JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS A 1901 : 2015

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

ICS 13.040.20 ; 71.040.40 ; 83.140.01
Reference number : JIS A 1901 : 2015 (E)

Date of Establishment: 2003-01-20
Date of Revision: 2015-03-20
Date of Public Notice in Official Gazette: 2015-03-20
Investigated by: Japanese Industrial Standards Committee
Standards Board for ISO area
Technical Committee on Architecture

JIS A 1901 : 2015, First English edition published in 2015-10

Translated and published by: Japanese Standards Association
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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

Printed in Japan IH/HN

Contents

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.

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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 applys 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 flaw 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	m^2
$\rho(0)$	Initial tracer gas concentration	$\mu g/m^3$
$\rho_c(t)$	Tracer gas concentration measured in chamber outlet air at a given time, t, after the test start	$\mu g/m^3$
ρ_s	Tracer gas concentration at sufficiently long time (equilibrium time) after the test start	$\mu g/m^3$
ρ_t	Emission test chamber concentration of target chemical substance at a given time, t	$\mu g/m^3$
q_A	Area specific emission factor	$\mu g/(m^2 \cdot h)$
q_l	Length specific emission factor	$\mu g/(m \cdot h)$
q_m	Mass specific emission factor	$\mu g/(g \cdot h)$
q_v	Volume specific emission factor	$\mu g/(m^3 \cdot h)$
q_u	Unit specific emission factor	$\mu g/(unit \cdot h)$
L	Product loading factor	m^2/m^3
Q	Air flow rate into chamber	m^3/h
V	Volume of chamber	m^3
k_a	Mass transfer coefficient of water vapour	m/h
l	Length of test specimen	m
m	Mass of test specimen	g
n	Air change rate	times/h
k_Q	Area specific air flow rate	$m^3/(m^2 \cdot h)$
t	Time	hours or days
u	Number of test specimens	unit
v	Volume of test specimen	m^3
η	Coefficient of air change performance	—
τ_n	Nominal time constant	h
$<\bar{\tau}>$	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.

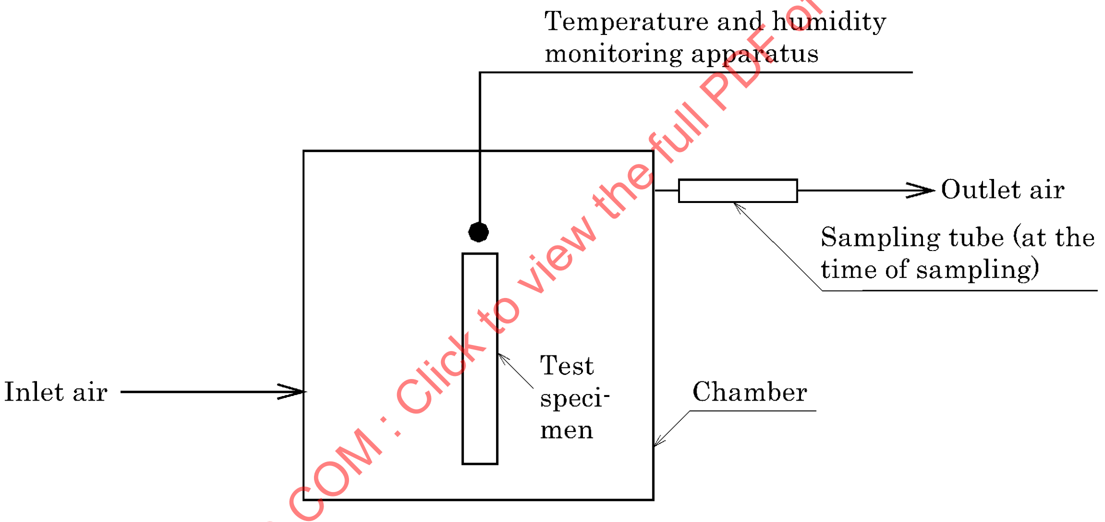

Figure 1 Outline of chamber

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 (±5 %) to 1 000 L (±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 chambers 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. polytetrafluoroethylene. 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 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 ± 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 ±0.5 °C

— Relative humidity ±5 %

— Air change rate ±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 η in the chamber is calculated from the temporal change by the nominal time constant, τ_n, divided by the mean age $<\bar{\tau}>$. 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.

Coefficient of air change performance $$\eta = \frac{\tau_n}{<\bar{\tau}>} \quad \text{(1)}$$

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

Step-up method $$\langle \bar{\tau} \rangle = \frac{Q}{V}\int_0^{\infty} t\left(1-\frac{\rho_e(t)}{\rho_s}\right)dt \quad \cdots\cdots (3)$$

Step-down method $$\langle \bar{\tau} \rangle = \frac{Q}{V}\int_0^{\infty} t\,\frac{\rho_e(t)}{\rho(0)}\,dt \quad \cdots\cdots (4)$$

8.5 Recovery and sink effects

The recovery of target chemical substances can be determined using standard gas of target component or gas of a known concentration emitted with permeation tube, etc. The concentrations generated shall be of similar magnitude to those expected during the emission tests of building products.

Two or more chambers may be connected in series.

The chamber performance shall ensure a mean recovery of not less than 80 % for toluene and *n*-dodecane. The recovery of other target chemical substances shall be also recorded. Dehumidified air shall be used in determining the recovery of hydrophilic target chemical substances.

Sink effects, leaks or poor calibration can cause difficulties to meet the minimum accuracy required for tests. Sink and adsorption characteristics are very much dependent on the type of chemical substances emitted. Additional recovery tests using target chemical substances with different molecular weight and polarity can be used to increase understanding of these effects. The mean recovery shall be calculated from the ratio of outlet concentration to inlet concentration at the chamber.

9 Chamber preparation

Before starting the test, the chamber shall be demounted and washed. After washed with water, it is heated in an oven to volatilize any remaining chemical substance. If the chamber cannot be placed in an oven, it is allowed to heat the inside of the chamber. After the heat-treatment, the chamber shall be cooled enough for the measurement.

10 Preparation of test specimen

The sample shall be prepared in accordance with JIS A 1902-1, JIS A 1902-2, JIS A 1902-3 and JIS A 1902-4. The time of setting the test specimen in the chamber shall be regarded as the test start.

11 Test methods

11.1 Background concentration and travel blank

An air sample of the chamber background is taken after one-day ventilation of an empty chamber before the start of a new emission test, to quantify any background concentration of volatile organic compounds from the empty chamber. Travel blank shall be analysed every time air is sampled.

Travel blank shall be low enough not to interfere with the emission determinations.

The background concentration of TVOC shall be 20 μg/m^3 or less. The background concentration of each target component, however, shall be 2 μg/m^3 or less.

11.2 Test specimen location in the chamber

The test specimen shall be positioned in the centre of the chamber to ensure that the air flow is evenly distributed over the emitting surface of the test specimen.

11.3 Time for measurements of chamber air concentration

After starting the test according to **11.3.1**, air sampling shall be started at predefined sampling times in accordance with **11.4**.

11.3.1 Emission test

Check the integrating air flow rate through the chamber and the air tightness and carry out air sampling. Verify that the outlet air flow rate during air sampling is equal to the inlet airflow minus the air flow at the time of air sampling.

Air samples shall be taken after 1, 3, 7, 14 ± 1 and 28 ± 2 days, in principle, after the test start. Air sampling may be carried out at additional times.

NOTE 1 The test durations may be selected depending on the purpose of the test.

NOTE 2 If decay studies are required, air samples can be taken after 28 days or longer after the test start.

NOTE 3 If the test chamber concentrations become lower than the quantification limit, the test may be completed.

11.3.2 Storage of test specimen

The test specimen shall be stored under the same conditions as in measurement, when removed from the chamber in long-term testing. The removed test specimens can be exposed to air freely, but they should be kept in a safe place to minimize contamination by other test specimens or the place where stored. In principle, the test specimens should be returned to the chamber at least 72 h prior to air sampling. Preservation of test specimens in temperature over 28 °C shall be avoided.

