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Indoor air —

Part 1:
General aspects of sampling strategy

Air intérieur —

Partie 1: Aspects généraux de la stratégie d'échantillonnage

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16000-1 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 6, *Indoor air*.

ISO 16000 consists of the following parts, under the general title *Indoor air*:

— *Part 1: General aspects of sampling strategy*

— *Part 2: Sampling strategy for formaldehyde*

— *Part 3: Determination of formaldehyde and other carbonyl compounds — Active sampling method*

— *Part 4: Determination of formaldehyde — Diffusive sampling method*

— *Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID*

— *Part 9: Determination of the emission of volatile organic compounds — Emission test chamber method*

— *Part 10: Determination of the emission of volatile organic compounds — Emission test cell method*

— *Part 11: Determination of the emission of volatile organic compounds — Sampling, storage of samples and preparation of test specimens*

The following parts are under preparation:

— *Part 5: Sampling strategy for volatile organic compounds (VOCs)*

— *Part 7: Sampling strategy for determination of airborne asbestos fibre concentrations*

— *Part 8: Ventilation rate measurement*

Introduction

The ISO 16000 series deals with indoor air measurements. This part of ISO 16000 is intended as an aid to planning indoor air pollution measurements. Additional parts of ISO 16000 describe the sampling strategy, including the conditions to be observed for the particular substances or groups of substances, such as the dependence of indoor air pollution concentrations on atmospheric humidity or temperature or other effects. The actual procedures dealing with indoor air measurements for the individual substances are also presented in other parts of ISO 16000.

An inappropriate monitoring strategy can contribute to the overall uncertainty of the measurement result to a greater extend than the monitoring procedure itself.

Attention should be given to the special role of the human sense of smell in identifying substances or classes of substances in indoor air. Here it is not so much the sensitivity of the sense of smell, but the memory of smell and the experience of the specialist (chemist, perfume specialist) that is important. Sensory information can greatly simplify the identification of air pollutants and consequently influence the sampling strategy. However, sensoric adaptation affects the sensory information, particularly in the case of persistent indoor pollutants.

The interpretation of indoor air measurements is assisted by the use of guideline values for acceptable indoor air quality. To draw a conclusion about whether and to what extent the concentrations of a pollutant measured in a room exceed the normal level or the level acceptable from the standpoint of health, it is useful to rely on guideline values or published literature. The column “Remarks” of Table C.1 (see Annex C) gives available World Health Organization (WHO) air quality guidelines for indoor air[1]. It is emphasized, however, that these values are not legally binding. In the absence of published guideline values, the investigator may consult peer reviewed journal articles or other literature for guidance on typical values observed in buildings without reported complaints.

Representatives of various technical fields should be involved in the planning of indoor air quality measurements.

Table A.1 of this part of ISO 16000 summarizes the most important types of indoor environment, and examples of the sources that may be encountered in them. The list is not, of course, fully comprehensive because of the large number of possibilities.

Table B.1 shows the sources of indoor air pollutants and the most important substances emitted. Table C.1 lists substances frequently detected and their possible sources. In some cases, the sources of indoor pollution arise outside the building; for example, benzene from vehicle traffic and petrol stations, and chlorinated hydrocarbons from nearby dry-cleaning establishments. Soil emissions may also be important if, for example, buildings have been erected on old landfills, industrial sites, or uranium-containing soils which emit radon.

Annex D contains a checklist relating to information to be recorded when indoor air measurements are carried out. This list is also intended to aid the user of this part of ISO 16000 in the subsequent assessment of the analytical result.

The sampling strategy procedure described in this part of ISO 16000 is based on Guideline VDI 4300 Part 1[2]. Similar national standards exist[3], [4], [5].

Indoor air —

Part 1:
General aspects of sampling strategy

1 Scope

This part of ISO 16000 is intended to aid the planning of indoor pollution monitoring.

Before a sampling strategy is devised for indoor air monitoring, it is necessary to clarify for what purposes, when, where, how often and over what periods of time monitoring is to be performed. The answers to these questions depend, in particular, on a number of special characteristics of the indoor environments, on the objective of the measurement and, finally, on the environment to be measured. This part of ISO 16000 deals with the significance of these factors and offers suggestions on how to develop a suitable sampling strategy.

This part of ISO 16000 is applicable to indoor environments such as dwellings with living rooms, bedrooms, do-it-yourself rooms, recreation rooms and cellars, kitchens and bathrooms; workrooms or work places in buildings which are not subject to health and safety inspections in regard to air pollutants (for example, offices, sales premises); public buildings (for example hospitals, schools, kindergartens, sports halls, libraries, restaurants and bars, theatres, cinemas and other function rooms), and also cabins of vehicles[6].

NOTE In some countries, workplaces such as offices and sales premises are subject to health and safety inspections with regard to air pollutants.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

Guide to the expression of uncertainty in measurement (GUM), BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1995

3 Special characteristics of the indoor environment

Careful planning of sampling and the entire measurement strategy are of particular significance since the result of the measurement may have far-reaching consequences (e.g. with regard to the need for remedial action or the success of such an action).

