VOC Emission Rate Specification for Personal Computers and Tablet Devices (Ver. 1)

January 2014

JEITA

Japan Electronics and Information Technologies Industries Association

Contents

Revision History

September 2005 Issued "VOC Guideline for Personal Computers (Ver. 1)."

March 2008 Issued "VOC Guideline for Personal Computers (Ver. 2)."

Main revisions

○ Revised the measurement method.

・Made sampling timings consistent with international standard ISO/IEC 28360.

・Added Windows Vista to the power-saving mode settings in the Power Options Properties figure.

March 2011 Issued "VOC Emission Rate Specification for Personal Computers (Ver. 1)."

Main revisions

○ Changed the document name.

○ Reviewed the scope.

・Specified the display size.

・Added tetradecane as an optional target substance

January 2014 Issued "VOC Emission Rate Specification for Personal Computers and Tablet Devices (Ver.1)."

Main revisions

○ Revised scope of application.

・Added tablet devices to the range of equipment covered.

1 Background and purpose of establishing Specification

Recently, buildings are more tightly sealed and insulated than ever, causing indoor air pollutants (e.g. chemical substances) from the living environment. This has resulted in “sick house (building) syndrome”, a situation that occupants suffer from health problems such as headaches and dizziness. Since the l980s, volatile organic compounds (VOCs) and aldehydes emitted from furniture and building materials have been major issues, and various measures have been researched and developed to suppress these substances. VOCs emission from other sources, including daily commodities, has also been highlighted lately.

In 1997, the 8Ministry of Health, Labor and Welfare (MHLW) established the indoor concentration criteria for formaldehyde as measures to combat "sick house syndrome” and the Committee on Sick House Syndrome (Indoor Air Pollution) was established to work on the supplementation and examination of the indoor concentration criteria.

The Ministry of Education, Culture, Sports, Science and Technology partly revised the Standards of School Environment and Health in 2002, in which formaldehyde and VOCs (toluene, xylene, and p-dichlorobenzene) concentrations were added to the inspection items of the air environment to maintain and improve sound indoor environment in school classrooms according to the criteria. And it was made obligatory to ensure that the indoor concentration level should not exceed the indoor criteria before introducing school equipment, including computers. Therefore, it was made mandatory for school equipment vendors to submit data about VOCs and aldehydes emission from the equipment and ensure that the indoor concentration level should not exceed the criteria. The Standards for School Environment and Health were revised in 2004 again, and currently six substances (ethyl benzene and styrene have been added) are covered by the regulation. In accordance with the enforcement of the School Health and Safety Act in 2009, the new Standards for School Environment and Health went into effect.

In 2004, the Small Chamber Method was standardized in JIS for determining emissions from building materials. Since there was no agreeable method for determining emissions from IT equipment in Japan, however, companies established their own test methods and criteria to deal with the situation.

In addition, some reports by the mass media gave the public a false impression that VOCs emission from PCs alone exceeded the indoor concentration criteria. Since the PC industry needed to eradicate this false impression, the IT Product Environment Committee organized the VOC Task Force and formulated this guideline in September 2005 to establish a standardized determination method and emission rate criteria, as well as to enlighten the public that the PC industry is making voluntary efforts to curb VOC and aldehyde emissions from PCs.

Then in September 2007, ISO/IEC 28360 “Determination of Chemical Emission Rates from Electronic Equipment” was established as an international standard for methods of measuring chemical substance emission rates. This ISO standard applies to copiers, information processing equipment, and digital home appliances, including PCs and displays. In Japan, JIS C 9913:2008 “Measuring method of volatile organic compounds and carbonyl compounds emissions for electronic equipment — Chamber method” consistent with ISO/IEC 28360 is now being drafted.

Under these circumstances, the VOC Task Group of JEITA, taking over the activities of the VOC Task Force, made the VOCs emission rate determination method in the guideline consistent with ISO/IEC 28360. Accordingly, JEITA revised this guideline to Ver. 2.

Recently, display screens have been getting larger and larger. However, the display size in this document is specified in view of the installation conditions because it is assumed that 40 machines are used in a PC laboratory. “VOC Emission Rate Specification for Audio and Visual Equipment” was issued in 2010, but there was some discrepancy in the target substances due to different use conditions. Thus, JEITA ironed out those differences and reviewed the target substances. Then the document name was changed from "VOC Guideline for Personal Computers" to "VOC Emission Rate Specification for Personal Computers (Ver. 1)."

In 2014, tablet devices, which have spread rapidly in the past several years, were added to the range of equipment covered due to their increasing use in the classroom. The specification was retitled "VOC Emission Rate Specification for Personal Computers and Tablet Devices (Ver. 1)."

2 Scope

2.1 Applicable equipments

This document applies to Desktop PCs (including keyboard and mouse), All-in-One PCs (including keyboard and mouse), Laptop PCs, Tablet Devices, and Displays.

Each PC category includes Thin clients. However, those sold as servers and 30-inch or larger displays are excluded from this document. Also, application to tablet devices is optional, since tablet devices are battery-powered and some models may be unable to meet testing conditions; for example, it may not be possible to configure them to operate continuously for the length of time required for testing.

2.2 Applicable substances

This document applies to the seven substances listed in Table 2, which are the six substances specified in the Standards for School Environment and Health plus acetaldehyde. Tetradecane, which is subject to the criteria for indoor air concentration stipulated by the Ministry of Health, Labor and Welfare, is an optional substance.

Table 1 Substances to be measured

Substance	Specified in	Remarks
Toluene	Standards for School Environment and Health	VOC
Xylene	Ditto	VOC
p-Dichlorobenzene	Ditto	VOC
Ethylbenzene	Ditto	VOC
Styrene	Ditto	VOC
Formaldehyde	Ditto	Aldehyde (VVOC)
Acetaldehyde	Ordinances, etc.	Aldehyde (VVOC)

2.3 Start of application

This document starts to apply from when each company is ready to measure.

3 Normative references

ISO/IEC 28360:2007, Determination of chemical emission rates from electronic equipment

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

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

4 Terms and definitions

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

(1) VOC

Abbreviation of volatile organic compounds, a generic term for organic compounds with volatility. In this document, VOCs are defined as volatile organic compounds that are identified between n-hexane and n-hexadecane when indoor air is gas chromatographed on a non-polar column.

(2) Aldehydes

Aldehydes are a generic term for organic compounds containing aldehyde groups. In general, they are formed by oxidizing alcohol and susceptible to further oxidization to form a carboxylic acid. Aldehydes are very useful as a raw material for various reactions because of great reactivity in the addition of carbonyl group (C = O) and the replacement with carbonyl group α -carbon.

