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Information technology — Office equipment — Determination of chemical emission rates from electronic equipment

Technologies de l'information — Équipement de bureau — Détermination des taux d'émission chimique d'un équipement électronique

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

ISO/IEC 28360 was prepared by Ecma International (as ECMA-328) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

This corrected version of ISO 28360:2015 incorporates the following corrections.

Figures 1, 2, 3, 4 and 5 have been replaced with revised versions containing the correct cross-references.

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Introduction

Globally, governmental agencies, academic institutions, environmental organizations and manufacturers have developed methods to determine chemical emissions from electronic equipment. These attempts however, resulted in a range of tests from which the results are not necessarily comparable, either qualitatively or quantitatively.

Following the publications of the 1st edition of ECMA-328 and the “Test method for the determination of emissions from Hard Copy Devices” (RAL-UZ 122), experts from the BAM and Ecma have collaborated to harmonise methods to determine the chemical emission rates from ICT & CE equipment in this 2nd edition.

In addition to stricter test procedures, the second edition uses generalised emission formulae, and their derivations developed in Annex C, to calculate emission rates from concentrations of analytes that are measured in Emission Test Chambers.

The 3rd edition was fully aligned with the 1st edition of ISO/IEC 28360:2007 adopted under ISO/IEC JTC 1's fast track procedure and published in September 2007.

In addition, the 4th edition fixes a number of errata on ISO/IEC 28360:2007 that JTC 1/SC 28 identified.

Following the publications of the 4th edition of ECMA-328 and the “Test method for the determination of emissions from Hard Copy Devices” (RAL-UZ 122), experts from the BAM, WKI, JBMIA and Ecma have collaborated to harmonise methods to determine the Fine Particle (FP) and Ultrafine Particle (UFP) emissions from hard copy devices in the 5th edition.

The 6th edition of ECMA-328 was aligned with the 2nd edition of ISO/IEC 28360:2012, and it added a new ozone calculation method. “Test method for the determination of emission from Hard Copy Devices” (RAL-UZ 122) has been replaced by “Test method for the determination of emission from Hard Copy Devices” (RAL-UZ 171) published in January 2013. Therefore, “RAL-UZ 122 option” is replaced with “RAL-UZ 171 option” in the 6th edition.

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Information technology — Office equipment — Determination of chemical emission rates from electronic equipment

1 Scope

This International Standard specifies methods to determine chemical emission rates of Analyte from ICT & CE equipment during intended operation in an Emission Test Chamber (ETC).

The methods comprise preparation, sampling (or monitoring) in a controlled ETC, storage and analysis, calculation and reporting of emission rates.

This International Standard includes specific methods for equipment using consumables, such as printers, and equipment not using consumables, such as monitors and PC's. Annex A specifies monochrome and colour print patterns for use in the operating phase of EUT using consumables (e.g. paper).

Examples of EUT that do not use consumables are:

- Monitors and TV sets (CRT, Plasma, LCD, Rear projector, Beamer).
- Video (VCR, DVD Player/Recorder, Camcorder).
- SAT Receiver (Set-Top Box).
- Audio units (CD Player/Recorder, Home theatre Systems, Audio Home Systems, Micro-/Mini, Midi Systems, Amplifier, Receiver).
- Portable Audio (CD Player, MP 3 Player, Radio recorder, Clock radio etc).
- Computer (desktop, tower, server), portable computers (Notebooks).

Emission rates from EUT using consumables may also be determined according to additional requirements identified by "RAL-UZ 171 Option".

Calculations use the generalised model and approximations thereof as developed in Annex C.

The emission rates determined with this method may be used to compare equipment in the same class.

Predictions of "real indoor" *concentrations* from the determined *emission rates* are outside the scope of this International Standard.

2 Conformance

Determinations of emission rates and total number of emitted particles conform to this International Standard when:

1. Executed using a Quality Assurance Project Plan, Quality Assurance and Quality Control as specified in ISO 16000-9;
2. Tested in a controlled ETC as specified in Clause 7;
3. Sampled/monitored and calculated as specified in Clause 8 and Annex B;
4. Reported as specified in Clause 9.

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For EUT using consumables, determinations according to additional requirements identified by “RAL-UZ 171 Option” herein conform to the RAL-UZ 171 Option.

