

EMISSION TEST CHAMBER FOR MEASUREMENT OF VOLATILE ORGANIC COMPOUNDS (VOC)

Norikazu Kobayashi ^{1†}, Huaipeng tang ¹, Mitsuo Shibamoto ², and Mikio Hashida ²

¹Research & Development Center, Shinryo Corporation, Tsukuba, Japan

²Shinryo Aqua Business, Ltd., Tokyo, Japan

ABSTRACT

It is well known that volatile organic compound (VOC) emissions from construction materials and office appliance occasionally have influence on human health. It is a social request that manufacturers reduce VOC emissions from their products. To measure emissions from materials, a high-precision chamber is required that can control environmental conditions such as ventilation, temperature, humidity, air flow, and VOC concentrations. We developed a high-performance VOC observation chamber for measurement of emissions from construction materials, furniture, office equipment, and household appliances. Thus, the chamber exhibited extremely low VOC concentration with considering to structural materials and air purification system. A domestic testing facility that adopted our chamber is the first manufacturer to receive certification from Federal Institute for Materials Research and Testing (BAM) in Germany, as a measurement institution for the determination of emissions (such as TVOC, ozone and dust) from hardcopy devices.

KEYWORDS

Volatile Organic Compounds (VOC), Formaldehyde, Emission Test Chamber,

INTRODUCTION

It is known that volatile organic compounds (VOC) emissions from construction materials and as for the office appliances such as copiers have a serious influence for human health. In such background, WHO established the guideline of indoor air quality for human health. After that, the standard of emission test chamber method about construction materials and hardcopy devices are established recently (i.e. 1, 2). In these standards, the emission test chamber is demanded that has environmental accuracy, for instance, cleanness, ventilation, temperature, and humidity control. We developed a high-performance VOC observation chamber for measurement of emissions from construction materials, furniture, office equipment, and household appliances.

DEVELOPMENT OF THE EMISSION TEST CHAMBER

The chamber specification

The emission test chamber consists of double chamber structure, the outer chamber with thermal insulation panel and the measurement room with welded stainless steel. We produced the emission test chambers of 1-25 m³ up to now. In this paper, we present the results about 5 m³ emission test chamber. The exterior of 5 m³ emission test chamber and the clean air supply unit are shown in Figure 1. The volume of measurement room is 5 m³ (W1,600 x D1,550 x H2,020 mm) and air change rate can be controlled by 2.5 to 25 m³/h (n=0.5 to 5 h⁻¹). Used materials of the chamber and its surrounding system are verified by emission tests, and we select zero or extremely low emission materials. These materials are cleaned up with solvent or acid, moreover mainly parts are baked out for reduction of emissions. Thus, the chamber exhibited extremely low VOC concentration with considering to

[†] Corresponding Author: Tel: + 81 29 864 6115, Fax: + 81 29 864 6127

E-mail address: kobayashi.no@shinryo.com

structural materials and the air purification system.



Figure 1 5 m³ emission test chamber
(Left: appearance of emission test chamber and control panel, Right: Clean air supply system)

The outline flow of the emission test chamber is shown in Figure 2.

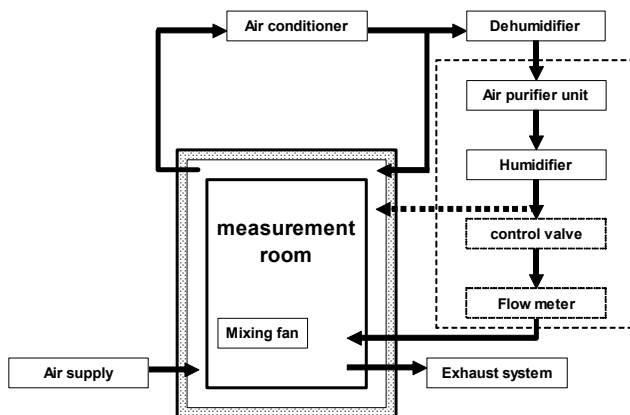


Figure 2 Outline flow of the VOC emission test chamber

The air handling system is classified four routes by air flow with the respective role. (1) Air supply: it supplies to outer chamber from room the same amount of aeration to measurement room. (2) Thermal conditioning: Thermal control of measurement room is carried by coordinating temperature with outer chamber. (3) Clean air supply system: It supplies conditioned clean air from thermal conditioning loop to the measurement room through the air purifier unit after dehumidification. (4) Exhaust system: It

exhausts air with emission gas from the measurement room to outside ambient room.

By these four systems, they control the measurement condition such as room pressure, ventilation, temperature and humidity. In this characteristic air flow, the chamber system can be kept stable high performance. Moreover, a mixing fan that measure to emission is adopted can be installed for air current control in chamber.

Ventilation and pressure control

In our system, air change flow is fine adjusted by needle valve with mass flow meter in the clean air supply system. On the other hand, pressure of the measurement room and the outer chamber are controlled by balance between supply and exhaust air volume. The pressure of the outer chamber is controlled by air supply unit to avoid sensitive swing caused by changing the air change flow, because supply air to the measurement room is gained from the outer chamber. A pressure of measurement room is controlled by exhaust valves that are adjusted by established air change rate. The measurement room and the outer chamber are kept higher pressures 20 Pa and 10 Pa respectively from ambient room.