(3) Criteria for indoor air concentration

The criteria for indoor air concentration as a “Guideline for indoor air pollution” established by the Committee on Sick House Syndrome (Indoor Air Pollution) of the Ministry of Health, Labor and Welfare (MHLW). The criteria are not the legal requirement values, but used as a target of indoor air quality. For more details, refer to the following URL. Annex 2 gives an abstract for reference.

(http://www.mhlw.go.jp/houdou/2002/02/h0208-3.html)

(4) Standards of School Environment and Health

The management criteria established by the Ministry of Education, Culture, Sports, Science and Technology to conduct proper environmental health tests, follow-up measures and daily environmental health management based on the School Health Law, and to maintain and improve school environmental health. These standards specify inspection items, inspection methods, criteria, and follow-up measures for each living environment (including illumination, noise, facilities, and equipment) and hygienic environment (including air, water quality, feeding service, harmful insects, and vermin). Regarding the air environment such as classrooms, there is a specification on formaldehyde and volatile organic compounds. For more details, refer to the following URL.

(http://www.mext.go.jp/a_menu/kenko/hoken/1292482.htm)

(5) EUT

A generic term for Equipment Under Test. Functional and compete, including consumables and accessories if applicable, ICT or CE equipment, from which chemical emission rates are determined as specified herein.

(6) Environmental chamber

The container or room used to measure chemical substances such as VOC emitted from EUT in the air, in which an EUT is placed. In this document, it is used to determine infinitesimal amounts of chemical substances emitted from IT equipment, and features the following performance.

a) To remove air pollutants from the ambient air.
b) To remove VOCs and other substances generated from the living environment.
c) To control the indoor conditions such as air flow rate and temperature.
d) To measure VOCs emission from IT equipment.

(7) Thin clients

Security-oriented terminal used in a business information system. It has a system configuration in which the capabilities of a client are limited to the minimal functions so that sources such as application software and files are managed on the server.

As for hardware, some clients have no built-in HDD, with a CF card mounted and the OS on the client, which is not writable. Others have no CF card mounted and the OS is loaded on the server. In either case, the thin client cannot function in isolation.

(8) Room ventilation rate

The number of times per hour (h^{-1}) when the air in a given room volume is exchanged with fresh ambient air through a ventilation fan, etc.

(9) Predicted maximum concentration

Given a constant emission rate from a product, constant room volume, and constant room ventilation rate, the mean concentration of the atmosphere in the relevant room increases rapidly with time, then converges to the constant value. This final value (μg/m^3) is called the predicted maximum concentration.

(10) Air volume

The capacity (m^3) of a building that requires ventilation, which is obtained with an actual gross floor area (m^2) multiplied by the mean height to the ceiling (m). The actual gross floor area means a gross floor area (sum total of the floor area of each story) with consideration of vaulted areas and ceiling height. The mean height to the ceiling means the height to the ceiling with consideration of the vaulted areas and hanging of the roof.

(11) Chamber air exchange rate

The ratio of the volume of clean air brought into the environmental chamber per hour to the volume of the chamber itself. This is expressed by frequency of air exchange per hour (h^{-1}).

(12) Emission rate

The mass of each substance [lμg/(h·unit)] emitted from the EUT per unit time.

(13) Relative humidity (rH)

One of the scales to indicate the amount of water vapor in the air (humidity). This scale indicates the degree of saturation by $(e/e_s)\times 100$ (e: vapor partial pressure, e_s: saturated vapor pressure), and is expressed as the percentage of vapor partial pressure to saturated vapor pressure. In general, “humidity” refers to relative humidity.

(14) Background concentration

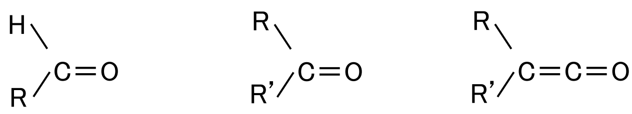
The concentration in the chamber with no EUT. Sometimes the air concentration that failed to be filtered out (e.g. the ambient air concentration due to air pollution, the indoor concentration due to emission from interior materials, and the residual concentration in the chamber from the previous measurement) may be mixed in the collected air, and may affect the measurement results. Therefore, the background concentration shall be pre-determined, and the determined concentration with the EUT subtracted from this background concentration shall be adopted as the concentration of emitted substances.

(15) DNPH cartridge

DNPH stands for 2,4-dinitrophenylhydrazine, and a DNPH cartridge is filled an absorbent impregnated with 2,4-DNPH. By allowing the air to flow through this cartridge, aldehydes can be collected as hydrazone derivatives.

(16) Carbonyl compounds

Among all the compounds having a carbonyl group (C = O), aldehydes, ketones, and ketenes are called carbonyl compounds. Those compounds in which the carbon (C) of the carbonyl group is joined to atoms other than carbon (C) and hydrogen (H) (e.g. oxygen (O) or halogen) are not called carbonyl compounds.



Aldehyde group **Ketone group** **Ketene group**

(17) Carbonyl compounds DNPH derivatives

The aldehydes that are derivatized with DNPH compounds. The DNPH-derivative compounds shall be separated and analyzed in a liquid chromatograph.

(18) High performance liquid chromatograph

The method used for aldehydes analysis. The typical analytes are organics dissolved in a solvent, and this method is commonly used to separate and identify the components of biological materials such as amino acids. Each element in the sample injected into the eluant (the mobile phase) sent with the liquid delivery pump is separated mutually while passing trough the packing material (the stationary phase) in the column (separation tube), and which is detected and determined with a detector connected to the column outlet. For packing materials, porous materials such as silica gel, alumina, and polystyrene are used, and an ultraviolet-visible spectrophotometer or a fluorescence detector or the like is used as a detector.

(19) Tenax tube

A hard glass or stainless steel tube with a 4-mm diameter filled with granular absorbent such as Tenax-TA, Tenax-GC, and Carbon-Molecular-Sieve. VOCs in air are absorbed and condensed by driving the air to be measured through this tube. Then, inert gas such as helium is passed through the tube while heated, so that the absorbed materials are desorbed quantitatively, and introduced to an analytical equipment such as GC/MS.

(20) Thermal desorption equipment

The equipment by which the heat is rapidly applied to the sample to volatilize, and the absorbed material is desorbed from the absorbent boundary.

