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Indoor air —

Part 15:
Sampling strategy for nitrogen dioxide (NO_2)

Air intérieur —

Partie 15: Stratégie d'échantillonnage du dioxyde d'azote (NO_2)

Reference number
ISO 16000-15:2008(E)

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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 16000-15 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 5: Sampling strategy for volatile organic compounds (VOCs)*
- *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 7: Sampling strategy for determination of airborne asbestos fibre concentrations*
- *Part 8: Determination of local mean ages of air in buildings for characterizing ventilation conditions*
- *Part 9: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test chamber method*
- *Part 10: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test cell method*
- *Part 11: Determination of the emission of volatile organic compounds from building products and furnishing — Sampling, storage of samples and preparation of test specimens*
- *Part 12: Sampling strategy for polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs)*
- *Part 13: Determination of total (gas and particle-phase) polychlorinated dioxin-like biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDDs/PCDFs) — Collection on sorbent-backed filters*

- *Part 14: Determination of total (gas and particle-phase) polychlorinated dioxin-like biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDDs/PCDFs) — Extraction, clean-up and analysis by high-resolution gas chromatography/mass spectrometry*
- *Part 15: Sampling strategy for nitrogen dioxide* (NO_2)
- *Part 16: Detection and enumeration of moulds — Sampling by filtration*
- *Part 17: Detection and enumeration of moulds — Culture-based method*
- *Part 23: Performance test for evaluating the reduction of formaldehyde concentrations by sorptive building materials*

The following parts are under preparation:

- *Part 18: Detection and enumeration of moulds — Sampling by impaction*
- *Part 19: Sampling strategy for moulds*
- *Part 24: Performance test for evaluating the reduction of the concentrations of volatile organic compounds and carbonyl compounds without formaldehyde concentrations by sorptive building materials*
- *Part 25: Determination of the emission of semi-volatile organic compounds by building products — Micro-chamber method*
- *Part 28: Sensory evaluation of emissions from building materials and products*

The following parts are planned:

- *Part 20: Detection and enumeration of moulds — Sampling from house dust*
- *Part 21: Detection and enumeration of moulds — Sampling from materials*
- *Part 22: Detection and enumeration of moulds — Molecular methods*
- *Part 27: Standard method for the quantitative analysis of asbestos fibres in settled dust*

Furthermore,

- ISO 12219-1[1], *Indoor air — Road vehicles — Part 1: Whole vehicle test chamber — Specification and method for the determination of volatile organic compounds in car interiors,* and
- the two International Standards for indoor air, ambient air and workplace atmosphere, ISO 16017-1[44] on pumped sampling and ISO 16017-2[45] on diffusive sampling

focus on volatile organic compound (VOC) measurements.

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[1] Under preparation.

Introduction

In ISO 16000-1, general requirements relating to the measurement of indoor air pollutants and the important conditions to be observed before or during the sampling of individual pollutants or groups of pollutants are described.

This part of ISO 16000 describes basic aspects to be considered when working out a sampling strategy for the measurements of nitrogen dioxide in indoor air. It is intended to be a link between ISO 16000-1, *Indoor air — Part 1: General aspects of sampling strategy*, and the analytical procedures.

This part of ISO 16000 presupposes knowledge of ISO 16000-1.

This part of ISO 16000 uses the definition for indoor environment defined in ISO 16000-1 and Reference [1] as dwellings having living rooms, bedrooms, DIY (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 with 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 and public transport.

The sampling strategy procedure described in this part of ISO 16000 is based on VDI 4300-5 [2].

Indoor air —

Part 15:
Sampling strategy for nitrogen dioxide (NO_2)

1 Scope

This part of ISO 16000 specifies the planning of nitrogen dioxide indoor pollution measurements. In the case of indoor air measurements, the careful planning of sampling and the entire measurement strategy are of particular significance since the result of the measurement may have far-reaching consequences, for example, with regard to ascertaining the need for remedial action or the success of such an action.