Temperature and humidity control

An air-conditioner is used to regulate temperature in normal room with air circulating. In the case of emission test chamber, it is difficult to adopt the air-conditioning system with circulation because influence of emissions and adsorption is not avoided. In this system, temperature control of the measurement room is performed indirectly through the wall by circulation type air-conditioning of the outer chamber. A load factor of ventilation air in measurement room is limited impact that can neglect an influence of the measurement room. We adopted a direct humidification method to supply clean air in the measurement room. In the clean air supply unit, the air is dehumidified first to keep efficiency of adsorbent. After air purifier unit, the air is humidified by steam humidifier. In addition, humidification uses pure water so that VOC included in humidification water does not pollute the supply air.

Air purification control

A chemical contamination from the chamber system and supply air affects the accuracy of results of emissions from samples. We selected extremely low VOC emission materials with emission test for a part of contact with gases. The wall of the measurement room is made by polished stainless steel. Pipes, air purifier unit, and other main parts consist of acid washed stainless steel, moreover important parts are heat-treated. The wall of the measurement room is all welded entirely to avoid air leak and to be easy to clean up. The air purifier unit removes chemical substance with adsorbent, and it supplies purified air to the measurement room. The air purifier unit keeps constant air volume treatment with each air flow rate of chamber, and the remaining is return to outer chamber. Thus, the performance of the air purifier unit does not depend on air change rate.

MEASUREMENTS

We measured the performance of the 5 m³ VOC emission test chamber. The specification of the chamber is mentioned above.

Air change flow (Air change rate)

Air change rate can be calculated by air change flow and the chamber geometric volume, but accuracy of the flowmeter should be checked by measuring air change rate. Air change rate was confirmed by CO₂ method described by JIS A1406:1974. First, CO₂ was filled in the measurement room about 3,000 ppm with established condition, and then we measured decrement of CO₂ concentration. CO₂ concentration was measured by LI-6252 CO₂ analyzer (LI-COR Inc).

Environmental accuracy and behavior with change setting

It needs long measuring period for the emission test of construction materials. On the other hand, it needs quick response of ventilation and humidity control for the emission test of hardcopy devices. Therefore, we confirmed whether the emission test chamber worked stable for a long time. After that,

we confirmed the response of chamber with modification of setting, which is corresponding to the test of a hardcopy device. A measuring device of temperature and hygrometer were installed in an outlet of measurement room, and as mentioned flowmeter is installed in the clean air supply system.

Background VOC concentration

We measured VOC and Formaldehyde to confirm the chemical cleanness of the emission test chamber. Before measurements, surface of the measurement room was wiped up with distilled water, afterward the emission test chamber was closed and kept purging for 12 h with test conditions at 23°C, 50%, 5 m³/h (n=1 h⁻¹). A mixing fan was running from purging phase to measurement end. VOCs were adsorbed in TenaxTA adsorbent tube and analyzed by GC/MS with thermal desorption system. Formaldehyde and other carbonyl compounds were collected by DNPH cartridge and analyzed by HPLC after elution. The measurement equipments are shown in Table 1.

Table 1 Measurement equipments

Target substance			sorbent	collected volume
VOC, TVOC	GC/MS	Agilent 6890/5973N	TenaxTA	10L
Formaldehyde	HPLC	Agilent 1100	DNPH	90L

We expected very low concentration of chemical substance in blank chamber, so we increased quantity of sampling volume to secure the sensitivity. Moreover, we performed sampling / analysis with extreme caution to avoid contamination. TVOC value was quantified with toluene by converting the total area of peaks between n-Hexane and n-Hexadecane substance.

RESULT

Air change flow (Air change rate)

We measured air change rate by CO₂ method to check the accuracy of flowmeter. The indication value of flowmeter and measured air change flow are shown in Table 2.

Table 2 Air change flow in the 5 m³ emission chamber

Flowmeter (m ³ /h)	CO ₂ method (m ³ /h)	deviation (%)
4.60	4.68	1.7
9.30	9.34	0.5
13.90	14.04	1.0
18.67	18.63	-0.2
23.22	23.26	0.2

The numerical values of the flowmeter are good agreement with measurement value in the range of air change rate corresponding to n=1 to 5 h⁻¹. The deviation is less than 2% that satisfies the 3% of a standard. After check of accuracy of the flowmeter, we adjust air change flow with needle valve.

Temperature and humidity accuracy

Temperature and related humidity behavior in 5 m³ emission test chamber is shown in Figure 3. At starting stage, it is set at 23°C, 50%RH, with air change flow of 5 m³/h (n=1 h⁻¹). It needs about 3 hours to stabilize the condition in chamber. After that, the environmental condition keeps stable adequate to specification. The accuracy of temperature and related humidity after starting the chamber between 3 to 11 hours are shown in Table 3.

