SLOVENSKI STANDARD
SIST EN 16980-1:2021

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Nadomešča:
SIST-TS CEN/TS 16980-1:2017

Fotokataliza - Metode preskušanja kontinuiranega pretoka - 1. del: Ugotavljanje razgradnje dušikovega oksida (NO) v zraku z materiali fotokatalize

Photocatalysis - Continuous flow test methods - Part 1: Determination of the degradation of nitric oxide (NO) in the air by photocatalytic materials

Photokatalyse - Prüfverfahren mit kontinuierlichem Durchfluss - Teil 1: Bestimmung des Abbaus von Stickstoffmonoxid (NO) aus der Luft durch photokatalytische Werkstoffe

Photocatalyse - Méthodes d'essai en flux continu - Partie 1 : Mesure de la dégradation du monoxyde d'azote (NO) dans l'air par un matériau photocatalytique

Ta slovenski standard je istoveten z: **EN 16980-1:2021**

ICS:

13.040.20	Kakovost okoljskega zraka	Ambient atmospheres
25.220.20	Površinska obdelava	Surface treatment

SIST EN 16980-1:2021 **en,fr,de**

EUROPEAN STANDARD

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EUROPÄISCHE NORM

EN 16980-1

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ICS 13.040.20; 87.040; 87.060.20; 91.100.10

Supersedes CEN/TS 16980-1:2016

English Version

Photocatalysis - Continuous flow test methods - Part 1: Determination of the degradation of nitric oxide (NO) in the air by photocatalytic materials

Photocatylyse - Méthode d'essai en flux continu - Partie 1 : Détermination de la dégradation du monoxyde d'azote (NO) dans l'air par des matériaux photocatalytiques

Photokatalyse - Prüfverfahren mit kontinuierlichem Durchfluss - Teil 1: Bestimmung des Abbaus von Stickstoffmonoxid (NO) aus der Luft durch photokatalytische Werkstoffe

This European Standard was approved by CEN on 9 May 2021.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 16980-1:2021) has been prepared by Technical Committee CEN/TC 386 “Photocatalysis”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by March 2022, and conflicting national standards shall be withdrawn at the latest by March 2022.

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

This document supersedes CEN/TS 16980-1:2016.

EN 16980-1:2021 includes the following significant technical changes with respect to CEN/TS 16980-1:2016:

— 3.2

  — addition of: “A sample illuminated surface area in m^2”

  — deletion of: “CIN concentration at reactor inlet” and “Fv,I fan flow at ith potential”

  — modification of abbreviations: “F Flow” to “Q Flow”, “V0” to “U_0”, “Vmin” to “U_{min}”, “MM” to “M”

— 6.3 (before 6.2) Modification of Figure 2

— 7.1 updated sentence: “Samples shall be eventually preconditioned following the supplier advices.”

— 8.1 updated formula: $C\left(\mu g\ m^{-3}\right) = 10^3 \frac{C\left(ppmv\right) \times M \times P}{R \times T} = ppmv \times k$

— 12 (before 11):

  — addition of: “a) international Standard used (including its year of publication)”;

  “b) any deviations from the procedure”;

  “c) the date of the test”;

— Annex A: change of figure “Typical trend of NO, NO_2 and NO_x concentrations during a photocatalytic test at nominal fan speed”

— Annex B: change of figure “Typical trend of NO, NO_2 and NO_x concentrations during a photocatalytic test at nominal fan speed”.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North

Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies a method for assessing the performance of photocatalytic inorganic materials contained in cement mortars and/or limes or ceramic-based matrices, paints or materials deposited as thin films or coatings on a variety of substrates for the photocatalytic abatement of nitric oxide in the gas phase. This method does not apply to the assessment of samples to be applied with flow perpendicular to the surface or flow permeating the surface itself as polymeric and paper filters, honeycomb structures and suchlike.

The performance for the photocatalytic sample under test is evaluated by measuring the degradation rate of nitric oxide (NO) using the method specified herein. The photocatalytic abatement rate is calculated from the observed rate by eliminating the effects of mass transfer. The intrinsic photocatalytic abatement rate is an intrinsic property of the material tested and makes it possible to distinguish the photocatalytic activities of various products with an absolute scale defined with physical and engineering meaning.