An inappropriate measurement strategy may lead to misrepresentation of the true conditions or, worse, to erroneous results.

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 16000-1:2004, *Indoor air — Part 1: General aspects of sampling strategy*

3 Properties, origin and occurrence of nitrogen dioxide

Nitrogen dioxide (NO_2, CAS No. 10102-44-0) is one of the important substances of the class of nitrous gases or nitrogen oxides. NO_2 is a reddish-brown gas with a sweet to pungent odour, which is also present to a minor extent as dimeric colourless N_2O_4. Information on properties of NO_2 and its effects on humans is summarized elsewhere (see References [3], [4], [5], [6] and [7]).

In all combustion processes, nitrogen oxides (NO_x) are formed by reaction of nitrogen and oxygen. The main combustion product is nitrogen monoxide (NO), a certain fraction of which reacts further with oxygen to form nitrogen dioxide. This reaction is exothermic so that cooling combustion exhaust gases promotes this secondary NO_2 formation.

In ambient air, heating power stations, motor vehicles, industrial heating systems and building heating systems are the most important emission sources of NO_2. Indoor NO_2 emissions are formed from combustion sources such as heating and cooking with solid fuel (wood, coal), liquid fuel (oil, kerosene) or gaseous fuel [town gas, natural gas, bottled gas (propane, butane)], especially in the initial heating phase. An unflued appliance that releases combustion gases directly into the indoor air can be a particularly strong source. In the literature, there are many reports on the results of NO_2 determinations in indoor air (see References [4], [8], and [9]). On the basis of these results, the average concentrations may range from under 10 $\mu g/m^3$ to 800 $\mu g/m^3$ under different conditions [2].

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[2] In the literature, some concentrations are also reported in ppm (1 mg/m^3 corresponds to 0,53 ppm at 293 K and 1,013 bar).

The concentration measured in indoor air is influenced by the frequency, duration and intensity of the indoor combustion processes. The air change rate with the outdoors and the NO_2 concentration of the ambient air affect indoor NO_2 concentrations. Further, decomposition reactions, i.e. those aided by indoor materials and surfaces, cause a decrease in NO_2 concentration.

The emissions from gas or kerosene apparatus can vary considerably. Thus, at the same output, kerosene heaters (see Reference [10]) were found to give values that were four times higher than those from gas heaters (see Reference [11]). These concentrations are of particular importance if the combustion gases are in connection with the indoor air, as is the case in non-hermetically sealed exhaust air systems. Tobacco smoke also contributes to NO_2 concentrations.

4 Regulations

Table 1 contains the Air Quality Guidelines (AQG) of the World Health Organization (WHO) [5] [6], the risk-related guide values for indoor air of the ad hoc working group *Innenraumlufthygiene-Kommission des Umweltbundesamtes und der Obersten Landesgesundheitsbehörden (ad hoc WG IRK/AOLG)* [12], Germany, as well as the effect-related Maximum Immission Concentration Values [3] (guide values). In addition, the table gives information on ambient air limit values for NO_2. However, it shall be explicitly stated here that these ambient air values shall not be used for the assessment of indoor air, but are being cited because of the interactions between indoor air and ambient air due to air change rate, mentioned above.

Table 1 — Assessment criteria for nitrogen dioxide

Value	Measurement period	Concentration µg/m^3	Area of validity	References
WHO	1 h	200	indoor air / ambient air	WHO (2000) [5] and WHO (2006) [6]
WHO	Annual mean	40	indoor air / ambient air	WHO (2000) [5] and WHO (2006) [6]
MIK [a]	1 year 24 h	20 50	indoor air / ambient air	VDI 2310-12 [3]
Ad hoc WG IRK/AOLG	0,5 h	350	indoor air	Reference [12]
Ad hoc WG IRK/AOLG	1 week	60	indoor air	Reference [12]
Limit value [b]	1 h 1 year	200 40	ambient air	Directive 1999/30/EC [13]
U.S. National Ambient Air Quality Standard	1 year (annual arithmetic mean)	100	ambient air	Environmental Protection Agency 40 CFR Part 50 [14]
California Ambient Air Quality Standards	1 h 1 year (annual arithmetic mean)	340 (0,18 ppm) [c] 57 (0,030 ppm) [c]	ambient air	Reference [15]
Environmental Quality Standards in Japan	1 h	113 (0,06 ppm)	ambient air	Reference [16]

