To Headwaters, Inc.

Test Report

Evaluation test of the inactivation efficacy of Portable ion air purifier "Air Tamer" on airborne virus (0.2 m^3 space)

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1. Test objective

The inactivation efficacy of the portable ion air purifier on airborne virus in the 0.2 m^3 test chamber was evaluated in this study. Evaluation method for the inactivation efficacy was referring to Annex D, "The evaluation test for removal efficacy on airborne virus" in Japan Electrical Manufacturers' Association standard JEM 1467 "household air cleaner".

2. Client

Name : Headwaters, Inc.

Address : 134 Pleasant Street, Marblehead, MA 01945 USA

3. Test laboratory

Name: Kitasato Research Center for Environmental Science

Address: 1-15-1 Kitasato, Minami, Sagamihara, Kanagawa 252-0329, Japan

4. Test period

December 18, 2018 ～ December 20, 2018

5. Test sample

Portable ion air purifier "Air Tamer" (Model No : A315, A310) ・ ・ ・Photo1

Photo 1. (Left : A315, Right : A310)

6. Test condition

・Natural reduction (as a negative control);

Time-dependent change in virus count was monitored when the test virus suspension was splayed into the chamber with turning off the test sample.

・Air Tamer (A315);

Time-dependent change in virus count was monitored when the test virus suspension was sprayed into the chamber with turning on the test sample.

・Air Tamer (A310) ;

Time-dependent change in virus count was monitored when the test virus suspension was sprayed into the chamber with turning on the test sample.

7. Test microorganisms

1) Test virus

Escherichia coli phage MS2 NBRC 102619

2) Host bacteria

Escherichia coli NBRC 106373

8. Reagents and apparatus

1) Main reagents

・Nutrient broth (Difco)
・Sodium chloride (Wako, special grade)
・Agar (Difco)
・Nutrient agar (Nissui)
・Phosphate buffered saline (Elmex)
・Sodium thiosulfate (Wako, 1st grade)

2) Main apparatus

・Test chamber (0.2 m^3; W 100×L 50×H 40 cm, specially ordererd)
・Circulation fan (BS-B-25, Yamazen)
・Fan (827CATCS、Caframo、Provided by your company)
・Laser particle counter (MODEL 3886, Kanomax Japan)
・Thermo-hygrometer (TR-72Ui, T&D)
・Nebulizer (Collison Nebulizer CN-31I、BGI)
・Glass impinger (specially ordered)
・AC voltage regulator (RSA-5、Tokyo Rikosha)
・Membrane filter (ϕ 0.22 μ m, Bottle Top Filter, TPP)
・Incubator (MIR-15 MIR-553, Sanyo)

9. Methods

1) Test procedure

The test system was shown in Photos 2, 3 and Figs 3, 4. The test sample, the circulation fan, fan, the laser particle counter, and the thermo-hygrometer were put in the test chamber. Two holes were made at the side panel of the test chamber. The nebulizer for spraying virus suspension was connected to the one hole and the glass

impinger for collecting airborne virus was connected to the other hole.

The test was carried out according to the procedure shown in Table 4. That is, after placing the test sample in the test chamber, the virus suspension was sprayed with nebulizer for 1 min into the chamber while operating the fun (wind volume unknown) attached to the sample and circulation fan (wind volume: approximately 0.5 m^3/min) with AC 20 V. After 2 minute circulation of the air, the virus aerosol was collected into the impinger (time 0). And then, the test sample was turned on and the aerosol was collected after 20, 40 and 60 minutes.

As a control (natural reduction of airborne virus), the same test was performed under the condition that the test device was turned off according to the procedure described in Table 3.

2) Preparation of test virus

The test virus was inoculated into the host bacterial suspension in nutrient broth which had been incubated at 36 ± 1 ℃ overnight. The virus/bacterial suspension was mixed with the semisolid agar medium (nutrient broth + 0.5% sodium chloride + 0.5% agar) and poured onto top of the agar medium. After 18 hour incubation at 36 ± 1 ℃, the culture was centrifuged and the resultant supernatant was filtrated through a 0.22 μm membrane filter to remove the host bacteria, and 10^{10} PFU/mL of virus was isolated. The virus suspension was diluted 100-fold with Nutrient Broth for the test.

3) Spray of the virus suspension

The test virus suspension was sprayed into the test chamber by the nebulizer for 1 minute at a liquid rate of 0.2 mL/min. The air pressure from the compressor discharge was set at 1.5 kg/cm^2 and the air flow rate was set to 6.25 L/min.

