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**Determination of the emission of volatile  
organic compounds and aldehydes by  
building products — Small chamber  
method**

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## Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

Consequently **JIS A 1901** : 2009 is replaced with this Standard.

This **JIS** document is protected by the Copyright Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

# Determination of the emission of volatile organic compounds and aldehydes by building products — Small chamber method

## Introduction

This Japanese Industrial Standard has been prepared based on the first edition of ISO 16000-9 published in 2006 with additional provisions including test conditions and test methods not specified in ISO and with some modifications of the technical contents, to correspond to the actual situations in Japan.

The portions given sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JF. The comparison table between previous and current editions of this Standard on technically significant revisions is given in Annex JG.

## 1 Scope

This Standard specifies a general laboratory test method for determination of emission rate of chemical substances emitted from building products into the air, by the use of chamber method.

This measurement procedure is applicable to building products such as boards, wallpapers and floor materials, adhesives, paints and coating materials, and heat-insulating materials. This Standard aims for volatile organic compounds (VOCs), aldehydes as target chemical substances.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

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* (MOD)

In addition, symbols, which denote the degree of correspondence in the contents between the relevant International Standard and JIS, are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21-1.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS A 1902-1 *Determination of the emission of volatile organic compounds and aldehydes by building products — Sampling, preparation of test*

*specimens and testing condition — Part 1 : Boards, wallpaper and floor materials*

JIS A 1902-2 *Determination of the emission of volatile organic compounds and aldehydes by building products — Sampling, preparation of test specimens and testing condition — Part 2 : Adhesives*

JIS A 1902-3 *Determination of the emission of volatile organic compounds and aldehydes by building products — Sampling, preparation of test specimens and testing condition — Part 3 : Paints and coating materials*

JIS A 1902-4 *Determination of the emission of volatile organic compounds and aldehydes by building products — Sampling, preparation of test specimens and testing condition — Part 4 : Heat-Insulating material boards*

JIS A 1962 *Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — Active sampling method*

JIS A 1965 *Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and gas chromatography using MS or MS-FID*

NOTE : Corresponding International Standard : ISO 16000-6 *Indoor air — Part 6 : Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID (MOD)*

JIS A 1966 *Indoor air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Pumped sampling*

JIS K 0123 *General rules for gas chromatography/mass spectrometry*

JIS K 0124 *General rules for high performance liquid chromatography*

JIS K 0557 *Water used for industrial water and wastewater analysis*

JIS Z 8401 *Guide to the rounding of numbers*

JIS Z 8703 *Standard atmospheric conditions for testing*

NOTE : Corresponding International Standard : ISO 554 : 1976 *Standard atmospheres for conditioning and/or testing — Specifications (MOD)*

### 3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply. This clause applies to volatile organic compounds (VOCs) and aldehydes as target chemical substances.

#### 3.1 chamber

enclosure with air inlet and outlet for air circulation, which can control operational

parameters for the determination of chemical substances emitted from building products

In this Standard, it is applicable to small emission test chambers with the capacity of 20 L to 1 000 L.

### **3.2 air change rate**

ratio of the volume of clean air brought into the chamber per hour (air flow rate) and the free chamber volume measured in identical units

### **3.3 air flow rate**

air volume entering into the chamber per time

### **3.4 area specific air flow rate**

ratio between the supply air flow rate and the area of the test specimen

### **3.5 nominal time constant**

reciprocal of air change rate

### **3.6 local age of air**

time required for the movement of the air from the chamber inlet to an arbitrary point in the test chamber

### **3.7 the mean age**

mean of the local age of air at all points in the test chamber

### **3.8 coefficient of air change performance**

ratio of the nominal time constant to the mean age

### **3.9 air velocity**

air speed over the surface of the test specimen in the test chamber

### **3.10 mass transfer coefficient**

coefficient of mass transfer derived from the concentration difference of target substances between the test specimen and the ambient air over the surface of the test specimen

### **3.11 building product**

product used in construction works

### **3.12 test start**

time when the test specimens are set into the chamber

### **3.13 time**

time (hour or day) from test start to the starting time of air sampling

### **3.14 sampling period**

period of time for air sampling from the chamber outlet, using sampling tube or other

devices

### 3.15 emission test chamber concentration

concentration of target chemical substance, measured in the chamber outlet

The ratio of the mass of target substance sampled in the chamber outlet and the volume of air sampling during the sampling period.