(21) Gas chromatograph mass spectrometer

An analytical equipment combining a gas chromatograph as a separation method and mass spectrometer as a qualitative and quantitative method for low-boiling organic compounds. After being heated and volatilized, the sample is resolved into its compounds by a gas chromatograph and introduced to a high vacuum mass spectrometer. The molecules are ionized and dissociated simultaneously in the mass spectrometer, thus producing fragment ions. Since the resultant molecular ions and fragment ions are specific to each molecule, the components can be qualified and quantified.

(22) ECMA328

Standard for the detection and determination of chemical emission from electronic equipment.

5 Criteria for VOC emission rates

5.1 Concept for setting criteria

The criteria by the Ministry of Health, Labor and Welfare are specified as indoor concentrations (μg/m^3). However, VOCs emission from PCs has to be determined based on the emission rate per product. Thus, the emission criteria are defined by using the following formula, expressing "the relationship between the indoor concentration and the emission rate."

Given that V is the room volume (m^3), n is the ventilation rate(h^{-1}), SER is the emission rate of each substance from one PC per hour (μg/h･unit), u is the number of PCs installed (unit) per room, and that the emission rates from PCs are constant with time, the maximum indoor concentration that can be expected, or the predicted maximum concentration C_{mx}(ug/m^3) can be expressed by the following formula.

$$\text{Predicted maximum concentration } (\boldsymbol{C_{mx}})\ (\mu g/m^3) = \frac{\text{Emission rate per hour } (\boldsymbol{SER})\ [\mu g/(h\cdot unit)] \times \text{Number of PCs installed } (\boldsymbol{u})\ (unit)}{\text{Room volume } (\boldsymbol{V})\ (m^3) \times \text{Ventilation rate } (\boldsymbol{n})\ (h^{-1})}$$

Among PC classroom at a school, office, and home where PCs are installed, PC classroom is expected to have the minimum air volume per product and the maximum concentration of the seven emitted substances in the atmosphere, judging from the room volume, the ventilation rate, and the number of PCs installed Therefore, the condition of an average PC classroom at a school was chosen as a model in this guideline. The specific condition is as following.

- Room volume: 180 m^3 (based on the Standards for School Environment and Health)
- Ventilation rate: 2.2 times/h (based on the Standards for School Environment and Health)
- Number of PCs installed: 40 (one PC per student)

[Reference]

The ventilation rates are specified in the Standards for School Environment and Health as follows:

Kindergarten/elementary school:	2.2 times/h or more
Junior high school:	3.2 times/h or more
Senior high school, etc.:	4.4 times/h or more

When the above formula is used to calculate the predicted maximum concentration, the emission criteria are determined assuming that the PCs would contribute to the share of approximately 10% of the Standards of School Environment and Health or the criteria for indoor air concentration by the Ministry of Health, Labor and Welfare.

5.2 Emission criteria

The emission rate determined in accordance with Section 6 " Measurement method of chemical emission rate " shall be equal to or below the emission criteria specified in Table 2.

Table 2 Emission criteria (Emission rates from product)*1

[Unit: µg/(h·unit)]

Substance	Laptop PC	All-in-One PC	Desktop PC *2	Display *2
Toluene	260	260	130	130
Xylene	870	870	435	435
p-Dichlorobenzene	240	240	120	120
Ethylbenzene	3800	3800	1900	1900
Styrene	220	220	110	110
Tetradecane *3	330	330	165	165
Formaldehyde	100	100	50	50
Acetaldehyde	48	48	24	24

*1: The criteria regulate not the indoor concentration but the emission rate from product determined based on this document.

*2: Since a Desktop PC is usually used with a Display, each value was set to 1/2 of that of the All-in-One PC.

*3: Optional target substance

6 Measurement method of chemical emission rate

This measurement method is provided for the PC based on ISO/IEC 28360.

6.1 Environmental chamber

6.1.1 Specifications

The environmental chamber shall meet the following requirements:

a) The chamber shall have an air supply opening to let in controlled air and a vent to exhaust the air from the chamber and the run parameters (airflow volume, temperature, and humidity) shall be controllable.

b) The walls, ceiling, floor, and mount of the chamber shall be made of glass or stainless steel.

c) The use of packing materials to fill up the through-hole as in item d) below shall be minimized.

d) The air quality in the chamber shall be kept homogenized as much as possible. Air leakage shall be minimized except for that through the air supply opening and the vent, and through through-holes if prepared for wiring the EUT control, power supply, and censor cables, and sampling VOCs and aldehydes.

e) The chamber size is recommended to satisfy the following formula:

$$0.01 < V_P/V_K < 0.25$$

V_P: EUT volume (*1)

V_K: Chamber volume

(*1) The EUT volume is calculated as a rectangular of the maximum outside dimensions under the installation conditions of the EUT at measurement as specified in 6.2.2 b).

6.1.2 Air conditioning

The chamber shall be set to and controlled to the following conditions:

Operating temperature: 23ºC ±2ºC

Operating relative humidity: 50%±5%

Chamber air exchange rate: 0.5 or l ACH (Check the air exchange rate periodically. Monitor the volume and the velocity of the airflow supplied into the chamber during measurement.)

6.1.3 Background concentration

The background concentrations in the chamber shall be low enough not to affect the emission rate determination.

6.2 Determination methods

6.2.1 Preparation

EUT:

Must use the equipment in the unopened, packaging with shipment.

Temperature and humidity record:

Record temperature and humidity in the chamber during measurement

Temperature and humidity measuring point:

Perform the determination either near the vent of or in the chamber, assuming that the air quality is kept homogenized. Avoid the proximity of the air supply opening.

