carbon dioxide, which was recognised by Pettenkofer more than 150 years ago as the indicator of "bad" air in the indoor environment. Today carbon dioxide is once again a measure of the quality of indoor air in school buildings. How to take effective remedial action against the CO_2 problem in classrooms is set out in the Guidelines.

I-2 Purpose and target groups

The "new" Guidelines are intended as a response to current requirements in school practice. The recommendations made here aim to help to avoid mistakes – from an indoor air quality perspective – in modernising school buildings, and to provide hygiene-specific support in the planning of new school buildings.

The Guidelines relate primarily to classrooms and assembly rooms in schools and vocational colleges in which pupils regularly have lessons. They should be applied by analogy to other types of schools and care facilities such as day nurseries. Many recommendations are also valid for indoor spaces in public buildings other than schools. Other statutory regulations (Ordinance on Hazardous Substances [Gefahrstoffverordnung], etc.) which apply to specialist technical areas of school buildings (for example, home economics practical areas, workshops, laboratories) will not be addressed further in these Guidelines.

The recommendations made in the Guidelines also apply to temporary school buildings ("demountables").

Who are the Guidelines aimed at?

The Guidelines are intended on the one hand for teachers, pupils and parents as those directly or indirectly affected, and for the school governors and those people at education authorities, planning departments, departments of health and the environment with responsibility for schools on the other hand. In addition the Guidelines provide information for all professional groups involved in planning, building, renovating or modernising school buildings.

I-3 Structure of the Guidelines

The Guidelines are laid out as follows:

- In the GENERAL SECTION the targets of the Guidelines and the target groups are addressed. The current indoor hygiene situation in German schools is described, followed by the parameters with regard to peripheral issues which will not be dealt with further. Various terms are explained and there are suggestions for further reading on the subject of indoor air hygiene.
- **PART A** deals with the hygiene requirements in the practical running of schools. Besides general requirements for maintenance and operation the important issues of cleaning and ventilation are considered, as well as minor building works.
- **PART B** provides an overview of important chemical and biological contaminants in schools.
- **PART C** looks at building and air conditioning requirements. The important issue of acoustic requirements is also addressed.
- **PART D** shows how to deal practically with problem cases and lists case studies with “typical” procedures.
- **PART E** provides a brief overview of existing renovation guidelines

The **APPENDIX** contains a specimen hygiene plan for schools and an index.

I-4 Current situation in German schools

The condition of schools in Germany is often unsatisfactory in terms of the fabric of the buildings. Older buildings exhibit problems such as ill-fitting windows, leakiness and signs of wear and tear on brickwork and roofs, as well as damp damage as a result of plumbing leaks. The number of new buildings erected after 1990 is comparatively small.

Today there are around 34,000 mainstream schools and about 10,000 vocational colleges in Germany.

Among the main (air) contaminants in schools are:

- Increased carbon dioxide resulting from inadequate ventilation and airtight windows.
- Excessive damp in the structure of the building or in the indoor air, resulting in microbial growth.
- Emissions from building materials, fixtures and fittings.
- Diverse odours in the case of inadequate ventilation.
- Emissions from cleaning materials.
- Possible release of dust and fumes in technology and science lessons.
- Particulate matter arising from discharges from outdoor and indoor sources.

What sort of health problems are reported after spending time in schools?

Among the problems mentioned by pupils, parents and teachers in relation to being in school are general disorders such as headaches, fatigue and poor concentration. Furthermore, symptoms such as irritations of the upper respiratory tracts and eyes, sinus infections and the occurrence of allergic symptoms can also be traced back to time spent in schools.

Many school buildings are clearly in need of renovation on account of their great age and many years of intensive use. In recent years the fire and health and safety regulations have also become ever more stringent. The Building Energy Conservation Ordinance demands, amongst other things, that in new-builds and comprehensive renovations of existing buildings the outer shell is made airtight to minimise the use of primary energy. The disadvantage when there is inadequate ventilation can be a possible accumulation of the chemical and biological substances released indoors.

Unfortunately, many local authorities lack the money for comprehensive and specialist renovations. The consequence is damp penetration through gaps in walls, roofs and pipework. Ill-fitting windows are actually a real advantage from a hygiene perspective, as they help to allow a minimum of air circulation in classrooms even if the windows and doors are closed. However, ill-fitting windows lead to energy loss and may expose pupils and teachers to draughts during lessons.

The remediation necessary, i.e. the extent of the repairs, modernisation and renovation of school buildings, depends on the actual condition of the building in each case – old and new buildings are equally affected. Because of the demands on the use of school buildings, particularly the classrooms, regular maintenance and repairs are extremely important in order to avoid structurally related hygiene problems later.

If extensive renovation work is due to take place, a comprehensive air-conditioning scheme should be included in the renovation plans, in order to improve the ventilation situation during later use. This can involve air-conditioning solutions, but could also be a design for an improved ventilation regime. Sensor-operated solutions (opening the windows when there is too much carbon dioxide in the air) are equally possible.

Noise control can be another problem in school buildings. Many classrooms suffer from undesirable reverberation. There can then be substantial interference to communication and aural comprehension between teachers and pupils.

Just as important as good acoustics is adequate and even lighting. Windows of adequate size are in any case compulsory. However, if these face exclusively west and east, it can cause excessive heat to build up in the rooms in summer. South-facing windows are generally less of a problem in this respect, contrary to long-standing opinion, because the sun is relatively high in the sky at midday, making it easier to employ shading at the windows.

The need to take precautions against overheating of rooms in summer will increase in the course of future climate changes.

Is it permitted to use windowless rooms as classrooms?

Under *Länder* building regulations, it is strictly prohibited to use windowless rooms for long periods of occupation, and therefore also as classrooms in schools.

I-5 Parameters

One indoor hygiene problem of the last decade has recently been consigned to the past – tobacco smoke. Owing to the laws protecting against the dangers of passive smoking which have now come into force in almost all German *Länder*, a general ban on smoking in schools and school playgrounds applies throughout Germany. Smoking rooms are not permitted in schools.

What is not covered in these guidelines?

Tobacco smoke: the negative health effects of tobacco smoke are well enough known. There is an absolute ban on smoking in school buildings and on the whole school premises.

II Terms and regulations

According to a recent study as part of the Federal Environment Agency's 2007 National Health Survey of Children and Adolescents, children aged between 3 and 14 spend 90 % of the day indoors in winter. Even in summer adolescents spend part of the day in enclosed spaces. The indoor environment includes the home, school, nursery schools, theatres, cinemas, libraries, sports halls, department stores, discotheques and transport. Thus, from a hygiene perspective, the study and reduction of indoor air contaminants is of central importance for health and well-being.

In general, pollution in the air in a classroom should be treated and assessed in the same way as pollution in the home. Health and safety at work regulations, which apply to individual areas of the school (workshops, etc.), do not preclude this. Air pollution limit values applicable to workplaces contaminated by industrial production processes cannot be applied to the inside of schools.

An ad hoc working group, made up of members of the Federal Environment Agency's Indoor Air Hygiene Commission (IRK) and the Working Group of the Supreme Health Authorities of the Federal States (AOLG), are devising guideline indoor air values for single substances based on a procedural model published in 1996 (cf. Section B-2). According to this, two guideline values are generally established for indoor air contaminants. Value II (RW II) is derived on a hygiene/toxicology basis, taking into account both population groups with sensitive reactions and children, and represents the concentration of a substance which, if reached or exceeded, requires immediate action, since this concentration is likely to endanger health, especially in people with sensitivities, if they spend a long time in the rooms. The need for action should be understood as the need for immediate inspection, e.g. with a view to deciding on remedial measures to reduce exposure. Value I (RW I) is calculated from RW II, taking into account a conventionally established safety factor (generally of 10), and can serve as the target remediation value. If a value is below RW I when a single substance is examined, according to current knowledge no damage to health is to be expected, even in the case of lifelong exposure to the substance concerned. For precautionary reasons action also needs to be taken in the region between RW I and RW II, for instance, to increase ventilation.

An overview of the indoor air guideline values derived on the basis of this model, which also applies to indoor areas in schools, can be found online at the following link:
http://www.umweltbundesamt.de/gesundheit/innenraumhygiene/richtwerte-irluft.htm.

III Further reading

The following collection includes a range of literature intended to provide the reader with further information on indoor air hygiene.

- Amt der Niederösterreichischen Landesregierung, Abteilung Umwelthygiene: Leitfaden für die Innenraumlufthygiene betreffend Vorbeugung, Untersuchung, Bewertung und Sanierung von Schimmelpilzbelastungen in Wohngebäuden [Lower Austrian state government, Department of Environmental Health: Guidelines for indoor air hygiene with regard to the prevention, investigation, assessment and remediation of mould contamination in residential buildings]. St.Pölten 2007.
  http://www.noe.gv.at/bilder/d25/Schimmelpilzleitfaden.pdf
- Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit: Luftqualität in öffentlichen Innenräumen – Frische Luft an bayerischen Schulen [Bavarian Health and Food Safety Authority: Air quality in public indoor spaces – fresh air in Bavarian schools].
  http://www.lgl.bayern.de/gesundheit/umweltmedizin/projekt_luft.htm
- Berufsgenossenschaft der Bauwirtschaft (BG BAU): Gesundheitsgefährdungen durch biologische Arbeitsstoffe bei der Gebäudesanierung (BGI 858). Handlungsanleitung zur Gefährdungsbeurteilung nach Biostoffverordnung [Building trade association (BG BAU): Health hazards from biological materials used in building renovation (BGI 858). Instructions for risk assessment in accordance with the Ordinance on Biological Agents]. (2006)
  http://www.bgbau-medien.de/site/asp/dms.asp?url=/zh/bgi858/titel.htm
- Freie und Hansestadt Hamburg: Frischer Wind in Schulen. Informationsbroschüre. Hamburg, Behörde für Wissenschaft und Gesundheit [Free and Hanseatic city of Hamburg: A breath of fresh air in schools. Information leaflet. Hamburg Ministry of Science and Health]. (2005)
- Institut für angewandte Hygiene: Österreichische Schulen – Hygieneplan [Institute of Applied Hygiene: Austrian schools – hygiene plan]. Graz (2007) **www.schule.at/gesundheit/hygieneplan2007.pdf**

- Landesgesundheitsamt Baden-Württemberg: Schimmelpilze in Innenräumen – Nachweis, Bewertung, Qualitätsmanagement. LGA-Berichte, [Baden-Württemberg Health Agency: Mould in indoor environments – detection, evaluation, quality management. Health Agency reports] Stuttgart (2001) (revised 2004)
- Landesgesundheitsamt Baden-Württemberg: Handlungsempfehlung für die Sanierung von mit Schimmelpilzen befallenen Innenräumen [Baden-Württemberg Health Agency: Recommended procedure for the remediation of indoor areas attacked by mould], 2nd revised edition, Stuttgart (2006)
- Landesgesundheitsamt Baden-Württemberg: Musterhygieneplan für Schulen und ähnliche Gemeinschaftseinrichtungen [Baden-Württemberg Health Agency: Specimen hygiene plan for schools and similar community institutions]. LGA, Stuttgart (2005)
- Niedersächsisches Landesgesundheitsamt (NLGA): Lüftungsempfehlung für Arbeitsräume (Büro- und Unterrichtsräume) [Governmental Institute of Public Health of Lower Saxony: Recommended ventilation for indoor workplaces (offices and classrooms)]. NLGA, Hanover (2004)
- Niedersächsisches Landesgesundheitsamt (NLGA): „Aufatmen in Schulen“ – Luftqualität und Raumklima in Unterrichtsräumen [Governmental Institute of Public Health of Lower Saxony: „Breathe deeply in schools” – air quality and indoor climate in classrooms]. NLGA, Hanover (2005)
- Niedersächsisches Landesgesundheitsamt (NLGA): Rahmenhygieneplan für Schulen (Entwurf) [Governmental Institute of Public Health of Lower Saxony: Framework hygiene plan for schools (draft)], Hanover (2007)
- Rahmen-Hygieneplan für Schulen und sonstige Ausbildungseinrichtungen gemäß § 36 Infektionsschutzgesetz. *Länder*-Arbeitskreis zur Erstellung von Hygieneplänen nach § 36 IfSchG [Framework hygiene plan for schools and other educational establishments in accordance with Article 36 Protection against Infections Act. Federal states' working group for the creation of hygiene plans in accordance with Article 36 Protection against Infections Act], Potsdam (2003)
- Umweltbundesamt: Leitfaden zur Vorbeugung, Untersuchung, Bewertung und Sanierung bei Schimmelpilzwachstum in Innenräumen (Schimmelpilz-Leitfaden) [Federal Environment Agency: Guidelines on the prevention, investigation, assessment and remediation of mould growth in indoor areas], Berlin/Dessau 2002

- Umweltbundesamt: Leitfaden zur Ursachensuche und Sanierung bei Schimmelpilzwachstum in Innenräumen (Schimmelpilz-Sanierungsleitfaden) [Federal Environment Agency: Guidelines on identifying the cause and on treating mould growth in indoor spaces]. Berlin/Dessau 2005
- Umweltbundesamt: Bauprodukte: Schadstoffe und Gerüche bestimmen und vermeiden [Federal Environment Agency: Building materials: Identifying and avoiding hazardous substances and odours]. Dessau 2006
- Unfallkasse des Landes Nordrhein-Westfalen (2008): Umsetzung der Gefahrstoffverordnung an Schulen Teil 1 und 2 [North Rhine-Westphalian Accident Insurance (2008): Implementation of the Hazardous Substances Ordinance in schools parts 1 and 2]: available at <**http://www.unfallkasse-nrw.de/index.php?id=4&no_cache=1**> link to download the documents “Prävention in NRW 3 und 4 - Umsetzung der Gefahrstoffverordnung an Schulen Teil 1 und 2” [Prevention in North Rhine-Westphalia 3 and 4 - Implementation of the Hazardous Substances Ordinance in schools parts 1 and 2]
- United Kingdom: Department for Communities and Local Government: The Building Regulation Documents. Building Bulletin 101, Ventilation of School Buildings. London (2006)

PART A: Hygiene requirements in the practical running of schools

A-1 General hygiene requirements

These guidelines relate to air hygiene questions in school buildings. However, in the practical running of schools there are often aspects over and above air hygiene to consider.

Just as in other buildings, specific fundamental hygiene requirements, or rather general hygiene requirements, must be met in schools, in order for it to be possible to spend time in the building without experiencing health-related problems.

Included in the general hygiene requirements (some of the points listed can only be implemented when planning new-builds) are:

- The school site should be located favourably with respect to airborne pollutants in the surrounding air, i.e. there should be as little pollution by hazardous substances as possible in the vicinity. There should be low traffic and industrial noise levels and a safe route to school for pupils. Conversely the noise emissions from the school itself should as far as possible not create any significant nuisance to the neighbourhood.
- The classrooms should be of sufficient size and be arranged practically in relation to the way the sun moves round. Where the proportion of glass in the façade exceeds 50 %, as is usual in school construction, all façades, with the exception of windows facing due north, require shading. This must have variable controls.
- Adequate light from daylight and – to supplement it – from artificial lighting should be provided at all times of day and throughout the year. Consequently the depth of the room should not exceed two to three times its height. The light reflectance of the component surfaces should be as high as possible (can be achieved by means on light colours on walls and ceilings).
- Effective structural noise insulation should prevent noise transfer to neighbouring rooms, corridors, etc. The classrooms should have low reverberation times for better speech intelligibility (DIN [German Institute for Standardisation] 18041 2004/2005; Acoustical quality in small and medium-sized rooms).

- Windows or other ventilation options should permit, through natural ventilation, the reduction of the concentration of air pollutants being produced in the room. All windows should be easy to open.

Regulations in individual *Länder*, in accordance with which windows have been structurally or manually altered for safety reasons so that they cannot be opened – for example, to prevent someone falling out of the window – are unacceptable in the opinion of the Indoor Air Hygiene Commission. Accidents must be prevented through other measures (including all pupils leaving the classroom during breaks, the classrooms being locked during breaks).

- In areas in which working with hazardous substances is a requirement, such as in laboratories, mechanical ventilation is absolutely essential. In the case of extremely polluted outside air conditions the installation of air-conditioning systems should be considered.
- All areas of the school building should be equipped with adequate heating, whereby the radiators should be of adequate dimensions, if possible should be run at low temperatures, and should be easy to clean.
- The furnishings and equipment in the rooms should be as free as possible of emissions hazardous to health. When purchasing new furniture attention should be paid to environmental quality labels (cf. Section A-5).
- Proper cloakrooms should be available in sufficient numbers so that wet clothing can dry and air. For fire safety reasons lockers and coat pegs are often not located in corridors nowadays, but in the classrooms. This makes adequate ventilation and dehumidification in these areas all the more important.
- A sufficient number of toilets equipped with washbasins should be available for pupils and teachers. The facilities must be cleaned and serviced regularly.
- Playgrounds and indoor recreation rooms of sufficient size should be available for use at breaktimes.
- All areas of the building should be easy to clean.

What general hygiene considerations should be taken into account in the practical running of a school?

Besides hygienically impeccable structural conditions, good accessibility to all rooms and areas, especially with regard to making cleaning easy, the provision of low-emission equipment, and regular heating and ventilation are the best prerequisites for a hygienically safe situation in schools.

A-2 Cleaning procedures

Cleaning procedures must be carried out regularly and properly in schools on account of the intensive use, including by vulnerable user groups. The minimum requirements for cleaning school buildings and sports facilities belonging to them are set out in DIN 77400 “Cleaning services – school buildings – requirements for cleaning”. This applies regardless of whether the cleaning is undertaken by the school’s own employees or by cleaning agencies.

In the introduction to the aforementioned DIN standard it is noted that cleanliness and hygiene are of particular importance in school buildings and that the environment in which children and young people are educated influences their health as well as their own perception of hygiene and their habits in that respect. Furthermore, it states that particular importance must be attached to school cleaning requirements, regardless of the prevailing budget situation within the local authorities, and to the cleaning intervals resulting from it.

According to DIN 77400 one of the general requirements for hygienic cleaning of school buildings is that the dust concentration is kept within acceptable limits through suitable cleaning methods (e.g. washing). When selecting the cleaning methods and systems the latest technology should be used, taking into account environmental considerations.

When establishing cleaning intervals in individual school buildings local conditions must be given particular consideration. Factors to bear in mind include location, use (and also extracurricular use), school layout, frequency of use, building fabric, nature of the external grounds (with unsurfaced areas considerably more dirt can be expected to be brought in) and seasonal influences.

The cleaning intervals set out in DIN 77400 are **minimum cleaning frequencies**. In DIN 77400 it is emphasised that, depending on local conditions and the factors mentioned above, more frequent cleaning than specified in DIN 77400 may be necessary.

The following cleaning procedures are based on these **minimum cleaning frequencies** and should therefore not be applied prescriptively to all local situations and seasonal conditions equally.

Corridors and **stairwells** together with classrooms and teaching areas are the most frequently used spaces in a school. These areas become dirty quickly. The entrance area, the traffic areas of the ground floor and the stairs to the first floor should be cleaned daily, even several times daily if necessary in winter, when more mud is brought in from outside. The other corridors and staircases should be cleaned at least every other day in summer, and more often in winter if necessary.

From a hygiene viewpoint washing, having first removed loose, coarse dirt, offers the best option for eliminating the various contaminants brought inside. Depending on the nature and composition of the floors to be cleaned it may be sufficient to add either surfactants to the washing water, or else specialist cleaners (for flexible floor-covering) must be used. More precise instructions in this regard should be stipulated in each individual case after consultation with the cleaning contractors or the floor manufacturer.

Only in exceptional cases will it be necessary to carry out disinfectant cleaning or surface disinfection of floors in corridors and stairwells. For example, this may be the case if there are increased occurrences of notifiable infectious illnesses in the school, when the relevant health agency will arrange for appropriate measures to be taken. This especially includes disinfecting handrails. In cases of contamination with blood, faeces and vomit disinfecting can also be necessary; however, this should only be carried out by designated staff and under strict observance of the school's existing hygiene, ventilation and cleaning plan (see Appendix 1).

In order to facilitate regular wet cleaning (washing) of corridors and stairwells in schools it is necessary for these areas to be fitted with suitable flooring.

Carpets and carpeting should therefore not be used in these areas (see paragraph on Carpeting).

Classrooms and teaching areas should be cleaned regularly. Studies have shown that perfectly hygienic conditions can be achieved in classrooms by washing the floor properly and wiping tabletops with a damp cloth every other day, if external conditions (state of the building, local circumstances) are good. Especially in the winter months and with unsurfaced outside areas, and if there is additional use (e.g. after-school clubs) cleaning should be carried out daily.

Can cleaning alone improve the air quality in classrooms?

A reduction in pollution in classrooms cannot be guaranteed through cleaning alone. Cleaning is important, but the reduction of existing sources of emissions and regular ventilation are equally important. Through ventilation the carbon dioxide concentrations (a classic indicator of inadequate fresh air supply), increased humidity in the indoor air and pollution by hazardous chemicals and particulate matter are reduced.

Carpeting, which is laid in some schools for reasons of noise control, should also be properly vacuumed at least every other day, if possible with a vacuum cleaner fitted with a HEPA filter or with a central vacuum cleaning system (VDI [guidelines from the German Association of Engineers] 4709). The manufacturer's instructions should also be observed. In this case, too, more frequent cleaning should be assumed if increased dirt is brought in or there is additional use. Carpeting in classrooms and teaching areas can pose a hygiene problem, as it is more difficult to clean than hard, washable floors. For this reason laying carpeting in new school buildings is not recommended. If carpets have to be renewed, e.g. because of wear and tear, they should if possible be replaced with hard, washable flooring.

"Cosy corners" present a particular hygiene problem in schools. The issue here is often second-hand, sometimes threadbare upholstered furniture, which is often piled up with cuddly toy animals, toys, cushions and blankets. If the school accepts these "cosy corners", which have frequently been set up with the support of the parents, they must definitely be included in the cleaning plan and cleaned thoroughly as well on a regular basis, e.g. by vacuuming them at least once a week. Items kept in these corners must also be subject to the cleaning procedures.

Linoleum has environmental advantages owing to its natural constituents – linseed oil, wood flour, limestone and jute – and is often used in public buildings, although it requires regular special care because of its composition. When cleaning and caring for linoleum there is a distinction between cleaning after installation, or initial cleaning, maintenance cleaning by washing, wiping with a damp mop or using a floor cleaner and deep cleaning followed by replenishing the protective finish. When selecting cleaning and maintenance products for linoleum absolute care must be taken to use only those with a pH value below pH9, as products that are too aggressively alkaline attack the natural materials in linoleum and can destroy the surface. For this reason soft soap may not be used either. It is recommended that the cleaning staff should be obliged to abide by the manufacturers' relevant care instructions.

Sanitary areas and **washrooms** including **changing rooms** in school buildings are of particular importance in terms of hygiene. Here thorough cleaning must be undertaken at least once a day and floors scrubbed regularly (to remove surface and ground-in dirt, having first removed coarse grit). Tiled walls and floors are ideal for this. Surface disinfectants can be appropriate if notifiable infectious diseases occur. In this case the health agency will organise suitable measures. Cleaning procedures involving disinfectants are not necessary in sanitary areas to prevent infection, but can be appropriate in the event of contamination of surfaces by faeces, vomit, etc.

Staffrooms, **school offices**, **administrative areas**, **offices and meetings rooms** should be cleaned twice a week, while side rooms (for lesson preparation, teaching materials, etc.) should be cleaned at least once a week and storerooms at least once a month.

Gyms (used only by the school) and areas with similar functions) must be properly cleaned on a daily basis. Here the type of cleaning depends on the floor construction and the nature of the floor surface. With additional use by sports clubs in the evening and at weekends suitably expanded cleaning programmes are necessary.

Where there are **kitchens and food distribution points**, the provisions of Regulation (EC) No. 852/2004 on food hygiene should be observed. This applies also to school meals kitchens and by the same token also to **home economics kitchens**. In addition the relevant hygiene regulations should also be complied with in **dining rooms**. The floors, sinks and fittings, wall tiles and storage units, tabletops and kitchen appliances (cookers, etc.) and washbasins must be cleaned on each day used (removing surface and ground-in dirt, having first removed larger debris).

As more and more schools go over to all-day schooling, they should ensure that a sufficient number of washbasins is available in the school.

Over and above the maintenance cleaning, deep cleaning, special cleaning and cleaning of glass as well as care programmes should be carried out to ensure adequate hygiene standards and minimise deterioration. After deep cleaning additional protective care measures may be required, depending on the type, composition and condition of the surfaces. In particular, protective films on flooring must be kept in good condition through regular care procedures. A thorough cleaning and care programme in accordance with the care instructions should be carried out in all areas of the school at least once a year. This involves not only cleaning the floors, but also the furniture and other items of equipment.

For both the routine cleaning and the thorough cleaning and care only cleaning products which pose no risk to health should be used. If several different cleaning products are used, a check should be made to ensure that the products do not neutralise each other's effect and that no substances harmful to health are produced by mixing them together. The recommendations for use should be followed. Safety instructions and risks posed by the product can be obtained from the safety data sheets.

Some surface disinfectants contain aldehyde (in recent years aldehydes such as glyoxal or glutardialdehyde have been used increasingly), quaternary ammonium compounds (QUATS), biguanide and amines. Some disinfectants, if used incorrectly (too high a dose of the active substances in the solution employed, inadequate or incorrect ventilation measures during use), can lead to residues of their active agents evaporating into the air building occupants breathe, resulting in harm to human health.

What must be cleaned in school buildings, and how often?

For sanitary areas a proper clean once a day is essential; if necessary they should be cleaned more frequently.

The entrance area up to the first floor should be cleaned daily, while the other corridors and staircases should be cleaned at least every other day. Classrooms and tabletops should be cleaned thoroughly at least every other day. Sports halls and similar areas require daily cleaning.

In other areas of the school cleaning programmes should be carried out as needed.

The use of added disinfectants is only necessary in special cases (diseases notifiable under the German Protection against Infections Act [Infektionsschutzgesetz] or in the case of contamination with blood, faeces or vomit). Disinfectant cleaning should not be undertaken in any area of the school without specific cause, i.e. just to prevent infections in general.

Sanitary areas and washrooms should be fitted out so that sufficient numbers of washbasins are available. Soap dispensers and paper towel systems should preferably be installed by the washbasins.

The production and use of cleaning plans is to be recommended. In relation to these it is advisable to set out the cleaning, ventilation and other hygiene procedures to be followed in a „Comprehensive Hygiene Plan".

A-3 Ventilation requirements

The most important function of ventilation is to renew the indoor air by extracting impurities in the form of gas and dust and the metabolic products from humans (odours, carbon dioxide, water vapour) and to supply fresh air from outside. In addition there are physiological requirements: achieving the most comfortable possible air temperature and humidity in the room, and achieving thermal balance.

Until now, because of the prevailing climate in Germany, school buildings have generally been designed and built in such a way that natural or "fresh air" ventilation through windows should suffice. However, in unfavourable locations (e.g. considerable noise pollution from the vicinity or high air pollution) the installation of ventilation systems may become necessary. In addition special extraction systems are required for laboratories where experiments producing high levels of smoke are carried out.