### 3.16 background concentration

emission test chamber concentration measured when clean air is brought into the chamber, without placing a test specimen

### 3.17 travel blank

volume of target chemical substances in a sampling tube to which all procedures except for air sampling have been applied in order to consider the contamination of a sampling tube and the contamination at the time of opening, closing and transportation

### 3.18 product loading factor

ratio of exposed surface area of the test specimen and the free emission test chamber volume

### 3.19 recovery

total measured mass of target chemical substances in the air exhausted from the chamber during a given time period divided by the total mass of known target chemical substances in the air supplied to the chamber in the same time period

NOTE 1 The recovery provides information about the precision of the tests carried out based on this test method.

NOTE 2 In case of targeting VOCs and aldehydes, the recovery test is carried out by using its standard gas or gas of a known concentration emitted with permeation tubes.

### 3.20 emission factor

mass of target chemical substances emitted per unit time during the time measured from the test start

In this Standard, area specific emission factor,  $q_A$  is applied.

NOTE 1 Emission factors can be defined according to different requirements, e.g., length specific emission factor  $q_l$ , mass specific emission factor  $q_m$ , volume specific emission factor  $q_v$  and unit specific emission factor  $q_u$ .

NOTE 2 ISO 16000-9 uses "specific emission rate".

### 3.21 sample

part or a piece of a building product

### 3.22 test specimen

part of the sample specially prepared for emission testing in a chamber in order to simulate the emission behaviour of the material or product that is tested

### 3.23 volatile organic compound : VOC

organic compound whose boiling point is in the range from (50 to 100) °C to (240 to 260) °C

The test method specified in this Standard shall apply to the range of VOCs detected between and including *n*-hexane and *n*-hexadecane with gas chromatography.

NOTE : The test method described in this Standard applies to the range of compounds specified by the definition of total volatile organic compounds (TVOC). The VOC that was selected and analysed from a product is called target volatile organic compounds (hereafter referred to as "target VOC").

For the guideline concentration of target VOCs, see Annex JE.

### 3.24 total volatile organic compound : TVOC

sum of VOC that is detected between and including *n*-hexane and *n*-hexadecane with gas chromatography

In this Standard, the calculated TVOC is converted to the concentration in the sum of peak areas using the toluene response factor.

NOTE 1 The calculated TVOC is similar to the sum of the extracted VOCs in the air.

NOTE 2 When GC/MS is used, TVOC shall be analysed by total ion chromatography (TIC) after measuring with a total ion mass spectrograph (TIM) [see 11.3 of JIS A 1965 and 8.8 a) of JIS K 0123].

### 3.25 aldehydes

organic compound containing carbonyl group, mainly represented by aldehyde and ketone

Formaldehyde is the simplest aldehyde. "Other carbonyl compounds" is the generic term for aldehydes and ketones, excluding formaldehyde.

NOTE : For the guideline concentration of target aldehydes, see Annex JE.

### 3.26 air

air used for testing, having the same composition as atmospheric air

### 3.27 tracer gas

gas used for determination of air flow rate

## 4 Symbols and units

The symbols and units shall be in accordance with Table 1.