6.2.2 Determination of chemical emission

Collect samples at each of the following experimental steps. Quantify the substances to calculate the emission rate of each chemical substance by the formula described later.

a) Background determination

Collect samples in the initial unloaded condition in the chamber (prior to the installation of the EUT).

b) Installation of EUT and operating status

· Bring in and place EUT at the center of the chamber. Handle accessories, if any, as follows:

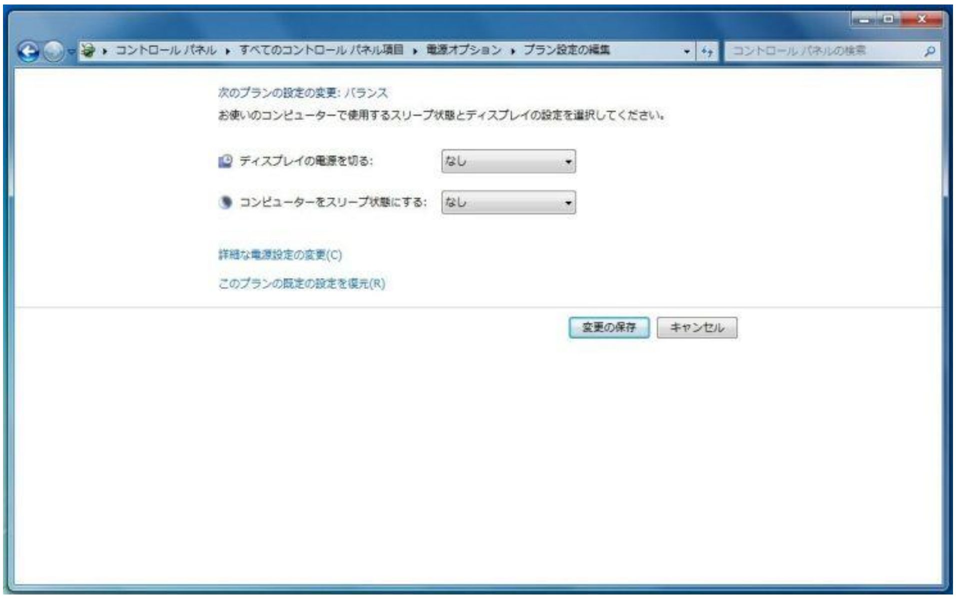
- Desktop PC (*2): With keyboard and mouse but no display
- All-in-One PC (*2): With keyboard and mouse
- Laptop PC (*2): Without mouse
- Display: Without PC
- Tablet Device: Without cradle

(*2) Thin clients can be measured as original models with built-in hard disk, if they cannot function alone.

· For measurement, switch on the EUT. The OS is booted and the desktop screen is displayed (with icons displayed on the screen) to allow application run.

· All the power-saving mode settings in the Power Options Properties dialog box shall be set to OFF as shown in Fig. 1. Settings for "Battery power" in Laptop PCs do not have to be changed as they are measured with a power source other than battery power. If the device has the manufacturer’s own power-saving software installed, keep the above settings on.

＜Windows 7＞



＜Windows 8＞

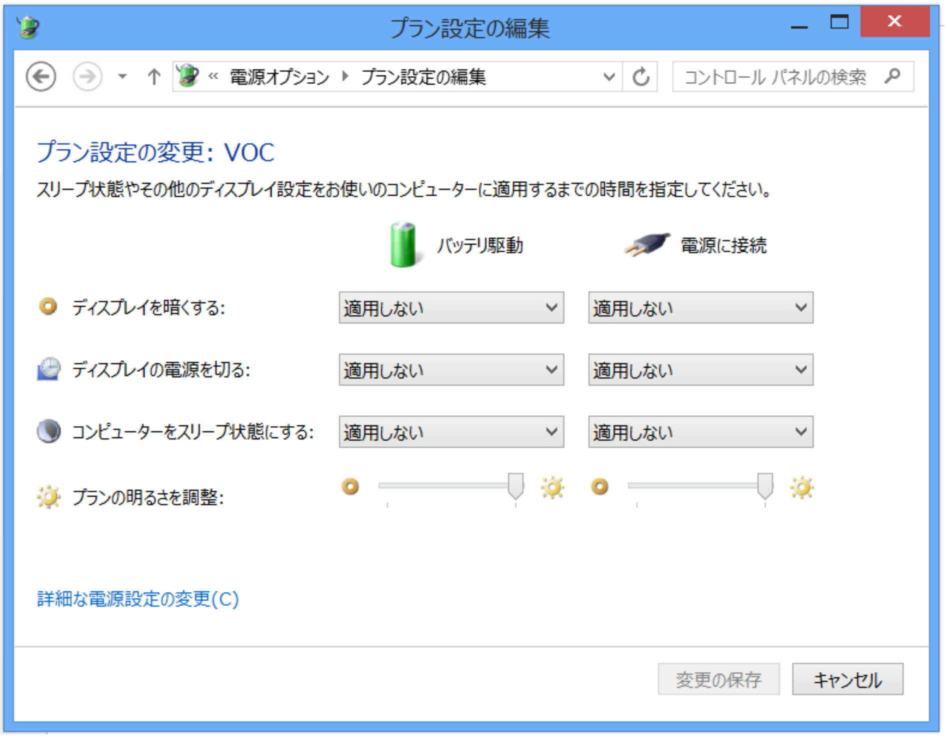


Fig. 1 Settings of Power Option Properties (Laptop PC)
Source: Microsoft Corporation

- The display screen shall be set to the maximum brightness.
- For a Laptop PC or a folding Tablet Device, the display shall be open 90 degrees or more.

c) Sampling timing

The target substances shall be collected in the chamber at the following timings after

EUT is installed in the chamber and put into operation.

Table 3 Sampling timing

Air exchange rate	Sampling timing
0.5 times/h	6 h later
1 times/h	3 h later

d) Quantification of substance

· Analysis of aldehydes

Dissolve and separate DNPH derivatives of carbonyl compounds in the DNPH cartridge by using acetonitrile and analyze them by using a high performance liquid chromatograph. The formaldehyde analysis method shall be as specified in ISO16000-3.

· Analysis of VOCs

Attach a Tenax tube to a thermal desorption equipment. Separate VOCs by heating and analyze them by using a gas chromatograph mass spectrometer. The VOCs analysis method shall be based on ISO16017-1.

e) Calculation of emission rate

$$SER_{UB} = \frac{(C_B - C_{B0}) \times n_B \times V_K}{u}$$

C_B: Concentration of each component (μg/m^3)

C_{B0}: Background concentration of each component (μg/m^3)

SER_{UB}: Emission rate of each component [μg/(h·unit)]

n_B: Air exchange rate (h^{-1})

V_K: Chamber volume (m^3)

u: Number of PCs installed (units)

7 Commentary

7.1 Relationship between concentrations in classroom and emission rates

7.1.1 Predicted maximum concentration

The maximum probable concentration, when the emission rates from PCs are constant and the classroom volume and ventilation rate are set, is calculated as the predicted maximum concentration.