[a] MIK (Maximale Immissions-Konzentration, maximum immission concentration), which, if adhered to, protects man and his environment to the best of the present knowledge as derived on the basis of relevant criteria.

[b] 200 µg/m^3 may not be exceeded more frequently than 18 times in one year. Date by which these limit values are to be met in all EU countries: 1 January 2010.

[c] Not to be exceeded. Values approved by the Air Resources Board in February 2007.

5 Measurement technique

5.1 General

A number of methods exist for measuring nitrogen dioxide in indoor air. In principle, these may be divided into short-term measurement methods and long-term measurement methods. Manual analytical methods are used for short-term measurements and diffusive samplers are often used for long-term measurements. When diffusive samplers are used, the analytical part is substantially similar to that used with manual analytical methods. In addition, the continuous monitoring instruments, which are usually used for ambient air measurements, can also be used for either short- or long-term measurements. However, in this case, the instrument costs and their noise could discourage their use indoors. Pre-testing of indoor concentrations can be performed, if indicator tubes with a sufficiently low minimum detection limit and good precision are available (see 5.4).

Analytical methods for determining nitrogen dioxide, which are suitable for use in the indoor environment, are described in 5.2. Automatic measuring systems which have been type-approved for NO_2 can also be used for the analytical task (e.g. chemiluminescence method).

In addition to the methods described in these standards, the usefulness and reliability of newer methods such as sensing based on amperometric sensors should be explored.

5.2 Short-term measurements

Short-term measurements are generally taken over a period of up to one hour. Measuring short-term peak concentrations requires the use of a continuous analytical monitoring instrument having a high time resolution (10 s to 20 s). ISO 7996 [17] and ASTM D3824 [18] are such continuous monitoring methods based on the principle of chemiluminescence. Alternative methods are manual methods where NO_2 is enriched actively by using suction pumps to pass the air through the sorbent medium. Measurements shall be performed according to ISO 6768 [19], ASTM D1607-91 [20], or VDI 4301-1 [21]. These methods are manual photometric reference methods (Saltzman method) that differ only slightly. These manual methods provide an average concentration for the duration of sampling and cannot provide a specific peak concentration. It should be noted that if the three photometric reference methods (Saltzman methods) are used, then the environment to be measured should be free of tobacco smoke. Tobacco smoke interferes with the chemical reactions and shall be removed by adequate ventilation before starting sampling.

5.3 Long-term measurements

In principle, continuous monitoring instruments are suitable for long-term measurements, but, owing to the above-mentioned problems, sampling with diffusive samplers is preferable (see Annex A). Enrichment systems of this type operate according to the principle of diffusion of a substance onto an adsorbent medium. Using diffusive samplers, NO_2 concentrations are integrated over a certain time (a few hours to days). Concentration peaks are therefore incorporated into the averaged value determined over time.

Diffusive samplers for nitrogen dioxide are described in the literature, as are methods for evaluating their performance (see Annex A). For epidemiological studies consisting of a large number of measurement locations, diffusive samplers are suitable sampling devices, as these are simple and unobtrusive in daily habitual use of the room. If required, they can also be worn by test persons and thus provide information on personal exposure. Since NO_2 reacts in the presence of ultra-violet light, direct UV light should be avoided where diffusive samplers are placed.