4) Collection of airborne virus

The virus aerosol in the chamber was collected at 10 L/min for 2 minutes (total 20 L) to the glass impinger containing 20 mL of phosphate buffered saline added with 0.015% sodium thiosulfate.

5) Count of virus number

Serial 10-fold dilutions of the each collected virus suspension were prepared with phosphate buffered saline. The each dilution was mixed with *E.coli*, and spread on nutrient agar with the semisolid agar, and incubated at 36 ± 1 °C for 23 hours. Plaques were counted to calculate the number of virus in 20 L of air was calculated.

6) Evaluation method for the inactivation efficacy

This test was carried out using Annex D of JEM 1467 as a reference. In JEM

1467, achieving 2.0-digit reduction in 90 minutes in the test space of 20～32 m^3 is required to conclude that the test sample is effective.

However, this test sample does not correspond to an air purifier used at home, and the volume of the test space is also different from JEM 1467. Therefore, the evaluation of the inactivation efficacy was performed using the method described below.

The approximate equation was calculated based on the time-dependent changes of airborne virus (logarithmic representation) and the inclination of the approximate equation was obtained. This inclination represents an amount of change in the number of virus per minute. Net inclination※1 was calculated by subtracting the inclination of control condition from that of test condition. Net LRV※2 and percent reduction※3 were calculated from the value of net inclination, and the inactivation efficacy of airborne virus was determined based on net LRV. The efficacy of the test sample was evaluated using the following formulae.

※1 Net inclination =

Inclination of test condition − Inclination of control condition

※2 Net LRV = −{ Net inclination × Test time (min) }

※3 $$\text{Percent reduction}(\%) = \left(1 - \frac{1}{10^{(\text{Net LRV})}}\right) \times 100\ (\%)$$

10. Results

Virus count of the sprayed suspension was 6.8×10^9 PFU/mL . The numbers of airborne virus at each measurement time were shown in Table 1 and Fig 1. Net LRV and percent of reduction were calculated from the number of airborne virus at each measurement time, and were shown in Table 2 and Fig 2, respectively.

In this test, net LRV (reduction rate) of the test samples "Air Tamer (A315)" and "Air Tamer (A310)" for airborne virus at 40 minutes were 3.0 (99.90%) and 2.5 (99.7%) respectively.

11. Reference data

The number of airborne particle, temperature and humidity in the test chamber were shown as a reference data.

12. Comment

It is judged that the test sample has the inactivation effect of airborne virus in 0.2 m^3 space when the net Log reduction value calculated by subtraction a control value exceeds 2.0.

The inactivation efficacy of these two samples were confirmed as the values of "Air Tamer (A315)" and "Air Tamer (A310)" were more than 2.0 at 27 min and 32 min, respectively.

Table 1. The number of airborne virus at each measurement time
(Unit : PFU/20 L-air)

Test condition	Time (min)			
	0	20	40	60
Control condition	12,000,000	2,400,000	700,000	190,000
"Air Tamer (A315)"	9,400,000	37,000	450	4
"Air Tamer (A310)"	9,100,000	68,000	1,400	20

Test sample : Portable ion air purifier "Air Tamer" (Model No : A315, A310)
Test virus : *Escherichia coli* phage MS2 NBRC 102619
Test space : 0.2 m^3