3 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.

ECMA-74, *Measurement of Airborne Noise emitted by Information Technology and Telecommunications Equipment*

ISO 554:1976, *Standard atmospheres for conditioning and/or testing – Specifications*

ISO 13655:1996, *Graphic technology – Spectral Measurements and colorimetric computation for graphic arts images*

ISO 16000-3:2001, *Indoor air – Part 3: Determination of formaldehyde and other carbonyl compounds – Active sampling method*

ISO 16000-6:2011, *Indoor air – Part 6: Determination of volatile organic compounds in indoor and chamber air by active sampling on TENAX TA sorbent, thermal desorption and gas chromatography using MS/FID*

ISO 16000-9:2006, *Indoor air – Part 9: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method*

ISO 16017-1:2000, *Indoor ambient and workplace air - Sampling and analysis of volatile organic compounds by sorbent tube / thermal desorption / capillary gas chromatography – Part 1: Pumped sampling*

EN 55013:2013, *Sound and Television Broadcast Receivers and associated equipment – Radio disturbance characteristics – Limits and methods for measurement*

CIE 15:2004, *Commission Internationale de l’Eclairage – Colorimetry, 3rd edition*

4 Terms and definitions

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

4.1
averaged concentration time series
simple Moving Average of total particle number concentration (Cp) over 31±3 seconds

4.2
averaged ozone concentration time series
Simple Moving Average of ozone concentration (Co3) over 80±5 seconds

4.3
aerosol
suspension of fine solid particles and/or liquid droplets in a gas

4.4
aerosol measuring system
AMS
device for measuring the total number concentration of aerosol particles within a size range at a certain frequency

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4.5
air exchange rate
n
ratio (n) of the volume of clean air brought into the ETC per hour [m^3/h] to the unloaded ETC volume [m^3]

4.6
air velocity
air speed [m/s] measured in the unloaded ETC

4.7
analyte
volatile organic compounds (VOC), carbonyl compounds, ozone, particulate matter, fine particles (FP) and ultrafine particles (UFP)

4.8
condensation particle counter
CPC
AMS capable to measure the total particle number concentration

NOTE AMS consist of a flow meter, a particle counting device, a computer and suitable software. An AMS may also be equipped with a particle size classifier.

4.9
consumables
toner, ink, paper and ribbon

4.10
emission test chamber
ETC
enclosure with controlled operational parameters for testing analyte mass emitted from EUT

4.11
equipment under test
EUT
functional and complete ICT or CE equipment from which chemical emission rates are determined

4.12
fast AMS
AMS with integrated particle size classifier

4.13
fine particles
FP
particles with particle size / diameter range between 0.1 µm and 2.5 µm

4.14
loading factor
ratio of the EUT volume to the volume of the unloaded ETC

4.15
hard copy devices
class of EUT using Consumables that includes printers, (Photo)copiers and Multi Functional Devices (MFD)

4.16
maximum usage time before testing
MUT
<EUT using consumables> ratio between the total number of prints carried out by the EUT and the printing speed of the EUT

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NOTE Maximum usage time is the maximum permitted time of operation before testing in order to consider the EUT as newly manufactured equipment for testing purposes.

4.17
operating phase
phase in which the EUT is performing its intended functions

4.18
particle
solid or liquid matter with defined physical boundaries suspended in a gas

4.19
particle emission rate
PER
averaged emission rate, i.e. total number of particles in a specified particle size range emitted during the operating phase

4.20
particle emission rate
PER(t)
time dependent emission rate of particles in a specified particle size range after the start of the operating phase

4.21
particle loss-rate coefficient
β
coefficient describes the loss of particles in a specified particle size range in an ETC

4.22
particle size / particle diameter
measurement category to describe the physical dimension of a particle

NOTE The term particle size is often used as a synonym for particle diameter. The particle diameter is used to assign a particle to a particle size class (e.g. UFP).

4.23
particulate matter
PM
quantity of particles measured by gravimetric methods

4.24
pre-operating phase
phase in which the EUT is connected to an electrical supply before the EUT is able to enter the operating phase

NOTE The pre-operating phase can include warming-up and energy saving modes.

4.25
post-operating phase
phase following the operating phase

NOTE The post-operating can include energy saving modes.