When the room volume is V (m^3), the ventilation rate is n (h^{-1}), the emission rate of a certain substance from one PC per hour is SER_{UB} [μg/(h/unit)], and the number of PCs installed is u (unit), the average concentration C_t (μg/m^3) of the substance in the room environment after t hour can be expressed by Formula (1) and its temporal changes can be profiled as in Fig. 2.

$$C_t\ (\mu g/m^3) = \frac{\text{Emission rate per hour } (\boldsymbol{SER_{UB}})[\mu g/(h/unit)] \times \text{Number of PCs installed } (\boldsymbol{u})\ (unit) \times \mathbf{t}\ (h)}{\text{Room volume } (\boldsymbol{V})\ (m^3) + \text{Ventilation rate } (\boldsymbol{n})\ (h^{-1}) \times \text{Room volume } (\boldsymbol{V})\ (m^3) \times \mathbf{t}\ (h)}$$

$$= \frac{\boldsymbol{SER_{UB}} \times \boldsymbol{u}}{\boldsymbol{V}} \times \frac{\boldsymbol{t}}{1 + \boldsymbol{n} \times \boldsymbol{t}} \quad \text{-------} \quad (1)$$

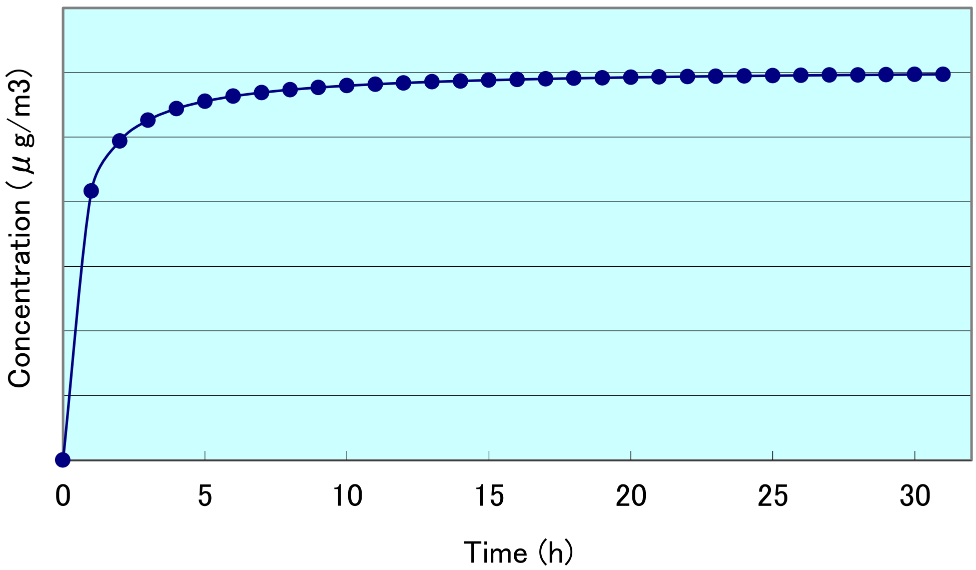


Fig. 2 Temporal changes of the average concentration in the room atmosphere

If the emission rate is assumed not to change with the passage of time, therefore, the predicted maximum concentration C_{mx} (μg/m^3) of each component in the seven substances can be calculated by using Formula (2).

$$\text{Predicted maximum concentration } \boldsymbol{C_{mx}}\ (\mu g/m^3) = \frac{\text{Emission rate per PC } \boldsymbol{SER_{UB}}\ [\mu g/(h/units)] \times \text{Number of PCs installed } \boldsymbol{u}\ (units)}{\text{Room volume } \boldsymbol{V}\ (m^3) \times \text{Ventilation rate } \boldsymbol{n}\ (h^{-1})} \quad (2)$$

7.1.2 Installation condition to determine the predicted maximum concentration

The room volume, the ventilation rate and the number of PCs installed are necessary to convert into the density of each room like PC classroom, an office and a house. It is a PC classroom of the schools that an atmosphere concentration becomes greatest by object materials emitting from PCs. If data is requested from a school or related party, the calculation of the predicted maximum concentration by using Formula (2) in the PC classroom used the following conditions.

- Room volume: 180 m^3 (based on the Standards for School Environment and Health)
- Ventilation rate: 2.2 times/h(based on the Standards for School Environment and Health)
- Number of PCs installed: 40 units (one PC per student)

The above conditions are determined by referring to "[Revised version] Standards for School Environment and Health." For example, the ventilation rate within a room is defined as follows:

Kindergarten/elementary school: 2.2 times/h or more
Junior high school: 3.2 times/h or more
Senior high school, etc.: 4.4 times/h or more

[Revised version] School Environment and Health Control Manual "Chapter 2 Standards for School Environment and Health Section 1"
(http://www.mext.go.jp/a_menu/kenko/hoken/1292482.htm)

7.1.3 Examples of calculation

Here are examples of calculating the predicted maximum concentration in a room based on the criteria by using Formula (2)

a) Predicted maximum concentration of formaldehyde in a PC classroom

When 40 desktop PCs and 40 displays are installed in a classroom of 180 m^3, the predicted maximum concentration of formaldehyde is as in Fig. 3.

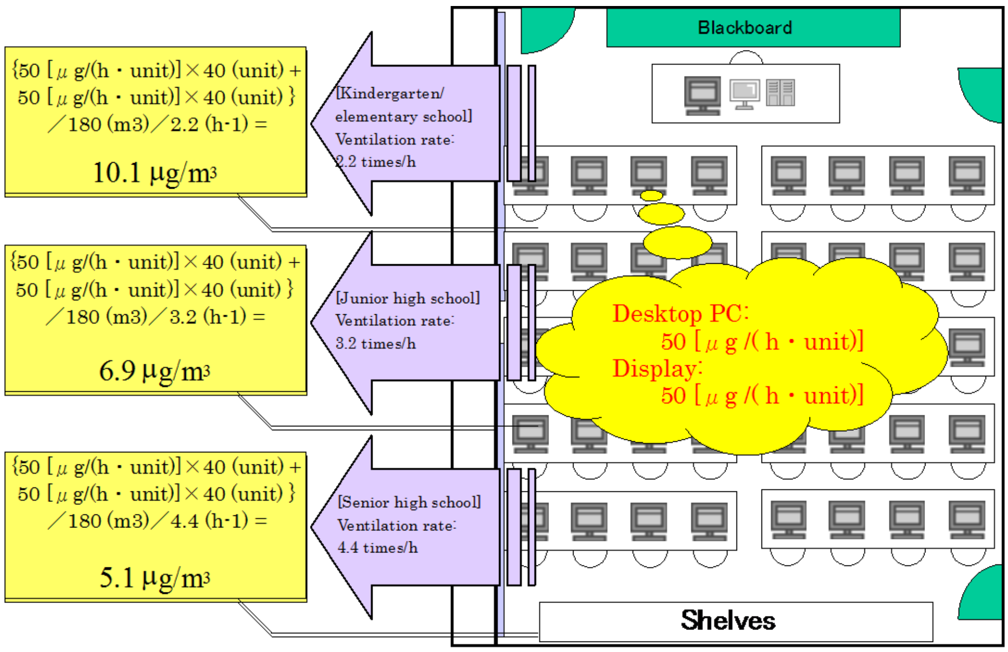


Fig. 3 Calculation of the predicted maximum concentration of formaldehyde in a PC classroom (Desktop PC and Display)

b) Predicted maximum concentration when the ventilation rate is changed

When 40 Desktop PCs and 40 displays are installed in a classroom of 180 m^3 and the ventilation rate is changed, the predicted maximum concentration is as shown in Table 4.