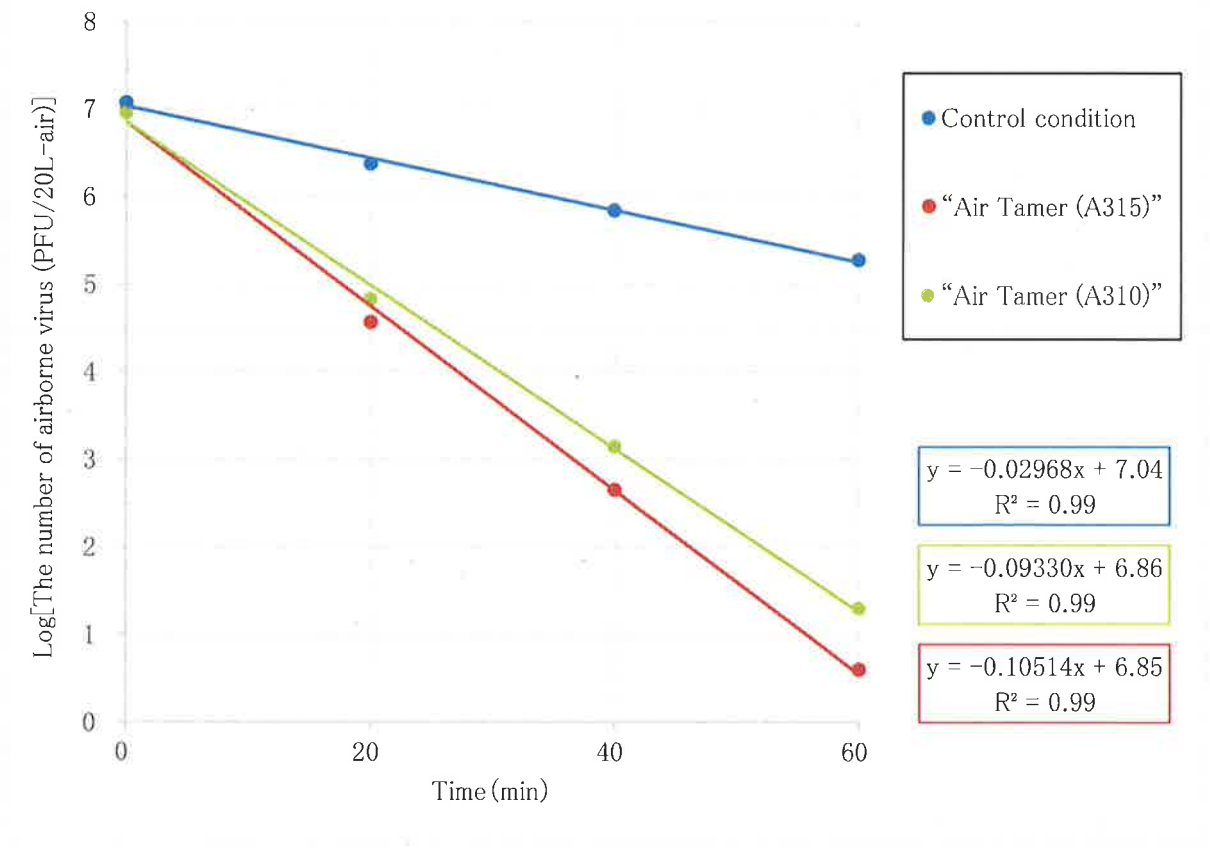


Fig 1. The number of airborne virus at each measurement time

Table 2. Net LRV and percent reduction at each measurement time

Test condition	Inclination	Net inclination	Time (min)			
			0	20	40	60
Control condition	-0.02968					
"Air Tamer (A315)"	-0.10514	-0.07546	0.0 (0%)	1.5 (96%)	3.0 (99.90%)	4.5 (>99.99%)
"Air Tamer (A310)"	-0.09330	-0.06362	0.0 (0%)	1.2 (94%)	2.5 (99.7%)	3.8 (99.98%)

Net inclination = Inclination of test condition − Inclination of control condition

Net LRV = −{ Net inclination × Test time (min) }

$$\text{Percent reduction}(\%) = \left(1 - \frac{1}{10^{(\text{Net LRV})}} \right) \times 100\ (\%)$$