11.4 Air sampling

As sampling tubes, Tenax-TA® [1)] or others shall be used for sampling VOC, and DNPH cartridge shall be used for sampling aldehydes. In 8 h or longer after supplying the chamber with clean air, the temperature and relative humidity shall be confirmed to be at steady state. Then a sampling tube shall be connected to the chamber and the outlet concentration in the chamber after one day as well as the travel blank shall be measured.

After that, the outlet concentration in the chamber and travel blank shall be measured at each given time.

If the concentration in the chamber is hardly predictable, two sampling tubes shall be connected to confirm there is no breakthrough in a series. Presence or absence of breakthrough shall be judged by formula (5). The absence of breakthrough can be confirmed when the calculated value is 95 % or over, because it means that target chemical substances are adsorbed only in the primary sampling tube. Sampling tubes shall be in accordance with **6.1.1** of **JIS A 1962**, **6.1** of **JIS A 1965** and **6.1** of **JIS A 1966**.

$$\frac{\rho_1}{\rho_1+\rho_2}\times 100 \geq 95 \quad (\%) \qquad (5)$$

where,

ρ_1 : concentration of tubing upstream of air (μg/m³)

ρ_2 : concentration of tubing downstream of air (μg/m³)

Note [1] "Tenax-TA®" is a commercially available product, given in this Standard for the convenience of users. Equivalent products may be used if they are proved to give the same results.

12 Analysis method

12.1 Analysis of VOCs

After connecting Tenax-TA® [1] tube to a thermal desorption apparatus, VOCs are desorbed by heating. Analysis of VOCs shall be in accordance with clause **9** of **JIS A 1965**, clause **10** of **JIS A 1966** or clause **10** of **JIS K 0123**.

12.2 Analysis of aldehydes

The DNPH derivatives of carbonyl compound in a DNPH cartridge is dissolved and desorbed using acetonitrile. Analysis method of aldehydes shall be in accordance with **9.3** of **JIS A 1962** or clause **8** of **JIS K 0124**.

13 Calculation of emission factor and expression of result

The area specific emission factor q_A at a given time, t, from the start of measurement after placing the test specimen in the chamber can be expressed by formula (6). The 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 can be expressed by formulae (7) to (10), respectively. Emission factor can be expressed in integral value and rounded off in accordance with **JIS Z 8401**.

$$q_A = \frac{\rho_t \times Q}{A} = \frac{\rho_t \times nV}{A} = \rho_t \times k_Q = \rho_t \times \frac{n}{L} \qquad (6)$$

$$q_l = \frac{\rho_t \times Q}{l} \qquad (7)$$

$$q_m = \frac{\rho_t \times Q}{m} \qquad (8)$$

$$q_v = \frac{\rho_t \times Q}{v} \qquad (9)$$

$$q_u = \frac{\rho_t \times Q}{u} \qquad (10)$$

NOTE 1 For certain purposes, emission factor q can be calculated from time concentration profiles, or by applying the decay model from concentration time data.

NOTE 2 The concentration ρ_t can be calculated after subtracting the travel blank from the total mass of chemical substances sampled at the chamber outlet.

14 Performance characteristics

Performance characteristics of this test method, when used in conjunction with **JIS A 1965**, shall be in accordance with **JIS A 1965** and **JIS A 1966**.

15 Test report

The test report shall include the following information, in principle.

a) **Test laboratory**

  1) Name and address of the laboratory

  2) Name of the responsible person

b) **Sample description**

  1) Type of product (and brand name if appropriate)

  2) Sample selection process (e.g. random)

  3) Product history (e.g. date of production, batch number, date of arrival to the test laboratory, date and time of unpacking and of test specimen preparation)

c) **Results** emission factor of target chemical substances (VOCs, aldehydes) and/or TVOC at a given time from the test start

d) **Data analysis**

  1) Describe the method used to derive specific emission factor q_A from measured emission test chamber concentration (specify mathematical models or formulae used), if any

  2) Describe the transformable formula, when test conditions of temperature and relative humidity are changed

e) **Test conditions**

  1) Chamber conditions (temperature, relative humidity, air change rate, mass transfer coefficient)

  2) Test specimen area and product loading factor

  3) With or without sealing

  4) Sampling of emitted target chemical substances (e.g. sampling tube used, volume sampled, sampling period and number of air sampling after introduction into the chamber)

f) **Devices** Information of equipment and procedure (e.g. chamber, seal material, seal box, clean air supply, temperature control and humidification system, integrating flowmeter, oven, air sampling devices, analyser)

g) **Quality assurance and quality control**

The quality assurance and quality control shall be as specified in Annex A, and as follows.

1) Background concentration and travel blank of target chemical substances

2) Recovery data to evaluate sink effect of target chemical substances

3) Number of measurements

4) In the case of duplicate sampling, results of individual analyses

5) Accuracy of temperature, relative humidity and air change rate

6) Quality assurance report

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Annex A (normative)
System for quality assurance and quality control

A.1 General

Chamber testing of volatile organic compounds (VOC) and aldehydes emitted from building materials/products shall be conducted within the framework of Quality Assurance Project Plan (QAPP). The QAPP shall contain a project description, data quality objectives/acceptance criteria, QA/QC approaches/activities, and QA/QC audits.

A.2 Project description

A brief description shall include what materials are to be tested, how the testing is to be conducted, and who is responsible for various project activities. The project experimental design should contain the necessary information for this portion of the QAPP.

A.3 Data quality objectives/Acceptance criteria

This section of the QAPP defines the precision, accuracy, and completeness desired for each parameter being measured.

A.4 QA/QC Approaches/Activities

The types of QA/QC activities that can be specified in the QAPP include establishment of a system of records/notebooks to ensure proper operation of equipment and recording of data. QC activities are carried out by project staff in a routine, consistent manner to provide necessary feedback in operation of all measurement systems. Such activities can include the following.

a) **At the time of introduction of the project**

   1) Manuals governing operation or all equipment used by the project

   2) QC validation of VOC sorbent tubes. QC validation of DNPH cartridges

b) **On routine basis**

   1) Manuals governing operation or all equipment used by the project

   2) Sample log to record receipt, storage, and disposition of materials

   3) Materials testing logs in which to record all pertinent information for each test, including chamber details, temperature control and humidification system, and ID number of analysis device to be used

   4) Aging log of VOC sorbent tubes and blank value log of DNPH cartridges

   5) Preparation log of standard solution used for analysis

   6) Daily recording of GC calibration accuracy and precision (i.e. control charting)

   7) Daily recording of analyser calibration

8) Determination of system blank

9) QC checking of organic collection sorbent tubes

10) Timely monitoring of percent recovery of the internal standard that was added to all samples or determination of QC check samples

11) Collection and analysis of duplicate samples

12) Separate electronic log to document location and content of electronically stored data

c) **On (a) regular basis**

1) Recording of routine maintenance and calibration of chamber systems

2) Routine maintenance, calibration and recording of analyser

3) Log of weight loss data for all permeation tubes or log of the air tightness of chamber

A.5 QA/QC Audits

The QA/QC program shall include periodic audits by QA personnel to evaluate compliance with QAPP protocols.

Annex JA (informative)
Example of chamber (20 L)

JA.1 20 L chamber

20 L chamber is convenient for transporting, demounting, cleaning, settling and heat treatment. This chamber is composed of a main chamber, an air control unit and others.

JA.2 Apparatus

Composition of 20 L chamber system is shown in Figure JA.1.