When using ventilation via windows or air vents in external walls it is important to reduce the impact of possible high noise levels from outside (e.g. traffic noise, aircraft noise) on classrooms. The installation of highly sound-absorbent ventilating windows or sound-insulated ventilation ducts can be necessary in this case.

To prevent the rooms from overheating through solar irradiance, windows, fixed glazing and skylights should all not be larger than necessary for appropriate day lighting without glare. Where the proportion of glass in the façade exceeds 50 %, as is usual in school construction, all façades, with the exception of those facing due north, require sunshading. Fixed sunshading devices have the disadvantage of reducing incoming daylight. Southerly aspects are, however, easier to fit with effective sun-protection devices. These devices must not impair the window ventilation and should not encourage the inflow of warm air rising up the outside wall.

The criterion for the renewal of air in a room is the air-change number. This is the quotient from the volume of the supply of exchanged air into the room and the volume of the room. It is defined as a dimensionless size per unit time (mostly one hour). An air-change number of 1/h ("one per hour") means that (arithmetically) the entire volume of air in a room is completely replaced in one hour. A distinction is made between natural air exchange, which occurs as a result of wind pressure difference and thermal lift, and mechanical air exchange by means of ventilation devices. With natural ventilation through wide-open windows the air-change rate is around 10–20/h.

The more polluted the indoor air is with carbon dioxide (CO_2) and other substances (cf. Sections B-1 to B-4), the greater becomes the air exchange required. With normal class sizes several changes of air per hour are required for the classroom, in order to extract enough of the carbon dioxide produced by the pupils exhaling from the air in the room. The necessary air exchange of around 25 to 30 m^3/h per person cannot be achieved through natural ventilation with closed windows (known as window gap ventilation), but only by regularly opening the windows wide for short periods ("intensive ventilation" for at least 5, preferably up to 10 minutes). Even more effective (if possible) is cross-ventilation via windows opposite each other. Therefore the room must really be aired in every break between lessons and – with double lessons or large classes – during lessons as well. (If this is necessary, the pupils should leave the rooms for safety reasons during this time.) It is also recommended that intensive ventilation be carried out briefly once or twice during the lesson.

How should the rooms be aired?

Basically using the windows. To do this **all** windows in teaching areas should be opened wide (intensive ventilation, cross-ventilation) before school starts and at least during every break (specifically including the five minute breaks, when the pupils normally stay in the room!) for the whole duration of the break. Ventilation by tilting the windows is largely ineffective, as hardly any air is replaced in this way.

In the winter months heat inevitably escapes during ventilation. To minimise energy loss the radiator vents should be closed during ventilation. Alternatively automatic vents with window contact switches can be installed. The reserve capacity of the heat generation should permit swift reheating.

The reserve capacity of the heating system must allow the rooms to warm up again quickly after ventilation – as otherwise ventilation would not really be considered acceptable by the users of rooms.

If manual ventilation with windows is not adequate to create or maintain hygienically ideal air quality during lessons as well, mechanical ventilation options can be installed to ensure sufficient air replacement even with the windows closed. High levels of noise and other emissions outside can also make mechanical ventilation systems necessary. If systems of this sort are installed, regular servicing must be guaranteed on hygiene grounds.

A-4 Requirements for and cleaning of school swimming pools

Swimming is extremely valuable in promoting good health. It is also particularly important in P.E. lessons. Some schools have their own swimming pools. Swimming is healthy, but can also cause hygiene problems. Every swimmer releases on average 2.3 to 2.6 billion germs, possibly including pathogenic micro-organisms such as *staphylococcus aureus*, *streptococcus pyogenes*, *salmonella spec.* as well as pathogenic viruses, into the water.

Therefore it is essential to ensure that no health risks are posed by the water in swimming and bathing pools. The Protection against Infections Act (Article 37) provides the legal foundation for this: "Water in commercially-run swimming or bathing pools, public baths and other not exclusively privately used facilities must be such that in using it there should be no need for concerns over harm to human health, especially through pathogens".

In order effectively to prevent the transference of pathogens, disinfection of the water in the pool is essential. Chlorine has for a long time proved valuable as an effective disinfectant on account of its rapid and long-lasting microbiocidal action. Chlorine gas or hypochlorite compounds (DIN 19643) are used. In some pools bromine is also employed, again because of its microbiocidal effect. However, it is more difficult for pool operators and health agencies to monitor this type of disinfection properly, since with the DPD method normally used for monitoring it is impossible to distinguish between free and bound bromine. For that reason bromine is not included as a disinfectant in the Federal Environment Agency's recommendation "Hygiene requirements at pools and their supervision" (Bundesgesundheitsbl-Gesundheitsforsch-Gesundheitsschutz 9, 2006). It should be noted when using chlorine and bromine that both substances cause irritation. Furthermore, because of the reaction of chlorine or bromine with waterborne organic substances, which are mainly brought into the pool water by swimmers (e.g. organic compounds from urine, sweat, mucus, hair, flakes of skin, cosmetics), but which are also to some extent already present in the water used (e.g. humic substances) hazardous disinfection by-products (DBPs) can be produced. The best known of the organic DBPs are the trihalogen methanes (THMs). They have an indicator function in relation to the health evaluation of pollution in swimming pool water. THMs also enter the air in indoor pools from the spray. Air pollution by THMs can be reduced by effective ventilation.

Regarding the assessment of organic DBPs, there is to date in the field of swimming pool water only a cumulative value of 0.02 mg/l for THMs in DIN

19643, which is based on technological feasibility. In evaluating health risks arising from swimming and bathing pool water it should be noted that two risks should be weighed up against each other, being the microbiological and the toxicological, whereby the microbiological should be classified as more relevant overall.

The treatment of swimming pool water is a technically complex procedure that requires a high level of expertise in pool technology on the part of the relevant operators. In the case of school-run swimming pools this is often only barely achievable, as they have no specialist staff. The technical operation of these pools is undertaken by the school caretakers or by local authority employees, who must be experienced in dealing with maintenance and pool machinery.

Central to swimming pool water treatment is the flocculation, filtration and the chlorination of the water (DIN 19643). Sometimes activated carbon adsorption or ozoning precedes or follows flocculation. Experiences show that it is the flocculation and filtration processes that are carried out incorrectly and that the requirements of DIN 19643 are not met. This also applies particularly to the regular cleaning of filters that is necessary.

Incorrect water treatment can lead to pollution of the pool water with *pseudomonas aeruginosa* (especially following filter contamination) and to legionella. There is an especially high risk of infection if the showers are contaminated with legionella because the hot water systems are set at a low temperature. Schools which operate a swimming pool should include the servicing and cleaning of the pool in the overall hygiene plan. In accordance with DIN 19643, specific measures to be undertaken in the pool regarding pool water treatment, showers and cleaning and disinfection procedures should be laid down in the hygiene plan. The school should ensure that the staff responsible for the pool machinery take part in regular training and development in this field. The recommendations of the Federal Environment Agency's Swimming Pool Water Commission (see Bundesgesundheitsbl-Gesundheitsforsch-Gesundheitsschutz 9, 2006) and further hygiene recommendations (e.g. pool hygiene plans) should also be taken into account here.

In a further recommendation from the Swimming Pool Water Commission (Bundesgesundheitsbl 1997) special instructions for preventing the contraction of warts after visiting swimming pools are being issued. Warts are caused by viruses. Moreover, there are various types of warts, which can occur most commonly on the backs and palms of the hands, the fingers, and on the soles of the feet (verrucas). Molluscum contagiosum (MC) causes lumps from pinhead-size to the size of a pea, with a smooth and often shiny surface, which sometimes has a dip in the middle. They can occur anywhere on the body. MC is transmitted through direct human contact (when playing, taking part in sport, etc.), whereas normal warts are mainly transmitted indirectly, through contact with material or objects containing the virus.

Infection does not take place via the water.

Children and young people should be informed about the contagiousness of warts by P.E. teachers or other responsible people. In doing this, the following points should be emphasised:

- You should avoid sharing the use of towels, massage oil, skin lotions, etc. among several people.
- You should refrain from going barefoot in swimming pools if you already have warts or verrucas.
- A visit to the doctor is recommended if you have warts.

When use of the swimming pool is over, the surfaces walked on with bare feet should be disinfected with an active virucide in accordance with the list of disinfectants from the German Association for Hygiene and Microbiology or the Robert Koch Institute. The scrubbing and washing procedure should be used for this. Spraying with disinfectant is not sufficient, as flakes of skin are not removed effectively by this.

A-5 Minor building works and renovations

After minor building works, maintenance and renovations there are always complaints from teachers, pupils and parents about poor indoor air quality. Problems with indoor air can be largely avoided when minor building and renovation projects are carried out correctly.

There are four aspects to be considered in relation to air hygiene prior to building and renovation work, in order to minimise later emissions:

- Choice of materials
- Quantity of materials
- Monitoring of the progress and completion of the work
- Coordinating and monitoring the time frame.

Building products and other materials release volatile organic compounds (VOCs) into the air in the room (cf. Section B-2). This can have negative impacts on the users of the room. The extent of these detrimental effects depends on the type and intensity as well as the duration of the VOC emissions. Particularly those materials to be used over large areas in the rooms, such as surface coatings, bondings, and floor coverings should be chosen so that the minimum of emissions are produced after installation and during later use.

In the context of these Guidelines it is not possible to give a list of building products and decorating materials to be recommended on a hygiene basis, as there is a vast array of products on the market, which is subject to regional variation and will change over time. In the Safety Data Sheets for the products the manufacturers and suppliers must list, amongst other things, substances subject to labelling regulations. Instructions for use and further product information can be found in the Technical Data Sheets. For the most part there is insufficient information on emissions behaviour in these data sheets. The Indoor Air Hygiene Commission recommends giving priority to manufacturers and suppliers of building products and other materials who respond to consumer demand for more detailed information.

Products marked with the Blue Angel ecolabel "low in emissions" or "low in hazardous substances" produce low levels of emissions and should preferably be used. The leaflet "Umweltzeichen für Bauprodukte. Bauprodukte gezielt auswählen" [Ecolabels for building products. How to choose the right building products] offers advice on product selection. This is available at **www.apug.nrw.de/pdf/Bauprodukte.pdf**. Unfortunately, products bearing the Blue Angel and other environmental labels are not yet available for all areas of application.

What should be considered when choosing materials?

Before starting minor building works, maintenance and renovations an overview of the type and amount of substances contained in materials needed for the building and renovation work should be available to the appropriate office. Initial information on this can be found in the Technical Data Sheets and the Safety Data Sheets. Further details can be obtained from the manufacturer or supplier. Some manufacturers have commissioned studies into the emissions behaviour of their products and can provide information on it. Products with the Blue Angel ecolabel should preferably be used.

Odours present a major problem in the choice of building materials. Many building products are not odour-free, especially when they are delivered fresh from the factory. These odours can then persist in the first few months after installation and lead to unpleasant effects for the users of the space. At present it is not possible to gauge how much odour pollution arises from products, even by only choosing the best materials, for example those tested in accordance with the AgBB [Committee for the Health Evaluation of Building Products] scheme (for the AgBB scheme see Section C-1) and approved by the Deutsches Institut für Bautechnik [German Institute for Construction Engineering]. The test conditions currently only include an analysis of volatile organic compounds (VOCs, see Section B-2) and semi-volatile compounds (SVOCs, cf. Section B-4). Various studies have shown that there is no correlation between VOC emissions and odour emissions. In future odours are also to be included in evaluations based on the scheme. There have been initial experiments with a process for the odour evaluation of construction products on the basis of measurements taken in test chambers for measuring emissions (cf. Further reading “Bauprodukte: Schadstoffe und Gerüche bestimmen und vermeiden” [Building materials: identifying and avoiding hazardous substances and odours] in Section III). This process, which is based on the evaluation of odour intensity by a trained panel (a group of people specially trained to recognise odours) with the aid of a standard of comparison, has proved its suitability and good reproducibility in a round robin test. As it has now gained general acceptance this process is currently undergoing international standardisation (ISO TC 146 / SC 6).

The products and materials selected and used should not only be low in emissions, but should also be as durable as possible. Every extension in the period of use postpones more building or renovation work with the potential to reduce indoor air quality.

The selection and use of low-emission construction products is one criterion for avoiding hazardous emissions, while the other is on-site monitoring whether these products are indeed being installed in the school building in the proper way. Proper supervision of the work by a project manager or comparable expert familiar with the indoor air hygiene requirements is therefore to be strongly advised.

In the case of layered construction of floors and other large surfaces care should be taken to carry out the separate stages in such a way that the solvents and other auxiliary volatile materials used evaporate as fully as possible before the next layer is applied (see manufacturer’s instructions). Particularly in the case of absorbent products and products covering large areas, or the corresponding subsurfaces, it is essential to ensure that no or only small quantities of volatile organic compounds are ingested (e.g. by applying a suitable barrier layer) from subsequent stages of work and during later cleaning procedures.

The formation of substance deposits between layers should be avoided if possible. For the same reason products containing volatile substances should not be allowed to penetrate gaps, cracks and cavities in large quantities.

Care should also be taken during renovations to ensure that the existing subsurface and residues of old material on it do not react to the new products in a way that could for example lead to odour pollution. The application of a suitable barrier layer can prevent reactions.

The emission of VOCs and SVOCs from construction products and decorating materials can be considerably restricted, but not completely avoided. Indoor air is almost always additionally contaminated by VOCs (less by SVOCs, which release gas more slowly) immediately after building and renovation work. For this reason a certain length of time should be factored in (this can take from one to several weeks, depending on the extent and type of renovation work) for the VOCs to escape before using the rooms again. In schools it is a good idea for minor building works and renovations to be scheduled for the beginning of the school holidays, so that most of the components have already been released from the materials before the room is used again. While the offgassing of the substances is taking place there must be intensive ventilation.

If hot water pipes and radiators have been newly painted, it is strongly recommended to run the heating system briefly when the paint is dry with nobody in the room. This will allow compounds that only occur in the paint layer at higher temperatures and often generate unpleasant odours and irritations to be released from the paint layer as far as possible in good time before the later use phase.

Once the construction and renovation work is complete the entire building should be intensively cleaned. Cleaning with water and the most thorough possible removal of all dust deposits, which may later act as “long-term storage” for semi-volatile organic compounds (cf. Section B-4) emitted during the renovation, is strongly advised.

What hygiene implications can and should an on-site project manager consider during renovation work?

- Check whether the products selected are actually used in the project. If necessary, check whether the materials delivered comply with all quality requirements (including emissions behaviour).
- Check whether the materials selected are unloaded properly and in sufficient time, if this is specified in the choice of material.
- Check whether the working instructions and advice from the manufacturer are being followed.
- Check whether adequate ventilation and evaporation time is being allowed when laying and fixing materials.

A-6 Workshops, laboratories and home economics practical areas

Workshops, laboratories and home economics practical areas count as special teaching areas used only for these purposes. There can be particular problems here, for example when carrying out experiments involving smoke production, which do not occur in normal classrooms, or at any rate not in this form. Extensive regulations exist for these areas, including in the Ordinance on Hazardous Substances and the German Food Law, which will not be discussed further in these Guidelines. In the following section possible pollution sources and existing regulations will be referred to briefly.

Workshops

Ventilation requirements for school workshops are laid down in the "Regeln für Sicherheit und Gesundheitsschutz beim Umgang mit Gefahrstoffen im Unterricht" [Health and safety rules for dealing with hazardous substances in lessons] (GUV 19.16 edition. January 1998, clause 5.2). In accordance with these adequate ventilation measures are required, amongst other things, when working in technical subjects and in art lessons, if hazardous substances are being used or could be released into the air in the room during the lesson. When welding is taking place air-conditioning measures are necessary, while for normal soldering natural ventilation is generally sufficient. In the case of woodwork low-dust working conditions must be created in the workshops. This can be best achieved by ensuring that:

- the daily exposure remains below half an hour per schoolday and the woodwork machinery is only used for a few days a year.
- the sawdust from standard woodworking machinery is vacuumed up at the point of production.
- the woodworking machinery is fitted with dust collecting units and certified dust extractors.

Laboratories

Areas used for science lessons, such as chemistry laboratories, must be equipped with at least one fume cupboard in accordance with GUV 19.16. The fume cupboards must ensure that gases, vapours, smoke, fumes and dust particles cannot escape into the classroom from inside the cupboard in hazardous concentrations or quantities. A dangerous explosive atmosphere must not be created inside the fume cupboard. A sliding front panel must be closed to protect people, in case hazardous substances splash or glass shatters.

Blow cleaning and sweeping raises sawdust residues and is absolutely prohibited. Sawdust must always be vacuumed up by machine.

Home economics practical areas

Kitchens come under the Berufsgenossenschaftliche Regel [professional association rule] (BGR 111; previously ZH 1/37) “Regeln für Sicherheit und Gesundheitsschutz bei der Arbeit in Küchen” [Health and safety rules for working in kitchens]. Home economics teaching rooms are also listed as areas to which it applies, but the rules should be applied in sense only, bearing in mind the school situation. According to the rules, during working times air and room temperature conducive to health must be provided, taking into account the work being undertaken and the physical demands of the workers. For equipment likely to produce increased vapour and cooking fumes, e.g. kettles, tilting frying pans, and deep-fat fryers, an extractor hood is required. During boiling, frying and baking tiny particles can be released; to date there has been little or no research into their hygienic importance. To be on the safe side, cooking processes of this sort should be carried out under the extractor hood. Large quantities of nitrous oxide can arise through the use of gas stoves for cooking. In such cases good ventilation should be provided in addition to the extractor hood.

What should generally be taken into account when working in workshops, laboratories and home economics kitchens?

When working in specialised teaching areas particular care is needed for the protection of pupils and teachers. The current regulations must always be observed. Fume cupboards should be installed in sufficient numbers and must function perfectly. Regular maintenance and inspections of the cupboards is essential. When using hazardous substances checks must be made to see whether alternative substances, preparations or products with a lower or preferably no health risk can be substituted. Contact with carcinogenic, suspected carcinogenic, mutagenic and reprotoxic substances (CMR substances) should not take place in any school subject. The exceptions are only teaching experiments in which the intention is to study the reaction of some substances with others. This sort of experiment may only be conducted by trained teaching staff (as a demonstration experiment) and must take place in the fume cupboard. Depending on the experiment additional individual safety measures may need to be taken (the wearing of facemasks, protective glasses and gloves, labcoats).

A-7 Copiers, printers and PCs

Recently there has been an increase in press reports that indoor air pollution from volatile organic compounds (styrene, benzene etc.) as well as from suspended particulate matter and ultra-fine particles can be released by copiers and printers.

The Federal Environment Agency and the University of Giessen also established in a 2007 study that ultra-fine and fine particles are emitted when laser printers are used. The results are available at: **http://www.umweltdaten.de/publikationen/fpdf-l/3016.pdf** and at **http://www.bfr.bund.de/cd/8644). VOCs are also released.**

The exact composition of the particles released by printers during operation is as yet unclear. The latest research at the University of Giessen and other institutions has shown that toner particles make up only a small fraction of the particle emissions. Further studies are needed for clarification.

Owing to the electrophotographic process, ozone can be produced during the operation of copiers and laser printers. The amounts of ozone released are dependent on the technical properties of the machine, the length of operation and the condition of the machines, as well as the size of the room in which they are installed. However, significant concentrations of ozone hardly occur any longer with modern machines. Newer machines (since about 1992) are fitted with effective ozone adsorbers.

There is often discussion in the public domain, in relation to office machinery, about the use and possible emission from fire retardants. For fire safety reasons plastics used in electronics for casings, circuit boards and cable insulation are treated with fire retardants (particularly halogenated organic compounds). Halogenated fire retardants may not be present in machinery with an ecolabel.

Are concentrations of substances harmful to health emitted by copiers, laser printers and other electronic equipment?

Copiers and laser printers can emit small quantities of VOCs and particles during operation. There is a possibility of briefly contaminating the air in the room when the toner cartridges are changed. For this reason toner cartridges should only be changed by designated staff and with great care. Larger, frequently used printers ("central printers") and copiers should be housed in separate rooms with their own ventilation system. When purchasing a printer only machines with the ecolabel (RAL-UZ 122) should be considered. Advice on purchasing and operating printers is also contained in the Federal Institute for Occupational Safety and Health's recommendations (available at: **www.baua.de/nn_5846/de/Publikationen/Faltblaetter/F44.html?__nnn=true)**

PART B: Contaminants in the indoor air in schools

In the following sections the sources of indoor air contamination will first be examined and their hygienic importance inside schools subsequently described.

B-1 Inorganic gases

Table 1 gives an overview of important sources of inorganic gases in indoor air. With the exception of ozone these inorganic gases are produced by burning fossil fuels. Carbon dioxide is also released through breathing.

Table 1: Sources of relevant inorganic gases inside schools	
Compound	**Source**
Carbon dioxide (CO_2)	People, naked flames
Carbon monoxide (CO)	Experiments with incomplete combustion of organic materials, home economics kitchens, outside air
Nitrogen dioxide (NO_2)	Home economics kitchens (gas cooker), Bunsen burners, outside air
Ozone (O_3)	Outside air (summer), copiers, laser printers

Carbon dioxide (CO_2) arises through burning organic materials and is released through breathing. The compound is of particular importance in school classrooms, as here – as in other enclosed areas that are densely occupied – a large number of people come together in a restricted space. As long as 150 years ago the hygienist Max von Pettenkofer drew attention to the facts of "bad" air when a long time was spent in living spaces and educational establishments and identified carbon dioxide as an important indicator in assessing indoor air quality. For a long time the Pettenkofer Number 0.1 volume percent (= 1000 parts per million (ppm)) was regarded as the evaluation yardstick in indoor spaces. By comparison the CO_2 content of outside air is around 350 ppm (in towns in some places even up to around 500 ppm).

The ad hoc working group of the Indoor Air Hygiene Commission and the Working Group of the Supreme Health Authorities of the Federal States (IRK/AOLG ad hoc working group) has produced an evaluation for carbon dioxide in indoor air (Table 2) (Ad-hoc AG IRK/AOLG, 2008: Gesundheitliche Bewertung von Kohlendioxid in der Innenraumluft [Health evaluation of carbon dioxide in indoor air], Bundesgesundheitsbl-Gesundheitsforsch-Gesundheitsschutz (in press)). According to this, guide values for carbon dioxide concentrations in indoor air are laid down, which are to be seen as snapshot values pertaining to the concentration at a given moment in time. It is divided into “hygienically insignificant” (CO_2 < 1000 ppm), “hygienically evident” (CO_2 1000–2000) and “hygienically unacceptable” (CO_2 > 2000 ppm). If a CO_2 value of 1000 ppm is exceeded the room should be aired, and if 2000 ppm is exceeded it must be aired. In both cases the aim should be to remain below 1000 ppm. If the situation cannot be improved in the long term by airing alone, air-conditioning measures should be employed or the number of pupils in the classroom should be reduced.

Table 2. Guide values for carbon dioxide concentration in indoor air (Ad hoc working group 2008)

Co_2 concentration [ppm]	Hygiene rating	Recommendation
< 1000	Hygienically insignificant	▶ No further measures
1000–2000	Hygienically evident	▶ Intensify ventilation measures (increase volume of air flow from outside or air exchange). ▶ Check and improve ventilation procedures
> 2000	Hygienically unacceptable	▶ Check ventilation possibilities and if necessary check extensive measures

The concentration of carbon dioxide in indoor air depends on the number, length of time spent and activity of the people present as well as on the construction details (volume of the room, air exchange number, etc.). Although the problem of carbon dioxide in rooms containing a large number of people has long been known, to date no convincing solutions have been found for schools. At the same time there are no clear regulations regarding responsibility, especially in the winter months, about how, when and by whom the classroom windows should be opened. As is to be expected, this results in high to very high CO_2 values (3000 ppm and above), but also in an increase in other indoor pollutants and water vapour. There is an urgent need to develop ideas for meeting the guide values given in Table 2.

To assist schools one could envisage a sensor-driven traffic light which changes from green to amber to red if specific CO_2 values are exceeded and indicates the need for action in accordance with Table 2. The measuring interval for the sensor-operated system should also be very carefully selected, in order to prevent the reading from changing constantly from one to another during operation and thus making the action to be taken unworkable. A measuring interval of at least 2 minutes is recommended.

If natural air exchange via open windows is impossible, air-conditioning measures must be introduced in order to keep the CO_2 concentrations at a low level.

Fresh air through windows or ventilaion systems in schools?

We are now undoubtedly on the threshold of a certain paradigm shift in thought and action. The current situation in many schools shows that in many places the CO_2 problem can no longer be brought under control through requests for regular and intensive ventilation alone. Air-conditioning measures then become essential in order to achieve permanent high quality air with a low CO2 concentration without depending on human intervention. Regular servicing and inspections of the system are necessary, so that this does not itself lead to hygiene problems.

Until 2005 a CO_2 value of 0.15 vol.- % (= 1500 ppm) in accordance with DIN 1946 Part 2 applied as the guideline hygiene value in Germany in schools with air-conditioning installations. In July 2005 DIN 1946-2 was replaced by EN 13779, which was amended in September 2007. This EN contains recommendations for planning and installing air-conditioning systems in all non-residential buildings intended for human occupation. Indoor air is subdivided into four quality levels (Indoor Air 1 to 4). Different ventilation rates per person or per m^2 floor area are derived from these quality levels

Table 3. Classification of indoor air quality in accordance with DIN EN 13779: 2007-09. The table contains the regulations from DIN EN 13779 in columns 1 to 3. Column 3 shows the relation of the CO_2 concentration in indoor air to the total CO_2 concentration. Column 4 indicates the absolute CO_2 concentrations in indoor air for an outside air CO_2 concentration of for example 400 ppm.

Category	Description	Increase in CO_2 concentration compared with outside air [ppm]	Absolute CO_2 concentration in indoor air [ppm]	Ventilation rate/ outside air flow volume [l/s/person] ([m^3/h/person])
IDA 1	High indoor air quality	≤ 400	≤ 800	> 15 (> 54)
IDA 2	Medium air quality	> 400–600	> 800–1000	> 10–15 (> 36–54)
IDA 3	Moderate indoor air quality	> 600–1000	> 1000–1400	> 6–10 (> 22–36)
IDA 4	Poor indoor air quality	> 1000	> 1400	< 6 (< 22)

Carbon monoxide (CO) is released during the incomplete combustion of fossil fuels. On busy roads, especially in conurbations, it also penetrates indoor spaces with the outside air during ventilation. Tobacco smoke represents another considerable source of emissions. Preventing the occurrence of carbon monoxide is yet another reason to emphasise the general smoking ban in schools. CO can also enter the indoor air through using gas for cooking in home economics kitchens – however, only where air extraction is inadequate. Carbon monoxide impairs the transport of oxygen with haemoglobin. However, the concentrations necessary for this are not normally to be expected in schools.

Nitrogen oxides (NOx = sum of nitric oxide (NO) and nitrogen dioxide (NO_2)) enter indoor air mainly through burning gas (Bunsen burners in laboratories, gas cookers in home economics rooms), apart from coming in from outside. This can be largely avoided by suitable air extraction when cooking with gas in home economics rooms. Short-lived raised concentrations of NO_2 in indoor air can also arise from the use of oil in lamps or larger numbers of candles. With prolonged high levels of exposure, nitrogen dioxide promotes the onset of diseases of the respiratory tracts.