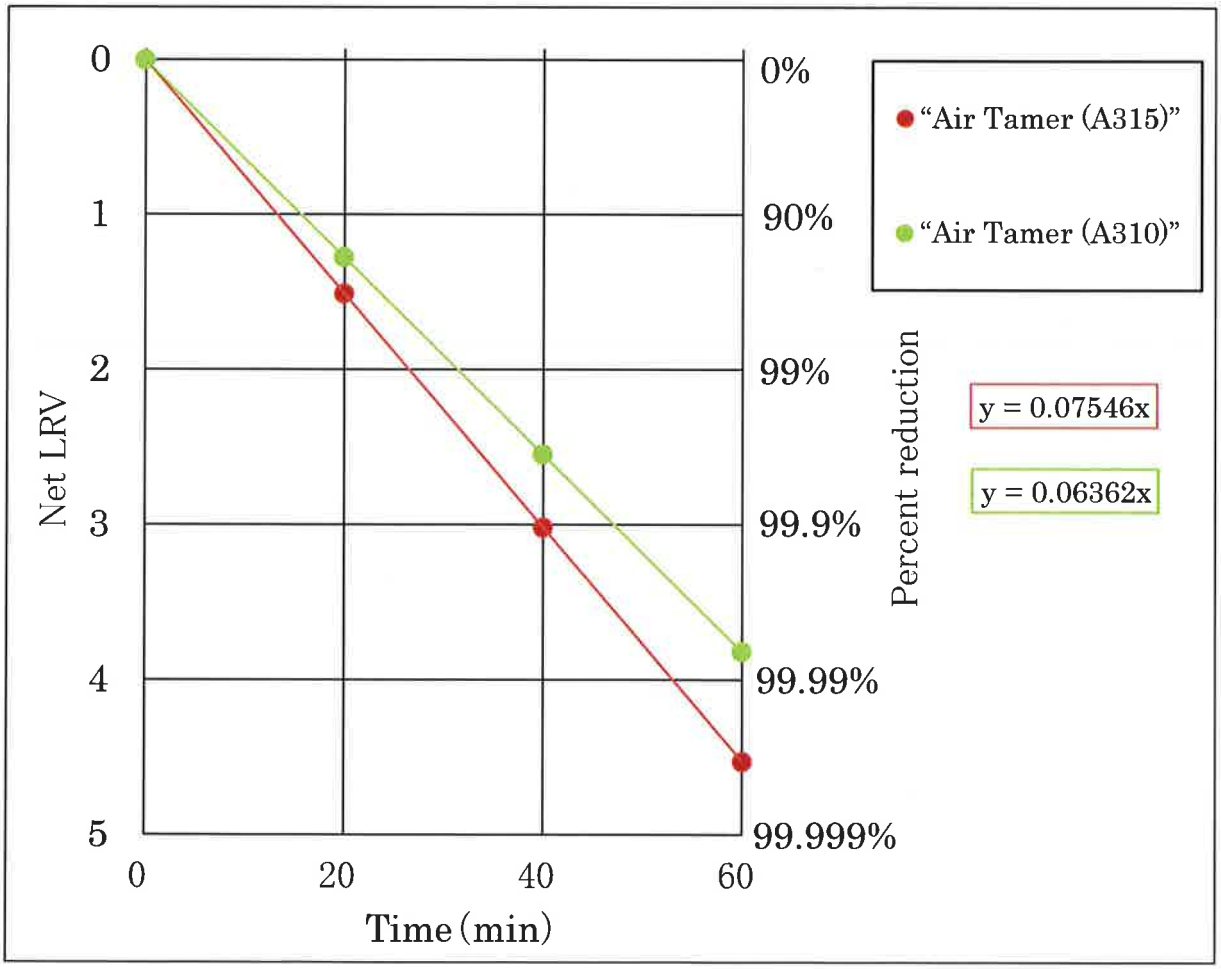


Fig 2. Net LRV and percent reduction at each measurement time

Table 3. Test procedure (Control condition)

Test condition	Equipment	Time (min) 0 20 40 60
To make homogeneous air in the chamber	Circulation fan	→
	Fan	→
Spray of virus	Nebulizer	1min, Dispersing virus for 2 min
Collect airborne virus	Impinger	2 min (10L/min) 2 min (10L/min) 2 min (10L/min) 2 min (10L/min)

Table 4. Test procedure ("Air Tamer (A315)" and "Air Tamer (A310)")

Test condition	Equipment	Time (min) 0 20 40 60
To make homogeneous air in the chamber	Circulation fan	→
	Fan	→
Spray of virus	Nebulizer	1 min, Dispersing virus for 2 min
Test sample	"Air Tamer (A315 or A310)"	→
Collect airborne virus	Impinger	2 min (10L/min) 2 min (10L/min) 2 min (10L/min) 2 min (10L/min)

Photo 2. 0.2 m³ Test chamber (side view) (A315)

Photo 3. 0.2 m³ Test chamber (side view) (A310)