For the measurements and calculations described in this document the concentration of nitrogen oxides (NO_X) is defined as the stoichiometric sum of nitric oxide (NO) and nitrogen dioxide (NO_2).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

CEN/TS 16599, *Photocatalysis — Irradiation conditions for testing photocatalytic properties of semiconducting materials and the measurement of these conditions*

EN ISO 9169, *Air quality — Definition and determination of performance characteristics of an automatic measuring system (ISO 9169)*

ISO 7996:1985, *Ambient air — Determination of the mass concentration of nitrogen oxides — Chemiluminescence method*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms, definitions and abbreviations apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
concentration of nitrogen oxides
NO_X
stoichiometric sum of nitric oxide (NO) and nitrogen dioxide (NO_2)

Note 1 to entry: For grade 999 nitrogen or air, the purity of the gas should be equal at least to 99,9 %.

3.1.2
photocatalyst
catalyst able to produce, upon absorption of light, chemical transformations of the reaction partners

Note 1 to entry: The excited state of the photocatalyst repeatedly interacts with the reaction partners forming reaction intermediates and regenerates itself after each cycle of such interactions.

3.1.3
photocatalytic material
material in which or on which the photocatalyst is added by coating, impregnation, mixing, etc.

3.2 Abbreviations and symbols

A	sample illuminated surface area in m^2
C	concentration
CSTR	Continuous Stirred-Tank Reactor
C^{IN}	concentration of NO and NO_2 at reactor inlet
$C^{\mathrm{OUT,DARK}}$	concentration of NO and NO_2 at reactor outlet under stable conditions in the dark (no illumination)
$C^{\mathrm{OUT,LIGHT}}$	concentration of NO and NO_2 at reactor outlet under stable conditions with illumination (lamp on) without sample
$C_{\mathrm{NO}}^{\mathrm{IN}}$	concentration of NO at reactor inlet
$C_{\mathrm{NO_2}}^{\mathrm{IN}}$	concentration of NO_2 at reactor inlet
$C_{\mathrm{NO}}^{\mathrm{OUT,DARK}}$	concentration of NO at reactor outlet under stable conditions in the dark (no illumination) without sample
$C_{\mathrm{NO_2}}^{\mathrm{OUT,DARK}}$	concentration of NO_2 at reactor outlet under stable conditions in the dark (no illumination) without sample
$C_{\mathrm{NO,S}}^{\mathrm{OUT,DARK}}$	concentration of NO at reactor outlet under stable conditions in the dark (no illumination) in presence of sample
$C_{\mathrm{NO_2,S}}^{\mathrm{OUT,DARK}}$	concentration of NO_2 at reactor outlet under stable conditions in the dark (no illumination) in presence of sample
$C_{\mathrm{NO}}^{\mathrm{OUT,LIGHT}}$	concentration of NO at reactor outlet under stable conditions with illumination (lamp on) without sample
$C_{\mathrm{NO,0}}^{\mathrm{OUT,LIGHT}}$	concentration of NO at reactor outlet under illumination of sample measured at fan speed at nominal voltage U_0
$C_{\mathrm{NO_2}}^{\mathrm{OUT,LIGHT}}$	concentration of NO_2 at reactor outlet under stable conditions with illumination (lamp on) without sample
$C_{\mathrm{NO_2,0}}^{\mathrm{OUT,LIGHT}}$	concentration NO_2 at reactor outlet under illumination of sample measured at fan speed nominal voltage U_0
k_{R}^{0}	intrinsic NO photocatalytic abatement rate

