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Indoor air – Part 15: Sampling strategy for nitrogen dioxide (NO₂) (ISO 16000-15:2008)

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EUROPEAN STANDARD
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English Version

**Indoor air - Part 15: Sampling strategy for nitrogen dioxide
(NO₂) (ISO 16000-15:2008)**

Air intérieur - Partie 15: Stratégie d'échantillonnage du
dioxyde d'azote (NO₂) (ISO 16000-15:2008)

Innenraumluftverunreinigungen - Teil 15:
Probenahmestrategie für Stickstoffdioxid (NO₂) (ISO
16000-15:2008)

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Foreword

This document (EN ISO 16000-15:2008) has been prepared by Technical Committee ISO/TC 146 "Air quality" in collaboration with Technical Committee CEN/TC 264 "Air quality" the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2009, and conflicting national standards shall be withdrawn at the latest by January 2009.

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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 (NO₂)

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 (NO₂, CAS No. 10102-44-0) is one of the important substances of the class of nitrous gases or nitrogen oxides. NO₂ is a reddish-brown gas with a sweet to pungent odour, which is also present to a minor extent as dimeric colourless N₂O₄. Information on properties of NO₂ 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 NO₂ formation.

In ambient air, heating power stations, motor vehicles, industrial heating systems and building heating systems are the most important emission sources of NO₂. Indoor NO₂ 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 NO₂ determinations in indoor air (see References [4], [8], and [9]). On the basis of these results, the average concentrations may range from under 10 µg/m³ to 800 µg/m³ under different conditions ²⁾.

2) In the literature, some concentrations are also reported in ppm (1 mg/m³ corresponds to 0,53 ppm at 293 K and 1,013 bar).

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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 NO₂ concentration of the ambient air affect indoor NO₂ concentrations. Further, decomposition reactions, i.e. those aided by indoor materials and surfaces, cause a decrease in NO₂ 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 NO₂ 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 NO₂. 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/m³ 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 NO₂ 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 NO₂ 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, NO₂ 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 NO₂ 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.