Ozone (O_3) can be emitted into indoor air in schools through the use of copiers and laser printers, or in general from machines which have sources of UV rays (cf. Section A-7). Modern office equipment gives off so little ozone that even in sensitive people breathing difficulties and impairments in lung function do not occur.

In high summer weather conditions ozone formed in the air outside also enters indoor spaces through ventilation. In general ozone is quickly broken down in the indoor environment.

B-2 Volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) represent a group of air pollutant substances that practically always occur in indoor air. VOCs are characterised as a group of very diverse substances by their boiling point and distinguished from the very volatile, semi-volatile and non-volatile organic compounds. According to convention organochemical compounds with a boiling point of 50–100 °C to 240–260 °C are described as volatile organic compounds (VOCs) (WHO 1989). In analytical practice organic compounds which can be determined in the elution range between n-hexane and n-hexadecane are described as VOCs. The sum of the volatile organic compounds eluted between n-hexane and n-hexadecane are designated TVOCs (total volatile organic compounds). Semi-volatile organic compounds (SVOCs) are organic compounds that lie in the retention range above n-hexadecane up to C_{22}, and very volatile organic compounds (VVOCs) those that appear below n-hexane. Table 4 gives an overview of VOCs often recorded in indoor spaces and their sources.

Table 4: VOCs often recorded in indoor spaces and their sources; [1] except formaldehyde, which belongs to the VVOC group	
VOCs and VOC groups	**Sources**
Alkanes, alkenes and cycloalkenes	Outdoor air, motorised traffic, fuels, solvents (solvent naphta) in varnishes, resins and stain removers
Aromatic compounds	Vehicle emissions, cigarette smoke, solvents, carpet back side (e.g. Phenylcyclohexene), foam products
Terpenes	Wood, solvents, “odour improvers”, fragrance additivesz
Naphthalenes	Bitumen tiles, tar adhesives, tarred felts, moth repellent
Alcohols	Cleaning products, solvents, sub-products from e.g. plasticizers
Aldehydes [1]	Kitchen vapour, disinfectants, alkyd resin paints, oil paints, linoleum by-products, cork flooring, wood products
Ketones	solvents (e.g. Methylethylketone), metabolites, seal coated surfaces
Esters	Solvents, softeners, heating costs distributor (methyl benzonate)
Glycol ethers	Solvents in water soluble paints and varnishes, cleaning products
Halogenated compounds	Degreasing, solvents, dry cleaning (tetrachloro-ethene), Tippex (1.1.1-trichloroethane), toilet blocks (p-dichlorobenzol)
Other compounds	Bonding agents (phenol), disinfectants (cresols), sealing compounds (butanonoxime)

In particular, the following VOCs are important for indoor areas in schools:

Alkanes and alkenes

Alkanes are straight-chain saturated compounds (aliphates) which are distinguished by the number of carbon and hydrogen atoms in the molecule. After renovations, but also after cleaning of classrooms, the group of nonane to tetradecane (9 and 14 carbon atoms respectively in the molecule; C-9 and C-14, respectively) is found especially frequently in the indoor air. In unfavourable circumstances light heating oil tanks can become sources of alkanes in the group between tetradecane (C-14) and octadecane (C-18). This group of alkanes with boiling points to over 300 °C is sometimes also used as solvents and, since strictly speaking it does not belong to the VOC group, is only mentioned for the sake of completeness. This applies likewise to the very volatile n-alkanes, such as methane (C-1) and butane (C-4), which are constituents of natural gas and are not generally measured with the usual indoor air analysis methods.

Alkenes (olefins) are unsaturated hydrocarbon compounds. Long straight-chain olefin compounds represent reagents and by-products. Saturated cyclic hydrocarbons such as cyclohexane and methylcyclohexane are used as solvents in varnishes, resins and stain removers in the indoor environment.

Aromatic compounds

Aromatic compounds (arenes) are hydrocarbon compounds with a closed ring structure, in which, in contrast to simple cyclic compounds, particular bonding properties exist between the carbon atoms in the ring. In schools practically the only source of benzene, the basic substance in the aromatic group with 6 carbon atoms, which is toxicologically particularly significant because of its carcinogenic effect, is traffic-polluted outside air (up to 1 % benzene is permitted in fuel).

In the past toluene was frequently used as a solvent. Nowadays higher aromatic compounds with 8 carbon atoms and more (called alkyl arenes) are used in place of toluene. These often also have an obvious odour. This is also the case with styrene, which is however rarely encountered in schools. Polynuclear aromatic hydrocarbons (e.g. naphthalene, indenes) are also generally of little significance in the indoor air in schools, except that bitumen and coal tar products were used in flooring construction, for example (moisture stop, woodblock floor adhesive); compounds of that kind are then released into indoor air.

Terpenes

Terpenes represent an important group of VOCs. The monoterpenes limonene, α- and β-pinene and δ-3-carene are frequently and increasingly to be found in indoor spaces. Naturally occurring gases from wood products, addition as fragrance and use as a “natural” solvent for various products (including paints, varnishes and wood treatments) are substantial routes of entry into indoor air. Terpenes are also found in comparatively high concentrations in precisely those buildings and rooms constructed or fitted according to environmental principles, especially if walls and ceilings are clad extensively in solid pine. Various terpene alcohols and terpene ketones (e.g. geraniol, camphor) are introduced into the indoor air with fragrances.

Alcohols

Apart from ethanol (also called ethyl alcohol), colloquially known as "alcohol", there are other compounds belonging to the chemical class of alcohols which are to be found in indoor air. Low alcohols such as ethanol or propanol, isopropanol und isobutanol occur in very many household products (e.g. cleaning agents, solvents, disinfectants and cosmetics). As a result of hydrolytic cleavage amongst other things 2-ethylhexanol, an alcohol which occasionally contributes to odour problems in indoor spaces, can enter the indoor air from softeners and plastics.

Glycols

Glycol ethers are technical solvents in frequent use, especially in varnishes, dyes and printing inks, stamping ink, wall paints, water-based enamels and ballpoint pen pastes, and are regularly detected in indoor air, since they are used as substitutes for the classic aliphatic and aromatic solvents mentioned above. Even enamels displaying the Blue Angel label may contain up to 10 % glycol compounds, and glycol compounds with boiling points above 200 °C are used in so-called solvent-free carpet adhesives. Glycols and glycol ethers (such as 2-buthoxyethanol, phenoxyethanol and diethylene glycol monoethyl ether) are polar compounds with boiling points above 120 °C. On account of their relatively high boiling point they can be emitted from surfaces over long periods (months).

Aldehydes

In contrast to the higher aldehydes, the simplest representative of this substance group, formaldehyde, does not belong to the VOC group, but to the VVOCs, on account of its low boiling point. Because of its wide distribution and its importance with regard to hygiene a separate section is devoted to it (see Section B-3).

Of the straight-chain aldehydes n-hexanal in particular often occurs in indoor air. Important sources are alkyd resin paints and varnishes.

In the course of drying, interlacing and also the oxidative degradation of the oil-based binders, the aldehydes are split off and released. Since linoleum also contains oil-based binders, aldehydes can be given off into the surrounding air from poorly maintained linoleum floors (cf. Section A-2). Benzaldehyde is found as a fragrance (like bitter almonds) in perfumed items.

Furfural is an aldehyde with a ring-shaped (cyclic) molecular structure, which can enter the indoor air if used in pressed cork products (e.g. floor tiles). Propanal (acrolein) is one of the unsaturated aldehydes with a particularly pungent odour. One way in which the compound is produced is in the thermal decomposition of fats (cooking vapour).

Ketones

Butanone (methyl ethyl ketone – MEK) and hexanone (methyl isobutyl ketone – MIBK) are solvents with various uses, e.g. in all-purpose adhesives, and can enter indoor air as the glue dries out. Cyclohexanone and acetophenone are occasionally given off into the indoor air from surface coatings.

Esters

Esters are frequently used solvents: ethyl acetate, butyl acetate and isobutyl acetate can occur in indoor air, particularly after alterations and renovation work. Texanol is used as an additive for varnishes, wood floor sealants and dispersion paints (latex paints), and ink-jet printer inks, to improve the film formation. Mixtures of esters and alcohols are coming onto the market in increasing quantities. Water-based paints can contain such mixtures and give off the corresponding compounds into the indoor air. Ester TXIB (texanol isobutyrate) is now used as a substitute for softeners (cf. Section B-4).

Halogenated organic compounds

Over the last ten years, concentrations of practically all halogenated organic compounds in indoor air have been falling. Halogenated organic compounds such as 1.1.1-trichlorethane used to be found in things such as "Tipp-Ex" fluids (use prohibited since 1991). Other substances and areas of use are p-dichlorobenzene from toilet deodorant blocks and moth repellents, strong-smelling mono- to trichloronaphthalenes from wood-based materials treated with fungicides, and chloranisols as decomposition products of wood preservatives. Of significance with regard to hygiene are the halogen-containing organic trihalomethanes and chloramines, which arise in indoor swimming pools as reaction products from pool water chlorination (cf. Section A-4).

Siloxanes

Also finding increasing use as solvents in enamels are volatile silicon compounds, known as siloxanes, such as methyl polysiloxanes (e.g. cyclopentasiloxane), which are often detected in the indoor air.

Nitrogen and sulphur-containing organic compounds

Many amines, anilines and other basic organic compounds are used as product auxiliary agents. They are very seldom detectable in indoor air and mostly have a noticeable odour. Dimethylformamide can be given off in small quantities into indoor air from acrylic fabric, and also possibly from moulded laminated plastic parts. Sulphur-containing organic compounds are used for example as an odour additive (so that escaping gas is smelt) in town and natural gas.

Microbial volatile organic compounds (MVOCs)

When mould growth occurs as a result of damp damage in indoor spaces (cf. Section B-7) volatile metabolic products of micro-organisms, e.g. various alcohol, aldehyde and ketone compounds can enter indoor air. Some of these microbially produced volatile substances are largely specific to micro-organisms, while others can also arise from various other sources, such as some terpenes or aromatic hydrocarbons, like toluene, for example. The substances which should be assigned mainly to microbial sources are called Microbial Volatile Organic Compounds (MVOCs). MVOCs can be measured in indoor air by special methods and used as indicators for the presence of microbial damage. In general MVOCs are present in indoor spaces in significantly lower concentrations (less than 1 $\mu g/m^3$) than VOCs. However, owing to their low odour threshold, they can produce noticeable odours (see following paragraph). Especially in the case of mould growth that is not immediately visible to the naked eye, MVOC readings can be helpful in identifying the damage (cf. Section B-7).

Risks to health cannot be deduced from contamination with MVOCs. The indicator effect of MVOCs is the significant point, and unusual readings should be seen solely as grounds for a careful search for hidden microbial sources.

Odour active volatile organic compounds (OVOCs)

Most volatile organic compounds do not produce noticeable odours in normal low indoor air concentrations. Odour active substances, which exude a noticeable odour even in very low concentrations and as a result possibly also over a fairly long period, are known as odour active volatile organic compounds (OVOCs). They have a molecular weight below 300g/mol, a relatively low boiling point and easily enter the gas phase. They often contain polar functional groups such as hydroxyl or carbonyl groups, or heteroatoms such as sulphur or nitrogen. Reference has already been made in the previous paragraphs to some examples of odour active volatile organic compounds, such as terpenes, 2-ethylhexanol, aldehydes, ketones, esters, halogen, nitrogen or sulphur-containing organic compounds and a few MVOCs. A compound of a newer type is butanonoxim, which can be given off into the indoor air, for example during the hardening of sealants. OVOCs present a major analytical challenge, as they can already release a noticeable odour in concentrations well below the normal required limit of 1 µg/m^3, and OVOCs are often not detected with routine VOC monitoring.

How can the release of volatile organic compounds into indoor air be avoided?

Especially after building and renovation work increased amounts of VOCs enter indoor air for a short period (from days to several weeks). Raised concentrations can be reduced by the selection of appropriate building materials and products, and through intensive ventilation during and on completion of the work. VOC emissions cannot be avoided entirely. Owing to their diverse fields of use VOCs can practically always be found in indoor air. Regular ventilation is the principal means of lowering concentrations.

Because of the many different VOCs it is particularly difficult to carry out a comprehensive health evaluation for this substance group. Many VOCs can cause nerve damage in the very high concentrations that occur in commercial workplaces, although not in schools. Some VOCs can trigger inflammation of the respiratory tract, as irritant by-products are formed in the metabolism of the nasal mucous membrane.

Whether a sensitisation can arise is a matter for debate. Some VOCs exhibit very low odour thresholds and can therefore be smelt in the indoor air. In some cases the odour thresholds are so low that the substances can be smelt, and yet cannot be registered with certainty using technical measuring methods (see comments above).

Furthermore, the toxic properties described in the literature relate as a rule to individual substances and to high concentrations that could generally only occur at specific workplaces. However, in the range of concentrations that also arise in “normal” indoor environments, non-specific complaints and symptoms are often associated with exposure to VOCs. These include irritations of the skin, eyes, mucous membranes and respiratory tracts, headaches, fatigue, poor concentration and major problems with unpleasant odours.

The evaluation of VOC concentrations in indoor air depends to a large extent on the accuracy of the measuring carried out previously. Before measuring is undertaken the aim of the measurement must be defined.

Checking that a guideline value is being adhered to requires the measuring to take place under operating conditions. In schools particular attention should be paid to the ventilation conditions. The result of an indoor air measurement depends largely on the framework and measuring conditions. It is therefore essential to ensure that the relevant recommendations are observed (Federal Environment Agency publication. Beurteilung von Innenraumluftkontaminationen mittels Referenz- und Richtwerten – eine Handreichung [Assessment of indoor air contamination using reference and guideline values – some tips]. Bundesgesundhbl-Gesundheitsfosch-Gesundheitsschutz 50: 2007, pp.990–1005; VDI Guidelines series 4300). Only laboratories with a documented quality assurance system who participate successfully in external group experiments and/or comparative laboratory research programmes should be given the measuring contract. .

Indoor guideline values for individual VOCs are deduced by the ad hoc working group, composed of members of the Indoor Air Hygiene Commission (IRK) and the Working Group of the Supreme Health Authorities of the Federal States (IRK/AOLG ad hoc working group), in accordance with a procedural scheme. It is recommended that these values are also adhered to inside schools (see Table 5).

Guideline value II (RW II) is a proven value relating to impacts, which is based on current toxicological and epidemiological knowledge of the impact threshold of a substance when uncertainty factors are introduced. It represents the concentration of a substance which, when reached or exceeded, requires immediate action, since this concentration is likely to pose a health hazard, especially to sensitive individuals spending long periods in the rooms.

A reading in excess of RW II should be combined immediately with a control measurement under normal conditions of use and – as far as possible and reasonable – with an assessment of the internal exposure of the users of the room.

Guideline value I (RW I) is the concentration of a substance in the indoor air at which, within the context of a study of an individual substance, on the basis of current knowledge, no damage to health is to be expected, even with lifelong exposure. A value exceeding this is linked with hygienically undesirable contamination outside the normal range. RW I can serve as a remediation target. It should not, however, be an "end in itself"; if possible a lower value should be achieved.

A value higher than Guideline value I indicates increased exposure unacceptable from a hygiene perspective. From a realistic point of view no structural or other alterations relating to the source should be carried out in the first instance, but above all ventilation and, depending on the individual case, cleaning should be stepped up.

Table 5: IRK/AOLG ad hoc working group guideline values for indoor air (as at 2008): as well as VOCs this contains SVOCs (cf. Section B4) and a guideline value for mercury-containing vapours			
Compound	**RW II (mg/m^3)**	**RW I (mg/m^3)**	**Year set**
Toluene	3	0.3	1996
Dichloromethane	2 (24 h)	0.2	1997
Carbon monoxide	60 (1/2 h)	6 (1/2 h)	1997
	15 (8 h)	1.5 (8 h)	
Pentachlorophenol	1 $\mu g/m^3$	0.1 $\mu g/m^3$	1997
Nitrogen dioxide	0.35 (1/2 h)	–	1998
	0.06 (1 week)	–	
Styrol	0.3	0.03	1998
Mercury (as metallic vapour)	0.35 $\mu g/m^3$	0.035 $\mu g/m^3$	1999
Tris(2-chloroethyl) phosphate	0.05	0.005	2002
Bicyclic terpenes (lead substance α-pinen)	2	0.2	2003
Naphthalene	0.02	0.002	2004
Non-aromatic hydrocarbon mixtures (C9-C14))	2	0.2	2005

At any time the current list including further information is definitive. This is available online at:
http://www.umweltbundesamt.de/gesundheit/innenraumhygiene/irk.htm#4

The IRK/AOLG ad hoc working group has also drawn up recommendations on limits of indoor air concentrations for Total Volatile Organic Compounds (TVOCs). The TVOC value is not toxicologically based, owing to the different composition of the mixture of substances occurring in indoor air, but represents a total hygiene evaluation for VOCs.

The TVOC evaluation is divided into 5 levels (see Table 6); the recommendations made at the previous level also apply – as far as is reasonable – at the next level up. The prerequisite for using the TVOC scheme is that toxicologically based guideline values of individual substances are not exceeded in doing so. A separate assessment is a fundamental requirement if substances with low odour thresholds are involved, as these can cause problems even in low concentrations because of their odour activity, or if abnormally high concentrations of individual substances occur.

Level 1

TVOC values below 0.3 mg/m³ are hygienically insignificant, provided that individual substance guideline values are not exceeded. They are designated "target values" (hygienic precaution range) and the aim should be to meet or if possible go below them in indoor spaces within an adequate period after completing a new-build or renovation work.

Level 2

TVOC values between > 0.3 and 1 mg/m³ can be classified as still hygienically insignificant, provided that individual substance guideline values are not exceeded. This concentration range indicates for example that solvent emissions are not yet completely expelled and points to the need for more intensive ventilation.

Level 3

TVOC values between > 1 and 3 mg/m³ should be assessed as abnormal and apply for a limited time (< 12 months) as upper limits for spaces intended for lengthy occupation. In residential, school or office spaces in normal use, where renovation or refurnishing has not recently taken place, a TVOC concentration of 1 mg/m³ under normal conditions of use should not be exceeded in the long term, as this would be judged to be an indication of an additional and possibly harmful VOC emission. The health implications of unusual instances of reference values being exceeded should be examined. An individual toxicological assessment, at least of the substances with the highest concentrations, is recommended. The follow-up measurement to test the indoor air quality is carried out under normal conditions of use.

Level 4

Spaces with TVOC values between > 3 and 10 mg/m³ are assessed as hygienically significant and should only be used temporarily (for a maximum of 1 month), if no alternative is available, and with the implementation of more intensive regular ventilation procedures. An individual toxicological substance evaluation or substance group evaluation should be carried out. The follow-up measurement to test the indoor air quality is carried out under normal conditions of use.

Level 5

TVOC values between >10 and 25 mg/m^3 are classified as hygienically unacceptable. Use of the room should as a rule be avoided; at the most only short periods should reasonably be spent there (less than one hour per day), and more intensive regular ventilation procedures implemented. At values > 25 mg/m^3 the room should not generally be used. The follow-up measurement to test the indoor air quality is carried out under normal conditions of use.

As well as the guideline values and TVOC classifications reference values, which are determined from the study of a large number of indoor spaces, can also be used in making a preliminary assessment of VOC concentrations. The latest reference values can be found in a publication from the Federal Environment Agency (Bundesgesundheitsbl-Gesundheits forsch-Gesundheitsschutz 50: 2007, pp.990–1005). A measuring laboratory should specify the source of the reference values used and must on no account link any health statements to the exceeding of a reference value (also often called an orientation value).

Table 6: Hygienic evaluation of TVOC values and resulting recommendations for action (Federal Environment Agency 2007)

Level / Concentration range / Questions requiring clarification / Recommendations

1

- Hygienically insignificant. No problems as a rule.
- Are guideline values being exceeded?
- No further measures.

2

- Still hygienically insignificant, provided that no values are exceeded for individual substances or substance groups.
- Isolated cases of health problems or odour perceptions, e.g. after minor renovation work or new furnishings in recent weeks.
- Are guideline values being exceeded? Are values significantly above reference values?

- Are the indoor climate conditions (air exchange, temperature, humidity) perfect?
- Adequate airing, especially after renovation work.
- Identify VOC sources (e.g. inspection of the space).
- Check use of cleaning and polishing products.
- Follow-up readings to monitor values exceeding the guideline value under normal use (see Chapter 9).

3

- Hygienically significant.
- Use of rooms that are occupied regularly only acceptable for a limited period (< 12 months).
- Within 6 months TVOC concentrations should fall significantly below the TVOC value recorded at the start.
- Incidents of health problems or odour perceptions, e.g. after major renovation work.
- Are guideline values being exceeded?
- Are values significantly above reference values?
- Are the indoor climate conditions (air exchange, temperature, humidity) perfect?
- Check values exceeding the guideline value immediately by follow-up readings under normal use conditions and bear in mind advice in Chapter 4 when making the evaluation.
- Test values significantly above reference values for relevance to health.
- In all cases: carry out search for source and check ventilation routines: implement intensive ventilation and if necessary establish conditions for use and ventilation.
- Control reading or follow-up reading recommended after approx. 1 month (under normal use).
- If after 12 months, despite the efforts described, the TVOC concentration remains above 1mg/m^3, adequate remediation measures should be incorporated in further planning.

4

- Hygienically significant
- Use of rooms that are used regularly only acceptable for a limited period (< 1 month).
- TVOC concentrations should fall below 3 mg/m³ within 1 month.
- Incidents of increasing numbers of health problems or odour perceptions, e.g. after major renovation work.
- Are guideline values being exceeded?
- Are values significantly above reference values?
- Are the indoor climate conditions (air exchange, temperature, humidity) perfect?
- Check values exceeding the guideline value immediately by follow-up readings under normal use conditions and bear in mind advice in Chapter 4 when making the evaluation.
- Test values significantly above reference values for relevance to health. Toxicological evaluation of individual substances or substance groups required.
- In all cases: carry out search for source and implement intensive ventilation; if necessary establish conditions for use and ventilation, and arrange appropriate minimisation measures. If the room must be used, then tolerable only with a time limit per day for a maximum period to be stipulated by the health agency (per day/number of hours/ limited period).
- Control reading or follow-up reading recommended after approx. 1 month (under normal use).
- If after 1 month, despite the efforts described, the TVOC concentration remains above 3 mg/m³, adequate remediation measures should be incorporated in further planning.

5

- Hygienically unacceptable.
- Avoid using room if possible. At most, use permitted for a limited numbers of hours over a restricted period.
- At values above 25 mg/m³ the room should not be used.
- TVOC concentrations should fall below 3 mg/m³ within 3 months.

- Health problems and odour perceptions usual, e.g. after faulty application or accidents.
- Are values significantly above reference values?
- Are guideline values being exceeded?
- Are the indoor climate conditions (air exchange, temperature, humidity) perfect?
- Monitor values exceeding the guideline value immediately by follow-up readings under normal use conditions and bear in mind advice in Chapter 4 when making the evaluation.
- Test values significantly above reference values for relevance to health. Toxicological evaluation of individual substances or substance groups required.
- In all cases: carry out search for source and implement intensive ventilation; establish conditions for use and ventilation, and arrange appropriate minimisation measures. If the room must be used, then tolerable only with a time limit per day for a maximum period to be stipulated by the health agency (per day/number of hours/ limited period).
- Control reading or follow-up reading within 1 month (under normal use).
- If by implementing minimisation measures a value below 10 mg/m^3 is achieved within the time frame under consideration, but a concentration of 3 mg/m^3 still exceeded, the recommendations in Level 4 apply. If after 1 month, despite the efforts described, the TVOC concentration remains above 10 mg/m^3, the room must not be used and adequate remediation measures should be arranged.

B-3 Formaldehyde

Formaldehyde (chemical name: methanal – CH_2O) is one of the best known and best researched air pollutants in indoor spaces. As a result of its diverse industrial uses in the manufacture of sheet and insulation materials, paints, cleaning agents and cosmetics the substance can usually be detected in indoor air. Wood-based materials (particle board, coated particle board, wood core plywood, veneers, fibreboard) and articles produced from wood-based materials such as furniture, doors and panelling are still the most important sources of formaldehyde in indoor areas.

Formaldehyde is an important constituent of adhesives in the sheet material industry. Amongst those used are urea formaldehyde adhesive resins (UF glues), phenol-formaldehyde adhesive resins (PF glues), melamine formaldehyde adhesive resins (MF glues) and melamine-urea-formaldehyde adhesive resins (MUF glues). After composite wood materials manufactured in this way were used for large surfaces and installations there were increased emissions of formaldehyde in the indoor air in school buildings in the past, and even today there still are still occasional instances.

Since the beginning of the 1980s formaldehyde emissions from wood-based materials have been regulated in Germany. The Chemicals Prohibition Ordinance (Chemikalien-Verbotsverordnung) stipulates that only those composite wood materials which are proven not to exceed an average concentration of 0.1 ppm under defined test conditions ("emission class E1") may be put on the market. Exceptions to this are wood-based materials to be laminated, for instance for making furniture, which is still permitted to emit significantly more formaldehyde nowadays. As an example, E1 wood-based materials for use as flooring are now standard. Sheet material products that are particularly low in formaldehyde (average concentration in a test chamber < 0.05 ppm under defined conditions) can be identified by the Blue Angel. The amount of formaldehyde given off from composite wood materials is also influenced by the climatic conditions in the room. Thus higher indoor air temperatures and higher relative humidity lead to an increase in emissions rates.

Some manufacturers have stopped adding formaldehyde to their wood-based materials and instead use polyurethane glues for adhesion. Although the diisocyanates in these are likewise not toxicologically insignificant during the manufacturing process, they do however remain bound up in the wood-based materials afterwards and therefore do not enter the indoor air.

In terms of health impacts through exposure to formaldehyde in indoor environments irritation of the mucous membranes is the most significant. With long-lasting high formaldehyde pollution, which occurred at some workplaces in previous decades, the irritation can lead to chronic inflammation of the nasal mucous membrane, from which cancer can develop. In 2004 formaldehyde was classified as "carcinogenic to humans" by the International Agency for Research on Cancer (IARC).

Formaldehyde has a pungent odour. The WHO estimates that some people perceive the odour of formaldehyde even at 0.03 mg/m^3. As long ago as 1977 the German Federal Ministry of Health (BGA) recommended a guideline value of 0.1 ppm (= 0.12 mg/m^3) of formaldehyde in indoor air, regardless of the actual indoor air temperatures and humidity. In view of the re-evaluation of the carcinogenic effect of formaldehyde this value was re-examined and confirmed by the Federal Institute for Risk Assessment (BfR) in 2006. The Indoor Air Hygiene Commission's ad hoc working group endorsed this proposal. In the view of these committees the risk of cancer below 0.1 ppm of formaldehyde is negligible.