The determination of indoor air pollutants proceeds, as a rule, by either of two approaches.

a) Sampling is carried out on-site using instruments that are as manageable and simple as possible, and subsequently analysis is carried out in the laboratory; or

b) sampling and analysis are performed on-site by direct-reading measuring systems.

An indoor environment is rarely static, since the concentration of any substance may be constantly altered by the strength of the source, human activity, ventilation rate, external or internal climatic conditions, chemical reactions and possible sinks (e.g. sorption by surfaces and furnishings). Because of the proximity of source to receptor, human exposure in the indoor environment is of special concern. In addition, the composition of indoor air may vary within and between rooms, and be less homogeneous than the outdoor air surrounding the building.

Equation (1) describes a simplified relationship of some of the parameters that affect the concentration of a substance in indoor air. In special cases, e.g. fibres [asbestos, MMF (man-made fibres)] additional boundary conditions should be considered (see ISO 16000-7).

$$\mathrm{d}\rho_\mathrm{i}/\mathrm{d}t = \left(q/V\right) + n\rho_\mathrm{o} - f\rho_\mathrm{i} - n\rho_\mathrm{i} \tag{1}$$

where

ρ_i	is the mass concentration of substance in indoor air, in milligrams per cubic metre;
q	is the strength (mass flowrate) of the source, in milligrams per hour;
V	is the volume of the room, in cubic metres;
n	is the number of air changes per hour;
ρ_o	is the mass concentration of substance in outdoor-air, in milligrams per cubic metre;
f	is the elimination factor per hour;
t	is the time, in hours.

The left-hand side of the equation represents the change in the concentration of the substance with time. The first two terms on the right-hand side describe the increase in the concentration due to emissions from a source and the penetration of outdoor air, while the last two terms represent the decrease in the concentration which may result from removal by ventilation or from elimination mechanisms, such as sorption of the compound by textiles in the room.

The most important term in Equation (1) is the source strength. It is often observed to vary with time, but this is not taken into account by Equation (1). If it is found that the variation is of particular significance, a more complex equation is needed. Depending on how the strength varies with time, a distinction can be made between a constant and a variable source strength, and both cases can be subdivided still further into regular and irregular emissions. The strength of continuous sources may also depend on room temperature, the relative humidity and the amount of movement of the air in the room, and may only change in the long term; i.e. over weeks and months. The emission rate of intermittent sources is generally only slightly affected by room-climate parameters and often varies within much shorter periods of time.

Particle board with aminoplastic bonding is an example of a source that continually emits pollutants into the air. Such a source emits formaldehyde over long periods of time in amounts that depend heavily on environmental factors such as temperature and relative humidity.

A gas cooker, which may be operated at varying conditions according to cooking requirements, is an example of an intermittent source having variable strength. However, a very regular emission pattern may be observed from day to day, since the preparation of meals is often subject to a regular schedule.

The occasional use of insecticide sprays represents a combination of an intermittent source and an irregular emission pattern.

4 Measurement objective

Indoor air measurements are mainly undertaken for the following five reasons, of which the first may be unrelated to, or may evoke the other four:

a) complaints by users about poor air quality,

b) the need to determine the exposure of occupants to certain substances,

c) the need to measure whether specified limit or Guideline values are being maintained,

d) testing the effectiveness of remedial treatment.

e) observed or suspected effects on the occupants' health.

In the first case an extended search for the causes of the complaint may be necessary, including the use of a questionnnaire to obtain a systematic record of the complaints. Often, there is a need to adapt the sampling strategy to the individual case. The other situations are easier to address, because information is available about the substances to be determined before monitoring is started.

The nature of a substance, its concentration and its effect on humans can also have a considerable influence on the boundary conditions chosen for the monitoring effort. Thus, in assessing the health implications of irritants, the maximum allowable exposure over short periods of time tends to be of interest. In the case of compounds that have potential long-term health effects (i.e. carcinogenic compounds), it is generally the mean exposure over fairly long periods of time that is of interest.

5 Sampling procedure

Sampling methods intended for outdoor use can often be used for sampling indoor air, provided that the equipment is suitable for the measurement task and does not have a substantial adverse effect on the normal use of the rooms in which it is used because of size, sampling rate and noise. This is particularly important in residential monitoring. In this case, the instrument used should be relatively noise-free and its sampling rate should not interfere with the normal ventilation rate. In positioning the monitoring equipment, consideration should be given to the fact that the concentration of the indoor air may not be homogeneous.

Time resolution of the measurement is an important factor. Different techniques may give different time resolutions, which will affect the interpretation of the result observed.

The hourly sampling volume in the room shall be less than 10 % of the ventilation rate. If the ventilation rate value is not available or cannot be measured, the hourly sampling volume should be less than 10 % of the room volume.