I	irradiance
LED	light emitting diodes
M	molecular mass
n_{calc}	calculated nominal value
P	pressure in atmosphere
PTFE	polytetrafluoroethylene
Q	flow
$Q_{v,0}$	nominal fan flow set by the manufacturer at the applied nominal potential U_0
	fan flow at its applied potential (i = 0..n)
R	ideal gas constant
RH	gas relative humidity at 25 °C inside the reactor
$U_{v,i}$	fan flow at its applied potential (i = 0..n)
η_{NO}^{dark}	conversion of NO in the dark
$\eta_{NO_2}^{dark}$	conversion to NO_2 in the dark
$\eta_{NO,lamp}^{PHOTO}$	conversion of NO under illumination without sample
$\eta_{NO\ ,i}^{total}$	conversion of NO measured at each fan flow $Q_{v,i}$
$\eta_{NO_2\ ,i}^{total}$	conversion to NO_2 measured at each fan flow $Q_{v,i}$
$v_{NO,i}^{photo}$	NO abatement rate at each fan flow $Q_{v,i}$
$v_{NO_2\ ,i}^{photo}$	NO_2 photocatalytic production rate at each fan flow $Q_{v,i}$
$v_{NO_x\ ,i}^{photo}$	NO_x abatement rate corresponds to NO abatement rate minus NO_2 photocatalytic production rate
$v_{NO}^{photoCAT}$	NO photocatalytic degradation rate intrinsic to the surface of the material, after removing the mass transfer limitations
$v_{NO_X}^{photoCAT}$	NO_x photocatalytic degradation rate intrinsic to the surface of the material, after removing the mass transfer limitations
UV-A	ultraviolet with wavelength (λ) situated between 315 nm and 400 nm (IUPAC)
U_0	fan nominal operating potential (in Volt)
U_{min}	fan minimum operating potential (in Volt) set by the manufacturer
S	sample
T	temperature in Kelvin
t_{stab}	time to reach the stability of NO concentration
UV	UltraViolet

V_r reactor net volume

4 Principle

The method consists in measuring the photocatalytic abatement of nitric oxide (NO) by photocatalytic materials as specified in Clause 1 using a Continuous Stirred-Tank Reactor (CSTR) with flow tangential to the sample. Information on the theory is reported in the specialized literature (Minero et al. 2013). The residual NO and NOx concentration at the CSTR outlet is measured by a chemiluminescence analyser accordingly to ISO 7996:1985.

The photocatalytic activity test is carried out using chromatographic grade air, also obtained by mixing pure gases, to which NO is added in such an amount as to simulate a high degree of air pollution. The NO concentration is set to (0,50 ± 0,05) ppmv.

5 Interferences

The measurement's interferences are reported in the technical specifications of the chemiluminescence analyser. As what is measured are all species that can be converted by reduction to NO, NO_2 concentration is here defined as $[NO_2] = [NO_x]-[NO]$. For interferences on chemiluminescence detection, see Winer et al. (1974).

6 Apparatus

6.1 General

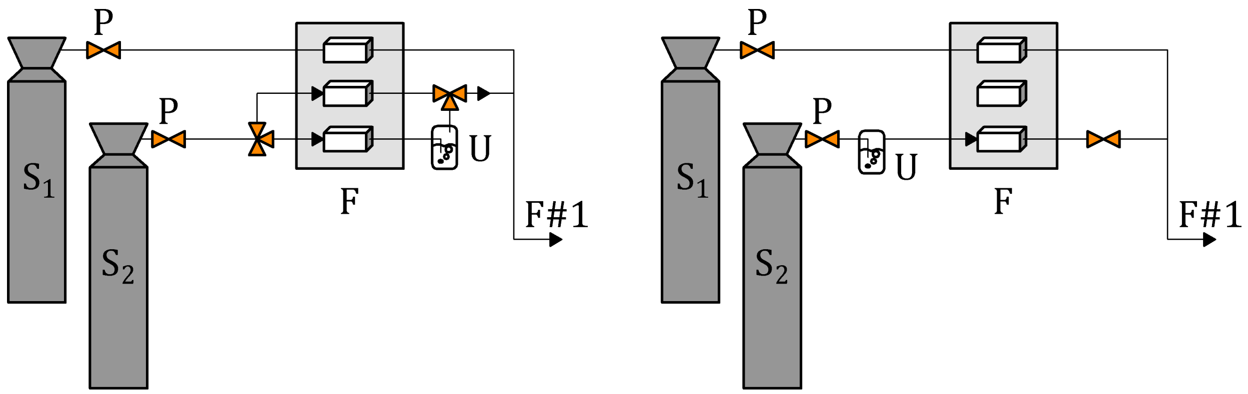
The test apparatus shall consist of the following main components.

6.2 Gas mixture preparation system

The system used for preparing the reaction mixture is shown in Figure 1.

The mass flow controllers, calibrated and traceable, shall ensure a maximum flow consistent with that needed for a correct test execution. To ensure the necessary accuracy, the flow shall not exceed 90 % of the rated full scale.