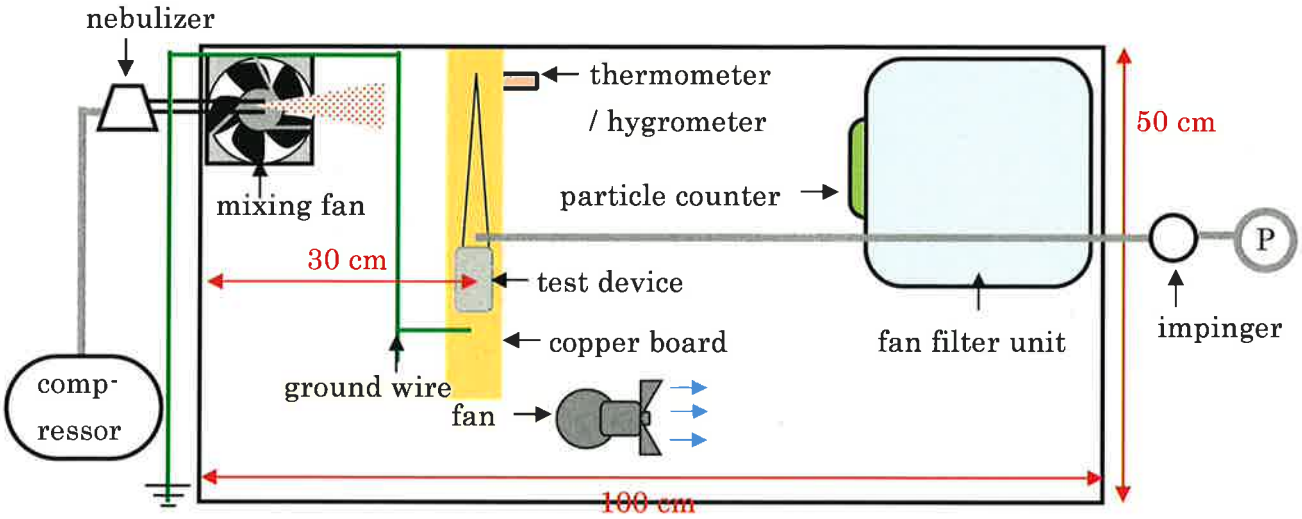


Fig3. 0.2 m^3 Test chamber (top view)