For determination of average concentrations of a substance over fairly long time periods (e.g. 8 h), diffusive samplers, which do not have some of the disadvantages of active samplers, may be used. However, care should be taken to assure that diffusion-controlled samplers are used only in areas with adequate ventilation such that the specified face velocity is maintained. Suitable quality assurance procedures in accordance with ISO/IEC 17025 shall be followed for both active and diffusive sampling.

NOTE 1 It is usual to refer to sampling times of up to 1 h as short-term sampling, and to times ranging from several hours to several days as long-term sampling.

NOTE 2 Sampling procedures are described in other parts of ISO 16000.

6 Time of sampling

It is essential to take into account the variation in the concentration of air pollutants with time when evaluating a measurement result. Pollutants such as cigarette smoke and chemical vapours (e.g. for cleaning) shall first be ventilated from indoor air, unless there is intention to take these pollutants into account for the evaluation of the measurement results.

Important parameters to which attention shall be paid in choosing the sampling time are the ventilation, the nature of the sources, the occupants and their activities, the type of indoor environment, the temperature and the relative humidity.

Opening a window inevitably decreases the substance concentration in a room (provided the outdoor air is not more heavily polluted with the substance of concern), and it may also disturb a previously established equilibrium.

In the case of short-term sampling, it is impossible to obtain representative results if sampling is started immediately after ventilation. If the substance to be determined is emitted constantly and continuously, for example by building materials or furnishings, several hours shall be allowed for the establishment of equilibrium after ventilating by opening a window. This effect is also important for long-term sampling. However, it is less important than for short-term sampling, especially if the sampling is carried out for a long time and under the actual living conditions.

For the reasons mentioned, it is important to plan the time of monitoring carefully, taking into account the interval of time between the end of the last ventilation and the start of sampling. If there are no serious objections, the procedure for short-term sampling shall include a waiting time of several hours after a change in ventilation before sampling is begun. Indications of the interval of time to be chosen in individual cases are found in other parts of ISO 16000 relating to the particular substance or group of substances (e.g. ISO 16000-2 and ISO 16000-5).

If indoor air pollutants are due to emissions from intermittent sources, the time of sampling depends on the monitoring objectives. It may correspond to the peak exposure period or cover the average exposure over a longer period.

If the building or room is equipped with a heating, ventilating and air-conditioning (HVAC) system, additional aspects shall be considered. For example, undesirable emissions may result from the HVAC system itself (e.g. from sealing materials, humidifier water, dust deposits), resulting in pollutants from one room being distributed throughout the entire building, especially if the HVAC has a high recirculation rate. Finally, the outdoor air drawn in by the HVAC may contain a high level of pollution (e.g. due to nearby sources). The operating parameters and the state of maintenance of the HVAC system shall always be included in the test report relating to an indoor air sample, and if operation is intermittent or restricted, at least 3 h shall be allowed to elapse with the HVAC system performing normally before sampling is started (see also Clause 8).

7 Sampling duration and sampling frequency

The duration of sampling is determined by

- the nature of the substances under consideration,
- the potential health effects of the targeted substance,
- the emission characteristics of the source,
- the limits of quantification of the analytical method,
- the measurement objective.

In many cases, particularly if only a few measurements are made, it is necessary to make compromises that do not take into account all three aspects at the same time.

The sampling duration chosen is particularly important in relation to the potential health effects of the targeted substance. For substances causing acute health effects, short-term sampling should be used, whereas long-term sampling should be used for substances having chronic effects on health. Long-term sampling methods do not detect short-term peaks in concentration. This may result in difficulties in interpretation of the measurement results, particularly if a substance also has a short-term effect on health.

In relation to the emission characteristics of the source, it is clear that emissions from a source that emits only for a short time can only reasonably be determined by a short-term measurement. Conversely, sources with long-term emissions are best dealt with by long-term measurements. However, it is quite possible that there are deviations from this general rule. For example, the short-term peak concentration of an insecticide due to aerosol spraying can only be determined with a short-term measurement, but long-term sampling may be quite appropriate after spraying if residual concentration levels in the room are of primary interest.

In some cases, the emission characteristics of suspected sources are initially unknown. In such cases, a continuous recording of measured quantities, for example total gaseous organic compounds using a flame ionization detector (FID) or photoionization detector (PID) for a limited time may provide useful information for developing the sampling strategy.

The sampling duration shall also be appropriate for the limit of quantification of the chosen analytical method, i.e. the mass of the analyte collected during sampling shall make possible an unambiguous identification and a reliable quantitative determination. At the same time, it should be remembered that the amount of analyte collected is not necessarily substantially increased by extending the sampling time over a longer period. When the intention is to determine the concentration of a compound originating from an intermittent source that is activated only on rare occasions and for short intervals, nearly as much substance may be collected in a 1 h sampling period as in 24 h. Furthermore, information may be lost if the choice of sampling time is unsuitable.

The sampling duration may be imposed on the analyst in some cases (e.g. when a standard or guideline value has been specified together with a time interval). Such is the case with tetrachloroethene, for which a legal limit value has been set in Germany[7] as a 1-week average. The average time was set for rooms adjacent to dry-cleaning shops to cover the full weekly pattern of emission levels that vary between working days and weekends.