As an example, to obtain the gas mixture only gases of chromatographic grade or higher purity shall be used. Instead of dry air cylinders, two separate cylinders of pure N_2 and O_2 can be used at the inlet of mass-flow controllers, adjusted so as to produce a mixture consisting of 20,8 % of O_2 and 79,2 % of N_2. The NO concentration to flow #1 is set to (0,50 ± 0,05) ppmv.



a) Relative humidity is set by regulating the flow to U, which is downstream to F

b) Relative humidity is set by regulating the pressure before U and F

Key

S_1 source of nitric oxide NO diluted in N_2

S_2 cylinder of air (chromatographic grade) or, alternatively, individual cylinders of N_2 and O_2 (chromatographic grade)

F flow controller with mass-flow controllers (2 or 3)

P pressure regulators with low-pressure manometers

U humidifier maintained at controlled temperature

F#1 flow entering the reactor

Figure 1 — Gas mixture preparation system

The humidification of the gas mixture can be obtained with two different configurations:

a) using two mass flow controllers regulating the flow to U, as in Figure 1 a;

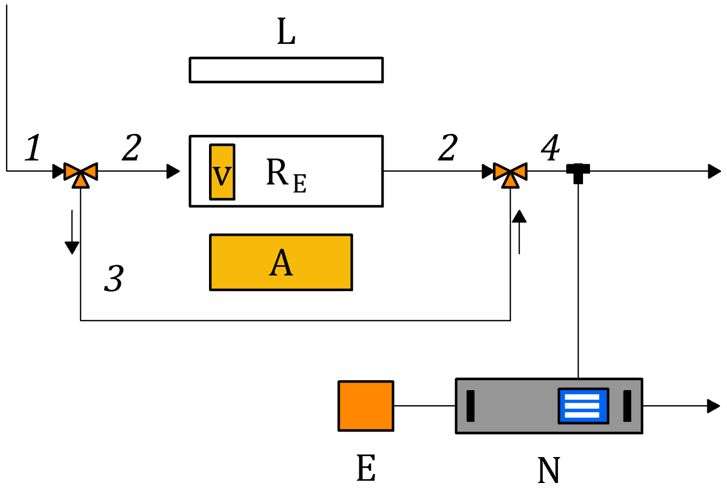
b) using one mass flow controller regulating the pressure on U, as in Figure 1 b.

The gas mixture preparation system shall ensure a relative humidity of (40 ± 5) % inside the CSTR reactor. The relative humidity shall be measured either inside the reactor R_E (see Figure 2) or immediately at its outlet on flow 2 of Figure 2 by means of a hygro-thermometer.

6.3 Illumination and measuring system

6.3.1 General

The light source arrangement and the measuring system are shown in Figure 2.



Key

R_E	reaction chamber, Continuous Stirred-Tank Reactor (CSTR) type
V	fan
A	power supply of fan V
N	NO/NO_2 chemiluminescence analyser
E	processing/logging unit
L	illumination system
1, 2, 3, 4	flow paths, with valves and tubing

Figure 2 — Illumination, reaction and measuring system

All parts of the test apparatus, including connections and pipes, which come into contact with the nitric oxide mixture should be made of chemically inert materials. For pipes and connections PTFE is recommended. The pipes of paths 1, 2, 3, 4 and the related connections shall have an outer diameter of 6×10^{-3} m (1/4") and inner clearance of at least 4×10^{-3} m to avoid overpressures that can affect the gas concentration inside the reactor.

Temperature should be measured and recorded inside the reactor during the test or immediately at its outlet on flow 2 by means of a hygro-thermometer. The gas temperature inside the reaction chamber should be (25 ± 5) °C.

6.3.2 Illumination system *L*

The illumination source shall consist of any lamp able to excite the photocatalyst (quartz mercury vapor lamps, UV-A fluorescent lamps, Xenon lamps, LEDs, lamps consisting of a metal vapor element combined with tungsten incandescence elements, etc.) as specified in the Technical Specification CEN/TS 16599.

The illumination system shall provide an average irradiance to the test sample surface within the range of wavelengths that are mostly adsorbed by the photocatalyst, equal to (10,0 ± 0,5) W/m^2.

The geometry of the illumination system shall be such that uniform illumination of the sample surface is ensured. The illumination is considered uniform if five independent measurements performed on the surface (one in centre position and the other four in positions perpendicular to each other and next to the edge of the sample) show a percentage variation compared to the average value of less than 10 %. The control of the uniformity of illumination and average irradiance shall be repeated each time the system geometry changes (position of the lamp or any filters or reflectors, sample position, etc.).