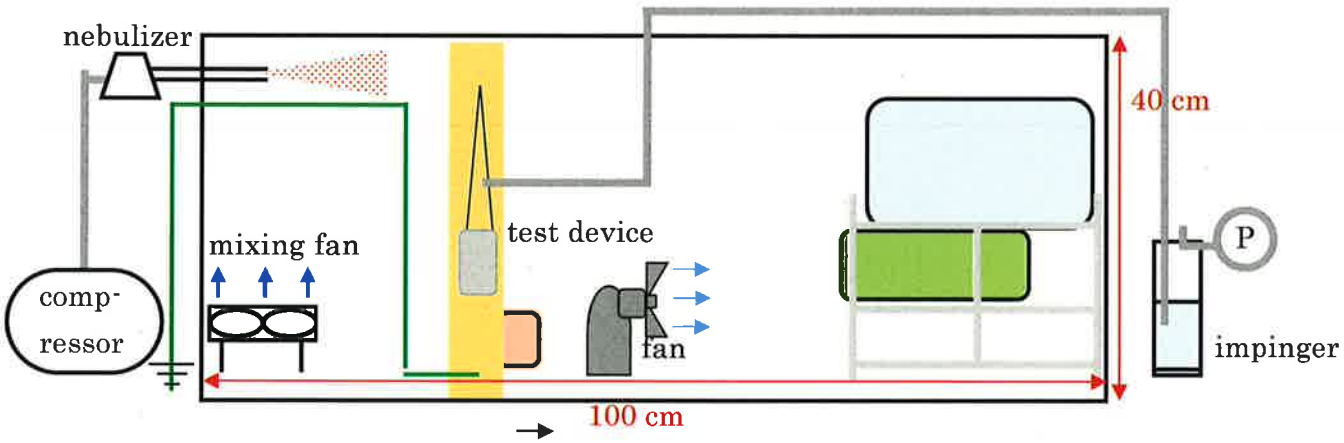
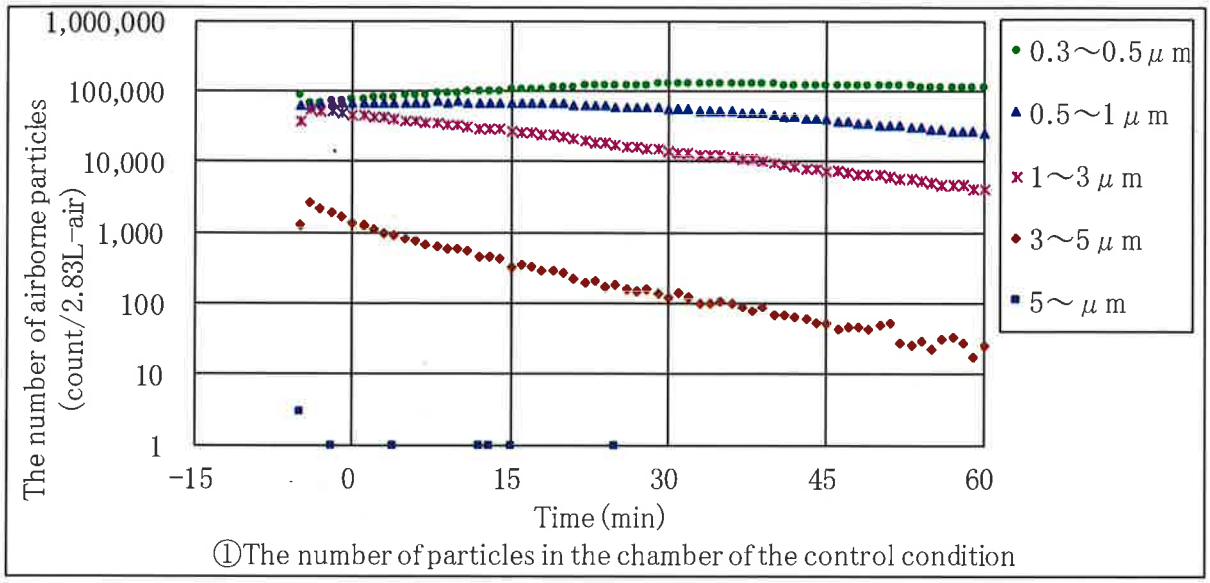
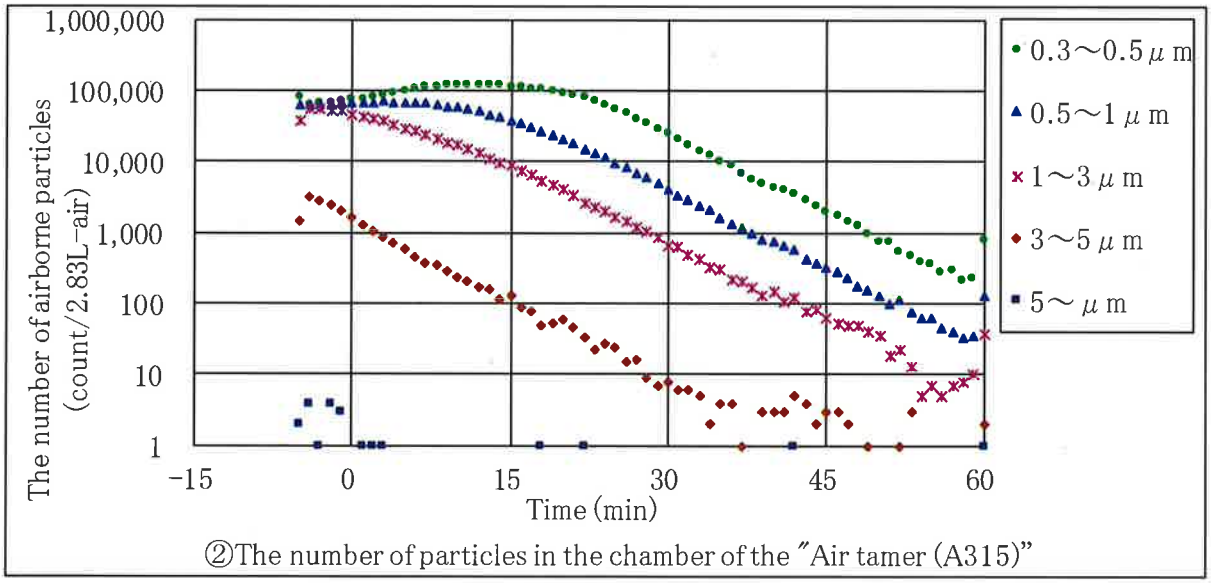