Due to cost considerations, the number of individual measurements carried out in a room is generally small. On the other hand there is a tendency to take the result of one (or only a few) measurement(s) as representative of the situation in the room under study. In this conflicting situation, it is essential to provide as much information as possible about those parameters that can have an influence on the result, in order to be able to judge whether the result reflects the average or an extreme condition.

Short-term sampling is often carried out under conditions that represent an extreme situation (e.g. low number of air changes, elevated temperature) in order to be able to estimate the maximum exposure. Long-term sampling is often used to determine the state of pollution under normal conditions of occupancy. The conditions of the use and occupancy of the room at the time of sampling shall be precisely documented.

For a comprehensive assessment, both a short-term sample and a long-term sample shall be collected. The assessment shall also take into account the changes in concentration that may result from changes in the ventilation pattern and the conditions of use and occupancy, including seasonal differences. This is especially important for some pollutants, e.g. formaldehyde and viable fungi.

In the case of formaldehyde, seasonal changes in concentration are particularly important since the emission of formaldehyde from wood-based materials bonded with urea/formaldehyde-containing resins is affected by temperature and relative humidity (see Clause 3).

The final sampling design is necessarily dependent upon the available resources, costs, data requirements and the time available for carrying out the study.

8 Sampling location

In addition to the changes in the concentration of a substance over time, account shall also be taken of the spatial variation. For measurements to be made in a building, it is therefore necessary to specify both the room to be monitored and a suitable sampling location in that room. The choice of the room depends on the purpose of the measurement. In buildings equipped with HVAC systems, measurements carried out in the intake and exhaust air may indicate sources of air pollutants.

Although it is frequently the purpose of a measurement to identify the pollutant sources in a room, the emphasis is generally on determining the exposure of the occupants to the pollutants. It is not possible in every case to specify beforehand the most appropriate location of the sampling device. In private dwellings, a choice may have to be made between the living area and the sleeping area. If sources are involved that are associated with certain activities of the inhabitants, it is often useful to sample in the living area, especially if the pollution-producing activities occur there. However, exposure to long-term emitting sources (e.g. building products) may be better characterized by a measurement made in the bedroom, because that is where people spend more time. In private dwellings, it is important that measurements should not have an effect on the normal use of the rooms.

In the case of measurements made in large rooms (halls, large offices, etc.), the possibility of subdividing the room shall be considered in selecting the sampling location and in evaluating the measurement result. This applies in particular to short-term measurements.

If the living room is closer to an outside pollutant source (e.g. a dry-cleaning establishment), it would not be logical to sample only in the bedroom.

The centre of the room is generally considered the most suitable location for sampling. However, if this is not possible, the sampler should be located no closer than 1 m to any wall. Samples should be taken about 1 m to 1,5 m above the floor, since this is the approximate height of the average breathing zone. Alternative locations may be required in specific circumstances; for example when measuring the emissions from cooking stoves. These emissions, which cause thermal movement of air in the room, result in marked concentration gradients. For example, significantly lower concentrations of NO_2 may be observed below the working level of a gas cooker than above it. Such concentration gradients may also be characteristic of other sources and may even be used to locate a source in a room. To this end, it is advisable to subdivide the room into different areas and to simultaneously sample each area. However, such a procedure is only successful if the individual areas of the room can be classified as similar in terms of ventilation, which is not always the case, particularly in artificially ventilated rooms. In occupied premises, care should be taken to assure that the sampling equipment is protected as much as possible from human intervention.

The prevailing movement of air in a room, which depends on the nature and extent of the ventilation, may also be of great importance in specifying the measurement point, particularly if diffusive samplers are to be employed. Diffusive samplers that have a large cross-section (so-called badge-type samplers) may under-estimate the concentration if the face air velocity is too low, as may occur particularly in the corners of rooms. Places in the sun, nearby heating systems, with noticeable draught and nearby ventilation channels should be avoided, because this may influence the measurement results.

9 Parallel outdoor air measurements

Due to the permanent exchange between indoor and outdoor air caused by infiltration and ventilation processes, it may be important to supplement indoor air measurements with a simultaneous measurement of the outdoor air[8] [if possible at the same level (floor) of the building]. The outdoor air samples should be taken in the vicinity of the building but not closer than 1 m. In making such measurements, it should be remembered that vertical concentration gradients may occur, for example for the components of vehicle exhaust gases in street canyons. If the building is equipped with an HVAC system, the outdoor air should be sampled near the air intake.

Information on the wind direction, wind velocity and other weather conditions at the time of sampling may be of interest.

Annex A
(informative)

Important types of indoor environment and sources of air pollutants

Table A.1 provides a non-exhaustive list of the most important types of indoor environment, and examples of the sources that may be encountered in them.