When the emission factor of VOCs, aldehydes are measured with 20 L chamber, the following apparatuses should be mainly used.

a) 20 L chamber

b) Seal box

c) Clean air supply (or cylinder)

d) Temperature control and humidification system (thermostatic bath, chamber, mixer)

e) Flow rate control apparatus

f) Temperature and humidity recorder

g) Integrating flowmeter

h) Air sampling device

i) Oven

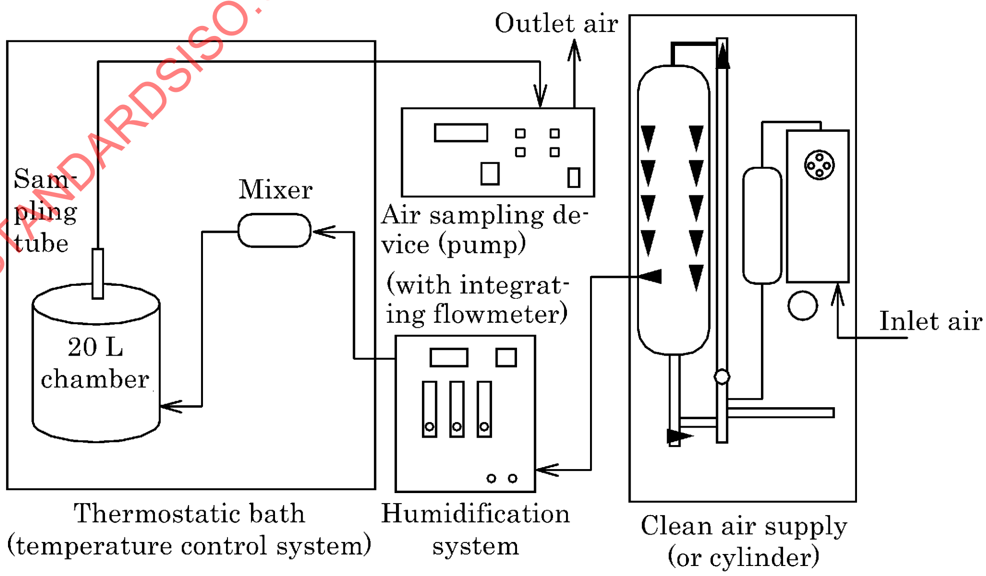


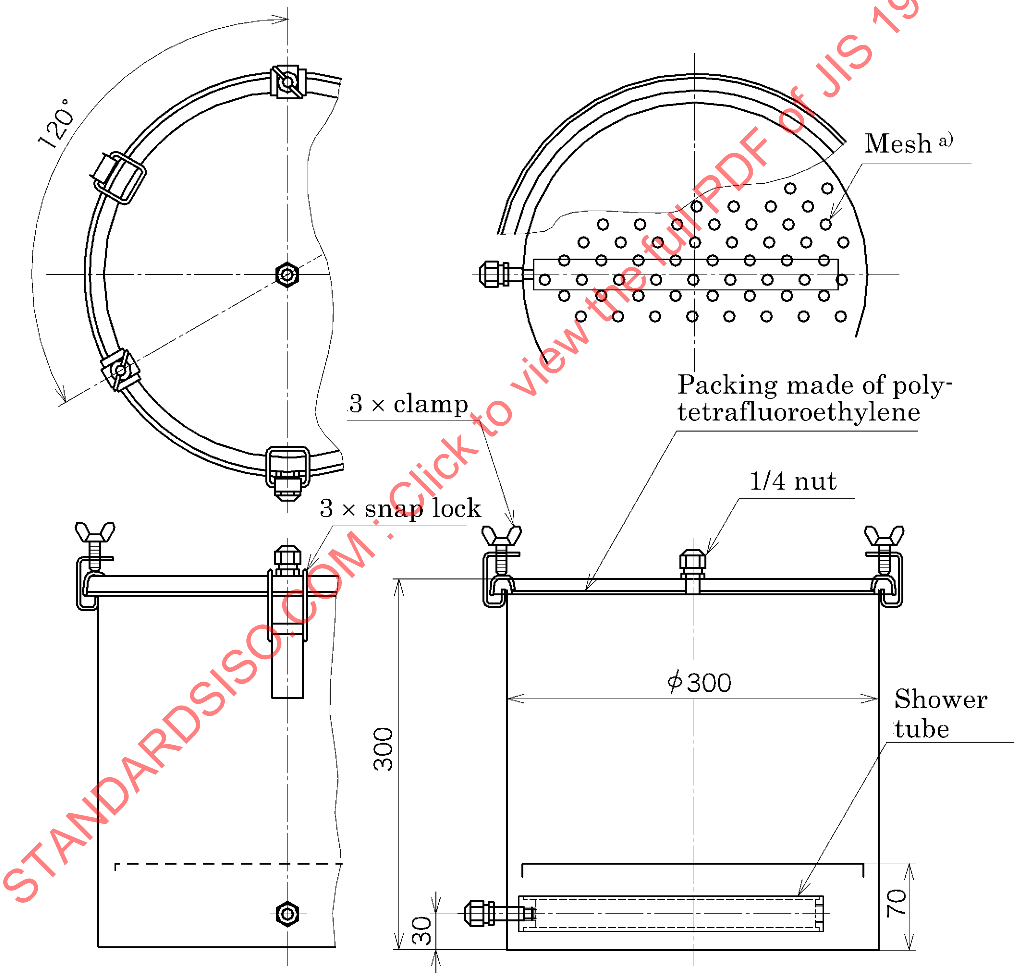
Figure JA.1 Composition of 20 L chamber system

JA.2.1 20 L chamber

Main chamber is made of stainless steel (SUS304) to minimize contamination caused by the system itself and the adsorption of contaminant. The chamber is made cylindrical to minimize leak from the joint and to reduce the weld.

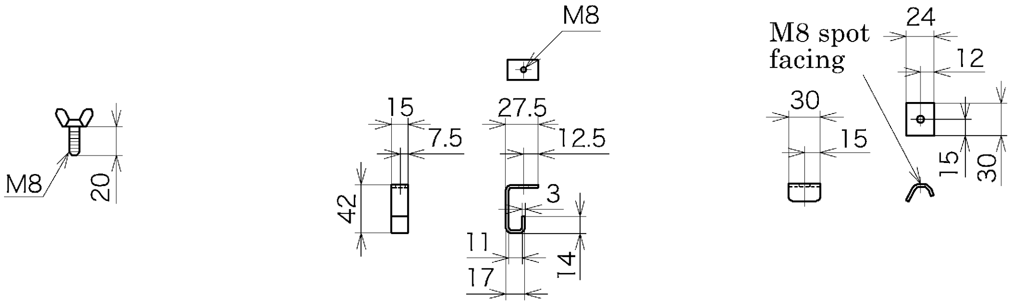
The packing is sealed with low emitting and low absorbing frame made of or coated with polytetrafluoroethylene. The components in the chamber are made of stainless steel, and are demountable therefore suited for washing and heat treatment. Fresh air is supplied to the chamber through a shower tube which is designed to mix the air thoroughly. An example of details for 20 L chamber is shown in Figure JA.2.

Unit: mm



a) 20 L chamber (container)

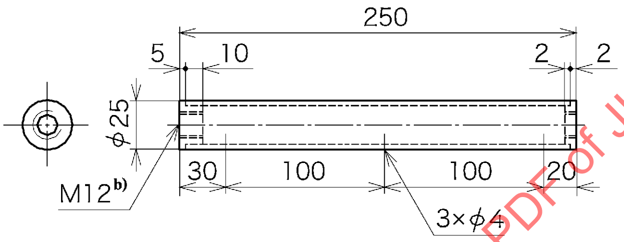
Unit: mm



b) **M8 butterfly nut**

c) **Clamp**

d) **Press plate for clamp**



e) Shower tube b)

Notes a) Opening area of mesh should be about 40 %.

b) Apply a shower tube to a nut-weld clamp (M12) for shower tube on the side (inside) for chamber as air inlet. Diameter of a clamp for a shower tube should be ϕ 7 mm.

Figure JA.2 Example of details for 20 L chamber

JA.2.2 Seal box

When setting the sample in the chamber, employ a seal box to seal the back and cut ends of the test specimen, so that chemical substances can be emitted only from the surface.

Seal box can hold a constant surface area of the test specimen according to the product loading factor. In the case of 20 L chamber, the product loading factor comes to 2.2 m^2/m^3 if two sets of the seal box shown in Figure JA.3 are used. Insert polytetrafluoroethylene frame in a gap between a test specimen and the stainless steel body, and fix the test specimen with screws from the back.

This method is useful to minimize the emission of chemical substances at the time of setting, because the body can be set up quickly, using only eight fasteners for fixing the cover of seal box and four screws for fixing a test specimen. An example of the composition of seal box is shown in Figure JA.3 and an example of the cross-section of a seal box is shown in Figure JA.4.