4.26
total number of emitted particles
TP
calculated total number of particles emitted in a specified particle size range

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4.27
total particle number concentration
C_p
particle number concentration in a specified particle size range

4.28
total volatile organic compounds
TVOC
the sum of the concentrations of identified VOC and the concentrations of the converted areas of unidentified peaks using the toluene response factor

NOTE This definition of “total volatile organic compounds” differs from the definition in ISO 16000-6:2011.

4.29
ultrafine particles
UFP
particles with particle diameter less or equal 0.1 µm

4.30
unit specific emission rate
SER
mass, in micrograms, of a specific analyte emitted per hour

NOTE If more than one EUT is placed in the ETC, the determined SER is divided by the number of EUTs to obtain the unit specific emission rate SERu.

4.31
volatile organic compounds
VOC
compounds that elute between n-hexane and n-hexadecane on an unpolar GC-column

5 Symbols and abbreviated terms

5.1 Abbreviated terms

AMS	Aerosol Measuring System
CE	Consumer Electronics
CPC	Condensation Particle Counter
DNPH	2,4-Dinitrophenylhydrazine
ETC	Emission Test Chamber
EUT	Equipment Under Test
FP	Fine Particles
FID	Flame Ionisation Detector
GC/MS	Gas chromatography/Mass spectrometry
ICT	Information and Communication Technology
MFD	Multi Functional Device
PTFE	Polytetrafluoroethene

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PVC	Polyvinylchloride
rH	Relative humidity
SER	Unit Specific Emission Rate
PER	averaged Particle Emission Rate
PER(t)	time-dependent Particle Emission Rate
TVOC	Total Volatile Organic Compounds
UFP	Ultrafine Particles
VOC	Volatile Organic Compounds

5.2 Symbols

α	Factor in the exponential particle decay function [cm^{-3}]
β	Particle loss-rate coefficient [h^{-1}]
C_s	Average mass concentration [µg m^{-3}]
C_{bg}	Background mass concentration [µg m^{-3}]
C_0	Initial mass concentration [µg m^{-3}]
C_{pre}	Average mass concentration during pre-operating phase [µg m^{-3}]
C_{ope}	Average mass concentration during operating phase and optionally during post-operating phase [µg m^{-3}]
C_p	Total particle number concentration [cm^{-3}]
$Cp_{,BG}$	Background particle number concentration [cm^{-3}]
Co3	Ozone concentration [mg/m3]
d	Equivalent Particle Diameter [nm]
m_{after}	Sample filter mass [µg] after sampling
m_{before}	Sample filter mass [µg] before sampling
m_{bg}	Sampled mass for chamber background [µg]
m_{pm}	Mass of particulate matter [µg] deposited on the filter
$m_{ref\text{-}after}$	Reference filter mass [µg] after sampling
$m_{ref\text{-}before}$	Reference filter mass [µg] before sampling
m_s	Sampled mass [µg]
m_{pre}	Sampled mass [µg] during pre-operating phase
m_{ope}	Sampled mass [µg] during operating and optionally post-operating phase

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n	Air exchange rate [h^{-1}]
p	Atmospheric pressure [Pa]
PER	Particle Emission Rate [h^{-1}]
R	gas constant [PaK-1], (for ozone: 339.8 [PaK-1])
SER_{bg}	Background SER [µg h^{-1}]
SER_{ope}	SER during operating and optionally post-operating phase [µg h^{-1}]
SER_{O3}	SER for ozone [µg min^{-1}]
SER_{pm}	SER for particulate matter [µg h^{-1}]
SER_{pre}	SER during pre-operating [µg h^{-1}]
SER_u	SER per unit [µg h^{-1} u^{-1}]
T	Ambient temperature [K]
TP	Total Number of Emitted Particles
t_{ope}	Operating phase duration [h]
t_G	Sampling time during operating and optionally post-operating phase [h]
t_{start}	point in time marking the start of operating phase
t_{stop}	point in time marking the end of particle emission
t_{pre}	Pre-operating phase duration [h]
Δt	Time-resolution of the UFP measurement [s]
u	Number of EUTs units
V	ETC volume [m^3]
V_s	Sampled air volume [m^3]
V_{bg}	Sampled air volume [m^3] for determination of C_{bg}
V_{pre}	Sampled air volume [m^3] in pre-operating phase
V_{ope}	Sampled air volume [m^3] in operating and optionally post-operating phase

6 Method overview

The flowchart in Figure 1 illustrates the method; clause numbers are indicated in brackets.