Table A.1 — Important types of indoor environment and the sources of air pollutants frequently encountered in them

Type of indoor environment	Emitting sources or processes (examples)
Private dwellings and living rooms	
a) **General sources**	Man, building materials, furnishings, renovation materials, cleaning agents, biocide-containing products, ventilation and air-conditioning systems, outdoor air, heating appliances, microbial growth
b) **Special areas**	
Kitchens	Gas appliances, cooking, cleaning products
Living rooms, bedrooms, bathrooms	Tobacco smoke, fireplaces, biocide-containing products, cosmetics, disinfectants
Basements, hobby rooms	Hobby activities, tobacco smoke, soil outgassing
Garages	Fuel, solvents
Public buildings	
a) **General sources**	Man, building materials, furnishings, renovation materials, cleaning agents, biocide-containing products, ventilation and air-conditioning systems, outdoor air
b) **Special areas**	
Offices	Office machines and supplies
Schools and day care centres	Teaching materials, toys
Hospitals	Disinfectants, cleaning agents, anaesthetics, sterilizing agents
Garages	Fuel, automobiles
Swimming pools	Outgassing from water
Transport vehicles	Fuel tanks, internal combustion engines, internal fitting materials, outdoor air

Annex B
(informative)

Sources of indoor air pollutants

Table B.1 shows the sources of indoor air pollutants and the most important substances emitted.

Table B.1 — Sources of indoor air pollutants and their most important emissions

Source/cause	Process/activity	Products used, sources in a narrower sense	Substances emitted
Biological sources			
People, domestic animals	Breathing		Carbon dioxide, water vapour, odorous substances from food; bacteria and viruses
	Sweating		Water vapour, odoriferous substances
	Digestion, excretion, skin scaling		Intestinal gases, odorifeous substances and excrement, decomposition products or pathological excretions, bacteria and viruses, allergenic dust
Cockroaches, dust mites and other insects	Excretion		Allergenic dusts
Rats, mice and other pets	Excretion		Allergenic dusts, bacteria, viruses, odoriferous substances
	Loss of hair, skin scaling		Allergenic dust
House plants	Evaporation		Terpenes and other odoriferous substances, water vapour
Mould growth	Primary and secondary metabolism, spore release		Fungal propagules, bacterial cells and components, microbial VOC, mycotoxins
Building products, building equipment			
Buildings and materials	Product processing, outgassing, ageing, abrasion, decomposition	Building substances, building preservatives and corrosion prevention agents, insulating materials, sealing materials, paints, concrete additives	Various gaseous and particles, e.g. solvents, plasticizers, monomers, oligomers, wood preservatives, flame-proofing agents, fibres (asbestos, mineral wool), radon (e.g. from granite), amines and ammonia
Ventilation and air-conditioning system	Operating and maintenance	Scrubbers, filters, insulating and sealing materials, deposits, heat exchangers	Microorganisms (e.g. legionella), biocides, fibres, odoriferous substances
Room furnishings	Product processing, renovation, outgassing	Furniture, floor coverings, domestic textiles, paints and varnishes, wall coverings	Monomers and oligomers from plastics, resins, surface coatings, adhesives (e.g. formaldehyde), fibres, solvents, plasticizers, stabilizers, biocides

Table B.1 (*continued*)

Source/cause	Process/activity	Products used, sources in a narrower sense	Substances emitted
Indoor activity			
Cooking and heating appliances	Combustion processes (heating, cooking), open fires	Coal, heating oil, gas, wood, foodstuff	Gases (municipal, bottled, natural), heating oil vapour, carbon dioxide, carbon monoxide, nitrogen oxides, water vapour, suspended particulate matter, hydrocarbons and many other organic substances (combustion and carbonization products)
Hygiene and personal care	Body and cosmetic care	Cosmetics and consumer products; shower and bath water	Solvents, propellants, perfumes, inorganic and organic aerosols (dyes, pigments, lacquers, resins), halocarbons
Sanitation products	Cleaning and care procedures; pest control	Detergents and cleaning agents, polishes, disinfectants, pesticides	Water, ammonia, chlorine, organic solvents, insecticides, bactericides and chlorine compounds, domestic dust
Home office	Office activities	Office suppies, EDP equipment, copiers	Organic solvents, low-volatility organic substances (plasticizers, flameproofing agents), toner components, ozone
Hobby and DIY (do-it-yourself) products	DIY activities, renovation, painting and the like	Paints, lacquers, adhesives, sprays, handicraft products, soldering irons	Inorganic and organic gaseous and aerosol-type substances, particularly propellants and solvents, dusts, suspended particulate matter, metal vapours, monomers, biocides
Tobacco	Smoking	Tobacco products	Carbon monoxide, nitrogen oxides, nicotine, aldehydes, nitrosamines and numerous other organic substances (e.g. polycyclic aromatic hydrocarbons, aerosols)
Garage store room	Storage	Fuels, paints, lacquers, cleaning agents, etc.	Fuel vapours, exhaust gas, solvents
Transportation			
Vehicles	Vehicle (car, use of vehicle, trucks, caravan, public transport)	Fuels, plastic and rubber material, insulating material, ventilation	Vehicle exhaust gases and particles (carbon monoxide, nitrogen oxides, hydrocarbons, polycyclic aromatics, benzene, lead-containing suspended particulate matter, diesel soot), plasticizers (e.g. phthalates) and other additives, aldehydes, monomers (e. g. styrene), ozone (aircraft cabins)
Outdoor air pollution			
Emissions due to human activities	Ventilation, infiltration and diffusion through building exterior	Trade and industrial establishments, traffic, house fire, agriculture, outside burning	Inorganic and organic gases and aerosols, solvents, ammonia, odorous substances, PAHs
Natural emissions	Ventilation, penetration of soil gases, windborne dust	Plants in flower, occurrence of radium in soil, sea spray, soil resuspension, natural decay	Pollen, radon, methane, sea salts, particles, microbes
Livestock	Excretion	Intestinal gases, odoriferous substances and excrement decomposition products or pathological excretions; bacteria and viruses, allergenic dust	Ammonia and sulfur compounds