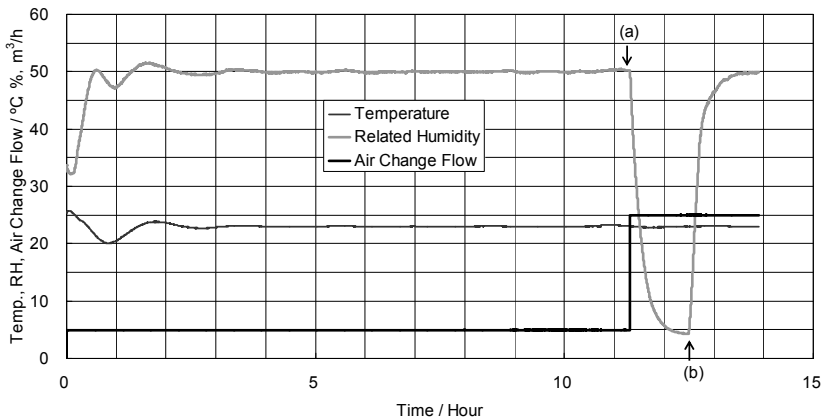


Figure 3 The behavior of temperature and humidity in the emission test chamber

Table 3 The accuracy of temperature and related humidity (3 to 11h in Figure 3)

	Temperature / °C	Related humidity / %RH
maximum	23.3	50.4
minimum	22.9	49.7
average	23.0	50.0

Next, air change flow and humidity are set 25 m³/h and 0%RH at (a) in Figure 3. In this phase, humidity of the supply air should be reduced immediately to avoid condensation of water in the measurement room caused by humidity emission from paper in printing phase of photocopy device. In our system, clean air supply system sends dry air by stopping humidification and it reaches about 4%RH in 1 hour. Finally, (b) in Figure 3, it takes about 1 hour to be stabilized at setting condition of related humidity in a phase conditions after setting at 25 m³/h. Temperature is completely stable regardless of setting ventilation and humidity.

Background VOC concentration

We measured TVOC and Formaldehyde in the measurement room and related parts; they are shown in Table 4-1 and Table 4-2.

Table 4-1 Background and related air quality of the emission test chamber

Measurement room	(µg/m ³)	Ambient establishment room	(µg/m ³)
TVOC	1.8	TVOC	94.0
Decane	0.4	Toluene	19.2
(unknown)	0.3	Xylene	8.3
BHT	0.2	Benzene, ethyl-	3.9
(unknown)	0.2	Benzene, 1,2,3-trimethyl-	3.2
Hexadecane	0.1	BHT	3.0
HCHO	0.6	HCHO	16.5

Table 4-2 Background and related air quality of the emission test chamber

Inlet of Air purifier unit	($\mu\text{g}/\text{m}^3$)	Outlet of Air purifier unit	($\mu\text{g}/\text{m}^3$)
TVOC	1.1	TVOC	not detected
Toluene	0.5	-	-
(<i>unknown</i>)	0.1	-	-
Benzene	0.1	-	-
Benzene, ethyl-	0.1	-	-
p-Xylene	0.1	-	-
HCHO	2.6	HCHO	0.3

Five higher concentration materials are denoted and '*unknown*' means undefined peaks by GC/MS. In the measurement room, TVOC and each individual VOCs are under $2 \mu\text{g}/\text{m}^3$. We point out that TVOC value of inlet of the air purifier unit is particularly low comparison with ambient establishment room. For our unique process of air flow, chemical substances are removed by circulation through the outer chamber and the air purifier unit. Therefore, stable supply of clean air is secured regardless of a change of setting or environment condition. TVOC value of the measurement room becomes a slightly larger than outlet of the air purifier unit. We think it is slight emissions from the mixing fan but we can neglect it enough.

CONCLUSIONS

We developed the emission test chamber for measurement of the emissions from construction materials and hardcopy devices. We measured the performance of the 5 m^3 VOC emission test chamber to confirm the accuracy of chamber. The stability about temperature, related humidity, and air flow rate are satisfied with requirement for long measurement period of construction materials. On the other hand, humidity can be reduced quickly because of directly humidity control of the supply air. Background concentration is very low in the measurement room. There is little pollution with mixing fan, but it can be neglected. The performance of the our emission test chamber is satisfied the standards for measurement of construction materials and office equipment.

ACKNOWLEDGEMENT

We thank Prof. Shinichi Tanabe of Waseda University for technical advices. We also thank chamber users for feedback about practical knowledge.

REFERENCES

1. ISO 16000-9 (2006) "Indoor Air - Part9: Determination of the emission of volatile organic compounds from building products and furnishing –Emission test chamber method".
2. BAM: Federal Institute for Materials Research and Testing (2003) "Test method for the determination of emissions from hardcopy devices with respect to awarding the environmental label for office devices RAL-UZ 62, RAL-UZ 85 and RAL-UZ 114, Appendix 4 to RAL-UZ62, 85, 114".
3. ISO 16000-6 (2004) "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/FID".