B-4 Semi-volatile organic compounds (SVOCs)

The group of semi-volatile organic compounds (SVOCs) includes substances and substance groups whose boiling range lies above that of VOCs (see definition in Section B-2). For most SVOCs ingestion from foods of animal origin represents the main exposure path. However, SVOCs can also be absorbed via indoor air. In the indoor environment the vast majority of SVOCs present are bound to suspended dust particles or to surfaces in the room. Among the most familiar SVOCs present in significant quantities are the fire retardants and softeners used in plastic products. These and other compounds, whose appearance in recent decades has been the subject of particularly intensive discussions, including in schools, namely polychlorinated biphenyls (PCBs), agents in wood preservatives and polycyclic aromatic hydrocarbons (PAHs) will be dealt with in more detail below.

Fire retardants

Fire retardants are designed to make plastics, wood and composite wood materials, insulating materials and textiles non-flammable. The fire retardants are in the form of an additive mixed into the product to be protected or are bound up reactively in the material. The substances applied as additives in particular can be released into the environment again later. Various inorganic and/or organic substance groups are used as fire retardants, in Europe being mainly aluminium oxides, boron oxides, magnesium oxides and antimony oxides, chlorinated paraffins, various brominated compounds such as polybrominated diphenyl ethers, and halogenated and non-halogenated organophosphate esters (OPEs). Fire-retardant agents in plastics often also perform the function of a softener at the same time (e.g. polybrominated diphenyl ethers).

To date the release of fire retardants into the indoor environment under normal living conditions or during normal use has been poorly understood. Research into the occurrence of phosphoric acid esters in indoor air was only carried out in the 1990s. Phosphoric acid esters were detected even in readings from house dust.

As well as their toxic properties the durability (persistence) and ability to increase in the body (bioaccumulation) of fire retardants also play a part. A particularly negative example of this is the polychlorinated biphenyls, which however have not been used as fire-retardant agents for some time (see following section on PCBs). The organobrominated compounds and OPEs are also critical in this respect. The IRK/AOLG ad hoc working group has proposed a sum guideline value for indoor air (RW I) of 0.005 mg/m^3

for tris(2-chloroethyl)phosphate (TCEP), tris(2-chloroisopropyl)phosphate (TCPP), tri-n-butyl phosphate (TBP), tris(2-butoxyethyl)phosphate (TBEP), tris(2-ethylhexyl)phosphate (TEHP) and triphenyl phosphate (TPP) (cf. guideline values in Section B-2).

Softeners, phthalic acid esters

Phthalic acid esters (phthalates) are added to plastics as softeners in large quantities (mostly more than 10 %). For this reason they are some of the substances which are found in relatively high concentrations in most environmental media and especially in food as well. Owing to their low volatility softeners are found in indoor environments less in the air than in dust deposits and on surfaces. Potential emission sources of phthalic acid esters in indoor areas are wall coverings, wall paints, floor coverings and electronic equipment. Building materials for walls and floors can be a relevant source of phthalic acid esters because of the considerable proportion of surface area in a room. The PVC used by preference in wall and floor coverings can for example have a phthalic acid ester content of more than 30 %. Until the end of the 1990s this mainly involved di-n-butyl-phthalate (DBP), diisobutyl phthalate (DiBP) and di(2-ethylhexyl) phthalate (DEHP). Nowadays the use of di-iso-nonylphthalate (DINP) is preferred. The diacid esters such as adipates which are also used as softeners have as yet seldom been detected in indoor environments. Phthalic acid esters are suspected of encouraging the phenomenon of “black homes” (the fogging phenomenon).

Polychlorinated biphenyls

Polychlorinated biphenyls (PCBs) were produced industrially from 1929 to the beginning of the 1980s. They are a mixture of various chlorinated single compounds (a maximum of 209 different compound types [congeners]). In the past they were widely used as insulators, fire retardants and softeners. Their sale and use has been prohibited in Germany since 1989 on account of their persistence, the accumulation in the environment and especially in the food chain, and their toxicity. Since then concentrations in the environment and also in the fatty tissue of the human body have been falling slowly.

Attention was first drawn to the occurrence of PCBs in indoor environments in the mid-1980s by PCBs leaking from condensers for fluorescent tubes. In the meantime these have been replaced and disposed of, as since 1.1.2000 condensers with a PCB content of over 50 mg/kg may no longer be used. PCBs were also used on a large scale as softeners in jointing compounds (on a polysulphide rubber base) and in flame-retardant or sound-absorbing coatings for acoustic ceilings (see section on fire-retardants). With these “open” applications PCB could enter the surrounding air directly. In the course of time even structural components and items of furniture in these rooms that were free of PCBs could be contaminated by them, and then in turn contribute to indoor air pollution (so-called secondary sources, e.g. floor and wall coverings). In the main this affected school buildings erected in the 1960s and 1970s.

Owing to the high cost of taking readings, not all possible PCB congeners in indoor air are measured. Instead measurements are restricted to the “indicator PCBs”. These include PCBs 28, 52, 101, 138, 153 and 180. As some PCB congeners also exhibit a dioxin-like effect, the Federal Environment Agency’s ad hoc guidelines working group has recommended including PCB 118, as the lead substance in this substance group, since 2007 (Bundesgesundheitsbl-Gesundheitsforsch-Gesundheitsschutz 50: 2007, pp.1455-1465), especially when it is ascertained by investigations or measurements that mainly highly chlorinated clophens have been used (perhaps in ceiling boards or coatings).

Two cases should therefore be distinguished:

a) If joint sealants containing PCBs with a chlorination grade lower than Clophen A60 are definitely present, the total PCBs, based on 6 indicator PCBs (excluding PCB 118), serve as an assessment criterion. Measures to reduce exposure should be examined for indoor air concentrations above 3 µg per cubic metre for total PCBs. At lower concentrations ventilation routines should be investigated and improved if necessary.

b) For ceiling boards and coatings containing Clophen A50 or Clophen A60 and PCB sources that cannot be identified with certainty the total PCB content can likewise be used to make an evaluation. Up to a concentration of 1 µg total PCBs/ m^3 will certainly be below a TEQ (toxic equivalent quantity) value of 5 pg/ m^3. At higher total PCB contents (> 1 µg/ m^3) the concentration of PCB 118 should be used for assessment. For indoor air concentrations above 0.01 µg PCB 118/ m^3 measures to reduce exposure should be investigated. At concentrations below this ventilation routines should be investigated and improved if necessary.

At present there are considerable differences between the *Länder* with regard to the health evaluation of PCBs in indoor air and to the extent of necessary remediation measures. In many of the *Länder* substantial parts of the German Institute for Construction Engineering’s “Guidelines for the assessment and remediation of PCB-contaminated building materials and components (PCB Guidelines)” have been introduced as the acknowledged technical rules for works, while in other *Länder* they only apply with substantial amendments. In order to facilitate a procedure for the whole of Germany, the ad hoc working group recommends in its 2007 statement that the health evaluation of PCBs is carried out dependent on the type of PCB source (sealants, ceiling boards, etc.).

There are also different regulations in the *Länder* with regard to health and safety. The health and safety recommendations applicable in each case should be observed.

As a basis for ordering further action to be taken a control measurement under defined ventilation conditions should be undertaken: in indoor spaces with ventilation regulations such as schools normal long-term measuring for PCBs should be carried out during several cycles of use, while adhering to the prescribed ventilation with the rooms in normal use, with ventilation during breaktimes taking place as prescribed. The measuring begins after the first time the windows are closed and ends before the last time the windows are opened (including several cycles of use). The measurements should preferably be carried out while the room is in use. If possible, measuring should take place throughout at least one complete school day, in order to register the influence of temperature in the course of the day.

The fundamental aim of PCB remediation should be to remove the primary sources and minimise the secondary sources as far as possible. During remediation work the ARGEBAU (Conference of the *Länder* Ministers and Senators responsible for urban development, construction and housing) guidelines for the evaluation and remediation of PCB-contaminated construction materials and components in buildings should always be observed in the version applicable to the appropriate Land (cf. Part E).

Pentachlorophenol

Until well into the 1970s timber and timber cladding in indoor environments was often treated with wood preservatives containing pentachlorphenol (PCP), with polychlorinated dibenzodioxins and dibenzofurans as contaminants. Because of their long half-life in treated wood PCP, dioxins and furans can still be detected in these indoor areas today, although the use of PCP has been prohibited in Germany since 1989. Some of the PCP released from the wood is taken up by the dust in the room and by furniture, curtains or carpets. PCP use should always be assumed if values above 0.1 µg/m^3 of indoor air, more than 5 µg PCP/g in accumulated dust (old dust) and more than 1 µg/g in "fresh dust" (dust that has not lain for longer than one week before the sample is taken) are detected.

If the indoor air concentration to be expected in the middle of the year is above 1 µg/m³, remediation is required. After remediation the aim should be to achieve long-term indoor air values below 0.1 µg PCP/m³ of air. Regulations on determining the need for remediation in PCP-contaminated spaces and suggestions for suitable remediation are set out in the ARGEBAU guidelines on the evaluation and remediation of construction materials and components in buildings contaminated with pentachlorophenol (PCP) ("PCP guidelines") – see Part E.

If chemical treatment against insects was needed at all for wood, dichlofluanid was the first substitute for PCP available, followed by tebuconazole, propiconazole and other agents.

Is the use of chemical wood preservatives still permitted nowadays?

It is not necessary to use chemical wood preservatives with biocidal agents in indoor environments. In the case of pest infestation alternative wood treatments (e.g. thermal conditioning) can be used if needed.

Chemical wood preservatives should not be used in construction components and fittings that are visible and accessible to the room.

Lindane

Lindane (gamma-hexachlorocyclohexane; γ-HCH) was used as an insecticide in agriculture and forestry, wood preservation and veterinary and human medicine from around 1945. For a long while lindane was particularly important in controlling wood-destroying insects and in pest control measures as part of the German Federal Communicable Diseases Control Act (Bundesseuchengesetz).

At that time lindane was usually present in "West German" wood preservatives in combination with pentachlorophenol in a ratio of around 1 part lindane to 10 parts PCP. In East Germany a combination of the agents DDT and lindane was preferred. Since lindane was generally used as an agent in wood preservatives together with pentachlorophenol, it is primarily the PCP contamination that is in evidence in affected school rooms. Therefore, by carrying out PCP remediation in accordance with the PCP guidelines, lindane contamination will generally be reduced at the same time.

Chloronaphthalenes

Until well into the 1970s chloronaphthalenes were used as wood preservatives in the manufacture of bonded wood-based materials, especially particle boards. These were used as flooring sheets and to a small extent as wall and ceiling linings as well as in demountable buildings where children's day nurseries and pre-school playgroups were housed. The mixtures consisted predominantly of mono- and dichloronaphthalenes. Chloronaphthalenes could be recognised by their typical musty smell (cf. Section D-2.2).

A guideline value I (RWI) of 20 µg/m^3 and a guidance vaIue II of 200 µg/m^3 for the evaluation of chloronaphthalenes were proposed by the Federal Ministry of Health of the time. When making a hygiene evaluation of indoor environments contaminated with chloronaphthalenes the unpleasant odour emitted by the substance must also be considered. Odour threshold values in the range 4–10 µg/m^3 are specified for the monochloronaphthalenes.

Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) arise from the incomplete combustion of fossil fuels or other organic materials. More than 200 of these compounds exhibiting three or more benzene rings are to be found in outside air, especially in conurbations. In indoor environments PAHs can enter the air from, for example, tobacco smoke, leaking flues from coal stoves and from using poorly functioning fireplaces.

Tar and tar products also contain PAHs. Until the 1950s and 1960s tar-based adhesives (or mixtures of tar and bitumen) were sometimes used in laying wood floors and occasionally also in laying linoleum floor coverings, mainly in houses and flats. However, only a few cases where adhesives of this kind were used in schools have so far come to light. In indoor environments where tar-based adhesive materials have been used, an increased PAH content in the glue can also cause house dust to be contaminated by PAHs.

Many PAHs are classified as carcinogenic, including benzo(a)pyrene (BaP), the lead substance in the PAHs. In 1998 a commission of experts at the Federal Environment Agency issued recommended values for benzo(a)pyrene (BaP) as the PAH lead substance for adhesives and house dust content. These were also adopted by the construction authority (ARGEBAU). In accordance with these, measurements of house dust concentrations are to be carried out when concentrations in adhesives exceed 10 mg/kg BaP, taking into consideration the condition of the parquet. If the BaP content exceeds 100 mg/kg of dust (dust deposits no more than a week old at the time of sampling) measures to reduce exposure should be undertaken in schools (German Institute for Construction Engineering, "Advice on PAHs", June 2000).

B-5 Dust

Dust is the collective term for solid particles that remain distributed through the air over a fairly long period (suspended) or settle on the floor and on surfaces within a short time (sedimentary). Dust particles can vary considerably in size. Particles smaller than 100nm are termed ultra-fine particulate matter, particles up to 2.5 µm particulate matter and particles larger than 2.5 µm as coarser particulate matter. All particles up to a diameter of around 30 µm are suspended dust (TSPs – Total Suspended Particulates). Depending on the size and density of the dust particles these remain suspended for a certain time. Particles of 10 µm and more are often deposited within a few minutes. Finer particles of, for example, 1 µm, can remain suspended for several days. Very fine particles of, for example, 10 nm, react with each other in the air and form larger particles, or are taken up by larger particles.

The smaller particles are, the further they can penetrate into the respiratory tracts. Particles more than 10 µm in size will barely get beyond the larynx, and only a small minority of them can reach the bronchial tubes and the pulmonary alveoli. Ultra-fine particles can enter the bloodstream via the pulmonary alveoli and spread through the body via the blood.

It is not only the size of the particles which is crucial for the health impact of dusts, but also their chemical and biological composition and their morphological structure and form. As with particle size, the composition, structure and form are characterised by the type of source from which they emanate.

With regard to the classification of dusts a distinction should be made between particulates in outside and indoor air. It can be assumed that outside the concentration of particles in the air is very quickly diluted. The particle concentrations and compositions are often similar, except during special weather situations and in special local conditions.

The situation in indoor environments is quite different; here the distribution areas are considerably smaller. Dilution effects are not as useful as in the air outside and in this case are particularly dependent on ventilation methods and air circulation in the building. Furthermore, in indoor areas it must be taken into account that particles will react more vigorously with each other or will be given off by wall surfaces. Electrostatic processes in the air also influence the distribution and emission of particles. The sources in the indoor environment vary and are dependent on individual use. Sedimentary particles can be returned temporarily to the suspended state through mechanical disturbance. As this happens the structure and properties of the particles can alter. The processes mentioned are largely dependent on the existing structural conditions at the site. This all leads to a wide variation in the level of pollution and its composition in the indoor environment, and to it being heavily characterised by the prevailing individual circumstances.

A variety of sources of particulate matter occur inside schools. Here we are mainly concerned with coarser particulate matter. Sources of this are:

- Outside air
- Dust brought in on shoes and clothes
- Particles released from skin and hair
- Particles released during cooking and baking in home economics practical areas (some coarser particles)
- Work in technology lessons, especially sanding and sawing.

In addition smaller particles also occur. Sources of these are:

- Outside air
- Use of Bunsen burners, and burning candles
- Smoke production from chemistry and physics experiments
- Particles released during cooking and baking in home economics practical areas (some smaller particles)
- Copiers and laser printers. In this case ultra-fine particles play a particularly important part, as the most recent research, including at the Federal Environment Agency, shows. (The results of the study are available at: **http://www.umweltdaten.de/publikationen/fpdf-l/3016.pdf)**

Outside air concentrations of suspended particulate matter also have a considerable influence on the concentrations of finer particles in schools, while the coarser particulate matter element mostly comes from indoor sources (see above). In areas of the school used regularly the particulate matter concentration inside can be markedly higher than in the outside air. This applies especially to the coarser element of the particulate matter. The dust concentration inside schools depends amongst other things on the frequency of use (number of pupils, how often the room is used), the size of the room and the type of use (classrooms for theoretical subjects, laboratories for physics, biology and chemistry experiments, craft rooms, etc.).

In technology lessons dust is created by sanding and sawing. In chemistry and physics laboratories dust is created by experiments producing smoke and by using Bunsen burners (cf. Section A6). Incidents of dust pollution during science experiments and craft work can be minimised by intensive ventilation, using extractors during particular sanding procedures and – if necessary – wearing a simple protective face mask (e.g. from the DIY store).

Besides chemical substances, biological substances, such as micro-organisms, bacteria and their metabolic products and cell components, pollen and its components, as well as allergens given off by animals, are also bound to dust in schools.

In the case of biological dusts (cf. Section B-7), we are concerned predominantly with coarser dusts, which can produce some very specific impacts, especially in people with corresponding predispositions (e.g. those with allergies). Cell components which can trigger allergenic or toxic effects can also make up an element of fine or ultra-fine particulate matter.

During combustion processes mainly fine particulate matter and also some ultra-fine particulate matter are given off into the indoor air. To a small extent fine and ultra-fine particles are also released while laser printers and copiers are in use (cf. Section A-7). However, the sedimentary particles stirred up again by mechanical activities, e.g. during lessons in the classroom, are predominantly coarser particles, when not only dust lying on the floor or the desks is raised again, but also that which is found on the skin, hair, clothes, etc. It should also be remembered that some of this dust is brought in from outside, on shoes, for example.

A health evaluation of suspended particulate matter in indoor environments is difficult, as population-related studies of the impact of particulate matter rely to a large extent on data on particulate matter pollution of the outside air. Convincing links were found between the suspended particulate matter concentration in the outside air and effects on health – even though the people where the studies were carried out spent the bulk of their time indoors. From that can be concluded that even indoors the particulate matter from the outside air makes a significant contribution to the effects observed. It is not yet clear what further contribution is made by indoor sources.

In their latest statement the IRK/AOLG ad hoc working group also comes to the conclusion that the health implications of dusts in indoor environments are difficult to evaluate at present (IRK/AOLG ad hoc working group, 2008: Gesundheitliche Bedeutung von Feinstaub in der Innenraumluft [Significance to health of suspended particulate matter in indoor air], Bundesgesundhbl-Gesundheitsforsch-Gesundheitsschutz, in press). The assessment criteria (limit values) used to assess particles in outside air are not applicable to schools, on account of the different source situation and composition of particulate matter.

Latest studies have therefore detected mainly coarser particulate matter particles in classrooms. However, according to current knowledge it is in fact the smaller particles (especially PM2.5 and even smaller particles) that are particularly important from a health perspective. Biological particles represent one possible exception to this.

Despite the uncertainties surrounding the health evaluation of particulate matter in the indoor environment it seems advisable, bearing in mind the possible relationship, to minimise the dust concentration in these spaces. Various studies in Germany have shown that a reduction in dust pollution in schools can only be expected with regular intensive ventilation and strict adherence to cleaning recommendations (cf. Appendix 1).

How can particulate matter pollution in schools be reduced as quickly as possible?

Effective ventilation is key to reducing concentrations of particulate matter, especially coarser particulate matter, in indoor air in schools. As long as there is no smoking, the particulate matter concentration in indoor spaces depends mainly on the quality of the air outside.

Measures to reduce the entry of particulate matter from the outside air, such as installing mechanical ventilation systems with filters for incoming air, should only be considered in situations with extremely polluted outside air. These systems should be serviced regularly (changing filters, checking that ventilation shafts are clean and do not leak).

B-6 Fibre dusts

The term fibre dusts denotes particles with a fibrous or needle-like structure. Important from a hygiene perspective are fibres longer than 5 µm, with a diameter less than 3 µm, which exceed a length to diameter ratio of 3:1. These fibres are known as critical fibres. They can penetrate the lung tissue during inhalation.

There are natural fibres and synthetically produced fibres. These two categories can be further subdivided into inorganic and organic fibres.

Among the natural inorganic fibres are asbestos, talcum and gypsum, while the natural organic fibres include sheep's wool, animal hair and cellulose fibres. Important synthetically produced inorganic fibres – also called synthetic mineral fibres (SMFs) – are glass (amorphous) fibres such as mineral wool (glasswool, rockwool, slagwool), ceramic fibres, continuous glass filaments and crystalline fibres/single-crystal fibres. In addition there are synthetic organic fibres (fibres produced from natural or synthetic polymers).

Do asbestos and SMF fibres have the same importance for health?

The structure is important for the release of fibres of the critical size. Asbestos fibres are crystalline fibres, whereas SMFs are generally amorphous. The latter exhibit a significantly lower tendency to form dust. Unlike asbestos they break across the grain and have a lower biopersistence. They are also bound by synthetic resin and other additives. These factors restrict the release of fibre dust.

Asbestos

Building products containing asbestos were still used in school buildings into the 1980s, and a distinction is made between materials made of asbestos cement (with an asbestos content of approx. 15 % by weight) and loosely bound asbestos products (e.g. asbestos spray, with an asbestos content of more than 60 % by weight). Asbestos cement products were used as roof and façade panels, windowsills or window boxes, drainpipes and for partition walls (lightweight walls). Asbestos spray was preferred in air-conditioning and shaft systems for fire safety reasons.

As a result of ageing processes and years of use these buildings have gradually begun to release fibres. Especially where ventilation shaft systems had been spray-coated with asbestos, fibres released by this could enter adjoining rooms directly with the airflow.

Is asbestos still a problem in schools today?

Building materials containing asbestos are no longer used in schools. In general the asbestos fibres in the asbestos cement products installed in the past are firmly bound in the building product. However, if any work is done on these products (e.g. drilling, sanding or cutting), large numbers of asbestos fibres can be released. For this reason work of this kind is not permitted. In the case of asbestos spray, which was frequently used in air-conditioning shafts, for sealing cavities, etc., the fibres are less firmly bound than in asbestos cement products, so that the release of fibres as a result of ageing is to be expected.

Asbestos is classed as a known carcinogenic for humans. The inhalation of asbestos particulate matter can cause three main diseases:

1. Asbestosis: hardening of parts of the lung tissue.
2. Lung cancer, often in combination with asbestosis, latency period (time until the disease emerges) 20–30 years. Smokers are especially affected.
3. Pleural/peritoneal cancer (mesothelioma), latency period 30–40 years.

These asbestos-related diseases occurred especially among employees in the asbestos industry, in whose workplaces up to 100 million asbestos fibres m^3 of air were measured.

The evaluation of and decision on remediation for loosely bound asbestos products in buildings must not be made on the basis of air measurements, but using the asbestos guidelines introduced into building regulations in 1996, in which the need for remediation and the urgency for it are established according to a points system. Fibre measurements from the air are only required to check the success of the measures taken.

Synthetic mineral fibres (SMFs)

Synthetic mineral fibres are frequently found in schools. In contrast to asbestos fibres these do not occur naturally, but are produced industrially from various inorganic source materials (glass, rocks such as basalt, oxide ceramics). They are used mainly for thermal and sound insulation. Thus SMFs have a completely different range of uses from previous asbestos products.

SMFs are used to make mineral wool (e.g. glasswool, rockwool) for felts, mats or boards as well as for loose wool. Synthetic mineral fibre products display excellent heat resistance and good insulating properties, and are relatively easy to work with. As with all mineral fibre products, those made of mineral wool give off fibre dusts, on account of the particular properties of the material (see notes in box), although far less than asbestos products, for example, which in any case were employed in areas other than heat insulation, as described above.

Since the 1980s, and still more since the 1995 Thermal Insulation Ordinance [Wärmeschutzverordnung] and the Building Energy Conservation Ordinance of 2002, several million cubic metres of mineral wool products have been used in buildings.

Mineral fibres built into suspended ceiling constructions for sound insulation purposes or in the form of acoustic ceiling boards have provoked discussion about the possible release of fibres from SMF products into indoor air, since, to provide effective noise control, the ceiling constructions must be perforated on the room side, with the mineral wool just lying loosely on top.

Extensive measurements carried out in a variety of buildings at the beginning of the 1990s showed that in general, where mineral fibre insulation had been used as directed, no concentrations of SMFs exceeding the normal background concentrations in the air outside were recorded.

In the normal use phase of buildings, the concentrations therein of SMF fibres of critical size, which can be clearly associated with the product used, are:

- usually **not raised** by fibre emissions, if heat insulation has been carried out properly (insulation on the outside wall; double-skin wall with insulating layer between; installation inside the room or in the roof space behind dense panelling, e.g. plasterboard, wood panels with vapour barrier behind (polyethylene film) and/or comparable constructions);
- usually **moderately raised** by fibre emissions, if the mineral wool products are installed in such a way that air is exchanged between them and the indoor environment. This is mainly the case with suspended ceilings without a properly functioning filter layer;
- in isolated cases **significantly raised** by fibre emissions (up to several thousand fibres per m^3 of air). This is constant where there are constructional failings or structures, which do not conform to the latest technical standards, or temporary if structural work is being carried out on building components containing mineral wool.

Since 1998, in accordance with the Hazardous Substances Ordinance, synthetic mineral fibres have been classified by their substance composition using the KI-Index (carcinogenicity index)[1]:

- KI value < 30: K2 – substances that should be regarded as carcinogenic in humans.
- KI value > 30 to < 40: K3 – substances giving cause for concern because of possible carcinogenic effect.
- KI value > 40: no carcinogenicity classification.

Fibres with a KI > 40 are considered free of suspicion of causing cancer on the basis of current knowledge, as they have a biopersistence of only approx. 30–40 days. According to the Chemicals Prohibition Ordinance the biosolubility can alternatively be established through other methods set out in it and the products tested in this way declared free of suspicion of causing cancer. Therefore the “KI criterion” is seldom used now as evidence of biosolubility.

[1] **The KI value is derived from the difference in the mass contents of the oxides of the elements Na, K, B, Mg, Ca., Ba and twice the Al oxide content**

Since about the end of the 1990s only appropriately tested biosoluble SMF insulation materials have been available on the market. There is no risk to health from these materials. In the case of SMF products installed earlier (until about 1998) necessary renovation measures, in the course of which fibres can be released, should be undertaken with caution and with good ventilation during the works. TRGS (technical rules for hazardous substances) no. 521 describes the protective measures that must be taken during demolition, renovation and maintenance work with old mineral wool.

SMFs can therefore be classified as far less hazardous than asbestos fibres. To date there are no studies which indicate a clear link between cancer in humans and an incidence of SMF pollution. The following reasons may be significant:

- Mineral wool insulation produces less fibre dust than comparable asbestos materials. This is evident both in the workplace and in investigations in the indoor environment. A fibre-related cancer risk could not be proven in the mineral wool insulation industry, whereas it is considered proven in the former asbestos industry.
- The lengthwise splitting of fibres observed in asbestos, which increases its danger, is not a concern with synthetic mineral fibres.
- The so-called biopersistence (i.e. the time it takes for a fibre to break down in the body) of SMFs has been shortened still further in recent years through suitable material composition.

SMFs can have an irritant effect. Thus SMFs released from acoustic ceiling constructions can lead to irritations of the eyes and the upper respiratory tracts in people spending a long time in the contaminated room. This can be largely avoided with acoustic ceiling constructions by installing a filter layer.

Are synthetic mineral fibres as dangerous as asbestos?

Mineral wool products should not be compared with asbestos – either in terms of areas of use or of significance to health (see box page –). For precautionary reasons, when using mineral wool products in indoor spaces care should be taken to ensure that fibres do not come into open contact with the air inside the room (e.g. in the case of acoustic ceilings by installing a filter layer). There is no reason on health grounds to remove correctly installed mineral wool insulation. In new-builds the use of mineral wool products with the environment logo or the RAL [German Institute for Quality Assurance and Certification] “Mineral wool” mark is recommended.