Unit: mm

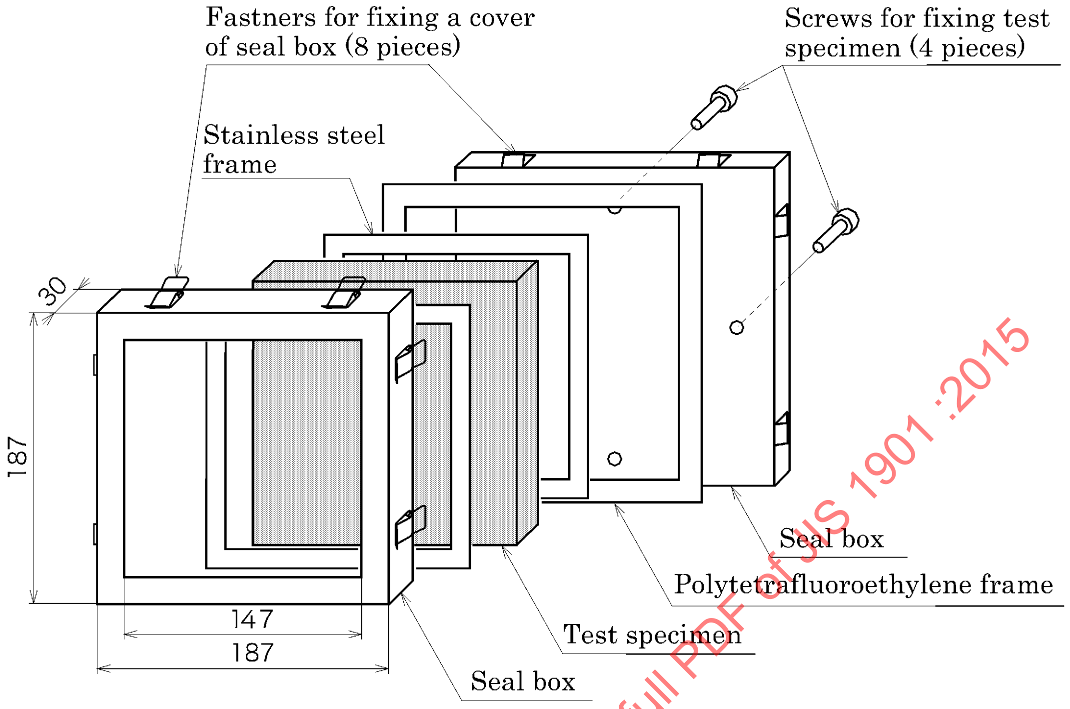


Figure JA.3 The composition of seal box (example)

Unit: mm

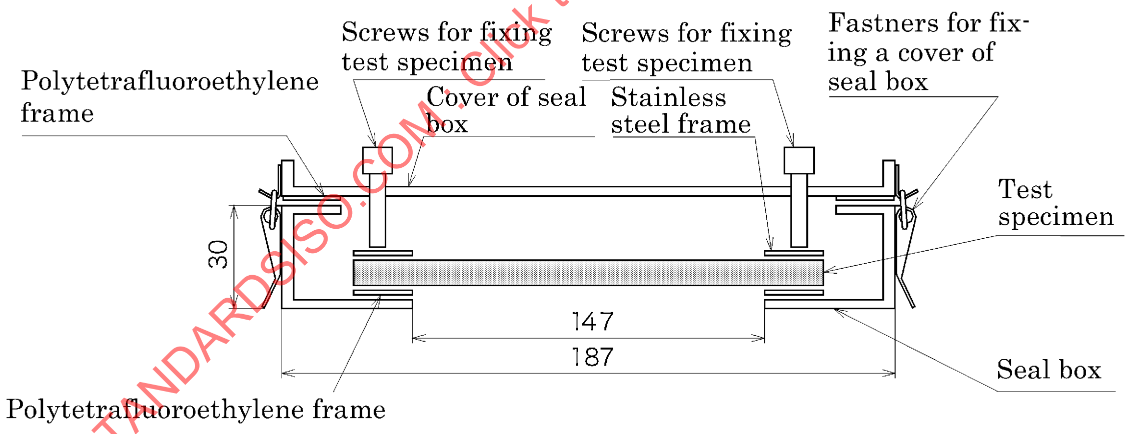


Figure JA.4 The cross-section of seal box (example)

JA.2.3 Clean air supply

The clean air supply should be in accordance with **6.4**.

JA.2.4 Temperature control and humidification system

The temperature of 20 L chamber should be controlled by installing the chamber body into a thermostatic bath controlled to the required temperature. The relative humidity and the flow rate of ventilated air should be controlled with an air control unit.

Divide the ventilation air, which is dehumidified and purified with the clean air supply, into two lines with the air control unit, introduce one of them into a tank filled with distilled water and bubble it to humidify. Wet air and dried air are joined in one line and sent to the mixer. After mixing, air is sent to the chamber.

JA.2.5 Flow rate control apparatus

The pump for air control unit should be the pump employed in a clean room, which can suck in and out at the same time (vacuum pump). Air sucked out is divided to two lines, and their flow rates are to be measured.

The chamber should be ventilated at a specified air change rate until sampling is carried out. The emission factor is calculated on the supposition of perfect mixing.

During ventilating, suck the air inside the chamber with a pump of the air control unit. The flow rate can be controlled by a digital-indicated flowmeter placed in front of the pump. In sampling, use an external sampling pump. Fresh air is supplied to the chamber through a shower tube which is designed to mix the air thoroughly.

JA.2.6 Temperature and humidity recorder

Temperature/humidity sensor and pressure gauge can be installed on a mixer, and and their data can be outputted if necessary. In the case of 20 L chamber, take values obtained with a temperature and humidity measuring apparatus as a temperature and humidity inside the chamber, and monitor them continuously.

JA.2.7 Integrating flowmeter

The integrating flowmeter should be in accordance with **6.6**.

JA.2.8 Air sampling device

The air sampling device (pump) should be in accordance with **6.7**.

JA.2.9 Oven

The oven should be in accordance with **6.8**.

Annex JB (informative)
Example of chamber (500 L)

JB.1 500 L chamber

A 500 L chamber is of capacity 500 L, and is the integrated chamber equipped with the clean air supply, and a temperature control and humidification system, etc.

JB.2 Apparatus

The composition of 500 L chamber system is shown in Figure JB.1.

When the emission factor of VOCs, aldehydes are measured with 500 L chamber, the following apparatuses should be mainly used.

a) 500 L chamber

b) Clean air supply (air pump, air filter, air cleaning filter)

c) Temperature control and humidification system (temperature control apparatus : temperature controller, circulating pump and tank for heating medium/humidity control apparatus : humidity automatic controller, humidification apparatus)

d) Flow rate/air velocity control apparatus (flow rate control apparatus : flow controller, mass flow controller, mass flow meter, integrating flowmeter/flow velocity controller : fan controller, fan, air speed sensor)

e) Pressure gauge

f) Recorder (temperature, humidity, pressure, air velocity)