Table 4 Predicted maximum concentration when the ventilation rate is changed

[Unit: μg/m^3]

Substance	MHLW Indoor concentration criteria	Ventilation rate (times/h)		
		2.2	3.2	4.4
Toluene	260	26.3	18.1	13.1
Xylene	870	87.9	60.4	43.9
p-Dichlorobenzene	240	24.2	16.7	12.1
Ethylbenzene	3800	383.8	263.9	191.9
Styrene	220	22.2	15.3	11.1
Tetradecane *1	330	33.3	22.9	16.7
Formaldehyde	100	10.1	6.9	5.1
Acetaldehyde	48	4.8	3.3	2.4

*1: Optional target substance

c) Predicted maximum concentration when the number of PCs and displays installed is changed

When the number of PCs and displays installed in a classroom of 180 m^3 is changed, the predicted maximum concentration is as shown in Table 5. (Ventilation rate: 2.2 times/h)

Table 5 Predicted maximum concentration when the number of PCs installed is changed

[Unit: μg/m^3]

Substance	MHLW Indoor concentration criteria	Number of PCs and displays installed (units)		
		20	30	40
Toluene	260	13.1	19.7	26.3
Xylene	870	43.9	65.9	87.9
p-Dichlorobenzene	240	12.1	18.2	24.2
Ethylbenzene	3800	191.9	287.9	383.8
Styrene	220	11.1	16.7	22.2
Tetradecane *1	330	16.7	25.0	33.3
Formaldehyde	100	5.1	7.6	10.1
Acetaldehyde	48	2.4	3.6	4.8

*1: Optional target substance

d) Predicted maximum concentration when the room size is changed

When 40 PCs and 40 displays are installed in classrooms of different sizes, the predicted maximum concentration is as shown in Table 6. (Ventilation rate: 2.2 times/h)

Table 6 Predicted maximum concentration when the room volume is changed

[Unit: μg/m^3]

Substance	MHLW Indoor concentration criteria	Classroom volume (m^3)		
		180	250	320
Toluene	260	26.3	18.9	14.8
Xylene	870	87.9	63.3	49.4
p-Dichlorobenzene	240	24.2	17.5	13.6
Ethylbenzene	3800	383.8	276.4	215.9
Styrene	220	22.2	16.0	12.5
Tetradecane *1	330	33.3	24.0	18.8
Formaldehyde	100	10.1	7.3	5.7
Acetaldehyde	48	4.8	3.5	2.7

*1: Optional target substance

e) Predicted maximum concentration in a six-mat room of a house

When a Desktop PC and a Display are installed in a six-mat room ($26m^3$) of a house as an example of PC use at home, the predicted maximum concentration in the room is as shown in Table 7. (According to the revised Building Standard Law, the ventilation rate was set to 0.5 times/h.)

Table 7 Predicted maximum concentration in a six-mat room of a house

[Unit: $\mu g/m^3$]

Substance	MHLW Indoor concentration criteria	Predicted maximum concentration
Toluene	260	20.0
Xylene	870	66.9
p-Dichlorobenzene	240	18.5
Ethylbenzene	3800	292.3
Styrene	220	16.9
Tetradecane *1	330	25.4
Formaldehyde	100	7.7
Acetaldehyde	48	3.7

*1: Optional target substance

The concentrations are based on the assumption of no emission from building materials or furniture. They are indexes indicating how much emission from the PC will contribute to the concentrations of the seven substances in a house atmosphere.

7.2 Emission behaviors of VOCs and aldehydes from PC

7.2.1 Deterioration with time of representative emission rates after unpacking

Fig. 4 shows example of deterioration with time of emission rates after unpacking new PC is put into operation.

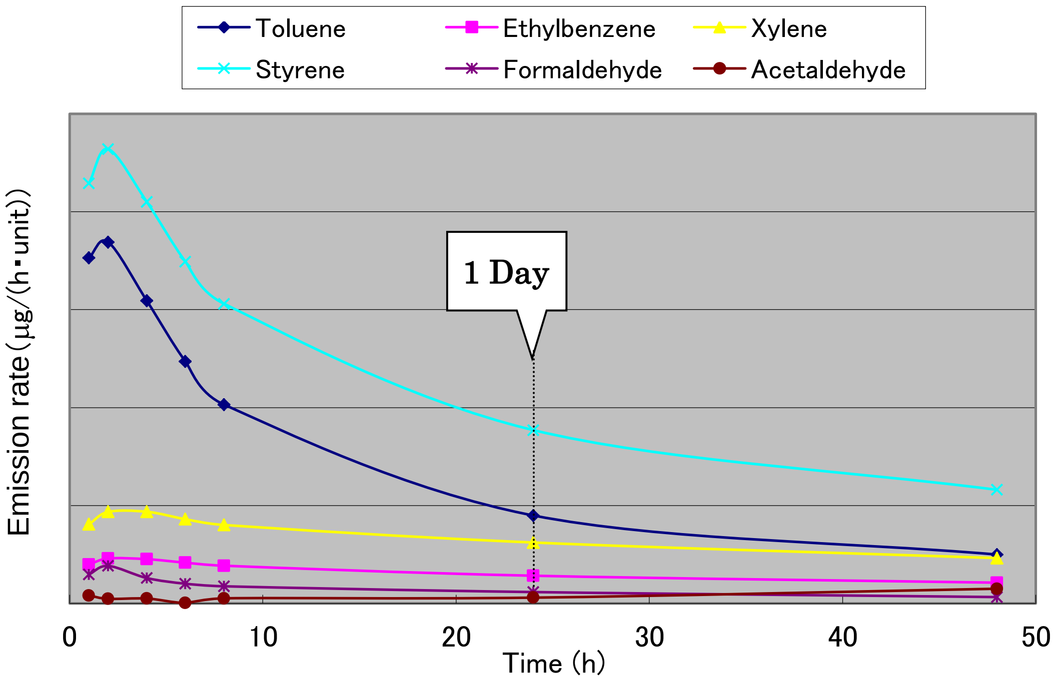


Fig. 4 Deterioration with time of VOCs and aldehydes emission rates from new PC (Desktop PC and Display)

Emission rates from a new PC temporarily increase after the power-on and reach the maximum values within a few hours, and then decrease with time. (*3)

*3: Measurement data from companies show the similar tendency of attenuation as in Fig. 4, but the emission rate differs from the products and substances. Fig. 4 shows no values on the vertical axis because the graphs are presented only to show the behaviors and are not based on typical PC values.

