INTERNATIONAL STANDARD

ISO/IEC 28360-1

Second edition
2021-10

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

Part 1: Using consumables

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

Partie 1: Utilisation de consommables

Reference number
ISO/IEC 28360-1:2021(E)

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Foreword

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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 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by ECMA International (as ECMA-328-1) 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 second edition cancels and replaces the first edition (ISO/IEC 28360-1:2018), which has been technically revised.

The main change compared to the previous edition is as follows:

— reorganization to incorporate RAL-UZ Options into the main text as one of the two methods for determining emission rates of VOC and carbonyl compounds.

A list of all parts in the ISO/IEC 28360 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

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

Following the publications of the 1st edition of ECMA-328 in 2001 and the “Test method for the determination of emissions from Hard Copy Devices” (RAL-UZ 122), experts from BAM and Ecma have collaborated to harmonise methods to determine the chemical emission rates from ICT & CE equipment in the 2nd edition.

In addition to stricter test procedures, the 2nd edition used 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 fast track procedure and published in September 2007.

In addition, the 4th edition fixed 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 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 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.

The 7th edition of ECMA-328 is fully aligned with ISO/IEC 28360:2015.

The 8th edition was divided into two parts, a part for electronic equipment using consumables and a part for electronic equipment not using consumables:

- Determination of Chemical Emission Rates from Electronic Equipment – Part 1 (using consumables)
- Determination of Chemical Emission Rates from Electronic Equipment – Part 2 (not using consumables)

The purpose of the split was to make the description of test procedures simpler (they included considerable differences between the two equipment categories) and to facilitate users’ understanding.

This 8th edition is fully aligned with “Test method for the determination of emission from Hard Copy Devices” (RAL-UZ 205).

The 9th edition is fully aligned with the third edition of ISO/IEC 28360:2018.

The 10th edition has been re-organised to incorporate RAL-UZ Options into the main text as one of the two methods for determining emission rates of VOC and carbonyl compounds.

One method (QEM), which is in harmony with DE-UZ 205[1], Test Method for the Determination of Emissions from Hardcopy Devices (Appendix S-M), originates from the former RAL-UZ 205 Options. The other method (CEM) employs the generalised constant emission model in the former editions. The two methods may yield slightly different emission rates, so the user is encouraged to select the one that satisfies their technical application.

Different elements of the two methods are described alongside each other in the main text. The models used to calculate emission rates in each method are explained in the informative Annexes C and D. Some requirements in the former RAL-UZ Options which appear too detailed and stringent as an international standard are now listed in the informative Annex E so that users can fully meet the requirements of DE-UZ 205[1] (Appendix S-M).

In this edition, it is deduced in the CEM that emission rates of VOC and carbonyl compounds during the operating phase (SER_{ope}) originate from the pre-operating phase (SER_{pre}) and printing (SER_{prp}) operations as well as in the QEM and the former RAL-UZ Options.

This part of the Standard is Part 1.

This Ecma Standard was developed by Technical Committee 38 and was adopted by the General Assembly of December 2020.

[1] The German Blue Angel Environmental Label changed the naming convention of its award criteria from RAL-UZ 205 to DE-UZ 205 in 2019.

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

Part 1: Using consumables

1 Scope

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

This Standard (all parts) includes specific methods for equipment using consumables, such as printers, and equipment not using consumables, such as monitors and PC's.

Part 1 specifies the methods to determine the emission rates of VOC and carbonyl compounds, ozone, particulate matter, fine particles (FP) and ultra-fine particles (UFP) from electronic equipment using consumables.

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

Part 1 has two different methods for the determination of emission rates of VOC and carbonyl compounds. The two methods use two different emission models, the quasi-equilibrium model (QEM) and the constant emission model (CEM) respectively, to determine the emission rates of VOC and carbonyl compounds during the pre-operating phase.

The quasi-equilibrium model method has been developed with hard copy devices for office or home use in mind whose energy-saving modes automatically activate during most intervals between operations. The calculation of emission rates during the pre-operating phase is based on the quasi-equilibrium assumption as shown in Annex C.

The emission rates determined with this method can be used to compare equipment in the same class since test procedures are specified more narrowly than the other method (CEM).

The constant emission model (CEM) has been developed for hard copy devices whose energy-saving modes have such a negligible effect on the determination of emission rates of VOC and carbonyl compounds that the generalised constant emission model shown in Annex D can be used for the determination of their emission rates during the pre-operating phase. This method presents more flexible test procedures than the QEM. Due to such features of this method, it may be used for hard copy devices whose idling mode usually lasts throughout intervals between operations, such as large hard copy devices used professionally. It may also be used for various equipment having different functions and structure for its intended use and the determination of carbonyl compounds requiring longer sampling duration due to a lack of sensitivity.

Annex A specifies monochrome and colour print patterns for use in the operating phase of EUT using consumables.

The operational readiness of AMS is confirmed according to Annex B.

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

2 Conformance

Determinations of emission rates and total number of emitted particles conform to this Standard (Part 1) 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.

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.

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

ISO 16000-3:2011, *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*

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 (C_p) over 31 ± 3 seconds

4.2
averaged ozone concentration time series
simple moving average of ozone concentration (C_{O_3}) over 80 ± 5 seconds

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

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

NOTE CPC (4.8) and fast AMS (4.14) belong to AMS.

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
instrument that measures the particle number concentration of an aerosol

NOTE For the purpose of this standard a CPC is used as a standalone instrument which measures the total particle number concentration within a device dependent size range.

4.9
constant emission model method
CEM
method to determine emission rates of VOC and carbonyl compounds using the constant emission model, assuming that an emission rate is constant throughout the pre-operating phase

NOTE This method can apply to the pre-operating phase which consists of the warming-up and following idling and energy saving modes as far as constant emission during that phase can be assumed.