g) Seal box

h) Air sampling device

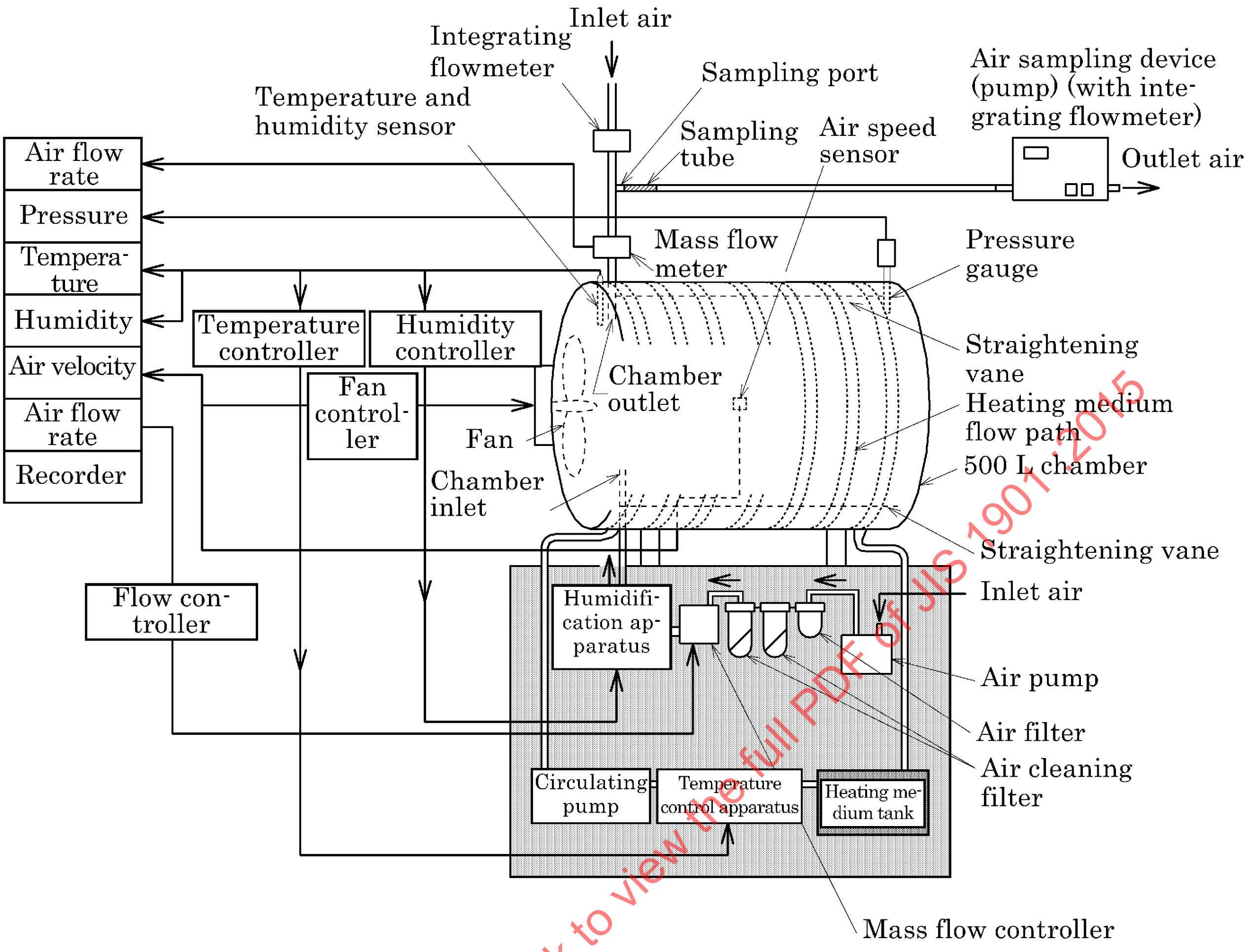


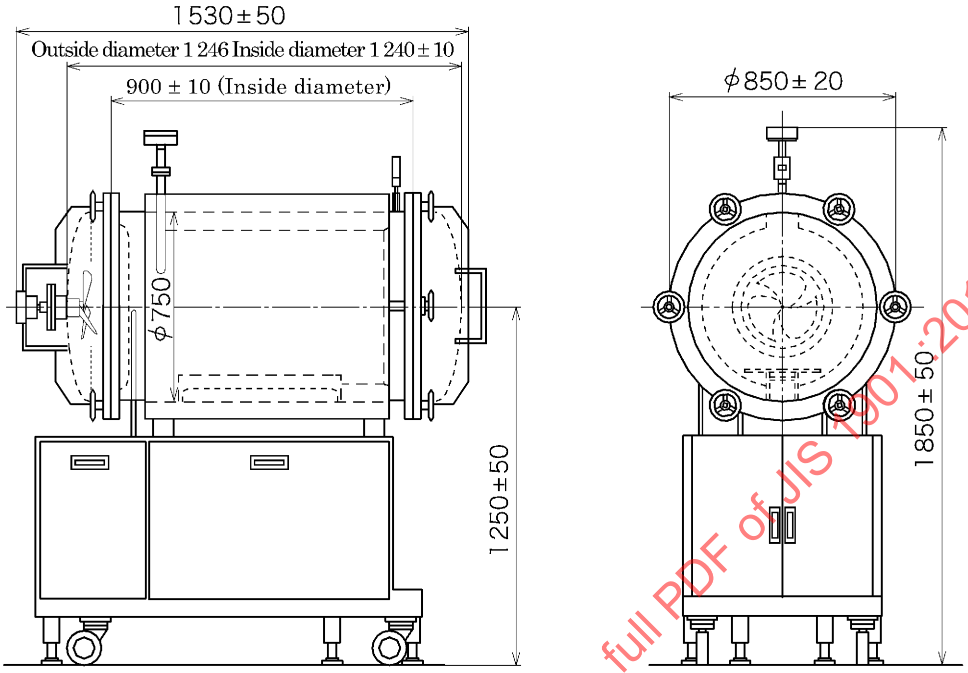
Figure JB.1 Composition of 500 L chamber system

JB.2.1 500 L chamber

Main chamber is made of stainless steel (SUS304) to minimize contamination caused by the system itself and adsorption of contaminant. The chamber is made cylindrical to minimize leak from the joint and to reduce the weld.

The two doors are provided in front and back of a chamber for putting in and out of the sample. In the centre of chamber, the sample horse is furnished. Sampling is carried out at a sampling port which is provided as a branch of the chamber outlet. Packing is sealed with the low emitting and low absorbing silicon O-ring. The components in the chamber should be made of stainless steel as much as possible, and be demountable therefore suited for washing after detachment. The clean air is supplied from a chamber inlet toward a fan in the chamber, in the stable current of air by using a fan and the straightening vanes. An example of details for 500 L chamber is shown in Figure JB.2.

Unit: mm



a) **Side view** b) **Front view**

Material of the chamber : made of stainless steel (SUS304) with all faces finished by electropolishing
Fan : Size : three blades of 50 mm in diameter
Material : made of stainless steel (SUS304) with all faces finished by electropolishing

Figure JB.2 Example of details for 500 L chamber

JB.2.2 Clean air supply

The clean air supply should be in accordance with **6.4**.

JB.2.3 Temperature control and humidification system

Control the temperature by using a temperature control apparatus with the circular system of heat transfer medium to the body of 500 L chamber. Control the humidity by humidification of wet air compressed system for the conditioning air which is dehumidified and purified with the clean air supply.

JB.2.4 Flow rate and air velocity control apparatus

Room air, purified with the clean air supply, is adjusted to predetermined flow rate with the mass flow controller and sent to a humidification apparatus. After adding moisture, clean air introduced in the chamber is introduced into a space between the chamber body and the straightening vane by a fan equipped at the end of the chamber. Clean air passes through the straightening vane, flows at the constant air velocity and is discharged from air outlet. A motor worked for a fan is installed outside the chamber to prevent the emission of contaminants (e.g. oil) into the chamber.

Air velocity in the chamber can be controlled with the number of fan revolutions. Measure the air velocity by clamping on the sample horse with two DIN-size, panel-mount and constant-temperature air speed sensors equipped with directly heated thermistor for a wind sensor, placing it perpendicular to the blow of the fan, 10 mm apart from both sides of the centre of test specimen.

JB.2.5 Pressure gauge

Equip a pressure gauge at the top inside the chamber. Install the suspended safety valve to prevent excessive increase of pressure inside the chamber which can add the load to the chamber.

JB.2.6 Recorder

Monitor and record continuously with a temperature and humidity sensor, anemometer and pressure gauge.

JB.2.7 Seal box

When setting the sample in the chamber, employ a seal box to seal the back and cut ends of the test specimen, so that chemical substances can be emitted only from the surface.

Seal box can hold a constant surface area of test specimen according to the product loading factor. In the case of 500 L chamber, the product loading factor is 1.1 m^2/m^3 if one set of the seal box shown in Figure JB.3 is used. The body of the seal box is made of stainless steel. Set a test specimen between an outer frame and a inner cap, join the two outer frames together and fix them with screws. To increase the air tightness, sealing may be performed by inserting polytetrafluoroethylene frame between an outer frame and the test specimen.

An example of the composition of a seal box is shown in Figure JB.3, and that of the cross-section of a seal box is shown in Figure JB.4.