7.2.2 Deterioration with time of representative emission rates

Fig. 5 shows the results of the measurement of the same PC used in 7.2.1. PC was measured for 10 days and powered-off for 12 days, and then measured again.

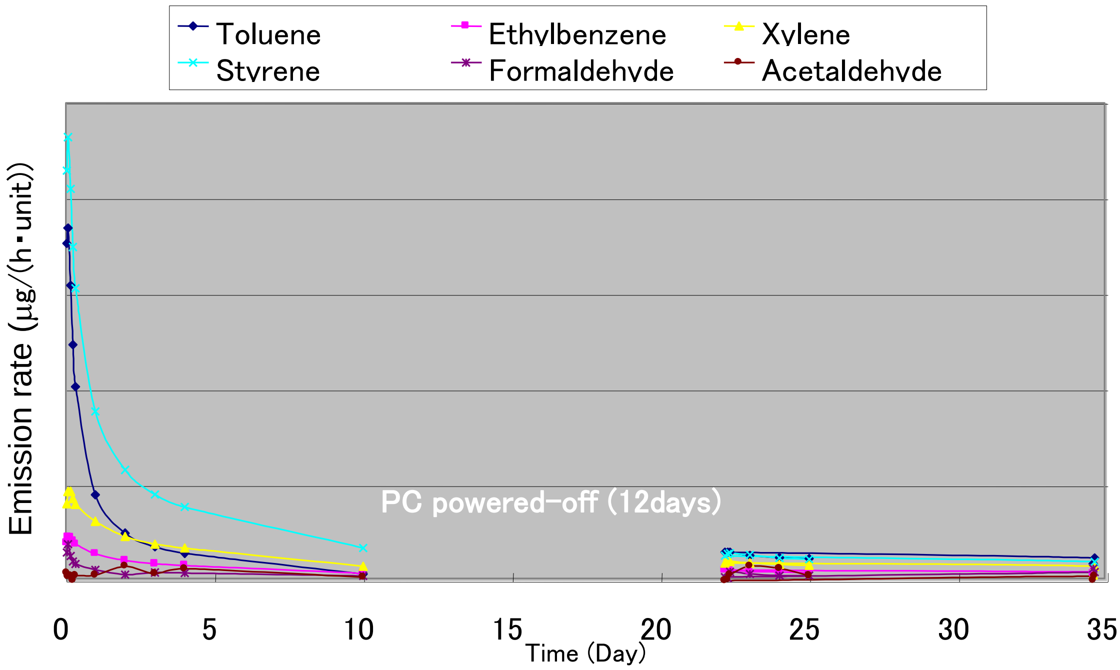


Fig. 5 Deterioration with time of emission rates prior PC powered-off and after PC powered-on again (Desktop PC and Display)

Once the initial emissions are finished, VOCs and aldehydes emissions from the PC remain low even when the PC is powered-on again, unlike from a new PC.

7.3 Main sources of VOCs and units of high emission rates

7.3.1 Main sources of VOC

Table 8 lists the officially announced main sources of substances.

Table 8 Main sources

Substance	Source	Use
Formaldehyde	Polyacetal resin (POM)	Switches, electronic parts, gears, cams, keyboard key switches, display swivels, and other mechanical components
	Phenol resin	Adhesives and plastic coating PC boards for power supply
	Urea resin Melamine resin	Electrical parts and high-grade coating
Toluene and xylene	Synthetic resin raw material, plasticizer raw material (phthalic acids), and coating material solvent	
Ethylbenzene	Synthetic resin raw material and styrene raw material	
Styrene	Styrene resin, SBR rubber, polyester, AS resin, and ABS resin raw material	Electromechanical parts, car parts, office machines, etc.
	MS resin	Electrical and electronic parts, and office machine parts
Acetaldehyde		Adhesives
p-Dichlorobenzene		Generally not used for electronic equipment

7.3.2 Units of high emissions based on measurement results

(1) Desktop PC

Substances with high emissions on the product level were measured for each unit. Table 9 gives some of the results. This measurement was conducted at a temperature higher than the operating temperature because its purpose was the relative comparison of emission rates.

Table 9 Emission rate of each unit

Unit	Product (1)				Product (2)			
	Temperature ºC	Toluene	Xylene	Styrene	Temperature ºC	Toluene	Xylene	Styrene
Cabinet	40	○	○	○	50	○	△	○
Keyboard with mouse	40	○	○	○	50	○	○	○
FDD+HDD+CD-ROM	50	○	○	○	50	○	○	○
Cable (internal and external	40-50	○	○	○	50	-	-	-
Motherboard	75	△	○	○	50	○	○	○
Power-supply unit	80	×	×	○	50	○	○	○
Gas sampling method	A specimen is put in a Tedlar bag and dry air is injected for a total of 10L with the specimen (14L if with the cabinet). After 2-hour heating by Drying Oven DX400, air is sampled from the Tedlar bag.				A specimen is put in a resin bag. After 30-minute heating at 50ºC in a high-purity nitrogen gas current, air is sampled from the bag.			

(○: Several 10s µg or less/unit △: About 100 µg/unit ×: About 500 µg/unit)

(a) On the product level, toluene and xylene are emitted. The analysis of each unit showed high emissions from the power supply and motherboard in Product (1). Product (2), however, did not show this tendency possibly because the heating temperature was lower than that of Product (1). In addition, xylene emission from the cabinet was high probably because of the coating. This emission from the cabinet of Product (1) was extremely small despite its coating.

(b) Although such styrene materials as PS and ABS are used popularly as PC cabinet materials, the emissions of ethylbenzene, styrene, p-dichlorobenzene, and acetaldehyde were small enough to ignore possibly because the cabinet temperature was comparatively low.