Annex C
(informative)

Examples of substances and their sources

Table C.1 lists polluting substances frequently detected and their possible sources. The substances primarily listed are those for which frequent measurements are available. Chemical compounds and other substances are not listed for which only a small amount of information about their concentration range is available. These include examples of diisocyanates, phthalates, nitrosamines, amines and pesticides.

Table C.1 — Substances frequently detected and their possible sources

Pollutant	Source	Remarks
Hydrocarbons		
Benzene	Open fires, tobacco smoke, vehicle exhaust gases, petrol, filling stations, (underground) garages	
Toluene	Paints and varnishes, wood preservatives, adhesives, printing ink, printing products, solvents, felt-tip pen, filling stations, petrol, vehicle exhaust gases, garages	AQG1): 260 µg/m^3 (1 week) 1 mg/m^3 (30 min; odour annoyance)
Styrene	Polystyrene (residual monomer) hobby goods (e.g. casting resin, melting granules)	AQG: 260 µg/m^3 (1 week) 7 µg/m^3 (30 min; odour annoyance)
Other aromatics	Solvents, landfill, vehicle exhaust	
C_6 to C_{15} alkanes	Vehicle exhaust gases, oil heating, cleaning agents, paints and varnishes	
4-phenylcyclohexene/trimeric isobutene	Carpet	
Polycyclic aromatic hydrocarbons (PAH)	Open fires, uncompleted combustion processes, tobacco smoke	
Terpenes, e.g. Δ^3-carene, pinene, limonene	Turpentine oil (paints and varnishes, floor care agents, wood preservatives, furniture-care agents), bath additives, cleaning products	
Halogenated hydrocarbons		
Tetrachloroethene	Dry cleaning	AQG: 250 µg/m^3 (24 h)
Dichloromethane	Propellants, paint strippers, solvents	AQG: 3 mg/m^3 (24 h)
Trichloroethene	Solvents	
1,1,1-Trichloroethane	Correction fluid	

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1) AQG: Air Quality Guidelines of the World Health Organization[1]

Table C.1 (*continued*)

Pollutant	Source	Remarks
Halogenated hydrocarbons (with moderate and low volatility)		
1,4-dichlorobenzene	Disinfectants, lavatory pans, deodorant, moth ball	
HCH isomers (e.g. lindane)	Wood preservatives, insecticides, paints and varnishes	
Pentachlorophenol	Wood preservatives, paints and varnishes, fungicides	
Polychlorinated biphenyls (PCB)	Sealing compounds, capacitors in fluorescent lamps, fireproofing agents	
Polyhalogenated dibenzo-*p*-dioxins/furans	Halogen-containing combustibles in open fires, wood preservatives (as an impurity), fireproofing agents, e.g. brominated phenyl ethers in plastics (televisions, computers)	
Other hydrocarbons		
Aldehydes		
Formaldehyde	Open fires, tobacco smoke, chipboards, insulating materials, disinfectants	AQG: 0,1 mg/m^3 (30 min)
Acetaldehyde	Open fires	
Acrolein, hexanal, nonanal	Frying, open fires, radiator varnish	AQG for acrolein: 50 µg/m^3 (30 min)
Ketones (acetone, 2-butanone, methyl isobutyl ketone)	Adhesives, nail varnish remover	
Alcohols (ethanol, propanol, 2-propanol, glycols)	Paints and varnishes, carpet and upholstery cleaners, cosmetics, adhesives, disinfectants, antifreeze (in motor vehicles), paint strippers, felt-tip pens	
1-ethylhexanol	PVC flooring	
Glycol ethers	Cleaning agents, paint solvents	
Phenols	Paint strippers, disinfectants, wood preservatives (carbolineum), tobacco smoke	
Esters	Paints and varnishes, furniture-care agents, adhesives, stain removers, shoe polishes, nail-varnish remover, solvents	
Phthalates	Floor covering, plastics	
(2,2,4-Trimethylpentanediol diisobutyrate)	PVC products, adhesives, paints	
(2,2,4-trimethyl-1,3-pentanediol isobutyrate)	PVC products, adhesives, paints	
Nicotine	Tobacco smoke	