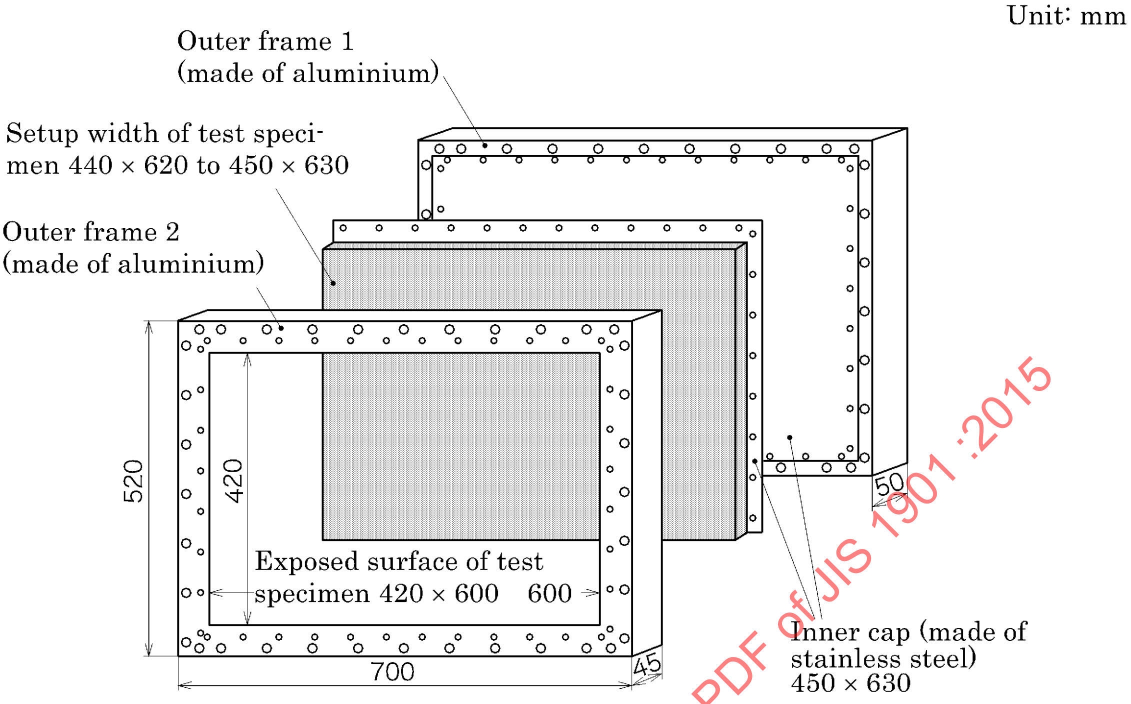


Figure JB.3 The composition of seal box (example)

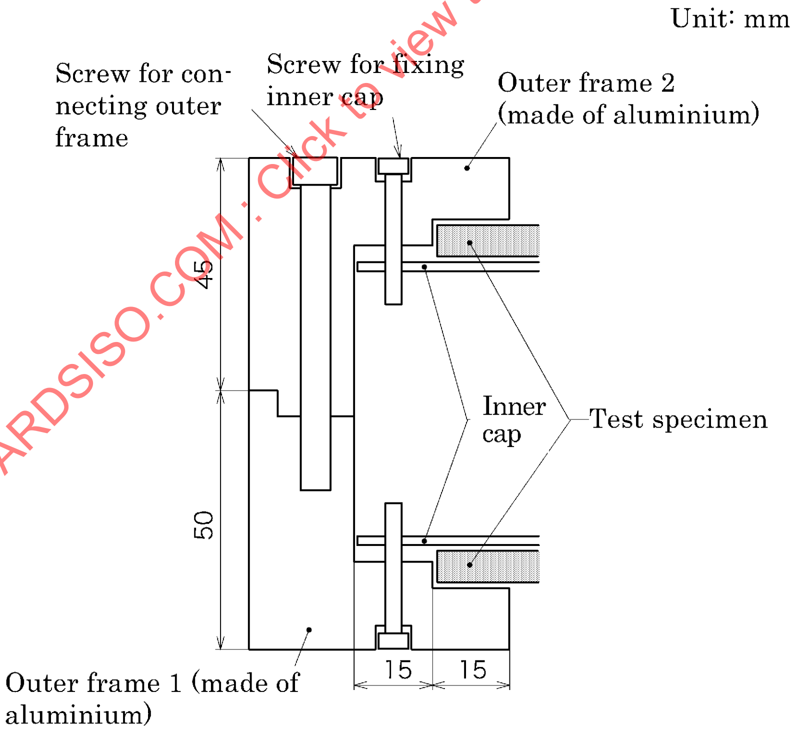


Figure JB.4 The cross-section of seal box (example)

JB.2.8 Air sampling device

The air sampling device (pump) should be in accordance with **6.7**.

Annex JC (informative)
Example of chamber (1 000 L)

JC.1 1 000 L chamber

1 000 L chamber is suitable for the emission test of relatively large test specimen. This chamber is composed of main chamber, air control unit, etc.

JC.2 Apparatus

The composition of 1 000 L chamber is shown in Figure JC.1.

When the emission factor of VOCs and aldehydes are measured with 1 000 L chamber, the following apparatuses should be mainly used.

a) 1 000 L chamber

b) Seal box

c) Air supply apparatus

d) Temperature control and humidification system (constant temperature and humidity room where the 1 000 L chamber system can be used)

e) Temperature and humidity recorder

f) Clean air supply

g) Flow rate control apparatus

h) Air sampling device

i) Analyser

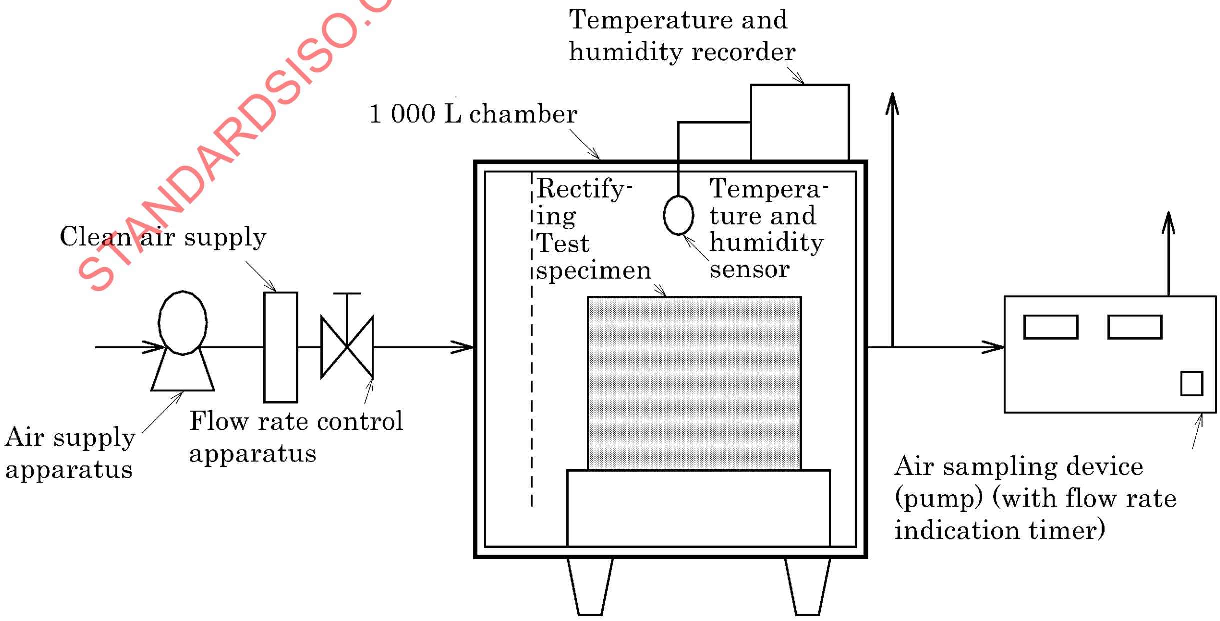


Figure JC 1 Composition of 1 000 L chamber system

JC.2.1 1 000 L chamber

Main chamber is made of stainless steel (SUS304) to minimize contamination caused by the system itself and adsorption of contaminant.