4.10
consumables
toner, ink, paper and ribbon

4.11
emission test chamber
ETC
enclosure with controlled operational parameters for testing analyte mass emitted from EUT

4.12
energy saving mode
mode in a lower power state than that of the idling mode which hard copy devices enter after a period of inactivity

4.13
equipment under test
EUT
electronic equipment from which chemical emission rates are determined

4.14
fast AMS
instrument with rapid time resolution and particle size classification

4.15
fine particles
FP
particles with particle size / diameter range between 0.1 µm and 2.5 µm

4.16
hard copy devices
class of EUT using Consumables that includes printers, (photo)copiers and Multi-Functional Devices (MFD)

4.17
idling mode
mode where hard copy devices are kept ready to perform its intended functions lasting from the end of warming-up mode or its operation to the start of an energy saving mode

4.18
loading factor
ratio of the EUT volume to the volume of the unloaded ETC

4.19
operating phase
phase in which the EUT is performing its intended functions

4.20
particle
solid or liquid matter with defined physical boundaries suspended in a gas

4.21
particle emission rate
PER
averaged time dependent particle emission rate between the points in time of the start (t_{start}) and end (t_{stop}) of particle emission

4.22
time dependent particle emission rate
PER(t)
time dependent emission rate of particles in a specified particle size range after the start of the operating phase

4.23
particle loss coefficient
β
coefficient describes the loss of particles in a specified particle size range in an ETC

4.24
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).

4.25
particulate matter
PM
quantity of particles measured by gravimetric methods

4.26
pre-operating phase
phase between the points in time at which the EUT is powered-on and the signal to start the operating phase is sent to the EUT

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

4.27
post-operating phase
phase following the operating phase

NOTE The post-operating phase can include energy saving modes.

4.28
quasi-equilibrium model method
QEM
method to determine emission rates of VOC and carbonyl compounds using the quasi-equilibrium model characterized by the assumption that the concentration of an analyte in the ETC reaches a quasi-equilibrium much earlier than expected in theory due to the activation of energy saving modes

4.29
specific emission rate
SER
mass, in micrograms, of a specific analyte emitted per hour

4.30
stabilizing period
t_s
Suspension time between the pre-operating and operating phases, which starts when the air exchange rate is changed and ends when the operating-phase begins if the air exchange rates during the pre-operating and operating phases differ

NOTE A certain length of suspension time may exist for preparation for sampling, conditioning of humidity in the ETC, stabilization of the air exchange rate and the concentrations of VOC and carbonyl compounds before the start of the operating phase.

4.31
standard particle emission rate
PER_{10}
calculated number of particles emitted during a 10-minute operating phase in a specified particle size range

4.32
total number of emitted particles
TP
calculated total number of particles in a specified particle size range between the points in time of the start (t_{start}) and end (t_{stop}) of particle emission

4.33
total particle number concentration
C_p
particle number concentration in a specified particle size range

4.34
total usage time before testing
TUT
ratio between the total number of prints carried out by the EUT and the printing speed of the EUT

NOTE Total usage time is equal to or shorter than 120 minutes to be tested as newly manufactured EUT.

4.35
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.

4.36
ultrafine particles
UFP
particles with particle diameter less or equal to 0.1 µm

4.37
volatile organic compounds
VOC
compounds that elute between n-hexane and n-hexadecane (including these compounds) on a nonpolar GC-column

5 Symbols and Abbreviated terms

5.1 Abbreviated terms

AMS	Aerosol Measuring System
CEM	Constant Emission Model Method
CPC	Condensation Particle Counter
DNPH	2,4-Dinitrophenylhydrazine
ETC	Emission Test Chamber
EUT	Equipment Under Test
FID	Flame Ionisation Detector
FP	Fine Particles
GC/MS	Gas Chromatography/Mass Spectrometry
MFD	Multi Functional Device
PER	Averaged Particle Emission Rate
PER(t)	Time-dependent Particle Emission Rate
PER_{10}	Standard Particle Emission Rate
PTFE	Polytetrafluoroethene (Polytetrafluoroethylene)
PVC	Polyvinylchloride
QEM	Quasi-equilibrium Model Method
RH	Relative Humidity
SER	Unit Specific Emission Rate
TUT	Total Usage Time Before Testing
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 coefficient [h^{-1}]
C_{bg}	Background mass concentration [$\mu g\ m^{-3}$]
C_{max}	Maximum mass concentration in the operating phase [$\mu g\ m^{-3}$]
C_{ope}	Average mass concentration during sampling in the operating and post-operating phase [$\mu g\ m^{-3}$]
C_{O3}	Ozone concentration [mg/m3]
C_p	Total particle number concentration [cm^{-3}]
C_{pbg}	Background particle number concentration [cm^{-3}]
C_{pre}	Average mass concentration during sampling in the pre-operating phase [$\mu g\ m^{-3}$]
C_s	Average mass concentration [$\mu g\ m^{-3}$]
C_0	Initial mass concentration [$\mu g\ m^{-3}$]
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_{ope}	Sampled mass [µg] during operating and optionally post-operating phase
m_{pre}	Sampled mass [µg] during pre-operating phase
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]
n	Air exchange rate during operating and post-operating phase [h^{-1}]
n_{pre}	Air exchange rate during pre-operating phase
p	Atmospheric pressure [Pa]
R	Gas constant [PaK-1], (for ozone: 339.8 [PaK-1])
SER_{bg}	Background SER [$\mu g\ h^{-1}$]
SER_{O3}	SER for ozone [$\mu g\ min^{-1}$]
SER_{ope}	SER during operating phase [$\mu g\ h^{-1}$]