Table 1 Symbols and units

| Symbol                       | Description                                                                                         | Unit                                       |
|------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------|
| $A$                          | Surface area of test specimen                                                                       | $\text{m}^2$                               |
| $\rho(0)$                    | Initial tracer gas concentration                                                                    | $\mu\text{g}/\text{m}^3$                   |
| $\rho_e(t)$                  | Tracer gas concentration measured in chamber outlet air at a given time, $t$ , after the test start | $\mu\text{g}/\text{m}^3$                   |
| $\rho_s$                     | Tracer gas concentration at sufficiently long time (equilibrium time) after the test start          | $\mu\text{g}/\text{m}^3$                   |
| $\rho_i$                     | Emission test chamber concentration of target chemical substance at a given time, $t$               | $\mu\text{g}/\text{m}^3$                   |
| $q_A$                        | Area specific emission factor                                                                       | $\mu\text{g}/(\text{m}^2 \cdot \text{h})$  |
| $q_l$                        | Length specific emission factor                                                                     | $\mu\text{g}/(\text{m} \cdot \text{h})$    |
| $q_m$                        | Mass specific emission factor                                                                       | $\mu\text{g}/(\text{g} \cdot \text{h})$    |
| $q_v$                        | Volume specific emission factor                                                                     | $\mu\text{g}/(\text{m}^3 \cdot \text{h})$  |
| $q_u$                        | Unit specific emission factor                                                                       | $\mu\text{g}/(\text{unit} \cdot \text{h})$ |
| $L$                          | Product loading factor                                                                              | $\text{m}^2/\text{m}^3$                    |
| $Q$                          | Air flow rate into chamber                                                                          | $\text{m}^3/\text{h}$                      |
| $V$                          | Volume of chamber                                                                                   | $\text{m}^3$                               |
| $k_a$                        | Mass transfer coefficient of water vapour                                                           | $\text{m}/\text{h}$                        |
| $l$                          | Length of test specimen                                                                             | $\text{m}$                                 |
| $m$                          | Mass of test specimen                                                                               | $\text{g}$                                 |
| $n$                          | Air change rate                                                                                     | times/h                                    |
| $k_Q$                        | Area specific air flow rate                                                                         | $\text{m}^3/(\text{m}^2 \cdot \text{h})$   |
| $t$                          | Time                                                                                                | hours or days                              |
| $u$                          | Number of test specimens                                                                            | unit                                       |
| $v$                          | Volume of test specimen                                                                             | $\text{m}^3$                               |
| $\eta$                       | Coefficient of air change performance                                                               | —                                          |
| $\tau_0$                     | Nominal time constant                                                                               | h                                          |
| $\langle \bar{\tau} \rangle$ | The mean age                                                                                        | h                                          |

## 5 Principle

The principle of this test is to determine the area specific emission factor of target chemical substances emitted from building products, to be tested by obtaining the emission test chamber concentration, passing air flow rate and surface area of the test specimen, performed in a chamber.

The area specific emission factor of target chemical substance at time,  $t$ , is calculated as specified in clause 13, by passing air through the chamber at constant temperature, relative humidity and air flow rate, and with knowledge of the emission test chamber concentration and air flow rate from the outlet air.

## 6 Apparatus

### 6.1 General

Equipment used to perform an emission test of target chemical substances emitted from building products shall be as follows.

- Chamber
- Sealing materials for test specimen
- Clean air supply
- Temperature control and humidification system
- Integrating flowmeter
- Air sampling device
- Oven
- Analyser

## 6.2 Chamber

An outline of chamber system is shown in Figure 1. The outlet air and inlet air shall not be circulated.

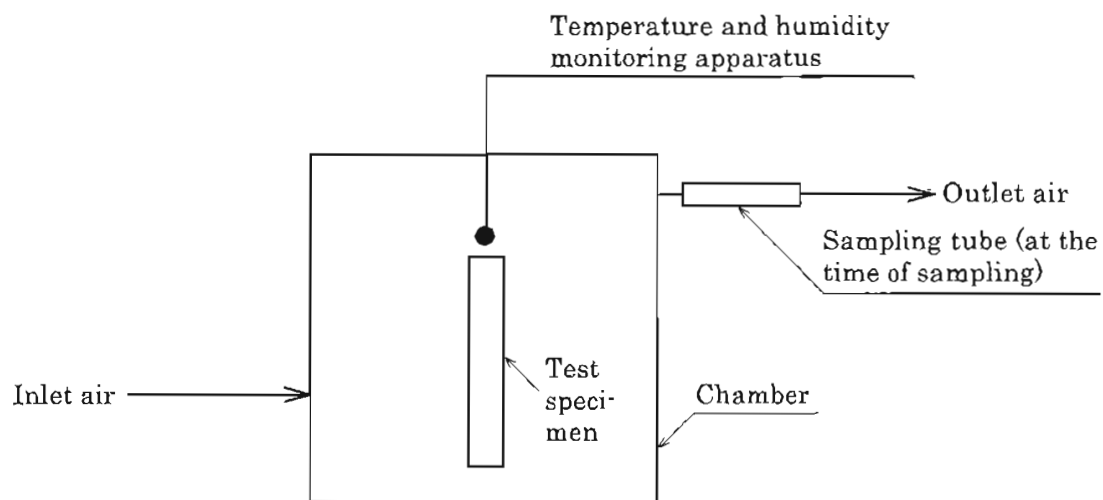


Figure 1 Outline of chamber

NOTE : For examples of chambers, see Annexes JA, JB, JC and JD.

### 6.2.1 Shape

The chamber shall be designed to ensure proper mixing of inside air. In principle, any components mounted on the chamber shall be detachable for washing and heat-treatment.