A pair of stainless steel pipes for sampling is equipped at the opposite sides of the chamber. At the side without sampling pipe, an opening of 50 cm square which can put the test specimen in and out is installed. During the test, the opening is sealed with polytetrafluoroethylene sheet and stainless steel sheet, with its air tightness maintained. A sensor of a temperature and humidity recorder is placed in the chamber from the centre of upper face of the chamber. All parts of the chamber are made of stainless steel and demountable therefore suited for washing and heat treatment. Fresh air is supplied to the chamber through a shower tube which is designed to mix the air thoroughly.

JC.2.2 Seal box

When setting the sample in the chamber, employ a seal box to seal the back and cut ends of the test specimen, so that chemical substances can be emitted only from the surface.

Seal box can hold a constant surface area of test specimen according to the product loading factor. In the case of 1 000 L chamber, the product loading factor is 1 m^2/m^3 if 16 sets of the seal box shown in Figure JC.2 are used. Insert polytetrafluoroethylene frame in a gap between a test specimen and the stainless steel body, and fix the test specimen with screws from the back.

This method is useful to minimize the emission of chemical substances at the time of setting, because the body can be set up quickly, using only eight fasteners for fixing the cover of seal box and four screws for fixing a test specimen. An example of the composition of a seal box is shown in Figure JC.2 and an example of the cross-section of a seal box is shown in Figure JC.3.

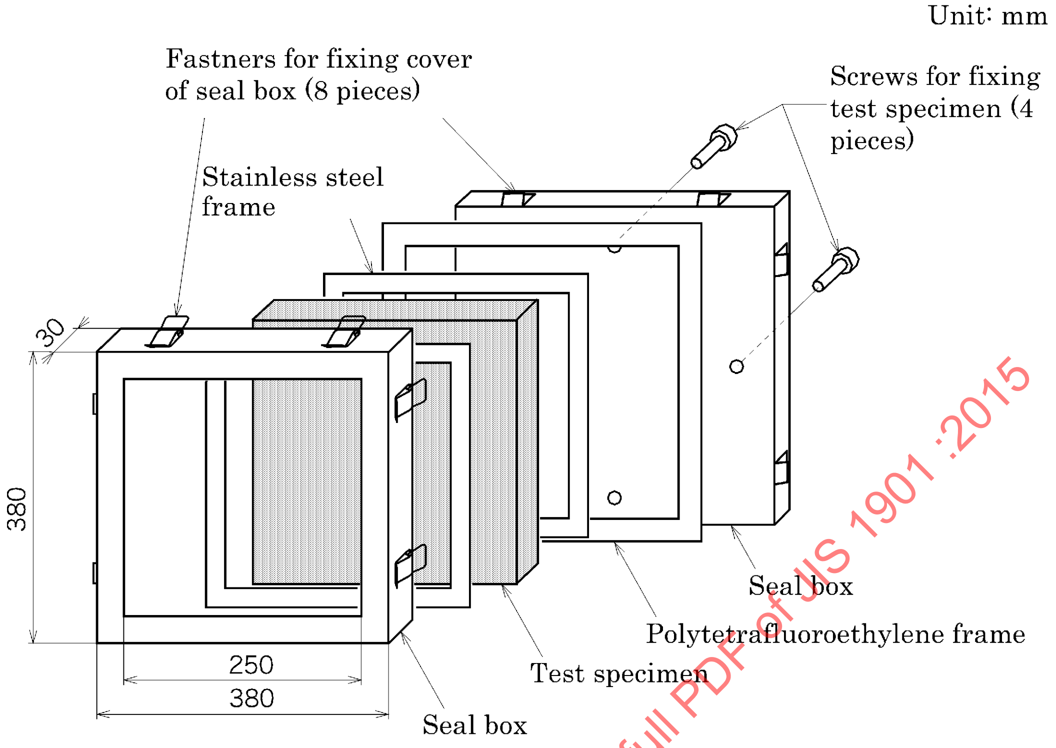


Figure JC.2 The composition of seal box (example)

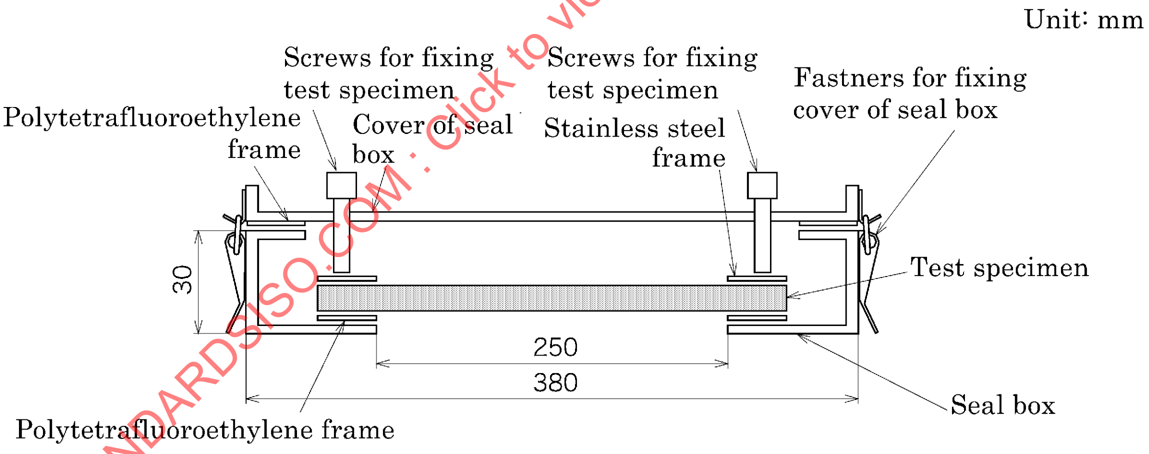


Figure JC.3 The cross-section of seal box (example)

JC.2.3 Clean air supply

The clean air supply is composed of a container with the stainless steel pipe welded at the both ends, in which 1 L of the absorbent, a mixture of hydrophobic zeolite 1 and manganese oxides 1, is supported on the corrugate form carrier of 400 cells. The absorbent should be newly prepared every two days. The absorbent can regenerate within 2 h by blowing warm air of 150 °C at 100 L/min. One pass rejection of toluene is 99.5 % or more.

JC.2.4 Temperature control and humidification system

Adjust temperature by installing the body of 1 000 L test chamber in the constant temperature and humidity room controlled to the required temperature and humidity. Clean ventilated air with the clean air supply, adjust the flow rate with the flow rate control apparatus and introduce the air into the chamber.

JC.2.5 Flow rate control apparatus

A pump of flow rate control apparatus should be the vacuum pump employed for the clean room, which can suck in and out at the same time. The flow rate of the pushed air is to be measured.

Until sampling is carried out, the inside of the chamber is ventilated at the specified air change rate. The emission factor is estimated on the supposition of complete mixing.

JC.2.6 Temperature and humidity recorder

A sensor for recording temperature and humidity and a pressure gauge can be installed inside the chamber, and their data can be outputted if necessary. 1 000 L chamber shall be continuously monitored with the temperature and humidity recorder installed in the chamber.

JC.2.7 Air sampling device

The air sampling device for collecting air in the chamber is composed of a suction pump, needle valve for controlling suction flow rate of the pump, mass flow controller for measuring of the flow rate, display for indicating the flow rate and timer for controlling the suction time.

JC.2.8 Analyser

Analyse VOC with a gas chromatograph mass spectrometer, and analyse aldehydes with a high performance liquid chromatograph.

Annex JD (informative)

Example of chamber (mass transfer coefficient control type)

JD.1 Mass transfer coefficient control chamber

A mass transfer coefficient control chamber is a type of chamber made by adding to an ordinary chamber the functions of keeping the constant air flow rate near the surface of the test specimen and of keeping the uniform concentration in the chamber at the outer border of boundary layer which is formed on the surface of test specimen. Generally, this is composed of an outer chamber equivalent to a common chamber; an inner chamber, placed inside the outer chamber, which can keep a constant air flow rate around the surface of test specimen and has sufficient space so that the boundary layer of concentration formed on the surface of test specimen can freely grow; and a blower (ventilator) which can generate constant air movement in the inner chamber. Both chambers should have sizes and shapes suitable for removing, washing and heat-treatment.