B-7 Biological substances

As well as the chemical and physical air pollutants described in the previous sections, substances of biological origin also always occur inside schools. This is basically unavoidable, as most of these substances are either brought in by those using the room or enter the room with the outside air during ventilation.

Pollution from biological substances in school buildings differs significantly from living spaces on some points, while on others there is no substantial distinction.

Thus, in contrast to homes, noteworthy infestations with house dust mites are only seldom to be expected in schools (in cosy corners, for example). Biological waste bins with kitchen and garden waste are rarely found inside schools as a rule. However, food remains left lying around are not infrequently the cause of microbial contaminations.

Animal allergens on the other hand play a part in both private houses where there are pets and in school buildings, as they are brought from home by the pupils and teachers. Studies in schools have shown that relevant concentrations of pet allergens can occur there, especially from cats and dogs. These can be far higher than the concentrations detectable in homes where pets are kept. The allergens are brought in on the clothes of people who live in houses with pets or have regular contact with; them.

The allergens can be found on all surfaces, such as tables, chairs, etc. or in house dust, which accumulates especially readily in carpeting. Hard floor coverings, which can be washed and therefore collect little dust, are therefore much easier to keep free of allergens than carpets. However, dust is more easily raised from hard floors if they are not cleaned regularly, which is why the type of flooring and frequency of cleaning must not be considered in isolation from each other.

In some classrooms it is also usual to keep plants or animals in cages. This can cause allergic reactions in a few people. If caged animals are kept, there is the additional problem that the straw and animal food also contain micro-organisms, which can be released. Likewise the soil in plant pots can be a source of mould (see below).

A further problem which can affect all buildings, regardless of the type of use, is damp-related **mould damage**. If a sufficiently high level of damp is present over a fairly long period, mould and other micro-organisms (bacteria, yeasts, protozoa) will grow inside or on most building materials. Although attacks of mould present a problem in many schools, they will not be examined in detail in these Guidelines, as there are already two sets of guidelines from the Federal Environment Agency which address this issue (Federal Environment Agency 2002 and 2005, see reference in Chapter III). The principles cited in these guidelines on the detection, evaluation and remediation of sources of mould in indoor areas are also valid for school buildings.

The causes of excessive moisture and consequently of mould growth in schools can vary considerably. Owing to poor construction damp from outside can penetrate into the building, e.g. moisture from the ground, if cellar walls have not been made suitably watertight, rainwater if roofs leak and heavy rain if facades are damaged. Water can escape inside the building, e.g. if pipes or hoses begin to leak. With excessive humidity in the building and/or structural components at too low a temperature, condensation can form on the surfaces of fittings. In this last case it is often not easy to establish the cause, because whether a component is too cold as a result of structural failings or because of inadequate heating, whether high humidity has arisen through insufficient ventilation, or perhaps as a result of as yet unidentified moisture damage to the building, can mostly only be established by means of readings, which must be taken and interpreted by experts. The Federal Environment Agency's guidelines on mould remediation ("Schimmelpilz-Sanierungsleitfaden", UBA 2005) contain directions for the systematic investigation of the causes of attacks and for their remediation.

In addition to mould **bacteria** from a variety of sources also occur in indoor environments. One source of bacteria is the users of the room. All humans are colonised on the surface of the skin and in the respiratory tract by various physiologically occurring bacteria (e.g. coagulase negative staphylocci, micrococci, and corynebacteria). These are also emitted into the air as a result of movement or by speaking and coughing, which is why bacteria are always detectable in the air of rooms that are in use. This air contamination is unavoidable and unproblematic, except in the rare cases when someone colonised by or ill from pathogenic micro-organisms (e.g. tuberculosis bacteria) is in the room. However, as air is an unfavourable habitat for many of these organisms, they mostly only survive for a short time.

Bacteria can, however, also grow where there is moisture damage indoors, but most bacteria require higher moisture levels to grow than mould. Actinomycetes are often detected where there is moisture damage. Like mould these bacteria form mycelia and spores and were therefore previously known as ray fungi (actino = ray, mycetes = fungi). Some actinomycetes can produce a powerful odour (musty, earthy, mouldy). The spectrum of varieties of actinomycetes occurring with moisture damage and their significance for health is the subject of ongoing research at present. With remediation measures to cure damp and mould attacks the growth of bacteria can also be prevented.

Humidifiers, indoor water fountains and old, poorly maintained air-conditioning systems with integrated rotating spray humidifiers can be another source of bacteria. Certain bacteria, e.g. types of the pseudomonas species, can multiply very easily in the parts carrying water. However, in schools the use of such equipment is generally superfluous, as the humidity in classrooms normally in intensive use is high enough, owing to the moisture given off by the occupants.

A quite different problem can arise in connection with showers in sports facilities and changing rooms. In some circumstances legionella, which can multiply especially easily in a temperature range of 25–45 °C, can occur in the hot water installation. **Legionella** is therefore mainly a problem in larger buildings with long runs and periodic lengthy stagnation of the water in the mains system. To prevent the growth of legionella the cold water should always be cold (< 20 °C) and the hot water hot (60 °C and at least 55 °C when it reaches the tap). A reduction in hot water inlet temperature to below 55 °C (e.g. to save energy) should be avoided. The only remedy for an incidence of legionella is a thorough analysis of the system with regard to the factors encouraging it and if necessary a rise in hot water temperature to at least 55 °C when it reaches the tap, as well as possible structural alterations to the mains water pipes leading to them, so that dead spaces or stagnation zones are largely avoided. In new installations, as well as the general technical standards, the regulations in the DVGW (German Technical Association for Gas and Water) factsheet W 551 for preventing growth of legionella should be observed (see also Part A-4).

Outbreaks of head lice in children are a recurrent problem in schools. Controlling outbreaks of head lice requires close cooperation between parents, school and health agency. Every case of lice must be reported by name in writing (by letter, fax or e-mail) to the health agency, in accordance with Article 34 of the Protection against Infections Act (IfSG). A precise plan of action should be put in place for the procedure in the event of the occurrence of lice (see the schools specimen hygiene plan in Appendix I for details).

The health assessment of substances of biological origin is very complex and must therefore be considered in a slightly different way. Sensitivities and allergies, irritant effects, infections, intoxications, unpleasant odours and discomfort must be regarded as possible effects.

Substances with an exclusively allergenic effect only induce symptoms in allergic people with a sensitivity to the corresponding allergen. Within schools this applies mainly to allergens originating in animals. Where these are suspected the allergologist is the best person to give further help, as it is usually no problem to diagnose an allergy to animal hair, cockroaches or house dust mites by means of medical tests.

It is not always easy to take countermeasures when typical symptoms occur at school in individual pupils or even staff with a corresponding allergy. Contamination can be reduced through regular thorough cleaning and by using certain furnishing materials, such as hard floors instead of carpets. It is not possible to prevent pupils and teachers from "bringing" the relevant allergens from home.

Assessing the health risks of mould damage is significantly more complicated. It is known from scientific, epidemiological studies that health problems can go hand-in-hand with moisture damage and mould growth in the indoor environment. For this reason mould growth indoors should be regarded as a hygiene problem and should not be tolerated. Nevertheless, the discovery of a source of mould inside the building should not be equated with an acute health risk to its users.

The fundamental assumption is that many types of mould can cause allergic symptoms if they have a suitably intensive or long-term influence. On the basis of current knowledge intoxications can be practically disregarded, as the concentrations of mycotoxins (the toxic metabolic products formed from moulds) to be expected in indoor areas are significantly below the concentrations considered acutely toxic. However, unspecific irritant effects of some bioaerosol constituents, which can lead to symptoms such as irritations of the throat and mucous membrane, are a possibility.

Infections with mould only present a danger to people with a suppressed or weakened immune system. This at risk group includes mainly people who have undergone bone marrow or organ transplants, and patients in the acute phase of chemotherapy or on long-term high doses of corticosteroids (substances having the same effect as cortisone).

The extent of the actual health risk from mould is dependent on a number of factors, including the extent and type of damage, but also on the individual sensitivity of the person living in or using the room. At present the scientific knowledge available is unfortunately inadequate for making a quantitative record of the damage with regard to the medical risk, and there are also no medical tests that can attribute the symptoms unequivocally to the existence of mould damage.

The latest recommendation from the Robert Koch Institute, „Schimmelpilzbildung in Innenräumen – Befunderhebung, gesundheitliche Bewertung und Maßnahmen" ["Mould formation in indoor environments –investigation into the findings, health evaluation and measures"] (Bundesgesundhbl-Gesundheitsforsch-Gesundheitsschutz 50: 2007, pp.1308–1328), provides assistance with a semi-quantitative risk assessment.

In conclusion it can be said that sources of mould should be removed or remedied for reasons of preventative health care, i.e. the precautionary principle, by which contaminations should be minimised before illness occurs (the minimisation rule), should be applied.

As explained above, although bacteria often occur around moisture damage, little is understood about their risk to health. There are a few studies in which the assumption is made that impacts on health are due to the presence of bacteria. Therefore the minimisation rule should also apply for precautionary reasons in respect of the growth of bacteria in moisture damage. The bacteria and other micro-organisms are also destroyed by the remediation measures indicated for mould, so that no further action is necessary.

Are air humidifiers a hazard inside schools?

Air humidifiers and also indoor fountains can contribute to the spread of germs, if equipment is not regularly cleaned and the humidifier water not regularly changed. Because of the risk of microbial colonisation there should be no humidifiers or indoor fountains in schools.

To avoid possible health risks from micro-organisms proper cleaning of sanitary areas should of course take place in schools as well (cf. Section A-2).

Another risk that can arise from bacteria and viruses is the transmission of infections from one person to another through droplet or direct contact transmission. However, the transmission of illnesses such as influenza, scarlet fever (streptococcus pyogenes) and whooping cough (bordetella pertussis) is not a problem specific to the classroom. To prevent these the relevant guidance from the Robert Koch Institute (e.g. Hinweise für Ärzte, Leitungen von Gemeinschaftseinrichtungen und Gesundheitsämter zur Wiederzulassung in Schulen und sonstigen Gemeinschaftseinrichtungen [Advice for doctors, managers of community institutions and health agencies on readmission to schools and other community institutions], updated July 2006. First published in Bundesgesundheitsbl 44 (2001): 830–843) should be observed and the children instructed in good hand hygiene and cough etiquette.

B-8 Radiation (radon)

Man has always been exposed to natural radiation. This radiation is made up of external radiation from space (cosmic radiation) and natural radioactive substances in rocks and soils (terrestrial radiation) as well as internal radiation from natural radioactive substances taken in with food or from the air.

A substance that arises from the radioactive decay of naturally occurring uranium or thorium in rocks is the radioactive noble gas radon. It is a natural radioactive noble gas with a half-life of 3.8 days which arises from the radioactive decay of uranium (half-life 4.5 bn. years) or its daughter product radium-226 (half-life approx. 1600 years). It is colourless, tasteless and odourless and occurs particularly in areas with granite rock. As a gas it moves easily through the soil and penetrates from the soil air through cellar walls and foundations into buildings. If radon escapes from the ground into the atmosphere it is very rapidly dispersed in the outside air, so that significantly lower concentrations are present in the outside air than in soil air. Normal concentrations in the outside air are between 10 and 30 Becquerel (Bq)/ m^3 (1 Bq denotes one radioactive disintegration per second). In Germany there are some regions with a particularly high radon content in the soil. These include some parts of the Bavarian Forest, the Black Forest, the Fichtel Mountains and the Erzgebirge (Ore Mountains) as well as the Eifel region. (The Federal Office for Radiation Protection's "radon map" (available at: http://www.bfs.de/de/ion/radon/radon_boden/radonkarte.html) provides information on the radon-contaminated regions of Germany.)

Owing to its alpha-radiating decay products inhaled radon leads to heightened radiation exposure of the lung. This increases the risk of lung cancer. After tobacco smoke radon is regarded as the second most common cause of cases of lung cancer in Germany. The level of the risk of developing lung cancer rises with the level of the concentration of radon in indoor air and with the length of time spent in the room. According to the results of epidemiological studies of the residential population of Sweden, England and Germany the risk of lung cancer increases by around 10 % when the radon concentration rises by 100 Bq per m^3. This makes radon the most important indoor carcinogen.

In the case of new-builds in radon-contaminated districts appropriate structural measures should be included in the design to reduce the radon risk inside the buildings. For example, ground source heat systems such as those likely to be used increasingly in energy-efficient new school buildings in future should be so well sealed that radon from the soil cannot enter the heat-exchanger. In existing buildings, in the view of the Federal Office for Radiation Protection, measures should be carried out for concentrations above 100Bq per m^3, bearing in mind the possible relationship. Increasing the ventilation in the room is a cheap measure that can be carried out in the short term to reduce radon concentrations.

PART C: Structural and indoor climate requirements

The following sections address the hygiene-related requirements which must be laid down for construction products and materials used in fixtures and fittings for indoor areas in school construction or refurbishment projects, followed by general aspects relating to indoor climate and ventilation.

C-1 Structural requirements, fixtures and fittings for indoor areas

Since 1989 the requirements for construction products which relate to health and environmental protection have been anchored in law in the EC Construction Products Directive (Directive 89/106/ EEC). In Germany the Directive was implemented by the Construction Products Act in 1992. Although both rulings lay down the framework for health protection, their practical implementation in standards and regulations is still partly being worked out. The Committee for the Health-related Evaluation of Building Products (AgBB) whose office is located in the German Federal Environment Agency (UBA) was founded in 1997 with the aim of minimising emissions of chemicals from construction products. In the following years the AgBB developed a scheme for evaluating emissions from volatile and semi-volatile organic compounds. Between 2002 and 2004 this “AgBB Evaluation Scheme” was tested with a view to possibly implementing it in practice. The evaluation scheme closes a major gap when verifying the fitness for use of a construction product. A construction product is considered “fit for use” if it satisfies the technical requirements and does not impair the health of the indoor users.

Bild 1: „Ü-Zeichen“ (Muster, Inschriften können variieren)

Like other testing criteria, including for example recipe specifications and the exclusion of certain hazardous substances, the AgBB scheme also forms an integral part of the principles for evaluating the health effects of construction products in indoor areas, which serve the German Institute for Construction Engineering (DIBt) as a basis for granting national technical approvals. The German Mark of Conformity is the label for construction products with national technical approval (see Figure 1).

The additional note “Emissions checked for conformity with DIBt criteria” indicates that an examination according to the AgBB scheme has been carried out. The first construction product which the DIBt approved after an emissions test in 2005 was a textile floor covering. Since then the institute has approved rubber, PVC and linoleum floor coverings and laminate floorings, using the emissions test. More construction products will follow.

In comparison to the AgBB scheme, the specifications for the Blue Angel label for emissions from volatile organic compounds are stricter, that is, the products must contain much lower concentrations of the test values. In addition, strict requirements also apply to other substances, e.g. formaldehyde, which the AgBB scheme does not take into account.

In conclusion, it can be said that construction products which have passed the health-related assessment according to the AgBB scheme satisfy the statutory minimum requirements. The Blue Angel incorporates further requirements regarding environmental and health protection and is available for construction products which have not yet been tested in accordance with the AgBB scheme.

Today selecting low-emission construction products is more necessary than ever. Stricter requirements for saving energy mean that building envelopes are made increasingly airtight. Without adequate ventilation the effect can be to create an accumulation of chemical and biological substances released into the indoor air. Using low-emission construction products as well as increasing the ventilation can help to prevent this. Products with the Ü Mark have been tested for pollutants and fulfil the statutory minimum requirements.

Products with the Blue Angel mark and added note “weil emissionsarm” (low in emissions) or “weil schadstoffarm” (low in hazardous substances) are even more suitable.

C-1.1 Building shell

The usual construction products for the building shell (mineral building materials, wood and metal) do not pose any danger to the occupants and building users. By analogy this also applies to many renderings, paints, wallboards and ceramic tiles. However, some of these construction products contain construction chemical additives which must be considered separately.

The specific properties of building materials used for the building shells of schools are outlined below. Particularly problematic materials in terms of hygiene are addressed by way of example.

Concrete is by far the most common building material in building shells. It consists of cement as a binding agent and natural aggregates such as sand or gravel, which harden to form a stone-like mass when mixed with water. Both concrete and cement and certain aggregates are standardised or tested for national technical approval if they deviate from the standard. In these "certificates of fitness for use" possible, harmful effects on health or the environment are considered.

Bricks, **lime-sand bricks**, **concrete blocks** and porous concrete blocks and the wall and rendering mortar required to build with them are often used for the external masonry. Wall bricks are formed from clay, sand, limestone and water, to which small quantities of auxiliary materials, e.g. porosity enhancing agents are added, and fired at temperatures of over 1,000 °C. In the firing process organic pollutants, also introduced into the "moulded bricks" when residues are used, are destroyed. Therefore once fired, bricks do not pose any health risk at all as a rule.

Lime-sand bricks are produced from lime, sand and water and hardened at temperatures of 160-220 °C. Given these base materials, they do not cause any health problems either. Similarly, the information on concrete given above applies to concrete blocks and porous concrete blocks. Here too the general point should be made that the majority of wall bricks are regulated by standards, and that deviations from the standards are dealt with according to the procedures for national technical approval described above.

Even the gas concrete and porous concrete blocks in popular use today as part of energy saving improvements in construction are free of additives and pose no health-related risk. This is not the case with external walls which are built using uprights (wood, usually steel in schools) with cavities in between in order to save energy. These are then filled with insulating materials and have only planking made of plasterboard or similar substances and a vapour barrier beneath this attached on the inside. Insulating materials can contain chemicals like formaldehyde and/or already be contaminated by microbes before delivery on site. This does not necessarily cause indoor air pollution later since the vapour barrier, provided it is sealed and installed correctly, also helps to prevent pollutants entering the indoor air.

Problems only arise when cracks and leaks emerge in the walls, allowing substances from the cavities to get into the indoor air. Problems also occur if damp penetrates the cavities during construction or later on and cannot dry out any more. Microbes can then grow concealed, which can have detrimental effects on the health of the users of the indoor areas (cf. Section B-7). Therefore, particular care must be taken in everyday practice to ensure that no damage is caused by damp getting into cavity wall constructions.

Mortar for walls and rendering is made from materials bonded with cement or lime which harden when water is added. As well as added materials such as sand, gravel or limestone, a range of auxiliary mixing materials is used, but since the proportions are small, they are rather insignificant as regards hygiene.

Wood is the building material man has used for longest and which, as a renewable raw material, has always been available almost anywhere. Since wood is flammable and susceptible to animal and plant pests however, it is important to follow certain rules when using wood in construction to prevent infestation from insects or fungi which destroy wood. According to DIN 68800-2 "Wood preservation – Part 2: Preventive constructional measures in buildings", today buildings can be constructed in such a way that load-bearing timber components and braces, including the roof structure, do not have to be treated with wood preservatives if the relevant components are visible or permeable to liquids, gases and insects. The timbers can be pre-treated by physical processes (thermal drying) so that only a small amount of moisture remains in the wood. Moreover, if this remains the case in the building later on, it will at least be very difficult for organisms which destroy wood to grow there. It is however true that dispensing with chemical wood protection requires careful planning and execution and can limit the choice of materials.

If the particular construction demands of a building mean that preventive treatment with wood preservatives cannot be avoided, only technically approved wood preservatives can be used on load-bearing components and braces.

Within the framework of the approval procedures for these kinds of materials, their effects on health and the environment are tested and assessed, taking account of their intended use.

It can be presumed that technically approved wood preservatives pose no risks to the building users when used correctly.

With **composite wood panels** (e. g. particle board or OSB panels) which are mainly used for large areas (e. g. as flooring panels), above all the release of formaldehyde emissions should be borne in mind (cf. Section B-3). Nowadays flooring panels are usually glued with waterproof adhesives (V 100). These glues emit little or no formaldehyde. The products are also clearly labelled for the users with the "E1" emissions class mark for low-formaldehyde or have "formaldehyde-free" printed on them. With the latter, isocyanates have been added to the glue but can no longer get into the indoor air once the glue has hardened during the production process. Today the largest quantity of composite wood panels (e. g. particle board and plywood which is not glued with a waterproof adhesive) is still glued with urea-formaldehyde-resin-based adhesives which can more readily emit formaldehyde over many years (see also C-1.3). Formaldehyde emissions can be reduced by means of coatings not permeable to formaldehyde. With OSB panels, higher-order aldehydes and carboxylic acids in particular can produce unpleasant odours in the indoor air. Nowadays using biocides in composite wood panels (V 100 G) is no longer permitted in indoor areas.

With **metals** used in building shells a distinction must be made between iron or steel and non-ferrous metals such as aluminium, zinc or copper. They pose no problem as regards hygiene since they emit no pollutants into the indoor air. However, this applies to the metals themselves, not to their coatings or varnishes. Essentially, materials which are powder coated ex factory (e. g. radiators) are emission-free.

C-1.2 Extensions and conversions

Emissions from construction products do not alone determine indoor air quality. Materials used in fixtures and fittings also play a part. The range of product materials used in indoor areas is just as varied as that of the materials used in building shells. It is also the case here that using eco-friendly and low-emission products can noticeably reduce indoor air pollution.

Extensions and conversions in school buildings should primarily be undertaken by specialist firms. Since teachers, parents and pupils are increasingly resorting to “self help” in view of the financial situation, experts should definitely be consulted before this kind of work is begun.

The recommendations listed together below can serve as initial information for work done by specialist firms and in “self-help” situations. Obviously, as well as their advice, the recommendations for use and manufacturer’s instructions on the packaging must be followed.

Besides technical approval which regulates the health-related fitness for use of construction products, the Blue Angel indicates particularly low-emission construction products and furnishings used in indoor areas (cf. Table 7). In order to determine the health effects of volatile organic compounds (VOCs), the Blue Angel also uses the scheme for assessing construction products in terms of health (AgBB scheme) with many products. However, the requirements for the maximum values for TVOCs (total volatile organic compounds) and SVOCs (semi-volatile organic compounds) are much stricter. With these the Blue Angel reduces the amount of pollutants permeating the indoor air and contributes towards preventive health care.

Tabelle 7: The Blue Angel for low-emission products

Criterias for Blue Angel label		Awarded products
RAL-UZ 12a	Low-emission paints and varnishes	Clear and coloured paints and varnishes, glazes, primers, radiator paints, etc..
RAL-UZ 38	Wood and wood-based products	Furniture, parquet, laminate, linoleum, panels
RAL-UZ 76	Composite wood panels	Particle board, fibreboard, floor boards
RAL-UZ 102	Wall paints	Emulsion paints, latex paints, Mixing paints, silicate emulsion paints
RAL-UZ 113	Floor covering adhesives and other installation materials	Adhesives for flexible floor coverings, parquet, fillers
RAL-UZ 117	Upholstery	Chairs, armchairs
RAL-UZ 119	Mattresses	Spring coil and foam mattresses
RAL-UZ 120	Flexible floor coverings	Rubber floor coverings, linoleum
RAL-UZ 123	Sealants for indoor areas	Silicones, acrylates
RAL-UZ 128	Textile floor coverings	Carpets

Furthermore, there are more labels originating in private initiatives and used by various producers internationally. These include “natureplus” from natureplus e.V. (environment organisation) for various construction products, ‘GUT’ from GUT e.V (the organisation of the European eco-friendly carpet producers), “EMICODE EC 1” from the Gemeinschaft Emissionskontrollierte Verlegewerkstoffe e.V (Association for the Control of Emissions in Products for Flooring Installation) and the “Scandinavian Trade Standards”. With these labelling systems, the testing institutions also determine emissions according to EN or ISO standards or related methods.

Varnishes:

Conventional alkyd resin varnishes can cause considerable indoor air pollution due to their solvent content (35-55 % w/w) and due to the fission products of the drying oils (aldehydes and carboxylic acids). The joint recommendation for using “solvent-reduced construction varnishes”, published by the Workgroup for Institutions for Statutory Accident Insurance and Prevention in Construction (Bau-BG), the German painters and varnishers guild, the paint and varnish industry and the German Federal Environmental Agency among others comes to the conclusion: “Taking their respective properties as a whole, dispersion varnishes are a technically equivalent alternative to conventional alkyd resin varnishes for most areas of application. Furthermore, because of their reduced solvent content, dispersion varnishes are generally much more compatible with health and the environment and therefore using these is preferable to using conventional alkyd resin varnishes.” More recent investigations on their fitness for use and emissions performance confirm this statement.

Many dispersion varnishes carry the Blue Angel mark. For a long time the tried and tested alternatives to conventional varnishes have been “low-pollutant varnishes” with the RAL-UZ 12a eco-label (max. 2–10 % w/w solvent content), which usually contain alcohols and Glycol ether in place of aliphatic and aromatic hydrocarbons. Due to their low solvent content, comparable low-pollutant varnishes cause noticeably less indoor air pollution.

What must be noted when using varnishes in renovations?

- Before painting and varnishing, a check should be made on whether the work requires using varnishes, or emulsion paints could be used instead. Emulsion and latex paints are the paints suitable for mineral subsurfaces (walls and ceilings).
- Low-pollutant varnishes or wood glazes with the Blue Angel label are the most suitable for protecting the surfaces of non-load-bearing timbers in indoor areas (living areas). Low-pollutant varnishes for protecting the surfaces of wooden components or objects exposed to the weather are also sold.
- Surface treating agents with a high solvent content should not be used for varnishing parquet. Water-based surface treating agents (water seals) based on acrylic or polyurethane resin should be used instead.

Wall paints, (emulsion paints, silicate paints):

Emulsion paints are generally held to be eco-friendly. Basically this is true for the main ingredients: water, fillers (e. g. chalk), titanium dioxide as a pigment (provided it is produced according to the EC Directive) and binders. However, emulsion paints cannot be produced from these ingredients alone. Useable emulsion paints need various additives as well and they contain preservatives. If a lot of these are used, they can cause indoor air pollution under certain circumstances. Silicate paints, also called mineral paints, contain water glass as their binder as well as inorganic colourings. Using modern (eco-friendly, low-emission) emulsion paints or silicate paints can significantly reduce indoor air pollution. These emulsion paints, also termed "ELF paints" (emission and solvent free) have been sold by the paint and varnishes industry for several years now. They have not yet become established on the market because they are more expensive than conventional emulsion paints.

What should be considered when using emulsion paints (wall paints)?

- Emulsion paints are suitable paints for covering large areas of walls, ceilings and façades. Using varnishes is not necessary here.
- Paints on the inside of external components should not adversely affect the water vapour diffusion performance of these external components.
- As far as protecting health and the environment is concerned, only low-emission wall paints should be used in indoor areas. Matt emulsion paints, silk gloss and gloss latex paints and silicate emulsion paints which hardly contribute to indoor air pollution with volatile organic compounds (VOCs) or do not do so at all (ELF paints) have the Blue Angel label "weil emissionsarm" (low in emissions)
- Preservatives included in the contents declaration on the cans of water-based paints should be noted, in order to protect allergy sufferers.