EN 13528-3[22] is a guide to selection for use and maintenance of diffusive samplers. When diffusive samplers are used, the method shall be completely documented together with its performance characteristics and measurement uncertainties.

5.4 Pre-testing

Screening tests provide an immediate, although not necessarily precise and accurate, indication of the nitrogen dioxide concentration. Criteria for selection of such screening tests include sufficiently low minimum detection limit (e.g. maximum 50 µg/m^3) and adequate precision (e.g. 25 %). Commercially available test tubes and direct-reading diffusive samplers meeting these criteria may be available that are relatively simple to use and provide results for planning further procedures. The results of screening tests may be used to decide whether further measurements are required. In certain cases, the screening tests may indicate that no further measurements are required (see Annex B). A nitrogen dioxide concentration near or above a given guideline value would emphasize the need for further measurements using the measurement techniques described in 5.2.

The screening tests should be conducted using the principles described above to design an appropriate strategy. Examples of screening tests are given in Annex B.

6 Measurement planning

6.1 General

In Clause 3, it is mentioned that the occurrence of nitrogen dioxide in indoor air is principally due to combustion processes using open flames. It may be concluded from this that domestic households will primarily be subject to corresponding investigations. It will be necessary to take into account here, as important factors, the emission characteristics of the sources (the majority will be point sources with intermittent emission) and the effect of ambient air due to air change. The results of a survey carried out in advance are an important component of measurement planning.

6.2 Measurement objective and boundary conditions

6.2.1 General

Before indoor air measurements can be carried out, the purpose of the measurement shall be clearly defined. The following types of objectives are possible when nitrogen dioxide concentrations are being determined:

a) compliance testing [checking compliance with a guideline value (e.g. in the case of complaints)];

b) research studies [studies with objectives such as determining indoor air pollution of significance to health (e.g. during epidemiological study programmes)];

c) determining the ratio of indoor and ambient air concentrations.

6.2.2 Compliance testing

A comparison of the data in Tables 1 and 2 shows concentrations exceeding preset guideline values. For this reason, checking of compliance with guideline values is important. If it is suspected that a guideline value has been exceeded, measurements shall in general be made under the conditions specified in connection with the guideline value.

Because of the intermittent character of the usual NO_2 sources, NO_2 shall be determined in indoor air under the conditions of use. Since these vary, the patterns of behaviour of the users with respect to activity of NO_2 sources shall be taken into account and documented in measurement planning. In cases of complaints, it should be noted that behaviour of users affects NO_2 emissions (including behaviour related to cooking practices and the thermostat setting, which influences space heating). Thus, it is important to carefully consider this issue in measurement planning.

To improve classification of the measurement result, and for a better understanding of the situation to offer recommendations on remediation,

- it is advisable to conduct and, if necessary, repeat measurements under particularly unfavourable conditions, i.e. with all available NO_2 sources activated,
- if specific complaints on the part of the room users arise under differing conditions, a measurement shall also be performed under these conditions for clarification, and
- when rooms which are ventilated via an air-conditioning system are investigated, the system shall be operated for 3 h under the usual operating conditions for the room prior to sampling.

After the measurement programme, is completed, if the offered advice requires changes in behaviour to reduce NO_2 concentrations, such recommendations should be practical and presented in a form that is acceptable to the user.

6.2.3 Research studies

An important first step in conducting research studies related to NO_2 concentrations or exposures requires that objectives of such studies be clearly established. In recent years, the NO_2 exposure of population groups has been investigated in various studies, including indoors, and the effect of operating gas appliances in dwellings has been studied in detail (see References [8] and [23]). It was found in these studies that the level of NO_2 emissions and NO_2 ambient air concentrations differs from user to user, from room to room and over time, *inter alia*, so that careful measurement planning is of the highest importance. The question as to whether the effect of concentration peaks which persist for only a short time or the mean exposure over a relatively long period is to be investigated is of considerable importance. In the first case, the use of automatic monitoring instruments is to be contemplated, and the measurement time and measurement period shall be selected as a function of the emission situation; in the second case, the use of diffusive samplers is generally appropriate.