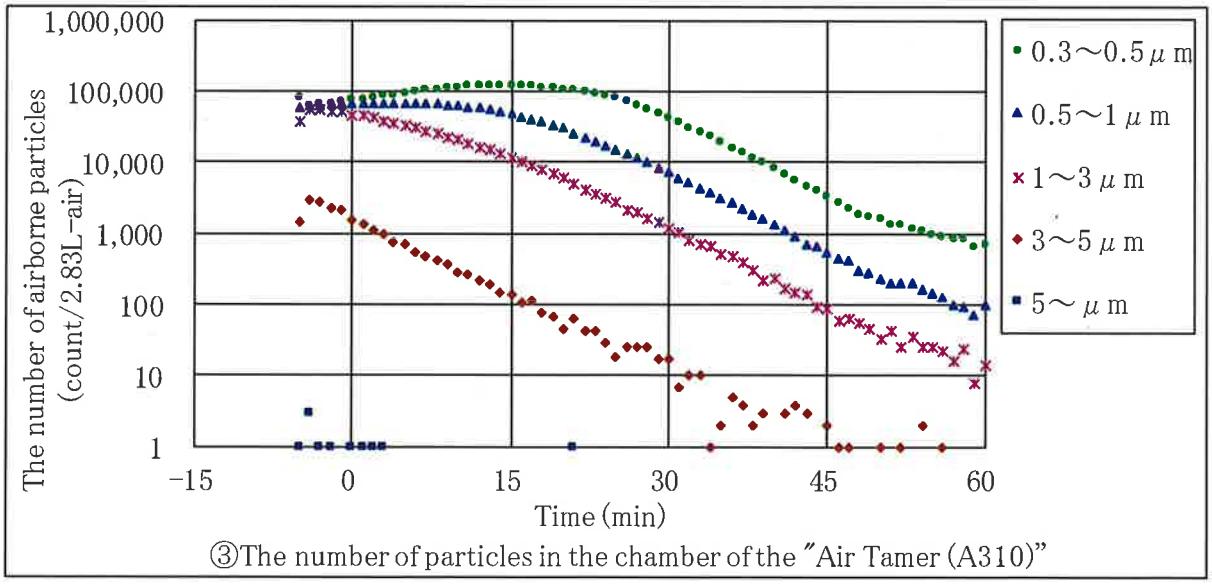
Fig4. 0.2 m^3 Test chamber (side view)



①The number of particles in the chamber of the control condition

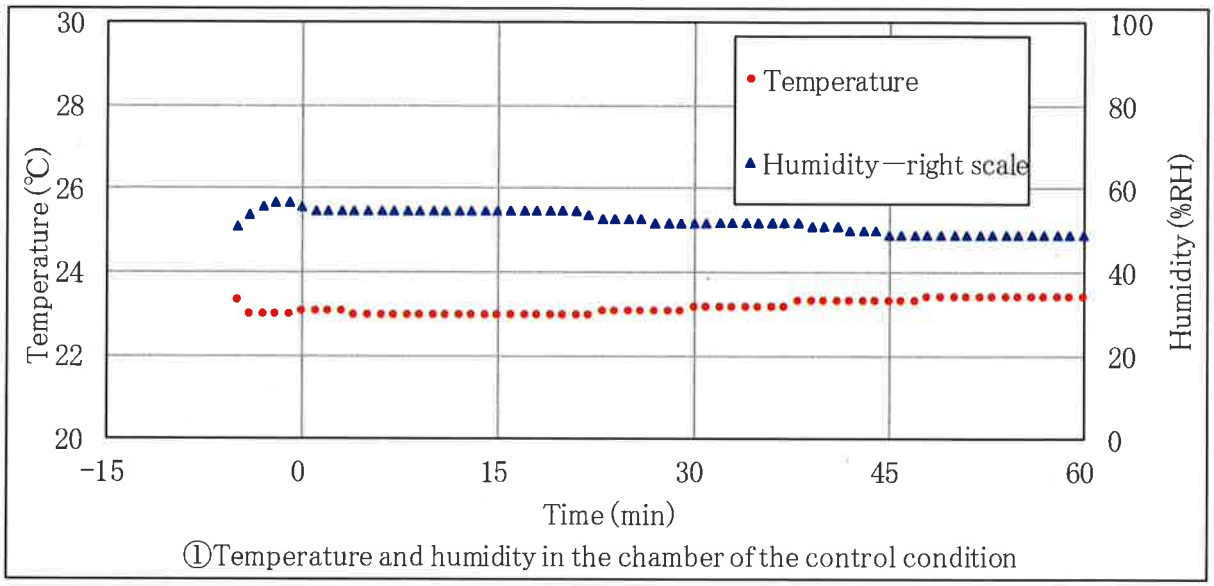


②The number of particles in the chamber of the "Air tamer (A315)"