Table C.1 (*continued*)

Pollutant	Source	Remarks
Inorganic components		
Carbon monoxide (CO)	Open fires, tobacco smoke, vehicle exhaust gases	AQG: 100 mg/m^3 (15 min) 60 mg/m^3 (30 min) 30 mg/m^3 (1 h) 10 mg/m^3 (8 h)
Carbon dioxide (CO_2)	Open fires, tobacco smoke, people, vehicle exhaust gases	
Nitrogen dioxide (NO_2)	Open fires, gas appliances, tobacco smoke, vehicle exhaust gases (in vehicle)	AQG: 200 µg/m^3 (1 h) 40 µg/m^3 (yearly average)
Sulfur dioxide (SO_2)	Sulfur-containing fuels	AQG: 500 µg/m^3 (10 min) 125 µg/m^3 (24 h) 50 µg/m^3 (yearly average)
Ozone (O_3)	Photocopiers, laser printers	AQG: 120 µg/m^3 (8 h)
Ammonia	Flooring, concrete, levelling agents, mortar/plasters	
Radon	Uranium and radium deposits close to the surface, building materials (granite, pumice stone and tufaceous rock), artificial plaster	
Mercury	Broken thermometer, paints	AQG: 1 µg/m^3 (yearly average)
Lead	Paints	AQG: 0,5 µg/m^3 (yearly average)
Particles		AQG: Dose-response relationship[1]
Settled dusts	Tracked-in dusts	
Asbestos	Insulating materials, freeable asbestos	
Fibrous dusts	Mineral wool, building materials	
Aerosols	Tobacco smoke	
Suspended particulate matter (PM) PM2.5 PM10 TPM (total particulate matter)	Fuel combustion, cooking, fungi spores, pollen, animals, humans, bacteria, wind blown dust	

Annex D

(informative)

Guidelines for information to be recorded during indoor air measurement

It has been found that it is of great benefit for the subsequent evaluation of the results to document the conditions in as much detail as possible during sampling. The following documentation scheme lists the desirable information. If necessary, some parts of the scheme may be omitted or new ones added.

The final structure of the protocol should be fixed, together with the individual planning of the measurements.

A Sample information

A1 Sample number: ....

A2 Pollutant monitored: ....

A3 Reason for the measurement: ....

A4 Address: ....

B Time and type of sampling/monitoring

B1 Time of sampling/monitoring

Start Date: .... Time of day: ....

Finish Date: .... Time of day: ....

B2 Type of sampling/monitoring

[ ] Automatic/continuous

[ ] Manual, active

[ ] Manual, diffusive

C Location of sampling/measurement

C1 Type of building/utilisation

[ ] Residential building

[ ] School/kindergarten

[ ] Office building

[ ] Prefabricated house

[ ] Gymnasium

[ ] Hospital

[ ] Warehouse/shop

[ ] Other building

C2 Age of building

[ ] < 6 months

[ ] < 2 years

[ ] < 10 years

[ ] 10 to 20 years

[ ] > 20 years

C3 Environment around the building (< 2 km)

[ ] Rural

[ ] Urban (suburb)

[ ] Urban (centre)

[ ] Light traffic

[ ] Heavy traffic

[ ] Industrial area

[ ] Heavy industry

[ ] Chemical industry

[ ] Small-scale industry

Type: ....

Distance: ....

[ ] Other: ....

[ ] Polluted soil

C4 Outdoor parameters during measurement

Mean outside temperature: .... °C

Mean wind velocity: .... m/s

Mean wind direction: ....

Mean relative humidity: .... %

Rain [ ] yes [ ] no

Snow cover [ ] yes [ ] no

C5 Utilization and heating of room

[ ] Room in private house

[ ] Kitchen

cooking stove operated with: ....

[ ] Living room

[ ] Bedroom

[ ] Office

[ ] Classroom

[ ] Other room: which one? ....

Area: .... m^2

Height: .... m

Type of heating:

[ ] Central heating

  [ ] Radiator

  [ ] Underfloor

  [ ] Hot-air

[ ] Single stoves

[ ] Open fireplace

Position of open fireplace (provide a sketch, if necessary)

[ ] Other: ....

Type of heating energy source:

  [ ] Oil

  [ ] Gas

  [ ] Coal

  [ ] Wood

  [ ] Electric

  [ ] Direct

  [ ] Oil radiator

C6 Position of room in building (provide a sketch, if necessary)

[ ] Room inside without window

[ ] Room has .... outer walls

Outer wall(s) directed to ....

Windows directed to:

- [ ] south
- [ ] north
- [ ] west
- [ ] east

Room directed to ....