After determining the objectives or specific goals for such studies, background information needs to be assembled. For example, information on the health effects of nitrogen dioxide can be obtained from chamber experiments performed under controlled conditions and using epidemiological field studies (see Reference [3]). Chamber experiments usually focus on the acute effect of relatively high concentrations, which occur over a relatively short period. In contrast, in epidemiological studies, the effect is frequently related to the more long-term mean concentrations, since for analytical reasons sufficiently high time resolution of the concentrations cannot be made. Additionally, workplace exposure studies, generally involving higher levels of concentrations, can be explored as necessary.

The measurements shall be performed under the climatic conditions of the room under which the room being investigated is usually used. These conditions should be within the comfort zone (see Reference [24]). If this is not possible, for example in kitchens where there is heating caused by the use of appliances, the practice can deviate from this. In all cases, deviations shall be justified and documented. Likewise, the type of active NO_2 sources and the duration of their activity during sampling shall be documented.

Since the sampling period is usually between one day and one week when diffusive samplers are used, no particular preparation of the room is required. In each case, tests shall be made to establish the performance of the sampler used, especially with regard to stability of the sampling medium and whether the amount of substance collected is sufficient for the envisaged sampling period.

Since diffusive samplers determine only average concentrations as long-term measurement methods (see 5.3), concentration peaks cannot be determined using the procedure described here.

6.2.4 Determining the ratio of indoor and ambient air concentrations

In contrast to most organic indoor air pollutants, NO_2 can also be present in ambient air at elevated concentrations and can thus cause higher NO_2 concentrations in indoor air. This is to be expected especially if the indoor space under consideration is located near a street canyon having heavy vehicle traffic. In this case, it is advisable to measure the ambient air concentration of NO_2 at the same time as the indoor air concentration. The result can be helpful with ventilation recommendations.

The I/A ratio of the indoor air concentration to the ambient air concentration provides information on the sources influencing the indoor air: if the quotient is less than one, the ambient air sources dominate; if it is greater than one, this indicates sources in the room. However, this rule is not valid under all conditions. It fails, for example, in the following cases:

- when only the result of an individual short-term measurement is considered (it is perfectly possible for I/A to be greater than 1 without a source being present in the room: if the NO_2 concentration in the ambient air decreases rapidly in a short time, for instance owing to change in wind direction, for a short time higher values may still be present in the room);
- when ambient air measurements are not recorded immediately in the vicinity of the building;
- when there are indoor sinks for NO_2, along with “scrubbing” or filtration of ambient NO_2 by the building envelope. If the indoor source is relatively infrequent and a long-term measurement is taken, the I/A ratio may be less than 1 even though the ratio could be well above 1 at times when the source is operating.

6.3 Measurement time

The measurement time is given by the measurement objective (see 6.2). In selecting a suitable measurement time, the concentration differences occurring at relatively long time intervals (e.g. annual variations, heating period/heating-free period), as well as concentration changes which are short-term in nature (gas oven usage, tobacco smoke, ventilation), shall also be taken into account.

6.4 Sampling period and measurement frequency

The measurement period is also determined by the measurement objective (see 6.2). The measurement frequency shall be incorporated into the measurement plan in accordance with the measurement objective and should be based on the measurement uncertainty (see 6.6) and the necessity of detecting peak values. Guidance on the effect of the averaging period on the concentration values is provided using the data of Reference [25] (see Table 2). The data were obtained using the continuously recorded data averaged over different periods. The ambient air concentrations during this time were 25 µg/m^3 to 70 µg/m^3. These results demonstrate that the range of short-term values can be much wider than the long-term values for the time period and location under consideration.