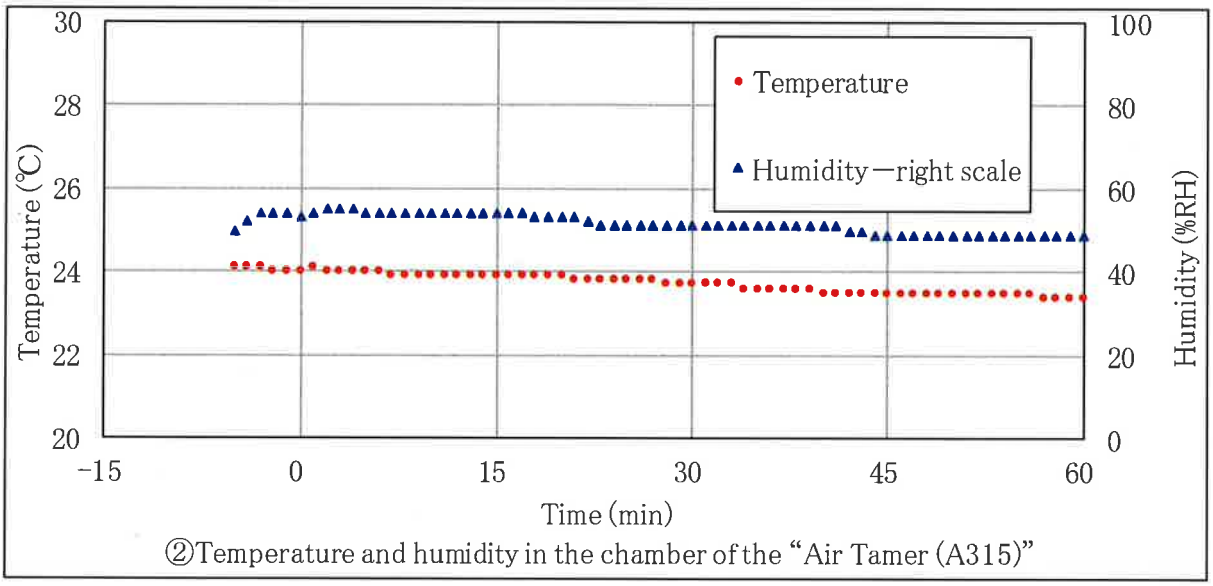


③The number of particles in the chamber of the "Air Tamer (A310)"

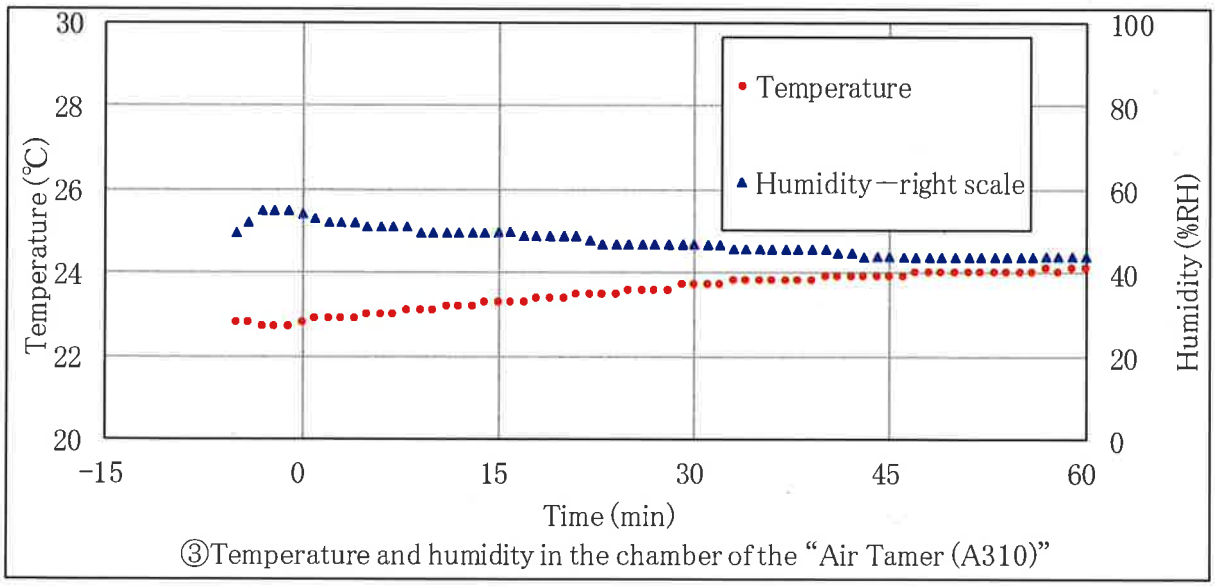
＊Measured by a laser particle counter (MODEL 3886, Kanomax Japan)



①Temperature and humidity in the chamber of the control condition



②Temperature and humidity in the chamber of the "Air Tamer (A315)"



③Temperature and humidity in the chamber of the "Air Tamer (A310)"

* Measured humidity in the chamber of the test device(TR-72Ui、T&D)