Floor covering adhesives:

Like varnishes, floor covering adhesives consist of four groups of materials: binders, solvents, fillers and additives. Today modern floor covering adhesives usually contain only water as their solvent. However, the emissions from these adhesives can differ in terms of their different production processes and additives. For certain bonds, for example, parquet on difficult subsurfaces, adhesives containing solvents, even adhesives with quite a lot of solvents, are still used today. Sometimes, using these adhesives in indoor areas can still affect people's health adversely a long time after their application. The reasons for this can be the poor condition of the subsurface (e.g. highly absorbent subsurfaces), incorrect subsurface preparation or high-boiling solvents in the adhesives which require a long time to evaporate completely because of their low vapour pressure. To prevent this indoor air pollution, already ensuring at the planning stage that the floor covering on the subsurface can be laid with a low-emission floor covering adhesive and, if necessary, including low-emission filler and primer, is recommended.

The low-emission "Blue Angel" eco-label for low-emission floor covering adhesives has been in existence since June 2003. The basic award criteria are based on the evaluation scheme developed by the Committee for the Health-related Evaluation of Building Products (AgBB). The aim of the AgBB is a uniform, comprehensible, health-related evaluation of construction products in Germany, with special reference to emissions from volatile organic substances. The Gemeinschaft emissionskontrollierter Verlegewerkstoffe (GEV) (Association for the Control of Emissions in Products for Flooring Installation) also awards the EC 1 mark for relatively low-emission floor covering adhesives, for which the requirements are less strict.

With floor covering adhesives based on emulsions, isolated emissions can be detected which do not originate directly from the substances themselves, but are the result of reactions (secondary emissions). These substances are carbonyl compounds (aldehydes, ketones and organic acids), some of which have only been found after tests lasting more than 28 days. Some of the substances have very low odour-thresholds, i.e. they can be smelled even in low concentrations and could therefore be responsible for unpleasant smells which in practice are usually the main cause of complaint. The origin of these secondary emissions could be linked to the use of tall resins (resin from beech trees, is used industrially in paper adhesives e.g.) or tall oils in adhesives. These can contain unsaturated fatty acids such as linoleic acid and oleic acid which are known to be converted into the substances referred to through oxidation by atmospheric oxygen. Floor covering adhesives with the Blue Angel mark cannot contain oxidisable ingredients.

Which floor covering adhesives should be used?

Nowadays the adhesives industry sells solvent-free, low-emission floor covering adhesives for all types of floor coverings (flexible floor coverings, carpets, parquet). Given suitable pre-treatment of the subsurface (e.g. filling), these adhesives can be used on all subsurfaces. Adhesive residues from old coverings must be removed beforehand.

Floor coverings:

Floor coverings form the top layer of the floor. Increasingly, concerns related to environmental and health protection also play a part in their selection besides technical, functional and design aspects. It is often not enough to consider the floor covering alone since its emissions performance can be influenced strongly by the subsurface, for example, by absorbent screed which can retain solvents or the adhesives applied. For this reason the entire structure of the floor, together with the underfloor, the laying technique and material should be included. Only floor coverings which can be damp wiped should be used if possible after new build or renovations in school buildings.

Which floor coverings should be used in schools?

- As regards damp wipe floor coverings, there is no “ideal” floor covering. Depending on the intended area of use and the necessary standard required, a selection should be made from three different product groups such as wood/wood-based products, flexible and ceramic floor coverings that will enable it to be used for the longest possible time. As regards the cost of care in terms of time and expense, no great difference between these product groups can be expected.
- Floor coverings in classrooms (not in corridors) are subject to approval by the German Institute for Construction Engineering (cf. C-1). For this reason it is essential to look for the presence of the Ü mark (see Figure 1, Section C-1) when purchasing floor coverings.
- Since then it has been possible to award the Blue Angel mark “weil emissionsarm” (low in emissions) to a range of floor coverings: rubber and linoleum coverings, parquet, cork and laminate.
- Ceramic floor coverings should be used anywhere where they must prove durable given constant, heavy use and frequent cleaning (e. g. sanitary facilities, cf. Section A-2).

Textile floor coverings:

Textile floor coverings should not be used in schools because of the comparatively high cost of cleaning in terms of time and expense (cf. Section A-2).

C-1.3 Fixtures and fittings for indoor areas

Furniture, particle board and other products made of wood-based materials represent a potential source of emissions due to their number and the relatively large area they occupy in teaching areas. The variety of the products used in indoor areas and the chemical products used in their manufacture has increased noticeably in recent years. Thus furniture and wood-based materials can contribute to indoor air pollution to a very varying extent.

Wood-based materials (particle board, coated particle board, wood core plywood, veneers, fibreboard) and products from wood-based materials such as furniture, doors and panels are a major source of formaldehyde in indoor areas. The release of formaldehyde is limited to these kinds of particle board and other wood-based materials which have been manufactured using adhesives based on urea-formaldehyde resins (cf. Section B-3). Only low-formaldehyde or formaldehyde-free furniture products should be used in schools.

With long-lived products such as school and office furniture which can have a considerable effect on the indoor air over a longer period of time, an indication that the products are less harmful to health and the environment is enormously important to the user. Building on the results of earlier research projects by the German Federal Institute for Materials Research and Testing, extended basic award criteria were developed for a ‘Low-emission furniture’ eco-label. These basic award criteria which still apply today are based on the product life of furniture items. An essential requirement limits emissions from furniture items into the indoor air.

The Deutsche Gütegemeinschaft Möbel e. V. (German Furniture Makers Quality Association) awards a quality mark for quality furniture (RAL mark). In contrast to the eco-label, with RAL labels, it is first and foremost the materials used, their treatment and processing and compatibility with the environment and health which are tested on the basis of existing statutory regulations and the relevant standards. The application area of the quality mark includes school furniture.

What should be considered when purchasing school furniture?

- Purchasing items of school furniture which are largely made of wood should be based on the requirements for awarding the eco-label RAL-UZ 38 (see Table 7, Section C-1.2).
- It is also recommended that, when purchasing furniture which is made mainly of materials other than wood, products which fulfil the requirements of the German Furniture Makers Quality Association (RAL-RG 430) especially as regards their fitness for use and durability should be considered.
- In individual cases a “furniture passport” is also available which gives information about the test result on possible emissions from the product.

C-2 Building climate

C-2.1 General physiological requirements

Human beings rely on complex regulatory mechanisms to keep their body temperature constant independently of the ambient temperature as far as possible. They only achieve this aim of maintaining a constant body temperature of 37 °C if the heat they develop matches the total heat they give off. Hypothermia and overheating are unlikely to occur if the balance between heat production and heat loss is maintained and there are no substantial variations. The body's heat production depends principally on the person's activity level (see Table 8). Heat exchange with the surroundings is determined above all by heat loss through the skin.

Table 8: A person's metabolic heat production when resting or taking part in some typical activities	
Activity	**Heat production, watt/person**
Rest (basic metabolic rate)	80
Sitting activity (reading, writing)	100–125
Light activity (laboratory)	150
Moderately vigorous physical activity (climbing stairs etc.)	170–230
Vigorous physical activity (competitive sport, construction work)	400–600

The following factors influence the heat exchange of human beings with their environment:

- Thermal conduction (e. g. through contact with furniture, floors etc.)
- Convection (heat transfer, e.g. via air currents)
- Evaporation (constant water evaporation through skin and mucous membranes, occasional evaporation through sweating)
- Heat radiation (e. g. heat emission to colder surfaces)

The (purely physical) process of heat exchange with the surroundings is also substantially influenced by the school pupils' clothes.

Under the thermal conditions usually encountered in social areas 90 % of the heat is exchanged by convection and radiation. Only at elevated ambient temperatures (at 27 °C and above) or during vigorous activities (P.E. lessons, playing on the playground) is a significant proportion of heat lost through evaporation. Convection and radiation are involved in heat exchange to almost the same extent. For this reason the temperature felt by human beings (= operative temperature) can be calculated as an arithmetical mean value of the temperature of the surrounding areas (radiated temperature) and air temperature with reasonable accuracy.

The typical situations in schools which can be linked to thermal load include above all:

- Warm conditions at the start of lessons due to increased heat loss after break time activity.
- Uncomfortably warm conditions, e.g. near window frontages due to increased absorption of radiated heat (solar radiation, radiator).
- Uncomfortably warm conditions at lesson start due to intense heat from solar radiation and no active sun protection in indoor areas facing east.
- Uncomfortably warm conditions at lesson start due to overheating, solar radiation in the afternoon in indoor areas facing west (even north-west) and due to inactive or non-existent sun protection and no cooling during the night or early mornings.
- Rise in operational temperature during heatwaves in summer.
- Rise in operational temperature and relative humidity during lessons due to heat and water vapour loss from the occupants in situations with inadequate ventilation.
- Uncomfortably cold conditions, e.g. near window frontages due to increased thermal radiation (cold outside wall) or increased convection (draughts).
- Uncomfortably cold conditions in the mornings due to late start of heating following overnight drop in temperature (heating system on night setback).

What are the physiological requirements of human beings which must be considered in teaching rooms?

- People's thermal comfort is influenced above all by air temperature, ambient temperature and air movement.
- Physically comfortable operative temperatures (for classrooms according to season and as a function of external air temperature between approx. 20–26 °C) should be maintained throughout the year as far as possible.
- Walls, floors and ceilings must be designed in such a way that no unpleasant thermal radiation exchange with cold surfaces occurs.
- Draughts should be prevented.
- Individual clothing should be suitable for the seasonal and spatial conditions and movement (academic lessons sitting down, P.E. lessons etc.).

C-2.2 Technical requirements

Structural and technical prerequisites to ensure perfect indoor air quality and a good building climate in school buildings also include a favourable situation and size of the school site in terms of urban planning and microclimate. These include a reasonable amount of sunshine, hardly any effects from the wind or turbulence, no large emission sources in the immediate vicinity of the school and a quiet location away from traffic. Also necessary are good building ground and a good architectural solution for the building itself which takes appropriate account of the required size, location and fixtures and fittings of the teaching rooms and all other functional rooms.

For several reasons protecting the classrooms from heat load in summer as a result of sunlight overheating indoor areas and high external temperatures is becoming increasingly important, that is:

- In classrooms a relatively large number of people (particularly with larger classes) occupy a fairly small space during lessons. The result is a heat loss that has the effect of internal heat load.
- Compared to the past, in modern schools the ceilings in indoor areas are now lower than they used to be for cost reasons. High ceilings are no longer common. This reduces air volume and the possibility of physiological heat loss through convection.
- For design reasons, larger window areas have become established in modern school building architecture. However, in summer these can give rise to unwelcome solar radiation.

- Thin partition walls and (for sound purposes) suspended ceilings with almost no capacity to absorb heat have become common interior fixtures with the result that in summer an unwelcome amount of heat is generated in indoor areas.

In addition, there is the fact that the possible effects of climate change which are only starting to be felt now, will pose a far greater problem for future generations of school pupils compared to today. Conserving heat in the winter will perhaps no longer be the main problem, but preventing indoor areas overheating in summer.

The great number of causes makes people assume that there are also many influencing factors which make it possible to counter solar radiation in summer effectively. Some of these factors are described in more detail in the following sections.

Building **orientation** together with the orientation of the main building façades containing windows are crucial. North-south façades perform favourably, east-west façades unfavourably. Contrary to popular opinion, south façades are not greatly irradiated by sunlight in summer because the sun in the south at its zenith is perpendicular to the earth at midday and therefore only shines on the façade at an angle. On the other hand, west façades are affected by almost direct solar radiation when the sun is lower in the afternoon, causing considerable problems in west-facing indoor areas. Moreover, during summer afternoons (four to five o'clock) the external air temperatures are also at their highest, meaning that almost none of the heat indoors can be "extracted outside" in summer; ventilating the indoor areas at this time brings more heat into the classrooms. The same applies to east façades during the morning. Most indoor areas facing eastwards have already been warmed up before the start of lessons or are heated up at the start. In contrast to west-facing indoor areas, those which are east-facing can be well ventilated in the mornings because the external morning air is still relatively cool in summer. North-facing indoor areas receive the least amount of solar radiation and only diffuse almost never direct radiation. However, diffuse radiation gives north-facing indoor areas excellent, natural light with no glare and for this reason art studios tend to face north. Rooflights receive very high amounts of solar radiation in summer. However, north-facing windows are rarely used in energy saving construction methods because people want to make use of the sun as a passive energy source to warm indoor areas in the winter, autumn and spring months.

The **size of the transparent window area** plays a crucial role in heating in summer. Façades with glazing proportions exceeding 40-50 % are not to be recommended. Together with the then necessary sun-protection devices, they cost several times the amount of non-transparent walls made of traditional building materials.

Depending on the orientation, large areas of glass require **sun-protection devices**. A sun-protection device must be external in order to be effective in energy terms. Devices located indoors have no energy-related effect as a rule; at best, they can shield against glare but offer no thermal protection. Sun-protection devices can be rigid or moveable. Generally a rigid device, e.g. in the form of a canopy, is only in the correct position (if at all necessary) if south-facing because the canopy prevents vertical radiation there from the sun at its zenith. At the same time, however, fixed sun-protection devices reduce the amount of daylight coming into areas further back inside. East and west-facing windows need moveable devices. No sun protection is needed for north façades (but it is for north-east and north-west orientations in summer to prevent indoor areas heating up in the early mornings and late afternoons). Moveable devices can be controlled automatically or manually. They should be automatically controllable for east façades because the sensors there have to respond as early as shortly after sunrise (at approx. five o'clock). Solar control glass is not to be recommended in school buildings; glass with high light transmission, moderate, non-heat-gain-optimised g value (total energy transmission level) of the glazing and externally located sun protection is preferable. The sun-protection effect is indicated by the "total solar energy transmittance"; it must be verified for the sun-protection device together with the glazing by a test certificate from an accredited testing institution.

Glass atria or foyers with glass roofs require the involvement of building physics experts to be properly designed and constructed. In summer horizontal glass roofs receive the strongest radiation of all building components. This can be as much as 1,000 W/m^2 at midday in extreme cases. Sun-shading in the form of exterior awnings or similar are indispensable here. However, the awnings must not obstruct the roof openings for ventilation or smoke extraction. External sun-protection devices must be protected against damage from snow or freezing water in winter. The same applies to photovoltaic elements installed in the roof. On the reverse side the photovoltaic elements emit relatively strong heat flows towards the inside. This is often underestimated; these have the unwelcome effect of additional powerful radiating ceiling heaters in the summer if they are not put up at a distance and back-ventilated with air from outside.

Heat-retaining components in building interiors (solid walls and ceilings) absorb indoor heat in summer. The indoor components are important; the retaining effect of the remaining sections of external walls (near the large areas of glass) is negligible. It is possible to prevent solar radiation coming in from outside in summer by having indoor components of the right dimensions. If they are intended to serve to retain heat, the surfaces of solid indoor components should not be covered with heat-insulating coatings because otherwise the radiated energy cannot be absorbed. Carpets or hanging rugs reduce the retaining capacity of a concrete slab for example. Using what are known as phase change materials (PCMs) can help to prevent classrooms overheating during the day. Depending on the set transition point (e.g. 25 °C), these materials which resemble wax are melted, and the heat which is absorbed without the temperature of the materials rising further can be "discharged" during the night through ventilation.

The heat retained in the indoor components during the day has to be removed from the interior again through increased **night ventilation**. If this does not take place, the indoor temperature keeps "swinging" higher day by day in summer. Fortunately, in our climate the external air temperature at night is usually low even in summer (this is often not the case in inner city locations) and it is possible to cool indoor areas by ventilating them at night. However, large openings which are designed to be secure against the weather and intruders or can be monitored by the caretaker must be in place to ensure school indoor areas are aired at night. Alternatively, ventilating indoor areas early in the mornings in summer when high outdoor temperatures are expected can certainly be effective and possibly easier to organise.

Evidently, protecting school indoor areas from overheating in summer can be achieved through a raft of measures; not all of these must be adopted at once in individual cases, rather, they should be selected singly or in combination as appropriate. Among others DIN 4108 (Part 2) gives guidance on this (due to the high internal load resulting from the large number of people in classrooms it is not expected that the maximum temperatures given in DIN 4108 (Part 2), including the short exceedance time, will be adhered to).

How high can the indoor air temperature in indoor areas in schools be in summer?

Permissible indoor air temperatures in schools and offices in summer cause regular discussions between building operators and those affected. However, according to the Workplace Ordinance there is a recommendation (not a mandatory regulation) that the indoor air temperature in the workplace should not exceed 26 °C. Yet the general building physics principle that in our latitudes it may be hotter for short periods during the day in summer applies. It is possible to adhere to this building physics principle in almost every case if the influencing factors referred to in this section (C-2.2) are consistently born in mind throughout the design phase. Strictly maintaining the recommended 26 °C would require the use of air-conditioning systems in schools.

C-2.3 Ventilation technology

Free ventilation:

This is window ventilation, also called “free” or “natural” ventilation whereby no ventilation systems or other ventilation equipment is used.

In schools the preference for using free ventilation often represents a compromise between cost and success. Classrooms cannot be ventilated by windows throughout the year in such a way that the desired limits of thermal comfort and air quality can be maintained at all times (cf. Section C-2.1). Particularly in winter it can happen that those sitting near the windows complain of feeling cold when the windows are opened for a long time to ventilate the room. On the other hand, adhering to the hygiene requirements in terms of carbon dioxide must be ensured if possible during and at the end of lessons (cf. Section B-1). For this reason it is essential that, even in the winter, classrooms are consistently ventilated during break times, as well as during long lessons or if the classes are very full.

Rooflights and pivot-hung windows should stay open at night during periods of warm weather (provided they are secured against break-in), so that the indoor areas can cool off more effectively.How can the way in which users ventilate schools help to improve air quality?

How can the way in which users ventilate schools help to improve air quality?

- Ventilating regularly, ideally using cross ventilation.
- Ventilating regularly, ideally using cross ventilation.
- Avoiding allowing indoor areas to get too hot or too cold.

Mechanical ventilation:

Mechanical ventilation (ventilation system) offers the advantage of maintaining a certain minimum number of changes of air independent of the building users. Moreover, mechanical ventilation has the added energy-related advantage that it can be connected to a heat recovery system. The air circulated to the indoor areas should consist of 100 % fresh air without any added “recirculated air” (“recirculated air” refers to air extracted from one area, which has been filtered and then recirculated back to the indoor areas). Correct design and construction and operation and maintenance require application of the relevant standards and guidelines, in particular DIN EN 13779 and VDI 6022.

Mechanical ventilation can help towards cooling the building with intensive ventilation at night during the summer months (cf. notes on night ventilation in Section C-2.2).

C-2.4 Acoustic requirements

Even in the best schools teachers cannot teach if the intelligibility of their speech suffers on account of poor acoustics in the building. Not only is it important to prevent the effects of noise from outside. Equally important are the design and construction requirements in and on buildings to improve the acoustics inside.

The acoustic design of schools and teaching rooms aims to create optimum conditions for promoting rather than compromising the health and achievement of pupils. This applies to the use and usability of teaching rooms, depending on the relevant environment (school buildings, surrounding area), but independent of pedagogic planning and the individual requirements of the children. A further, fundamental aspect of the sustainable acoustic design of teaching rooms is seeing acoustics as an integral, indispensable part of building design.

Area of application:

Acoustic design affects the acoustic properties of the entire school building, including the building itself and the indoor areas, that is:

- general teaching rooms,
- specialist teaching rooms (music, sport etc.),
- social areas, including
- corridors and stairways.

Only by considering these holistically (see Figure 1), is it possible to achieve optimum working and learning conditions. The building acoustics properties include the sound insulation of walls (external and internal), ceilings, roofs, doors and windows against noise (e. g. traffic noise outside and voices, music etc. inside), of floors against impact sound (e. g. people walking, including chair movement etc.) and against noise from building services equipment and installations.

The properties of the acoustics in indoor areas include mutual speech intelligibility and the way the area helps to amplify or muffle the sounds, in particular of speech.

The laws of physics result in varying degrees of interaction between structural and acoustic properties in buildings. Thus the resulting sound insulation between adjacent areas depends on both the sound reduction of the wall components and the sound proofing in the rooms themselves.

Acoustic parameters and values:
A) Sound insulation

Building acoustics values and their respective limit values are set out together in Tables 9-11.

Table 9: Required minimum sound reduction (weighted sound reduction index Rw) of components between indoor areas in school buildings according to DIN 4109

Component part	between teaching rooms and..	Min. sound reduction index Rw [dB]
Walls	Teaching rooms	47
Walls	Specialist teaching rooms (music, sport, workshops etc.)	55
Walls	Corridors	47
Walls	Stairways	52
Doors	Corridors	32

Table 10: Maximum impact sound pressure level (weighted normalised impact sound pressure level Ln w) in indoor areas in school buildings, according to DIN 4109

Component part	between teaching rooms and..	Max. normalised impact sound pressure level L'n,w [dB]
Walls	Teaching rooms	46
Walls	Specialist teaching rooms (music, sport, workshops etc.)	46
Ceilings under corridors		53

Table 11: Maximum noise level (characteristic sound pressure level LA f) in teaching rooms caused by building services systems, installations and various systems in school buildings with reference to DIN 4109	
The effect of noise in …	**Max. Sound pressure level (sum level) LA, f [dB(A)]**
Teaching rooms	30
Specialist teaching rooms (music, sport, workshops etc.)	35

The values in Table 11 only apply during the day, i.e. during school hours. It is essential that strange noises, e.g. isolated or recurring volume peaks or volume fluctuations and isolated, pronounced sounds be avoided.

With reference to sound insulation against outside noise, the requirements of DIN 4109 apply to the external components of school buildings. In particular, noises resulting from traffic or other sources, which have recurring volume peaks or volume fluctuations and isolated, pronounced sounds must be taken into account.

B) Indoor acoustics

Traditionally, the best known parameter for describing the acoustic properties of indoor areas is reverberation time. The values which must be adhered to are given according to area and apply to the areas when unoccupied. They are summarised in Table 12. The values apply to the usual audio frequency range, i.e. to the octave bands from 63 Hz to approx. 8 KHz (mid-frequencies).

Table 12: Obligatory reverberation time values, including tolerance, in indoor areas in school buildings	
Area type	**Reverberation time T in s**
Teaching rooms (with a volume below 300 m³)	recommended 0.5 ± 0.05 s
Teaching rooms, sports halls, gyms and swimming pools (dependent on volume)	according to DIN 18041 “Audibility in small to medium sized rooms”

A high level of speech intelligibility is important in schools. The reverberation times given in Table 12 therefore differ slightly from those in DIN 18041. Noise-absorbent ceilings should not be used alone to reduce reverberation time. The rear wall area beneath the ceiling is also suitable.

A high level of speech intelligibility is important in schools. The reverberation times given in Table 12 therefore differ slightly from those in DIN 18041. Noise-absorbent ceilings should not be used alone to reduce reverberation time. The rear wall area beneath the ceiling is also suitable.

In larger sports halls and areas used for similar activities, a correctly determined reverberation time which takes account of the often varied uses of the hall should be maintained in any event. It is recommended that special consideration and treatment be given to the indoor acoustics in specialist event and music areas, e.g. school halls.

Recommendations for additional indoor areas in school buildings can be found in Table 13. They do not target good speech intelligibility so much as attenuation of very loud noises which occur there from time to time.

Tabelle 13: Recommended reverberation time values, including tolerance, in indoor areas of school buildings (cf. Figures 2 and 3)

Raumart	Nachhallzeit T in s
Corridors, stairways	$T = V/1000\ m^3 + 0.8$

In the equation the V is the volume for connecting areas, e.g. those separated by doors, in m^3. The calculated values should be consulted for areas measuring approx. $100 m^3$ to $800\,m^3$. Reference values for small or larger volumes are shown in Figure 2.

Besides the reverberation time, the ambient noise level also determines the acoustic properties in indoor areas. The ambient noises produced outside the relevant area at least are addressed through the properties in paragraph “A” (sound insulation).

General advice on practical acoustic design:

Acoustic quality as described in this guide is important for both existing and new school buildings. With proper planning all the parameters referred to can easily be implemented, using commercially available components. This is also true in the context of the remaining structural and building physics requirements for school buildings.

In standards, guidelines/directives and other literature, there is a wealth and variety of building design options for all aspects of sound insulation (e. g. DIN 4109) and for configuring indoor acoustic conditions (e. g. DIN 18041). In many cases, especially for new buildings or larger refurbishments or extensions, an acoustics expert should be consulted if possible.

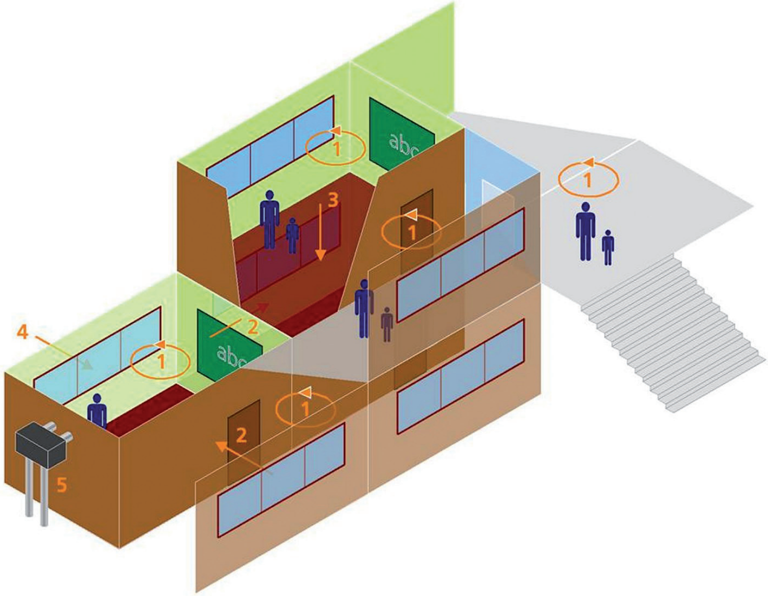


Figure 2: Indoor acoustic (1 – reverberation time) and building acoustic (2 – sound insulation of walls etc., 3 – impact sound insulation of ceilings and floors, 4 – sound insulation of external building components 5 – noise from building services installations) influences on the quality of school buildings

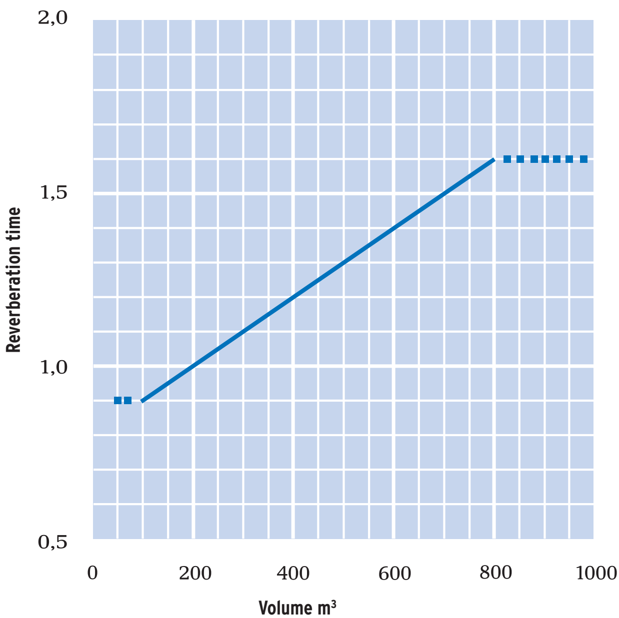


Figure 3: Recommended reverberation-time values as a function of the volume for corridors and stairways in school buildings.