C7 Siting of sampling equipment/measuring instrument in room (provide a sketch, if necessary)

Distance from wall: .... m

Height above floor: .... m

C8 Floor of room in building:

[ ] Ground floor

[ ] .... floor

D Ventilation conditions before sampling/measurement

D1 Room with window ventilation (openable windows)

Type of window:

- [ ] Single window
- [ ] Insulated glass window with rubber seal
- [ ] Box-type window

The sealing provided by the windows in the room is obviously

- [ ] good
- [ ] poor

D2 Ventilation state before measurement

[ ] Room thoroughly ventilated

Time: .... min

[ ] Windows and doors kept closed

Time: .... h

[ ] Normal ventilation pattern used by room occupants

D3 Room with ventilation and air-conditioning system

[ ] Plant in operation for .... h

[ ] Plant switched off for .... h

D4 Information on ventilation and air-conditioning system

System is fitted with humidification

[ ] Steam

[ ] Spray

[ ] System is operated with .... % recirculation

[ ] Date of last maintenance of system ....

[ ] overall

[ ] partial

E Room climate and ventilation conditions during sampling/measurement

E1 Room with window ventilation

[ ] Windows and doors closed

[ ] Normal ventilation pattern used by room occupants

E2 Room with ventilation and air-conditioning system

[ ] System normally in operation

[ ] System switched off

E3 Indoor-air parameters

Mean room temperature: .... °C

Mean relative room humidity: .... %

F Room fittings and condition

F1 Wall and floor

[ ] Paper wall coverings

[ ] Plastic wall coverings

[ ] Painted plaster

[ ] Coated boards

[ ] Wood panelling

[ ] Carpeted floor

Bonded? [ ] Yes [ ] No

Age: .... years

[ ] Plastic floor

Bonded? [ ] Yes [ ] No

Age: .... years

[ ] Floor tile

[ ] Other ....

F2 Renovation

[ ] Renovation within the last three months

What was renovated? ....

[ ] Other changes to the room or its immediate vicinity (for example, adjacent rooms) within the last three months?

What were they? ....

F3 New furniture within the last three months

[ ] Yes [ ] No

F4 Water damage

[ ] Yes [ ] No

Time: ....

Type: ....

Location: ....

Repaired?

[ ] Yes [ ] No

When: ....

F5 Visible mold

[ ] Yes [ ] No

Description:................................

G Activities of room users

G1 Number of people

Normal occupancy: .... individuals

During sampling/measurement, ... individuals were permanently in the room.

Pets: ....

G2 Tobacco smoke

[ ] Non-smoking room

[ ] Smoking room

Average amount of tobacco consumed in the room per day:

.... cigarettes/cigars/pipes

[ ] There was smoking in the room before the start of the measurement:

[ ] regularly

[ ] irregularly

What? ....

How much? ....

When was the last time? ....

[ ] In adjacent room

[ ] There was smoking in the room during the measurement

What? ....

How much? ....

G3 Use of products in room

Products were used in the room for the following purposes:

[ ] Cleaning the floor

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Floor care

Trade names of products: ....

[ ] rarely [ ] occasionally [ ] frequently

[ ] Furniture care

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Window cleaning

Tradename of products: ....

[ ] rarely [ ] frequently

[ ] Room-air purifier

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Insect elimination

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Cosmetics

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Hobbies

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Other

Trade names of products: ....

[ ] rarely [ ] frequently

[ ] Additive for humidifier water of ventilation and air-conditioning systems and room humidifying apparatus

Trade names of products: ....

[ ] rarely [ ] frequently

Bibliography

[1] Regional Publications. European series No. 91/2000

[2] Revised values see webpage: www.who.int/environmental_information/Air/Guidelines/Chapter3.htm

[3] VDI 4300 Part 1, *Indoor air pollution measurement — General aspects of measurement strategy*

[4] XP X 43-401, *Air quality — Strategy for sampling of chemical pollutants from indoor atmosphere of premises — Recommendations*

[5] XP X 43-402, *Air quality — Auditing of air quality in non-industrial premises — Dwelling houses and similar premises*

[6] XP X 43-403, *Air quality — Quality audit of the air in non-industrial premises — Buildings for office use and similar premises*

[7] Sondergutachten Mai 1987, *Luftverunreinigungen in Innenräumen*. Gutachten des Rates von Sachverständigen für Umweltfragen. Servicecenter Fachverlage, Kunsterdingen, Germany

[8] 2nd Regulation on Implementation of Federal German Pollution Control Act (Zweite Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes [Verordnung zur Emissionsbegrenzung von leichtflüchtigen Halogenkohlenwasserstoffen — 2. BImSchV vom 10. Dezember 1990, BGBl. 1, p. 2694, geändert am 5. Juni 1991 (BGBl. 1, p. 1218)]

[9] SEIFERT, B., Vergleich der innerhalb und außerhalb geschlossener Räume auftretenden Konzentrationen anorganischer und organischer Verbindungen. In: K. Aurand, B. Seifert and. J. Wegner (eds.): *Luftqualität in Innenräumen. Schriftenreihe Verein für Wasser-, Boden- und Lufthygiene* **53**. Gustav Fischer Verlag, Stuttgart, New York, 1982, pp. 41/74

[10] ISO 16000-7, *Indoor air — Part 7: Sampling strategy for determination of airborne asbestos fibre concentrations*

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