Table 2 — Ranges of NO_2 maxima for measurement periods of 1 min, 1 h and 24 h and with averaging over all 12 dwellings studied according to Reference [25]

	Maximum concentration in µg/m^3		
Location	**1 min average**	**1 h average**	**24 h average**
Kitchen	400 to 3 800	230 to 2 000	50 to 480
Living room	200 to 1 000	100 to 900	50 to 260
Bedroom	60 to 800	50 to 700	20 to 100

In the U.S., a similar relationship was observed when the relationship between 24 h averages (maximum 24 h average 800 µg/m^3) of NO_2 and corresponding annual average (200 µg/m^3) were examined based on the data available in the 1960s [26] as reported in Reference [27].

6.5 Measurement location

Generally, one sampling point per room will be sufficient; this should be at a height of 1,50 m and at a distance of at least 1 m to 2 m from the walls. In kitchens, when gas appliances are being operated, it shall be expected that concentration gradients can build up (see References [28] and [29]). If required, measuring the airflow conditions can give helpful information here. The flow conditions can be established using a hand-held anemometer. To investigate the dispersion and distribution of NO_2 in the room, and in the search for sources, pre-tests can also be performed using direct-indicating testing tubes. The sampling plan shall always include a measurement in the main area occupied by the room users.

If, for particular questions, the measured values obtained in the room are to be related to those present in the ambient air, the ambient air shall be sampled in the vicinity of the room under test (e.g. balcony or in front of a window not used for room ventilation).

If an outer wall fireplace is present, the effect of exhaust air on the ambient air acting on the room shall be taken into account in the selection of the measurement point.

In the case of a building with mechanical intake of outdoor air for its air-conditioning system, the ambient air measurement shall be performed in the vicinity of the outdoor air supply inlet.

6.6 Measurement uncertainty and presentation of result

During measurement planning, the measurement uncertainty shall be specified, as well as the performance characteristics to be included in the measurement report.

Measurement uncertainties are inevitable. They are caused especially by the fact that the number of measurements is always limited and by uncertainties in the analytical determination. The uncertainty range of the result is decreased by increasing the number of parallel measurements. However, the representativeness of the result of an individual measurement or of parallel measurements shall be seen within the context of concentration changes in time and space. If the measured value is close to the guideline value under test, it is advisable to perform a repeat measurement.

If parallel measurements have been carried out, in addition to the mean value the individual values shall also be reported. The standard deviation is then suitable for reporting the measurement uncertainty.

The measurement report should contain, in addition to a reference to the analytical method used, a presentation of the performance characteristics valid at the time when the measurement was carried out, especially the limits of detection and determination.

When diffusive samplers are used, the conversion equation used to calculate the result shall be reported.

In the measurement results, numerical data are usually reported so that the last decimal place (significant place) at the same time reflects the order of magnitude of the measurement uncertainty.

6.7 Quality assurance

Depending on the objective, preparation of the room before beginning measurements, the measurement time, the sampling period and the frequency and location of measurement shall be specified. In addition, it is necessary to comply with and record, before and during measurements, the specified boundary conditions which relate especially to the ventilation state and complete documentation of the use of sources which emit nitrogen dioxide in the indoor environment and in the immediate vicinity of the building. Such a protocol should be established during the appropriate measurement planning. General guidelines concerning information to be recorded during indoor air measurement are given in ISO 16000-1:2004, Annex D.

For quality assurance, in each analytical series, a field blank shall also be included and analysed. The analytical effort should be commensurate with the objective. When diffusive samplers are used, at least two samplers per room should be used.

The quality demands of the client shall be defined in the measurement strategy.

To select and define the elements of quality assurance, the following questions should be addressed when preparing the sampling strategy:

- Does the measuring laboratory have a documented quality assurance system (e.g. according to ISO/IEC 17025 [30])?
- What calibration procedures are used, how often and how extensively?
- Are collocated measurements necessary?
- How are the uncertainties defined (e.g. according to the GUM [31])?
- Does the laboratory participate in interlaboratory tests?