Since a large amount of styrene was detected from a specific desktop PC (other than Product (1) and (2)), however, each unit was analyzed. This analysis identified the Styrofoam shock absorber, power supply, and cable as the sources. By further analysis, styrene from the Styrofoam was found to be contaminating the power supply and cable.

(c) Although the emission of formaldehyde was concerned because phenol boards are used for the power supply and FDD, and several grams of polyacetal resin (POM) are used for the optical disk and FDD, the emission was slight. Although not verified by unit evaluation, the emission may be from the PC board in the power supply that has a large area and generates heat.

(2) LCD display

On the product level, toluene is strongly emitted from some products and formaldehyde is also emitted. Although not verified by unit measurement, the emission may be from the power supply (PC board, etc.).

(3) Laptop PC

Compared with other PCs, the emission of every substance is low, and is even lower than the limit of measurement. The emission rate depends on the amount and temperature of material and emission from inside the product, but increases as the temperature becomes higher. Unlike other PCs, Laptop PC has such advantages that the ventilation efficiency by fan is low and a tightly sealed AC adapter and optical disk are used. By unit analysis for reference, emissions of toluene, xylene, and ethylbenzene from the AC adapter and a slight emission of xylene from the cabinet were detected.

7.4 For a safe and comfortable environment

To realize a safer and more comfortable environment, it is recommended that PCs are used in consideration of their characteristics given in Section 7.2. For example,

- Unpack and operate PCs for a while in a well-ventilated place prior to installation
- Keep the room well ventilated at the unpacking and at the beginning of PC operation.

Annex 1
VOC Classification

The classification method regulated by the World Health Organization (WHO) is being generally used at present, and that is classified in the boiling point as shown in Table 10 though there is no international unified classification of VOC.

Table 10 VOC classifications by the WHO

Boiling point range	Classified name	Examples of VOC and boiling point
<50°C	VVOC: Very Volatile Organic Compound	Methane (-161°C) **Formaldehyde (-21°C)** Methyl mercaptan (6°C) **Acetaldehyde (20°C)** Dichloromethane (40°C)
50°C =< <260°C	VOC: Volatile Organic Compound	Acetic ether (77°C) Ethanol (78°C) Benzene (80°C) Methyl ethyl ketone (80°C) **Toluene (110°C)** Trichloroethane (113°C) **Ethylbenzene (136°C)** **Xylene (140°C)** **Styrene (145°C)** **p-Dichlorobenzene (174°C)** Limonene (178°C) L- nicotine (247°C) **Tetradecane (253.5°C)**
260°C =< < 400°C	SVOC:Semi Volatile Organic Compound	Chlorpyrifos (290°C) Dibuthylphthalate (340°C) Bis(2-ethylhexyl)phthalate (384°C) Dioctyl phthalate (390°C)
400°C =<	POM:Particulate Organic Matter	PCB Benzopyrene

NOTE: The underlined substances are covered by this specification. Its application to tetradecane is optional.

Annex 2
MHLW Indoor concentration criteria

Abstract from MHLW press release "Interim Report by the Committee on Sick House Syndrome (Indoor Air Pollution) - Summary on the discussions at the 8th and 9th meetings" at the website of the Ministry of Health, Labor and Welfare, on Feb. 8, 2002 (http://www.mhlw.go.jp/houdou/2002/02/h0208-3.html)

Table 11 The chemical substances of which MHLW sets the indoor concentration criteria

#	Volatile Organic Compound	Indoor concentration criteria	Toxicity Index	General Use
1	**Formaldehyde**	**100 μg/m^3 (0.08 ppm)**	Nose, throat irritation in human inhalation exposure	Urea, melamine, and phenol polymers, adhesives, and antiseptics
2	**Acetaldehyde**	**48 μg/m^3 (0.03 ppm)**	Influence on nasal olfactory epithelium in rat respiratory exposure	Adhesives, antiseptics, and chemicals for photographic development
3	**Toluene**	**260 μg/m^3 (0.07 ppm)**	Influence on neurobehavioral function and reproductive development in human inhalation exposure	Adhesives for interior materials, solvents and diluents for paints
4	**Xylene**	**870 μg/m^3 (0.20 ppm)**	Influence on central nervous system development of the newborn in pregnancy rat inhalation exposure	Adhesives for interior materials, solvents and diluents for paints
5	**p-Dichlorobenzene**	**240 μg/m^3 (0.04 ppm)**	Influence on liver, kidney, etc. in beagle oral exposure	Insecticides for clothing and toilet perfumes
6	**Ethylbenzene**	**3800 μg/m^3 (0.88 ppm)**	Influence on liver and kidney in mouse and rat inhalation exposure	Adhesives for interior materials, solvents and diluents for coatings
7	**Styrene**	**220 μg/m^3 (0.05 ppm)**	Influence on brain and liver in rat inhalation exposure	Styrene polymers
8	**Chlorpyrifos**	**1 μg/m^3 (0.07 ppb) For child: 0.1 μg/m^3 (0.007 ppb)**	Neurodevelopmental influence on the newborn and morphological influence on the brains of newborn babies in mother rat oral exposure	Termite exterminators
9	**Dibuthylphthalate**	**220 μg/m^3 (0.02 ppm)**	Influence such as constitutional abnormality on the genitals of the newborn in mother rat oral exposure	Paints, pigments, adhesives, processing agents and plasticizer for vinyl chloride product
10	**Tetradecane**	**330 μg/m^3 (0.04 ppm)**	Influence of C8-C16 mixture on liver in rat oral exposure	Kerosene and paint solvents
11	**Bis(2-ethylhexyl)phthalate**	**120 μg/m^3 (7.6 ppb)**	Patho-histological influence on testicular in rat oral exposure	Plasticizers
12	**Diazinon**	**0.29 μg/m^3 (0.02 ppb)**	Influence on plasma and erythrocyte cholinesterase activity in rat inhalation exposure	Insecticides
13	**Fenobucarb**	**33 μg/m^3 (3.8 ppb)**	Influence on cholinesterase activity in rat oral exposure	Termite exterminators
	Total volatile organic compound (TVOC)	**Tentative: 400 μg/m^3 (1000 μg/m^3 in new construction)**	As low as rationally achievable range based on the results of the domestic indoor VOC fact-finding	

The criteria of the above-mentioned substances are set based on the toxicity caused by short-term exposure for formaldehyde, and by long-term exposure for other substances respectively. The provisional target value of total volatile organic compound (TVOC) is set as low as rationally achievable range based on the results of a fact-finding of houses in Japan, and is used as an index to indicate the indoor air quality, independently of the criteria of each substance.

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