PART D: Procedures in problem cases

D-1 Basic procedures

In this section examples of problem cases (case studies) are presented. Awareness of problems inside schools, nursery schools and day nurseries will generally be related to the cause, in most cases because of symptoms of illness or a particular occurrence. However, specific enquiries because of media reports or routine checks and precautionary investigations can also be the catalyst.

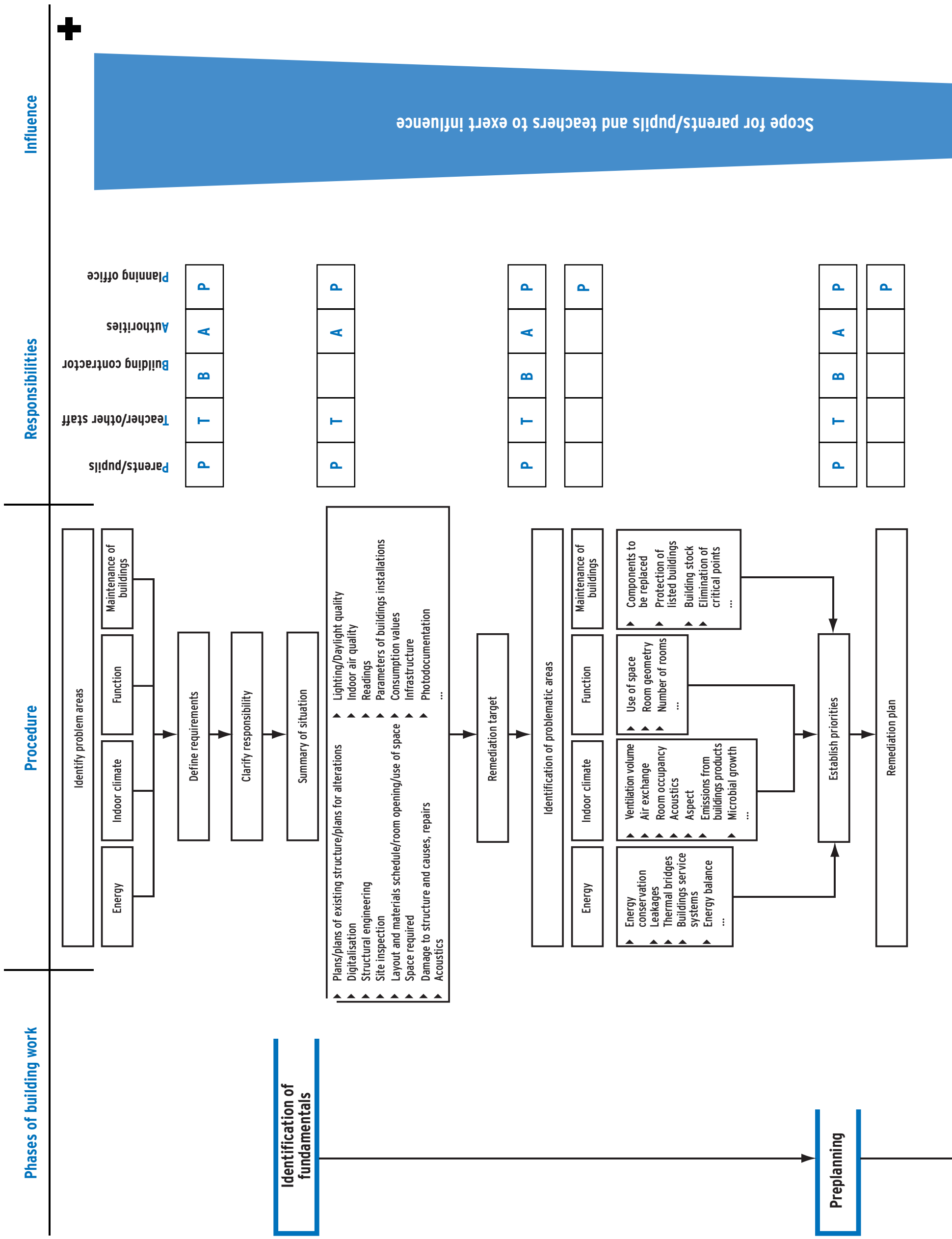
In most cases public health service institutions, i.e. the health and environment agencies, the industrial health service or the appropriate accident insurers are involved as the primary contacts of the institutions' controlling authorities. In these cases a structured procedure should be expected, generally resulting in a rational and efficient solution to the problem, which, in the context of risk communication, should lead to acceptance by those affected.

The situation often becomes more difficult if a need for serious action is established from inappropriate measurements and exaggerated evaluations, and extensive unnecessary follow-up investigations and recommendations for remediation ensue.

The following case studies are set out as a structured procedure and deal with the cause (e.g. health problems), a summary of the situation (Site inspection, questions asked, building construction, files), further action through investigations (readings, enquiries), evaluation of the results, the consequent recommended action and measures, and the outcome achieved (continued use, acceptance).

The following action plan, which clarifies the individual stages, can be seen as a suggested procedure in problem cases. It does however depend on bringing in expert competence from the health authorities at an early stage and involving those responsible (school authority, building authority, industrial health, accident insurers, etc.) and those affected (e.g. parents, users) equally through transparency of the process; moreover, all participants should understand and accept the steps chosen and decisions taken. This also includes taking the complaints and health problems seriously, making information available at all times, involving those affected in the decision-making process, and committing outside agents (measuring institutes, renovation companies, tradesmen, etc.) to quality assurance (e.g. minimum measuring requirements), as well as carrying out a final check and inspection (assessment of success), if possible with all participants.

Diagram 4: Flow chart: procedures in cases of illness, see double page following.




Energy
Indoor climate
Function
Maintenance of buildings
Energy concept
Room temperatures-conservation
Heating times
Cooling / warming needs
Air quality
Needed air exchange
Reducing sunlight influence
Room use
Room allocation
Rearrangement
Conservation
Thermic building structure
Air tightness
Heating construction
Hydraulic system
Controller
Heating system
Minimum of window apertures
Manual, hybrid ventilation
Heat protection
Day light ilumination
...
Management utilities
Room division
Acustics
...
Tested with Function and energy
...
Plan of design
Options for renovation/reconstruction
P T B A P
Analysis of options
P
Observation of comfort conditions
Examination of cost-effectiveness
Simplicity
Contemplation of the Building Energy Conservation Ordinance
...
Authorization of plan
Final decision
P T B
Examination of permit-obligations
B P
Contract
Invitation for tender
B
Direction design
Detailed plan
P
Construction time plan
Usage period of school
...
Transference of teaching establishment
Observation
Implementation
P
Supervision
Optimization of running conditions
P T B A P

D-2 Case studies

D-2.1 Mineral fibres from suspended ceiling construction

Cause/authority contacted: Health agency notified by school authority because of teachers' health problems.

Situation: Teachers complaining of eye and throat irritations and itchy skin.

Site inspection: Suspended construction slatted ceiling in the staffroom. For noise control, mineral wool mats have been laid on the slats without a filter layer. The ventilation system blows incoming air directly into the suspended ceiling above the level of the slats and insulation mats. There are considerable dust deposits on the cupboards.

Investigations: An examination of fibres (in accordance with VDI 3492) revealed a combination of mineral fibres with a KI of < 30 and a classification in the category K2. Indoor air measurements produced a respirable inorganic fibre (WHO fibre) content of 7000 / m^3.

Evaluation: The construction is evaluated as inadequate and unacceptable (no filter layer, incoming air blowing through it). The emission of fibres is significantly raised (to more than 1000 fibres per m^3), since the technical construction does not meet with up-to-date technical standards.

Recommendations: Remove the mats, observing health and safety at work conditions, and replace with a problem-free material with a filter layer. Alter the air supply into the room by putting in vents at the level of the slats or by turning off the ventilation system. Wash surfaces in the rooms regularly. Use vacuum cleaners with particulate matter filters (HEPA filters).

Action and outcome: Risk communication with school management team and staff, explanation of the toxicological evaluation of synthetic mineral fibres. Clear reading after completion of remediation (< 500 F/ m^3). No problems since.

D-2.2 Chloronaphthalene in prefabricated school buildings

Cause/contact with authorities: Request from the school authority (local authority) to the health agency owing to unpleasant odours, presumably because of a mould attack following flood damage in a school complex.

Situation: This concerns a 1970s school complex of prefabricated construction. Water damage occurred in the rooms as a result of leaking flat roofs. Unpleasant odours had been evident for some time, which were attributed to the flooding. Mould readings had already been taken by the local hygiene institute, showing a raised germ count in the indoor air. No explanation for the unpleasant odours. Schoolchildren complained of stinging eyes, burning skin, sore throats and headaches. The parents reported a smell "clinging" to the children's clothes ("stale school").

Investigations: Analyses of the indoor air produced an unremarkable sample of the usual VOCs, but with the unusual addition of chloronaphthalenes (CNs) at levels up to 50 $\mu g/m^3$. Further readings revealed a significant dependence on temperature and a concentration range of 1–5 $\mu g/m^3$ for naphthalene and between 2 and 50 $\mu g/m^3$ for mono- and dichloronaphthalene. A "musty" odour was recorded by the people taking samples. Examination of the material samples identified the source of the CNs as type V 100 G waterproof particle board. Further enquiries to the manufacturer revealed the use of the wood preservative Basileum SP-70, which contains chloronaphthalene, on the reverse side of the boards.

Evaluation: The evaluation was carried out using a provisionally derived guideline value (intervention value) of 200 $\mu g/m^3$ and an environmental hygiene target value of 20 $\mu g/m^3$ because of the unpleasant odour and the credible effects observed on health.

Recommendations: From an indoor hygiene point of view, because of the water damage and detection of the localised mould attack, and because of the amounts of chloronaphthalene, a comprehensive remediation (removal of the V 100 G boards, roof renovation) or rebuilding was recommended.

Action: Local council, staff and parents were informed of the facts in public briefing meetings held jointly by the health agency and the specialist agencies.

Outcome: The local authority decided to demolish the school, because of its age (intended for 20 years' use when erected) and the high cost of renovation, and erected a new building in solid construction.

D-2.3 Odour pollution in classrooms after the long holidays

Reason/contact with authorities: Health agency contacted by the school authority on account of an unusual “chemical smell” in eight classrooms at a primary and secondary school.

Situation: This concerns rooms in the old part of a primary and secondary school, which according to the senior management is 100 years old and has never been affected by health problems or bad odours until now. Two years ago the old box-type windows were replaced with modern plastic windows. At the beginning of the summer holidays the cleaning staff polished the woodblock floor – as usual – with a liquid wax. From the safety data sheet it can be seen that the product contains naphtha (petroleum, low aromatic content).

Site inspection: Old building in very good state of repair, with old, well maintained woodblock floor. Strong odour of “floor polish”.

Investigations: Indoor air readings using active sample-taking (NIOSH tubes) over four hours, after doors and windows were kept closed overnight. Result: very high solvent concentrations in all eight rooms with TVOC contents between 10 and 23mg/ m^3. The guideline value RW II was exceeded for the alkane and aromatic group of substances and for naphthalene. The profile of the indoor air matched the composition of the floor wax, to which the intensive odour of alkyl aromatics was traced back. As constituents of the solvent these have a lower odour threshold than the alkanes.

Evaluation: According to the recommendations of the IRK/AOLG ad hoc working group (cf. Section B-2) the pollution should be classified as “category 5”: TVOC values between > 10 and 25mg/ m^3 are classified as hygienically unacceptable. Using the room should generally be avoided, although spending a short time in it each day (less than 1 hour per day) is reasonable if more intensive regular ventilation measures are carried out. At values > 25mg/ m^3 the room should not be used at all. Values exceeding RW II demand an immediate inspection, e.g. regarding measures and decisions to reduce exposure. The follow-up reading to check the indoor air quality takes place under normal use.

The use of the floor polish at the beginning of the holidays was established as the cause of the unpleasant odour. This continued to have an effect over a fairly long period, as there was no active ventilation in the holidays after the polishing took place. As a result of installing tightly closing windows the natural air exchange was no longer sufficient to remove the solvent odour from the air inside, as it had been in previous years.

Recommendations: Since there was no alternative, it was recommended that the rooms be used on condition that particularly intensive ventilation measures were implemented until the outcome of the control readings.

Action and outcome: Follow-up readings were immediately arranged under normal conditions of use. The results showed TVOC concentrations between 0.06 and 0.4 mg/m^3. The naphthalene contamination of the indoor air was between 3 and 10 $\mu g/m^3$ and thus in the range between RW I and RW II. The comparative TVOC readings under standardised conditions (without airing beforehand and windows closed overnight) showed a significant drop (previously 23, now 1.5 mg/m^3).

The results were set out in a risk communication to senior management and staff, parents' representatives, education authority and planning department and continued use assessed as tolerable with strict adherence to ventilation measures. Follow-up inspections in four weeks were arranged, and it was recommended that in future a floor wax without aromatic content should be used, ensuring adequate airing after the floor is polished. The manufacturer was contacted with the recommendation to include advice on increased ventilation after use in the instructions and to check the combination of solvents used in the formulation, since, contrary to the information given, a product containing aromatics had presumably been used.

Two months after the incident the manufacturer replied that a different solvent had been used in the formulation from the one he had specified. The faulty batch was taken off the market.

D-2.4 Persistent indoor air pollution resulting from the use of solvent-based cleaner on woodblock floors

Cause/contact with authorities: Telephone call from the headteacher 10 weeks after thorough cleaning on account of a turpentine-like odour.

Site inspection: Two-storey extension (built in 2000) at a primary and secondary school, containing four classrooms, a group room and a computer room. Floor consisting of unsealed wooden boards (robust, can be sanded repeatedly).

Facts: Thorough cleaning during 2003 summer holidays with C4, a solvent for – according to the manufacturer – "effortless removal of old layers of wax, oil, fat and grease", then hard gloss wax. Same treatment in all rooms except computer room, especially strong odour in one classroom on the ground floor.

Investigations: Initial measurement of VOC content in the classroom, taking through around 600 litres of air. Sample already "overloaded", no analysis possible. The follow-up VOC reading showed between 7 and 40 mg/m^3 for the total VOCs. Analysis of the cleaner C4 showed a corresponding spectrum of VOCs. Comparative readings in the old building produced nothing unusual. In the following years repeated readings in all affected rooms under controlled conditions and in normal use (up to 17 readings in one classroom).

Use of the rooms was subject to a strict ventilation regime, which was followed relatively well.

Outcome: The profile of the analyses remained similar throughout and only fell very slowly (alkanes, terpenes). Under normal conditions of use the values were always significantly lower. Over the whole investigation period there were no complaints about adverse effects on health. The classroom which was initially most contaminated also retained a noticeable solvent smell for the longest time. The last readings in February 2006 were in the order of less than 1 mg/m^3.

Action: Despite the claim "For use on solvent-proof flooring, e.g. unsealed wood floors" it is recommended that this product should not be used on wood floors, especially where there are cracks and easily accessible cut surfaces. Corresponding advice to the manufacturer to change the claim accordingly has received no response to date.

Recommendation: To the school: Continue with thorough airing. Use a specialist floor oil analysed in a laboratory beforehand, applied sparingly to the surface. To the cleaning staff in the building: C4 cleaner should no longer be used in the area concerned.

D-2.5 Indoor air contamination with dibasic dimethyl esters (DBE)

Cause/contact with authorities: Health office informed by the school authority after abnormal indoor air contamination established by a contracted laboratory. When doing this, the laboratory referred to the recommendation expressed by the IRK/AOLG ad hoc working group in the instructions for evaluating indoor air pollutants to call in the appropriate regional authority in cases of raised values. The readings were taken because of complaints of health problems among children and teachers.

Site inspection: Primary school in good state of repair with carpeted floors in the classrooms. Unpleasant "sweet" smell in a section of the building renovated six months earlier. There were no indications of this in the other parts of the building that had been upgraded previously.

Facts: In the second half of 2007 this part of the building was renovated following the same pattern as other sections the year before and new carpeting was laid. In the invitation for tenders the architect expressly specified the use of environmentally friendly products. After the renovation there were immediate complaints about bad odours and adverse effects on health (irritation of the respiratory tracts). At first the odour was considered to be related to the renovation, and owing to the choice of materials and the information on the safety data sheets it was assessed as harmless to health. After the complaints had persisted for six months an environmental laboratory was finally commissioned to take indoor air readings.

Results of the investigations: In the rooms concerned, except for significantly raised concentrations of dibasic dimethyl esters (sum $\sim$ 1500 µg/m^3), an otherwise normal VOC profile (other VOCs approx. 300–400 µg/m^3) was found.

Outcome: The profile of the analyses was similar (C4-C6 dibasic dimethyl esters between 600–1600 µg/m^3) in the rooms that were renovated six months earlier. In normal use with intensive ventilation the values were lower (under 100 µg/m^3).

Action: In a provisional evaluation the regional authority responsible derived a provisional guideline value (intervention value of 500 µg/m^3 and a target value of 50 µg/m^3 for the sum of the C4-C6 dibasic dimethyl esters (CAS 95481-62-2). Because of the excess values and the adverse effects on health reported all suspected rooms were immediately taken out of use. Further readings were arranged to clarify the extent of the contamination and to establish the source/cause, including by core samples and tests on materials. The parents received a letter informing them of the situation and a questionnaire was distributed to find out about adverse health effects among children in the rooms concerned and in uncontaminated rooms (control group). Within a week 230 out of 350 questionnaires were returned and analysed. These showed a higher prevalence of nasal irritations, sore throats and hoarseness, coughs and shortage of breath, and headaches among the children in the contaminated rooms compared with the control rooms. The increased and unusual disorders among the children who had been exposed could plausibly be attributed to the toxicity of the dibasic esters. The results of the investigations and the survey were explained at a public meeting at the school, where parents reported an immediate improvement in the symptoms. A second survey followed three weeks later. By this time, having vacated the rooms, the children's disorders had subsided and were at the same level as the control group.

Recommendation: Rooms not to be used until the cause of the contamination was identified and eliminated. As this was the first time that DBEs had been shown to contaminate indoor air, a corresponding report was submitted to the Federal Institute for Risk Assessment in accordance with Article 16 ChemG. The case was subsequently examined further with the participation of the construction company and the manufacturer of the building materials used. They were able to pinpoint the cause as the use of a polyurethane levelling compound with a high DBE content in the floor construction. After these experiences the use of dibasic esters in indoor environments must be regarded as critical.

The example shows that in cases of unusual indoor contamination with "new" substances and of the existence of adverse effects on health the appropriate professional institutions should be informed immediately, and that – despite the instruction to use environmentally friendly products – abnormal indoor air pollution, in this case even detrimental to health, can occur time and again.

D 2.6 Health problems in a new wing of a primary school

Cause: Two years after building a new school wing with a total of 4 classrooms and 2 multipurpose rooms obvious symptoms first appeared in pupils and staff at the end of September/beginning of October. Parents reported that 10 children were suffering from severe to very severe symptoms and that 9 out of 10 of the children were good to very good pupils. The following complaints were reported: severe headaches (6 children), stomach ache and nausea (7 children), peribronchitis (1 child), skin rashes or unexplained allergies (2 children), red and stinging eyes (3 children). The skin reactions extended to the legs and occasionally also to the face and neck. Some of the children had a large number of absences. One child was examined by doctors for a tumour because of extreme headaches – with negative results. It was noticeable that the symptoms first arose when the heating was on and that 4 of the 10 children sat directly next to the heaters. It was also striking that symptoms such as reddening of the eyes had always begun in school and subsided in the afternoon. The children were all receiving medical treatment, and no cause could be identified. The doctors ruled out organic causes. The teachers complained of headaches and sore throats.

Action: After the first complaints had been lodged with the town council an industrial health institution was commissioned to carry out air measurements (passive collectors). Nothing unusual was found. However, in 6 air readings altogether only toluene, xylenes and ethyl benzenes were analysed. Based on the values measured the director of the district health office gave the all-clear.

Course of events: The health problems continued to increase during the following three years. In particular, more and more children in the “new classrooms” in this wing were suffering symptoms. Eventually the parents of 16 children refused to allow their children to have any further lessons in the new building. At that time five teachers in all were keeping a written record of the appearance of the symptoms, especially headaches, but also difficulties in swallowing, throat irritations, and reddening of the skin. The classes were moved to other rooms in the old building; teachers’ and pupils’ symptoms disappeared completely.

Investigations: 3 1/2 years after the first indoor air readings were taken further investigations were commissioned. Firstly, after an inspection of the property in question, a VOC air measurement with activated carbon and silica gel collectors and a MVOC air measurement with activated carbon tubes were carried out (active sampling). These produced indications of microbial damage (evidence of the main indicators 1-octen-3-ol, 3-methylfuran and dimethyl disulphide). The VOC air measurement produced a very low total TVOC concentration of 230 $\mu g/m^3$, although at 24.2 $\mu g/m^3$ there was an abnormal concentration of 2-ethyl-1-hexanol, which was traced to the hydrolytic disintegration of the softener compound DEHP. The measurement with silica gel collection tubes revealed 109 $\mu g/m^3$ of 2.6-di-t-butyl cresol.

In all seven material samples of insulation material (polystyrene) and the dividing layers (foil and paper board) were taken out of the floors and analysed. In five of the seven samples a massive microbial infestation was detected: this was particularly severe in the insulating material, with 850,000 CFU/g of mould (aspergillus versicolor, penicillium spp., acremonium sp.) and 14,000,000 CFU/g of bacteria (actinomycetes and bacillus spp.). Emissions analyses of the flooring materials (PVC with adhesive and filler) revealed abnormal emissions of 2-ethyl-1-hexanol. When the floor was opened up it was discovered that there were high levels of damp in the floor under the insulation layer and that there was an obvious to strong musty odour from the floor.

The cause of the high moisture levels was established after lengthy investigations. In this case they were not caused by structural failings, but by the cleaning staff, who, in the course of washing the PVC floors each week always tipped large quantities of water onto them and liked to sweep it to the sides with “squeegees”. The water ran into the gaps at the edges.

Recommendation: The floors were renovated on account of the findings. After that the symptoms subsided. The MVOC concentrations in the indoor air were monitored over 12 months in all, and only reached background levels after about a year. As the symptoms had disappeared completely after the remediation, despite MVOC concentrations that were still raised at the start, this is a clear indication that the MVOCs did not directly cause the symptoms, but were simply an indicator of the microbial damage.

PART E: Remediation guidelines and procedures

In response to the contamination of buildings with hazardous substances which became apparent since the 1980s, the "pollutants" project group of the Bauministerkonferenz [building ministers' committee] (Arbeitgemeinschaft der für Städtebau, Bau- und Wohnungswesen zuständigen Minister der 16 *Länder* [Conference of the *Länder* Ministers and Senators responsible for urban development, construction and housing] – ARGEBAU) devised a set of guidelines. These were introduced as compulsory technical building regulations in the majority of the *Länder* and should therefore generally be observed during remediation work – in schools as elsewhere. In addition ARGEBAU published the PAK-Hinweise [Advice on PAHs] (June 2000), through the German Institute for Construction Engineering (DIBt), which can be consulted as non-binding recommendations for renovating woodblock floors laid with tar-based adhesives. The guidelines and recommendations referred to are set out in brief below.

E-1 Asbestos

In May 1989 the "Richtlinien für die Bewertung und Sanierung schwach gebundener Asbestprodukte in Gebäuden" (Asbest-Richtlinien) [Guidelines for the evaluation and remediation of loosely bound asbestos products in buildings (Asbestos Guidelines)] were published by the ARGEBAU project group. A revised edition was issued in January 1996 and subsequently introduced as technical building regulations by the construction authority in all *Länder*.

These guidelines include various evaluation figures, according to the type of asbestos product, the structural condition, the availability of the product, and the nature and frequency of the use of the space by the group of people concerned. The sum of the evaluation figures then shows whether remediation is required immediately, in the medium term or in the long term. In some cases an indoor air measurement may also be necessary. On completion of remediation work, to monitor its success, readings of the concentration of asbestos fibres in the indoor air should be carried out in accordance with the asbestos guidelines. After successful remediation the asbestos concentration should be below 500 fibres/ m^3 of air.

For most of the relevant school buildings, which were constructed in the 1960s and 1970s, this evaluation may be completed in the meantime using the asbestos guidelines and appropriate remediation measures carried out.

The principles of asbestos remediation are summarised in the following (in an extract quoted from the asbestos guidelines):

1. “Remediation measures must be planned as a closed concept from the beginning of the work to the disposal of the waste in accordance with the applicable regulations.
2. Only those firms should be commissioned who are familiar with the work, the hazards arising from it and the necessary protective measures and who have access to the necessary tools and equipment.
3. Protective measures are necessary at all times during the remediation.”

The planning departments are responsible for the remediation works, and appoint competent firms in accordance with Point 2. If the remediation has not yet been carried out, it is essential to ensure that fibres are not released into the indoor air through servicing, cleaning or maintenance work.

E-2 Polychlorinated biphenyls

After the problem of contamination of buildings with PCBs – mainly emitted by sealants containing PCBs, which were manufactured and used until the mid-1970s – came to light (cf. Section B-4), the “Richtlinie für die Bewertung und Sanierung PCB-belasteter Baustoffe und Bauteile in Gebäuden (PCB-Richtlinie)” [Guidelines for the evaluation and remediation of PCB contaminated materials and components in buildings (PCB guidelines)] were devised by the pollutants project group. These guidelines contain a health evaluation, list remediation procedures, evaluate their urgency and give advice on the up-to-date health and safety at work regulations as well as an overview of relevant laws and ordinances relating to the disposal of PCB contaminated products. In addition recommendations for determining the PCBs in the indoor air analytically are provided. The guidelines were published in the reports of the German Institute for Construction Engineering (DIBt No. 2, 1995, pp.50–59). They have been introduced as technical building regulations by the construction authority in most *Länder*, even if with considerable alterations in some cases, and as such should be regarded as binding in construction law.

It is a prerequisite for proper remediation that the measures are planned as a closed concept from the beginning of the work to the disposal of the waste, and that only those firms are commissioned who are familiar with the relevant problems and potential hazards and who have access to the necessary tools and equipment. The remediation work must be carried out with as little dust as possible. The first stage of a permanent remediation is generally the removal of the primary sources. In some cases separating off the area of the building contaminated with PCBs from unpolluted areas with solid structures (dividing walls, etc.) can also be a sensible temporary measure. If the indoor air concentration cannot be lowered to the target values specified in the guidelines immediately with these measures, the remediation of secondary sources is necessary as well. The secondary sources, often covering large areas (e.g. walls and ceilings), can be resurfaced, separated off or even removed.

After remediation the PCB concentration in the indoor air should not exceed 0.3 µg/m^3 of air in the middle of the year if possible. As the PCB concentration in indoor air is subject to seasonal variations in temperature, a single reading is not necessarily representative of the mid-year value. VDI Guidelines 4300 part 2 contains information on a suitable measuring strategy for determining PCBs in indoor air.