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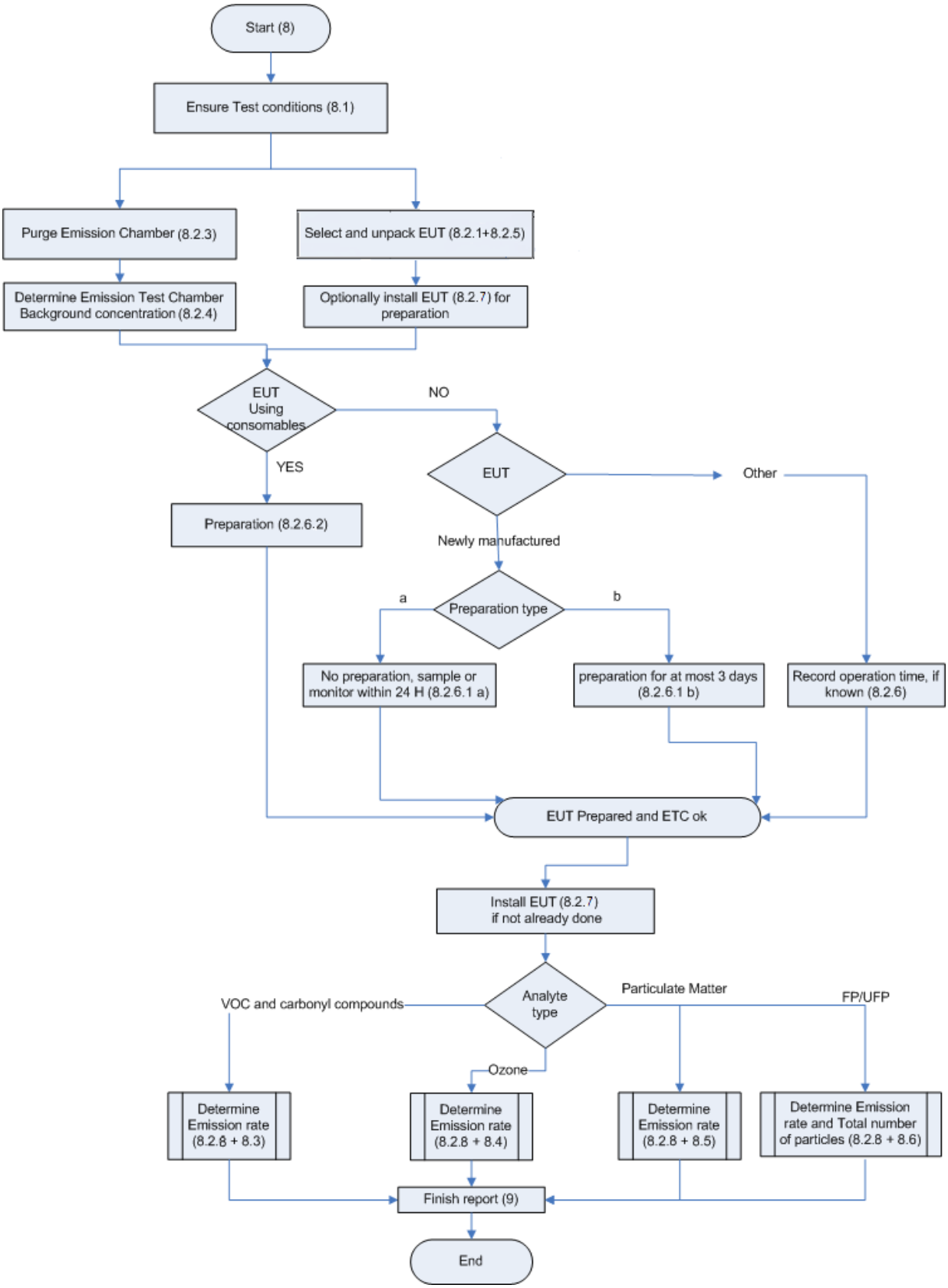

Figure 1 — Determination method overview

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7 ETC requirements

7.1 Construction materials

ETC construction materials shall comply with ISO 16000-9.