The part of chamber coming into contact with the emitted target chemical substances shall be made of stainless steel or glass, with a volume of 20 L ( $\pm 5\%$ ) to 1 000 L ( $\pm 5\%$ ). Mixing devices, e.g. fan, and sealing materials of the chamber shall be low emitting and low adsorbing materials which do not contribute to the emission test chamber background concentration.

Chambers of capacity from several L to and excluding 20 L may be used for tests of adhesives, paints and coating materials, if they are confirmed to correlate with cham-

bers of capacity 20 L or more.

#### 6.2.2 Air tightness

The chamber shall be kept airtight in order to avoid air change with uncontrolled external air. The pressure in the chamber shall be positive against the laboratory atmosphere pressure, and the inside of the chamber shall be kept airtight.

With the inside kept airtight, the chamber can avoid any influence from the laboratory environment.

#### 6.2.3 Air supply and mixing facilities

The chamber shall have facilities (e.g. electronic mass flow controller) capable of continuously controlling the air flow rate at a fixed value. The requirements shall be in accordance with 7.5 and 8.4.

#### 6.3 Seal of test specimen

When measuring the chemical substances emitted only from the surface of test specimen, seal the edges and the underside of the test specimen with materials like aluminium foil.

#### 6.4 Clean air supply

Air to be supplied in the chamber shall be as clean as possible, therefore clean air supply or clean air of gas cylinder shall be used to prevent increase in background concentration.

#### 6.5 Temperature control and humidification system

The control of temperature shall be carried out either by placing the chamber in the laboratory environment controlled to the required temperature such as thermostat or by maintaining the inside of the chamber at required temperature. In principle, the relative humidity shall be controlled by maintaining the required relative humidity of supply air. Temperature and relative humidity shall be monitored continuously and independently of the system for controlling the temperature and humidity.

In addition, precautions shall be taken to avoid condensation of moisture or spray of water in the chamber.

#### 6.6 Integrating flowmeter

The air flow rate shall be accurately measured within the emission test chamber by setting an integrating flowmeter is set on the chamber outlet. Alternatively, other equipment of performance at least equivalent thereto may be used.

#### 6.7 Air sampling procedure

For the sampling of air, the exhaust air at the chamber outlet shall be used. When a multiport sampling manifold is used, the air shall be sampled directly from the chamber outlet. If a duct and a tube are to be used, they shall be as short as possible, and maintained at the same temperature as the chamber.

The duct and tube shall be made of materials of minimal adsorption, e.g. polytetra-

fluoroethylene. If the air flow rate at the time of air sampling is smaller than the air flow rate of the chamber, the air flow rate shall be held constant using a sampling manifold, etc. The exhaust air from the chamber shall be discharged from the laboratory environment.

NOTE : A multi-port sampling manifold may be used to provide flexibility for duplicate air sampling.

## 6.8 Oven

The oven shall be used to volatilize target chemical substances adhered within the chamber.

## 6.9 Analyser

VOC shall be analysed by gas chromatograph using FID detector (GC/FID) or by gas chromatograph using mass spectrometer (GC/MS). For the analysis of aldehydes, high performance liquid chromatograph (HPLC) shall be used.

VOC analyser shall be in accordance with clause 6 of JIS A 1965, clause 6 of JIS A 1966 or clause 5 of JIS K 0123, or performed by other devices of accuracy at least equivalent thereto. Analyser for aldehydes shall be in accordance with 6.3.1 of JIS A 1962 or clause 5 of JIS K 0124. Alternatively, other devices of accuracy at least equivalent thereto may be used.

## 7 Test conditions

### 7.1 General

Test shall be performed under the test conditions specified in 7.2 to 7.5, and at the pressure close to the atmospheric pressure.

### 7.2 Temperature and relative humidity

Temperature in the chamber shall be 28 °C and relative humidity shall be 50 % given in JIS Z 8703. The performances of the chamber shall be controlled within the following range of conditions.

- Temperature      28 °C ± 1.0 °C
- Relative humidity    (50 ± 5) %

Alternative temperature and humidity conditions should be used according to the test purpose, in order to confirm the temperature humidity dependence.

Initial variance can be observed in the chamber environment when loading a test specimen, because of the differences of temperature and relative humidity between the laboratory environment and the chamber. These variances shall be recorded. The ranges of temperature and relative humidity indicate variance by change with time. The distribution of temperature and relative humidity in the chamber shall be minimized.