JD.2 Apparatus

An example of mass transfer coefficient control chamber is shown in Figure JD.1. An outer chamber illustrated in this Figure is of volume 1 000 mm (x) × 800 mm (y) × 500 mm (z). The chamber is made of stainless steel (SUS304), and has a glass window for interior observation.

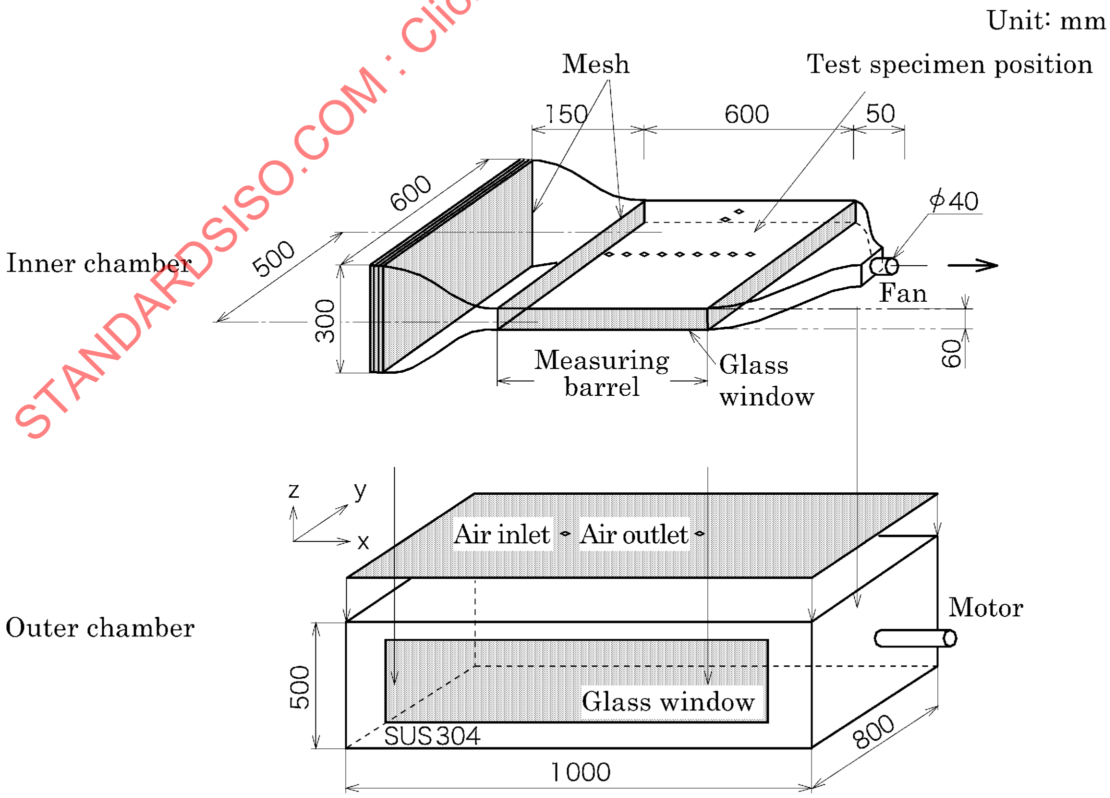


Figure JD 1 Example of mass transfer coefficient control chamber

An inlet nozzle for rectification is installed in the inner chamber, in order to obtain the uniform wind velocity at an inlet of inner chamber and form automatically the boundary layer of velocity on the surface of a wall. The test specimen is placed at one side of this inner chamber. On the surface of test specimen, the boundary layer of concentration is formed by the mass emission from surface of test specimen. The thickness of the boundary layer of concentration should be smaller than that of the cross-section of the inner chamber. A fan which generates air movement is installed inside the inner chamber. A motor driving the fan, installed outside the outer chamber to prevent contamination inside the camber, works the fan with a sealed drive shaft. In order to prevent contamination in the chamber, materials like lubricant should not be used to seal the drive shaft.

JD.3 Measurement of mass transfer coefficient by liquid surface vaporization

Obtain the mass transfer coefficient of the surface of the test specimen from the steam pressure (equal to that obtained at the chamber outlet), transpiration rate of pure water (transpiration mass per unit time) and saturated vapour pressure of pure water in the test chamber, by placing on the installation surface of the test specimen the vessel filled with pure water of the same area as the installation surface.

The surface temperature will drop as transpiration draws away evaporation heat. Therefore, measuring the surface temperature of pure water is significant for determining the saturated vapour pressure. If there is a large gap between the ambient air temperature and the surface temperature, it is required to keep the surface temperature almost equal to the ambient air temperature.

In the measurement of mass transfer coefficient, volatile liquid other than pure water may be used. However, it must be confirmed that vapour of volatile liquid is non-toxic and concentration of the vapour is sufficiently less than the lower explosive limit.

The mass transfer coefficient k_a (m/s) should be calculated with formula (JD.1).

$$k_a = \frac{q_w}{A \times (\rho_{sat} - \rho_o)} \cdots\cdots (JD.1)$$

where,

k_a : mass transfer coefficient (m/s)

q_w : transpiration rate (mg/s)

A : surface area of test specimen (m^2)

ρ_o : vapour concentration at test chamber outlet (mg/m^3)

ρ_{sat} : saturated vapour concentration of liquid surface (mg/m^3)

The mass transfer coefficient per hour $k_a'a'_m$ (m/h) can be obtained by multiplying k_a by 3 600 times.

JD.4 Emission test with controlled mass transfer coefficient

The mass transfer coefficient control chamber should be used to carry out the emission test for building products whose mass transfer coefficient may affect seriously its emission performance, such as paint surface still not dried.

Generally, the convective heat transfer coefficient at the wall of quiet room is 3 W/(m^2·K) to 6 W/(m^2·K). The mass transfer coefficient corresponding to the relation of Lewis rule is 2.5×10^{-3} m/s to 5.0×10^{-3} m/s, if the specific heat of air is 1 200 J/(m^3·K). Corresponding mass transfer coefficient per hour, k_a, is about 9 m/h to 18 m/h. The mass transfer coefficient on the surface of test specimen should be adjusted approximately to these values to carry out the emission test.

Emission quality may be affected by the concentration of emission substance in the chamber. When the concentration in the chamber is near the concentration of saturated vapour pressure of emission substance, product loading factor and air change rate need to be adjusted so that the concentration in the chamber corresponds to the actual concentration in the room.

Annex JE (informative)

Guideline concentrations for target VOCs and aldehydes

This Annex is intended to give the guidelines on indoor air pollution specified by the Committee on Sick Building Syndrome (Indoor Air Pollution) in the Ministry of Health, Labour and Welfare for information, and not to constitute the provisions of this Standard.

According to the scientific knowledge currently available, these guideline values have been established on the basis that exposure to chemical substance of a given concentration or less during lifetime will not risk human health. These values should be updated, if necessary in the future, with new knowledge and progress of the international evaluations based on the information to be acquired hereafter.

JE.1 Target VOC and aldehydes

An example of target VOC is shown in Table JE.1, and that of aldehydes is shown in Table JE.2. These specifications, however, do not suffice for measurement of SVOC like phthalic ester and repellent for ants.

Table JE.1 Example of target VOC

Name of chemicals		CAS-No.	Guideline concentration
toluene		108-88-3	260 μg/m^3
xylene	*o*-xylene	95-47-6	870 μg/m^3
	m-xylene	108-38-3	
	p-xylene	106-42-3	
p-dichlorobenzene		106-46-7	240 μg/m^3
ethylbenzene		100-41-4	3 800 μg/m^3
styrene		100-42-5	220 μg/m^3
tetradecane		629-59-4	330 μg/m^3

Table JE.2 Example of Aldehydes

Name of chemicals	CAS-No.	Guideline concentration
formaldehyde	50-00-0	100 μg/m^3
acetaldehyde	75-07-0	48 μg/m^3

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