7.2 Air tightness

The ETC air tightness shall be as specified in ISO 16000-9.

7.3 Air mixing efficiency

The air mixing efficiency in the ETC shall be as specified in ISO 16000-9.

8 Determination method

8.1 Test conditions

8.1.1 General

To meet the operational requirements specified herein, ETC parameters such as temperature, relative humidity and supply airflow shall be controlled and measured at regular intervals and recorded in accordance with ISO 16000-9 and shall be reported as specified in Clause 9.

8.1.2 Operating temperature and relative humidity (rH)

Tests shall be executed at (23 ± 2) °C and (50 ± 5)% rH according to ISO 554. For EUT used in alternative climatic conditions, higher operating temperature and humidity conditions may be used as specified in ISO 554.

Consult 8.2.8.3.2 for special requirements on rH for EUT using consumables.

8.1.3 Air exchange rate (n)

For unloaded ETCs with a volume larger than 5 m^3, n shall be in the range from 0,5 to 2,0. For unloaded ETC's with a volume of 5 m^3 or smaller, n shall be in the range from 0,5 to 5,0.

8.1.4 Air velocity

The air velocity in the unloaded ETC shall be in the range from 0,1 to 0,3 m/s.

8.1.5 Sampled air flow

The sum of sampled airflow shall be less than 80% of the inlet airflow into the ETC.

8.2 Handling of EUT and ETC

8.2.1 Selection and storage of EUT

EUT shall be selected from normal manufactured batches or shall be a prototype that is representative for EUT from such batches. For determinations using the RAL-UZ 171 Option, EUT shall be stored in an air-conditioned room (23 °C, 50% rH) in its original packaging and tests should be executed within 10 working days after delivery of the EUT.

8.2.2 Loading Factor

To ensure detection of a minimum emission within a practicable time, the ETC with capabilities as specified in 7 shall be selected such that the loading factor is in the range of 1:4 to 1:100.

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8.2.3 ETC purging

The selected ETC shall be unloaded and its interior walls shall be cleaned as described in ISO 16000-9.

The ozone half-life, the period of time for the ozone concentration (C) to drop from C to C/2, shall be greater than 10 minutes, when n = 1.

To determine the ozone half life, the ETC should be deactivated by exposure to an ozone concentration of 0,2 mg/m^3 to 0,4 mg/m^3 for at least ten minutes or until a stable concentration is reached.

Thereafter, the ETC shall be purged with 4 ETC volumes of clean air.

8.2.4 Background concentrations (Cbg)

Following purging, the C_{bg} of Analyte in the unloaded ETC shall be determined and recorded.

NOTE C_{bg} may stem from e.g. emissions from the ETC itself and sampling tubes or filters.

The C_{bg} values at n = 1, shall be below the limits in Table 1.

Table 1 — Background concentrations

Analyte	Limit
VOC and carbonyl compounds	2 [µg/m^3] for any analysed substance
TVOC	20 [µg/m^3]
Ozone	4 [µg/m^3]
PM	10 [µg/m^3]
FP and UFP	C_p = 2000 [cm^{-3}]

8.2.5 EUT unpacking

Emissions from packaging may influence measurements considerably; in addition packaging itself may emit VOCs that are not representative for EUTs in typical use. Therefore, the EUT to be tested shall be removed from the shipping containers and all protective shipping packaging such as spacers, film wrapping and any other shipping/packaging elements before preparation (as specified in 8.2.6).

NOTE After unpacking, installation (step 8.2.7) may precede the preparation step (8.2.6).

8.2.6 Preparation of the EUT before testing

8.2.6.1 EUT not using consumables

Newly manufactured equipment is known to emit higher levels in the first days of use, which is not representative for the normal emissions over the intended lifetime.

For newly manufactured equipment, one of the following preparatory operations shall be executed:

a) The EUT shall not be operated before testing; testing shall start within 24 hours after unpacking.

b) The EUT shall have been in operation for a maximum of three days or equivalent before the start of testing.

For other equipment, that may have been operated longer than three days, no preparation shall be executed; in this case, the number of days that the EUT has been in operation shall be recorded, if known, otherwise “not known” shall be reported.

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