NOTE : Emission factor highly depends on the temperature and the relative humidity.

### 7.3 Supply air quality and background concentration

The quality of supply air and background concentrations shall be low enough not to interfere with the emission determinations.

The pure water used for humidification shall not contain interfering target chemical substances. The water quality shall be at least A1 specified in JIS K 0557, and the target component shall not be detected.

### 7.4 Mass transfer coefficient

The mass transfer coefficient over the surface of the test specimen in the chamber should be about 9 m/h to 18 m/h, by converting it into water vapour.

When a fan is set in order to stir the contents of the chamber, forced convection field shall not be of mass transfer coefficient 18 m/h or over.

NOTE 1 The volume of the mass transfer coefficient sometimes influences the emission factor for evaporative controlled emission. The emission factor depends on the substrate to be used.

NOTE 2 The mass transfer coefficients of about 9 m/h to 18 m/h correspond approximately to air velocities of about 0.1 m/s to 0.3 m/s over the surface of the test specimen.

### 7.5 Area specific air flow rate and air change rate

At steady state, the emission test chamber concentration depends on the area specific air flow rate which is selected as a parameter in designing the emission test conditions. The standard air change rate shall be  $0.5 \pm 0.05$  times/h.

For the evaporative controlled building products such as adhesives and coatings (e.g. wet adhesives and coatings), appropriate measurement can be carried out by increasing air change rate or decreasing the product loading factor. The air change rate,  $n$ , and the product loading factor,  $L$ , shall be kept on the same conditions, when comparing results obtained from different chambers.

NOTE 1 Air change rate,  $n$ , and product loading factor,  $L$ , can influence the emission factor.

NOTE 2 For target substances which considerably adsorb to building product itself (e.g. formaldehyde), the measurement results of emission factor can be compared only when the results are common in the rate of the product loading factor to the air change rate ( $L/n$ ,  $n/L$  values).

## 8 Verification of the test conditions

### 8.1 Monitoring of the test conditions

Temperature, relative humidity and air flow rate shall be monitored and recorded continuously with the following accuracies.

For the temperature and relative humidity, the outlet air may be measured.

- Temperature  $\pm 0.5$  °C
- Relative humidity  $\pm 5$  %

— Air change rate  $\pm 10\%$

## 8.2 Air tightness of chamber

The air tightness of chamber shall be regularly checked with a minimum frequency of every 12 months, or by pressure drop measurement, by comparison of simultaneous measurement of flow rates at the inlet and the outlet or by measurement of tracer gas dilution.

## 8.3 Air change rate in chamber

An integrating flowmeter is set at the chamber outlet, and the air change rate,  $n$ , is obtained by calculating the measured air flow rate  $Q$  divided by the chamber volume,  $V$ .

The variance of the set value of air change rate shall be minimized. The air change rate shall be regularly checked with a minimum frequency of every 12 months, by using the tracer gas procedure.

When the test is carried out on the outlet by using an integrating flowmeter, one should be aware that the back pressure introduced by the instrument can lower the flow rate through the chamber.

## 8.4 Coefficient of air change performance in chamber

The test to determine the coefficient of air change performance in the chamber shall be carried out by placing the test specimen or the inert substrate (e.g. glass plate or stainless steel sheet) of the same size as the test specimen in the test chamber. The coefficient of air change performance shall be calculated as follows.

- a) **Step-up method** After the tracer gas is adequately mixed with the supply air at constant concentration and flow, the time course of concentration in the chamber outlet shall be measured. The coefficient of air change performance  $\eta$  in the chamber is calculated from the temporal change by the nominal time constant,  $\tau_n$ , divided by the mean age  $\langle \bar{\tau} \rangle$ . The coefficient of air change performance should be at least 90 %.
- b) **Step-down method** The age of the air at the chamber outlet shall agree with the mean age. Alternatively, the tracer gas concentration at the chamber outlet may be measured by supplying clean air after thoroughly mixing tracer gas in the chamber by using a fan or other devices. The coefficient of air change performance is calculated from the temporal change of concentration.

The coefficient of air change performance, the nominal time constant and the mean age obtained in a) and b) can be expressed by formulae (1) to (4), respectively.

$$\text{Coefficient of air change performance } \eta = \frac{\tau_n}{\langle \bar{\tau} \rangle} \dots\dots\dots (1)$$

$$\text{Nominal time constant } \tau_n = \frac{V}{Q} \dots\dots\dots (2)$$