Annex A
(informative)

Information on diffusive samplers

NO_2 sampling by diffusive transport to triethanolamine was used for the first time by Palmes (see References [32], [33], [34] and [35]). The diffusive samplers consist of round Plexiglas tubular pieces and onto one end are fastened triethanolamine-coated stainless steel nets (cellulose or glass fiber filters have also been used). The steel nets are extracted with water after exposure of the sampler. The extract is used for photometric determination, for example using the Saltzman method [19]. The detection limit after 24 h exposure of the sampler is 28 µg of NO_2/m^3 and, after an exposure of one week, 4 µg of NO_2/m^3. The diffusive sampler can be sent by post and (sealed with a stopper) kept for up to six months at room temperature after exposure (see Reference [36]).

Other diffusive samplers based on the same principles as the Palmes tubes have been designed and are typically more sensitive and reproducible; therefore, more modern diffusive devices are often used (see References [37], [26], and [27]). Ion chromatography is often used for analysis.

Diffusive samplers shall be tested under room conditions using an independent method (ISO 6768) [19] (see also References [38] and [39]). Any effects of temperature, relative humidity and air movement should be taken into account during this testing. A certain minimum air flow is necessary — in the case of Palmes tubes in the range between 0,05 m/s and 0,1 m/s (Reference [40]), 0,1 m/s in the case of samplers of the badge type (Reference [41]), since the substance from the environment is brought to the enriching medium by diffusion within the system, and not using a pump, as is the case with active measurement systems. If, owing to insufficient air movement, an inadequate number of molecules is transported to the tube, the atmosphere in the immediate vicinity of the sampler becomes depleted, which leads to an underestimation of the concentration (Reference [42]). The extent of this effect is dependent on the sampler geometry.

Annex B
(informative)

Examples of screening tests

B.1 General

Screening test methods are of the type which can quickly provide an indication of the air pollution present without using expensive analysis techniques. They are an important tool to compensate for a lack of information. The result can facilitate a decision as to the extent of further required measurements. When using screening tests, the basic demands of the measuring strategy have still to be considered (see 5.4).

B.2 Direct-reading detector tubes

Direct-reading detector tubes measure nitrogen dioxide in the range of 48 µg/m^3 to 19,1 mg/m^3 (0,025 ppm to 10 ppm). Typical commercially available devices respond with changes in colouration of the layer when nitrogen dioxide is present in the air. The measuring system consists of the detector tube and a bellows pump to suck the air sample through the tube. The detector tube contains a granular layer which is impregnated with N,N-diphenylbenzidine for the detection of nitrogen dioxide (Reference [43]). The volume which is drawn with the bellows pump through the detector tube depends on the nitrogen dioxide concentration in the air sample.

Table B.1 — Sample volumes and measuring ranges of a typical detector tube

Measuring range of NO_2 ppm	**Air sample volume** l	**Valid scale range** ppm	**Evaluation**	**Standard deviation** %
0,5 to 10	0,5	0,5 to 10	indication = ppm	10 to 15
0,25 to 1	1	0,5 to 2	indication : 2 = ppm	10 to 15
0,05 to 0,2	5	0,5 to 2	indication : 10 = ppm	30
0,025 to 0,1	10	0,5 to 2	indication : 20 = ppm	30

In the presence of nitrogen dioxide, the following reaction takes place:

$$NO_2 + C_6H_5–NH–C_6H_4–C_6H_4–NH–C_6H_5 \rightarrow \text{bluish grey reaction product}$$

When nitrogen dioxide is present in the air, a colour change from pale grey to bluish grey will occur. The length of the colour change is a measure of the concentration and can be read from the scale of the tube. If there is no colour change or the reading is significantly below the guide value, no further measurements are required. Interfering pollutants are chlorine and ozone which react in the same way as nitrogen dioxide. Nitrogen monoxide is not indicated.