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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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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).

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

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.