E-3 Pentachlorophenol

In 1996 the ARGEBAU pollutants project group devised guidelines for the evaluation and remediation of PCP-contaminated building materials and components in buildings (the PCP Guidelines). The Guidelines were published in the German Institute for Construction Engineering reports (DIBt No.2, 1997, pp.6–15). The PCP guidelines were also introduced by the construction authorities in most *Länder*.

The flow chart shown in the guidelines for determining the need for remediation envisages that it will first be established whether wood preservatives have been used in construction materials and components in the building in question, or whether other PCP sources should possibly be sought. If wood preservatives have been used, staged tests will be needed on the dust, the treated wood and the indoor air, in accordance with the aforementioned flow chart. The remediation decision should be deduced from these on the basis of the limit values stipulated. Possible remediation measures could be – if viable from a construction perspective – both the removal of the treated materials and measures such as resurfacing and lining or separating off the area with treated components. The applicable legal requirements for the disposal of materials containing PCPs are set out in the guidelines.

For precautionary health reasons an indoor air value of < 0.1 µg PCP/m^3 of indoor air should be the long-term goal to aim at when carrying out remediation work. The success of the renovation should be verified by determining the PCP content of the indoor air on the basis of the VDI Guidelines 4300 part 4 and 4301 part 2.

In wood preservatives PCP was usually present with the insecticide lindane in the proportion 10 parts PCP to 1 part lindane (cf. Section B-4). According to the evaluation of the former Federal Institute for Health Protection of Consumers and Veterinary Medicine (BgVV) adverse health effects can very probably be ruled out if an indoor air value of 1 µg lindane/ m^3 of air is maintained. Indoor air values of 1 µg lindane/ m^3 of air and above are only reached after using wood preservatives if the PCP pollution is also significantly above 1 µg/ m^3. The PCP related remediation then required also reduces the lindane concentration far enough.

E-4 Polycyclic aromatic hydrocarbons

In 2000 the ARGEBAU pollutants project group devised the "Hinweise für die Bewertung und Maßnahmen zur Verminderung der PAK-Belastung durch Parkettböden mit Teerklebstoffen in Gebäuden (PAKHinweise)" [Advice on evaluation and measures to reduce PAH contamination by woodblock flooring with tar-based adhesives in buildings (PAH Advice)]. This was published in DIBt report No. 4 (2000) pp.114–123.

The tar-based adhesives that were used to glue woodblock flooring, mainly in the 1950s but occasionally right up to the 1970s, came briefly to public attention in the 1990s, after raised PAH concentrations were discovered, for the most part in buildings formerly occupied by US forces in Germany. These were traced back to adhesives under dilapidated woodblock floors. As the semi-volatile PAHs are mainly taken up by dust, the project group reached the following evaluation: "In the case of PAH contamination by tar-based wood floor adhesives no risk threshold can be set, at which measures are urgently needed to meet planning legislation, over and above precautionary measures. However, the ad hoc working group considers the occurrence of certain BaP concentrations undesirable on hygiene grounds ..."

Benzo(a)pyrene (BaP) is regarded here as the lead substance for the group of polycyclic aromatic hydrocarbons.

The project group assumed that in general repairing the damaged wood floor by filling the defective joints and then sealing it is sufficient and complete removal of the flooring and stripping off or sealing off the tar-based adhesives is only necessary in severe cases. The project group came to the following conclusion for evaluating the success of the remediation:

1. In rooms used for long periods measures to reduce exposure should be introduced if house dust concentrations exceed 100mg BaP/kg of fresh dust.

2. In homes or other spaces where babies or small children regularly spend several hours a day over a fairly long period and where exposure to dust is to be expected from the type of use, e.g. in day nurseries or children's homes, measures to reduce exposure should be carried out if house dust concentrations exceed 10mg BaP/kg of fresh dust.

In some justified cases additional medical examinations were recommended. The PAH Advice also contains recommendations for health and safety at work and for disposal of waste containing PAHs.

Appendix 1:

(Specimen) school hygiene plan

In accordance with Article 36 para.1 of the Protection against Infections Act (IfSG) schools have a duty to set out internal procedures for the maintenance of infection hygiene in hygiene plans, in order to minimise risk of infection. The plans should be drawn up in the following stages:

- Analysis of the risks of infection
- Evaluation of the risks
- Risk minimisation
- Establishment of monitoring procedures
- Review of the hygiene plan
- Documentation and training.

The following specimen hygiene plan provides suggestions for devising a hygiene plan appropriate to the specific circumstances of the school concerned.

Cleaning plan

The cleaning plan should be appropriate to the specific circumstances (hard washable floor or carpeting) of the school concerned in accordance with the guidelines in DIN 77400 "Cleaning Services – School Buildings – Cleaning Requirements" for both the school buildings and the attached sports facilities (see also A-2 Cleaning Procedures).

The following areas should be taken into account:

- the entrance area
- the ground floor traffic areas and the stairs to the first floor
- the remaining corridors and staircases
- classrooms
- sanitary areas, including changing rooms

- staffrooms, school offices, administrative areas, offices and meetings rooms
- storerooms
- gymnasia
- school meals kitchens, home economics rooms and dining halls

Thorough cleaning and maintenance should be carried out in all areas of the school at least once a year. For routine cleaning and the annual intensive cleaning or maintenance only cleaning products which pose no health risk should be used. If several cleaning products are used, a check should be undertaken to make sure that the products do not react with one another and that mixing them does not produce substances hazardous to health.

"Cosy corners" in schools should be avoided if possible. If, however, these do exist, it must be ensured that they are cleaned thoroughly to an appropriate standard every week.

Ventilation plan

If the school has no mechanical ventilation, the classrooms should be aired, where possible with cross-ventilation, at least after every lesson (45 minutes) and at the beginning and end of the school day during term-time. The senior staff decides who airs the classroom after every lesson and how it is to be aired. In the lower school the teacher who is present should be responsible for this. In the upper school a pupil rota can be drawn up for this function.

As humans have no sensory organ for detecting the CO_2 content of the air, ventilation "traffic lights" can be a means of visualising the indoor air quality. "Ventilation behaviour training" can be carried out in this way.

Besides regular maintenance, existing indoor air-conditioning systems must be inspected in accordance with the technical regulations (VDI 6022 – Hygiene requirements for air-conditioning systems and appliances). A special inspection is needed for the system components which contain moisture in the form of water or condensing water, such as humidifiers or heat exchangers.

Noise reduction plan

In schools the noise from the vicinity (road, rail and air traffic, industrial activities), from poor room acoustics or from the pupils themselves can present a particular problem. The Workplaces Ordinance prescribes an average measurement of 55 dB(A) for work places with predominantly intellectual activity.

1. Noise from the surrounding area

Possible measures to reduce the effect of traffic noise from busy roads:

- Ventilation bursts instead of continuous ventilation to reduce the entry of noise from outside
- Installation of soundproof windows

2. Room acoustics

Speech intelligibility is influenced mainly by the reverberation time. The acoustic properties of a room are established and evaluated objectively by measuring this reverberation time. The reverberation time in a classroom should be in the region of 0.5 seconds. By installing noise-absorbent material in a room the reverberation time is reduced and the acoustics optimised.

Simple measures for improving room acoustics:

- Muffling contact of moveable furniture with the floor
- Fitting felt pads to chair and table legs
- Oiling squeaking drawers
- Installing noise-absorbent furnishings
- Putting up curtains at the windows
- Putting up wall hangings or cork tiles (e.g. pinboards)
- Installing panelling on walls from floor level up to about 1.5 metres (agreement from education department or public works department required)
- Checking ceiling panels and installing noise-absorbent ceiling and wall panels if necessary (agreement from education department or public works department required)
- Using quieter appliances (e.g. computer stations with quiet fans)

When constructing new school buildings, undertaking remediation or renovation or submitting complaints the new April 2004 edition of DIN 18041 “Acoustic quality in small to medium-sized rooms” should be referred to.

3. Organisational and educational recommendations

- Putting up rules for hearing and listening
- Covering the topic „Noise and the effects of noise” in class (materials for this are available free of charge from the Federal Centre for Health Education (BZgA))
- Using visual aids for noise reduction, e.g. Soundear or “noise traffic lights”
- Reducing class sizes
- Having short breaks in the middle of double lessons
- Conducting training in improved social behaviour
- Speaking slowly to improve speech intelligibility
- Ensuring eye contact between speaker and listener
- Introducing some physical exercises if concentration flags
- Voice training for teachers to protect vocal cords
- Stress management programmes for teachers

Water hygiene

In schools **showers** in sports facilities and swimming pools can pose a particular problem with regard to legionella contamination. To prevent legionella showers that are not used every day should be rinsed through by running the hot water daily for around 5 minutes (set the maximum temperature to at least 60oC). Limescale deposits should be removed from the shower heads at the required intervals. The health agency should be consulted about the necessity for regular bacteriological inspections for legionella.

If **drinking water** is used in the preparation of food or drinks, the water in the pipes should be run off first.

The water in **school swimming pools** should be treated in accordance with the guidelines in DIN 19643. It must be ensured that the water in swimming and bathing pools does not pose any health risk. The Protection against Infections Act (Article 37) provides the legal basis for this: “Water in swimming and bathing pools in commercial operations, public baths and in other not exclusively privately-used facilities must be such that there should be no concern that any harm to human health, especially from pathogens, could arise from using it".

In this regard particular attention should be paid to the proper disinfection of the pool water. The limit value for trihalogen methanes of 20 µg/l laid down in DIN 19643 must be complied with. It must be ensured that the staff responsible for the pool machinery receive regular further training in this field. With regard to this the recommendations of the Federal Environment Agency/the Bathing Water Commission (see Bundesgesundheitsbl – Gesundheitsforsch – Gesundheitsschutz 9, 2006) and other hygiene recommendations should be taken into account.

Verruca infections in swimming pools and gymnasia /sportshalls

Besides the generally widespread athlete's foot infections the occurrence of verrucas is sometimes observed in relation to the use of swimming pools and sports halls. Verrucas / warts and molluscum contagiosum (MC) are among the most common skin complaints caused by viruses. They can occur at any age, but warts, especially MC, are particularly common among children and adolescents.

Wart viruses are usually transmitted by direct or indirect contact. This can occur through physical contact, but also through shared use of towels, sandals etc. or through contact with flakes of skin on the floor. Properly disinfected pool water plays no part in transmission, as the pathogens are rendered inactive by the chlorine in the water. It is more likely that transmission arises through damp seating and floors round the pool and in the shower and changing room cubicles, if these have previously been used by a carrier of verrucas or athlete's foot. For this reason these surfaces are disinfected at least once a day at public baths.

Measures to prevent transmission (prophylaxis):

- Teachers, especially P.E. and swimming instructors and pre-school staff should be informed about transmission routes.
- Parents should also be informed and should explain the relevant measures to their children. The soles of children's feet and between their toes should be inspected frequently.
- Before swimming one should wash thoroughly from head to toe, so that the chlorine in the water does not lose its disinfectant effect because of organic substances (sweat, oils).

- Sandals should be worn in indoor pools and changing rooms.
- Shared use of towels, lotions etc. by several people should be avoided.
- One should not walk about barefoot in communal facilities with athlete's foot or verrucas that have not cleared up.
- The doctor administering treatment should decide on participation in swimming or P.E. lessons, if this involves physical contact (possibly with a written certificate).
- Operators of swimming pools, saunas and sports facilities should carry out or arrange for the cleaning of passageways, showers and changing rooms, as well as other areas used with bare feet, every day, or where necessary, several times daily.
- At the end of the working day all surfaces used with bare feet in swimming pools, saunas and sports facilities should be cleaned using a disinfectant tested for its virucidal efficacy. The product should be applied with the scrub and wipe procedure. Spraying alone is not sufficient, as skin flakes are not effectively removed by this.

Kitchens

Home economics kitchens and school meals kitchens should be treated in the same way with regard to the hygiene requirements to be met in them. People suffering from an infection as defined by Article 42 of the Protection against Infections Act (IfSG) or from infected cuts or skin complaints, from which there is a risk of pathogens being transmitted via food, may not be employed in the kitchen. In accordance with Article 43 of the Act the kitchen staff should be advised of the working restrictions once a year.

The kitchen staff should receive annual training in food hygiene.

Hand disinfection by those working in kitchens is required in the following cases:

- when starting work
- after breaks
- after each visit to the lavatory
- after dirty jobs
- after working with critical raw goods (e.g. raw meat, poultry)
- after coughing or sneezing into one's hand, every time after using a handkerchief.

Only preparations that have been tested and proven effective may be used. In the case of hand disinfectant products these should be chosen from the disinfectants list issued by the Deutsche Gesellschaft für Hygiene und Mikrobiologie [German association for hygiene and microbiology].

Wall dispensers should be provided at washbasins for washing and disinfecting hands in the kitchen area. The contents of soap and disinfectant dispensers should be checked weekly. Before refilling the dispensers should be cleaned out. Liquid soaps and disinfectants should be kept in their original containers.

The procedure should be described:

For example: both sides of the hands to be covered, together with wrists, between the fingers, fingertips, cuticles and thumbs and left for 30 seconds for the disinfectant to work. 3 to 5ml of disinfectant (a cupped hand full) is needed.

The **floors** in the kitchen area should be cleaned daily. Protective clothing should be provided for particular tasks (e.g. cleaning floors). This protective clothing should be changed daily, or as necessary.

Surface disinfection is necessary:

- when working with critical raw goods (e.g. raw meat, poultry)
- after finishing work on surfaces where animal products have been prepared.

The disinfectant is applied to the surface concerned and spread vigorously with a cloth or sponge (scrub and wipe disinfection). The disinfectant must be left to take effect before the surface is used again. Surfaces that come into contact with food should be rinsed with clean water afterwards.

To prevent deterioration in food quality through pest infestations foodstuffs should be packaged correctly (e.g. wrapped up or in bins) and the packages labelled with the date opened / date processed and the contents.

The following in-house food inspections should be carried out:

- goods inspection on arrival for packaging, best before dates, various types of damage to goods
- daily temperature checks on refrigerators and freezers (refrigerator < 8 °C, ***freezer < -18 °C)
- weekly check on best before dates on foods
- in the case of foods prepared on site, samples should be stored in freezers for 96 hours, separated according to ingredients.

Animal pests (parasites)

In schools animal pests can both attack humans in the form of parasites such as lice, or occur as pests in classrooms.

Outbreaks of head lice in children are a recurrent problem in schools. Controlling outbreaks of head lice requires close cooperation between parents, school and health agency. Every case of lice must be reported by name in writing (by letter, fax or e-mail) to the health agency, in accordance with Article 34 of the Protection against Infections Act (IfSG). A precise plan of action should be put in place for the procedure in the event of the occurrence of lice.

Example:

- If a child is found to have head lice, he/she should (after consultation with the parents) be sent home as soon as possible, to commence treatment. if that is not possible, e.g. because the parents cannot be contacted, the child can remain in the building until the end of his/her usual session. Close contact during the following hours should be avoided via discreet measures.
- With the agreement of the relevant health agency the school informs the pupils' parents or guardians of the outbreak of lice. In doing so any discrimination against the children affected should be avoided.
- The parents are asked to examine their children carefully, and in the case of infection to carry out treatment as directed by a doctor. At the same time examination and if necessary treatment of all contacts (families, friends etc.) should take place.

- If treatment of the head lice infection is undertaken immediately and according to the enclosed directions using a product recommended by the Robert Koch Institute (doctor's prescription advisable, also regarding insurance claims), the affected children can, depending on the infection, *return to school straight away on the day after the initial treatment*, if the parents confirm the correct implementation of this measure by written reply or a doctor can rule out the further spread of head lice with a high degree of certainty. The reply should reach the form teacher promptly, within three days at the latest. It is essential that the parents should be made aware that a *second treatment is necessary within 8-10 days.*

- If no reply is received within this period, the establishment should where possible attempt to contact the parents of the children affected (e.g. by telephone). If necessary they should be asked to attend another examination. If individual parents are not willing to cooperate despite the information received, a legal basis for further steps (meeting with parents, examination to establish fitness for school) is available in the education act.

- The Protection against Infections Act lays down that the child should be readmitted to school as soon as "in the opinion of a doctor" there is no longer any risk of a further spread of lice. The Act does not demand a written certificate. In practice it can be assumed that the doctor informs the patient at the start of treatment when there will no longer be any risk of contagion. A doctor's certificate should be presented if the same child is re-infected with head lice within four weeks.

- In the case of frequent occurrences of head lice in one school advice to parents and checks on replies in particular should be stepped up. This applies both to replies from the affected children and to replies from children who have had contact. Only when all the parents of children in contact send replies or otherwise confirm, e.g. by telephone, that their children are free of lice, can the school be sure that the information has reached all parents and that perhaps previously unidentified cases of lice are therefore being treated. The extent and type of advice and the procedures should be laid down in consultation with the relevant health agency, which, depending on the situation, supports the school in carrying out the necessary measures.

Kitchen areas are particularly at risk from animal pest infestations. Kitchens should therefore be inspected regularly for **pest infestations**. In the event of an infestation pest control measures using the most up-to-date methods should be carried out by a specialist company. Particular care should be taken so that food does not come into contact with pest control preparations while this is taking place.

Food waste must be stored in sealable containers, which should be cleaned out each time they are emptied. Waste stores must be able to be kept clean and free of animal pests. Kitchen windows that can be opened to the outside should be fitted with insect mesh.

Infectious diseases

A hygiene risk from bacteria and viruses can arise through transmission of infectious germs from one person to another via droplet or contact transmission. The transmission of diseases such as influenza, scarlet fever (*streptococcus pyogenes*) and whooping cough (*bordetella pertussis*) is however not a problem specific to schools. To prevent them the enclosed directions from the Robert Koch Institute (e.g. Hinweise für Ärzte, Leitungen von Gemeinschaftseinrichtungen und Gesundheitsämtern zur Wiederlassung in Schulen und sonstigen Gemeinschaftseinrichtungen [Advice for doctors, management of community facilities and health agencies on readmittance to schools and other community facilities], updated version of July 2006, first published in Bundesgesundheitsblatt 44 (2001): pp. 830-843) should be observed and the children instructed in hand hygiene and cough etiquette.

First aid

Minor cuts should be cleaned with tap water (drinking quality) before dressing.

The first aider should wear disposable gloves and disinfect his/her hands before and after administering aid. The nature of the injury should be entered in the accident book in the first aid cabinet. The parents should be informed of the cause, nature and severity of the injury.

Information should be provided near the first aid cabinet on who the first aider in this area is and which doctor to call (provide telephone number) for more serious accidents. This notice board should also display instructions on how to deal with cases of poisoning (provide emergency number for poisons) and fires.

Checking first aid contents

Suitable first aid materials in accordance with the prevention of accidents regulation "GUV Erste Hilfe 0.3" are contained in:

- large first aid chest equipped in accordance with DIN 13169
- small first aid chest equipped in accordance with DIN 13157.

The first aid cabinet should additionally be equipped with an alcohol-based hand disinfectant in a securely sealed container. Used materials (e.g. disposable gloves and plasters) should be replaced promptly, and regular checks should be undertaken on the contents of the first aid chests. In particular, the expiry date on the hand disinfectant should be checked.

Treatment of contaminated surfaces

Surfaces contaminated with blood, vomit or other potentially infectious bodily fluids should be scrubbed with a disinfectant-soaked cloth and the affected surface disinfected again afterwards. Disposable gloves should be worn throughout.

Procedures in the event of hygiene problems

If "classic" hygiene problems arise in a school or indoor contamination with harmful substances is suspected or established, the first action is to inform the school authorities. They will inform the relevant health agency and the relevant occupational health department. These institutions will together put in place the necessary crisis management measures. This crisis management includes informing teachers, pupils and parents. If it is necessary to undertake environmental health inspections or building surveys or call in further professionals, these should be organised by the school authorities after consultation with the relevant health agency and the relevant occupational health department. The school authorities are responsible for checking the necessary competence of the tradesmen brought in. The teaching staff, pupils and parents should be informed of the results of these investigations.

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Tabelle 6: Hygienische Bewertung von TVOC-Werten und daraus resultierende Empfehlungen für Maßnahmen (Umweltbundesamt 2007)

Stufe	Konzentrationsbereich [mg/m³]	Hygienische Bewertung	zu klärende Fragen	Empfehlungen
1	≤ 0,3 mg/m³	▶ Hygienisch unbedenklich. In der Regel keine Beschwerden.	▶ Liegen Richtwertüberschreitungen vor?	▶ Keine weiteren Maßnahmen.
2	> 0, 3–1 mg/m³	▶ Hygienisch noch unbedenklich, soweit keine Richtwertüberschreitungen für Einzelstoffe bzw. Stoffgruppen vorliegen. ▶ In Einzelfällen Beschwerden oder Geruchswahrnehmungen, z. B. nach kleineren Renovierungsmaßnahmen oder Neumöblierungen in den letzten Wochen.	▶ Liegen Richtwertüberschreitungen vor? Liegen auffällige Referenzwertüberschreitungen vor? ▶ Sind die raumklimatischen Bedingungen (Luftwechsel, Temperatur, Luftfeuchte) einwandfrei?	▶ Ausreichend Lüften besonders nach Renovierungsarbeiten. ▶ VOC-Quellen ermitteln (z. B. Begehung des Raumes). ▶ Verwendung von Putz- und Reinigungsmitteln überprüfen. ▶ Nachmessungen zur Kontrolle von Richtwertüberschreitungen unter Nutzungsbedingungen (s. Kap. 9).
3	> 1–3 mg/m³	▶ Hygienisch auffällig. ▶ Nutzung bei Räumen, die regelmäßig genutzt werden, nur befristet akzeptabel (< 12 Monate). ▶ Innerhalb von ca. 6 Monaten sollten TVOC-Konzentration deutlich unter den anfangs gemessenen TVOC-Wert abgesenkt werden. ▶ Fälle mit Beschwerden oder Geruchswahrnehmungen, z. B. nach größeren Renovierungsarbeiten.	▶ Liegen Richtwertüberschreitungen vor? ▶ Liegen auffällige Referenzwertüberschreitungen vor? ▶ Sind die raumklimatischen Bedingungen (Luftwechsel, Temperatur, Luftfeuchte) einwandfrei?	▶ Richtwertüberschreitungen umgehend durch Nachmessung unter Nutzungsbedingungen kontrollieren und bei der Bewertung die Hinweise in Kap. 4 berücksichtigen. ▶ Auffällige Referenzwertüberschreitungen auf gesundheitliche Relevanz prüfen. ▶ In jedem Fall: Quellensuche durchführen und Lüftungsverhalten überprüfen: intensiv lüften und ggf. Nutzungs- und Lüftungsbedingungen festlegen. ▶ Kontrollmessung bzw. Nachmessung nach ca. 1 Monat empfohlen (unter Nutzungsbedingungen). ▶ Liegt nach 12 Monaten trotz der beschriebenen Bemühungen die TVOC-Konzentration weiterhin über 1 mg/m³, so sind adäquate Sanierungsmaßnahmen in die weitere Planung aufzunehmen.
4	> 3–10 mg/m³	▶ Hygienisch bedenklich ▶ Nutzung bei Räumen, die regelmäßig genutzt werden, nur befristet akzeptabel (< 1 Monat). ▶ Die TVOC-Konzentration sollte innerhalb eines Monats unter 3 mg/m³ abgesenkt werden. ▶ Fälle mit Häufung von Beschwerden oder Geruchswahrnehmungen, z. B. nach größeren Renovierungsarbeiten.	▶ Liegen Richtwertüberschreitungen vor? ▶ Liegen auffällige Referenzwertüberschreitungen vor? ▶ Sind die raumklimatischen Bedingungen (Luftwechsel, Temperatur, Luftfeuchte) einwandfrei?	▶ Richtwertüberschreitungen umgehend durch Nachmessung unter Nutzungsbedingungen kontrollieren und bei der Bewertung die Hinweise in Kap. 4 berücksichtigen. ▶ Auffällige Referenzwertüberschreitungen auf gesundheitliche Relevanz prüfen. Toxikologische Bewertung von Einzelstoffen oder Stoffgruppen erforderlich. ▶ In jedem Fall: Quellensuche durchführen und intensiv lüften und ggf. Nutzungs- und Lüftungsbedingungen festlegen und geeignete Minimierungsmaßnahmen veranlassen. Ein ggf. notwendiger Aufenthalt ist nur mit zeitlicher Beschränkung pro Tag über einen vom Gesundheitsamt vorzugebenden maximalen Zeitraum (pro Tag stundenweise/zeitlich befristet) tolerabel. ▶ Kontrollmessung bzw. Nachmessung nach ca. 1 Monat empfohlen (unter Nutzungsbedingungen). ▶ Liegt nach 1 Monat trotz der beschriebenen Bemühungen die TVOC-Konzentration weiter hin über 3 mg/m³, so sind adäquate Sanierungsmaßnahmen in die weitere Planung aufzunehmen.
5	> 10–25 mg/m³	▶ Hygienisch inakzeptabel. ▶ Raumnutzung möglichst vermeiden. Ein Aufenthalt ist allenfalls pro Tag stundenweise/zeitlich befristet zulässig. ▶ Bei Werten oberhalb von 25 mg/m³ ist eine Raumnutzung zu unterlassen. ▶ Die TVOC-Konzentration sollte innerhalb eines Monats unter 3 mg/m³ abgesenkt werden. ▶ In der Regel Beschwerden und Geruchswahrnehmungen z. B. nach Fehlanwendungen, Unfällen.	▶ Liegen auffällige Referenzwertüberschreitungen vor? ▶ Liegen Richtwertüberschreitungen vor? ▶ Sind die raumklimatischen Bedingungen (Luftwechsel, Temperatur, Luftfeuchte) einwandfrei?	▶ Richtwertüberschreitungen umgehend durch Nachmessung unter Nutzungsbedingungen kontrollieren und bei der Bewertung die Hinweise in Kap. 4 berücksichtigen. ▶ Auffällige Referenzwertüberschreitungen auf gesundheitliche Relevanz prüfen. Toxikologische Bewertung von Einzelstoffen oder Stoffgruppen erforderlich. ▶ In jedem Fall: Quellensuche durchführen und intensiv lüften und Nutzungs- und Lüftungsbedingungen festlegen und geeignete Minimierungsmaßnahmen veranlassen. Ein ggf. notwendiger Aufenthalt ist nur mit zeitlicher Beschränkung pro Tag über einen vom Gesundheitsamt vorzugebenden maximalen Zeitraum (pro Tag stundenweise/zeitlich befristet) tolerabel. ▶ Kontrollmessung bzw. Nachmessung innerhalb von 1 Monat (unter Nutzungsbedingungen). ▶ Wird durch Minimierungsmaßnahmen 10 mg/m³ im betrachteten Zeitraum zwar unterschritten, eine Konzentration von 3 mg/m³ allerdings weiterhin überschritten, gelten die Maßnahmenempfehlungen wie unter Stufe 4. Liegt nach 1 Monat trotz der beschriebenen Bemühungen die TVOC-Konzentration weiterhin über 10 mg/m³, so sollte die Raumnutzung unter-bleiben und es sind adäquate Sanierungsmaßnahmen zu veranlassen.

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