To TOSHIBA CARRIER (THAILAND) CO., LTD.

Test Report

Evaluation test of the removal efficacy of the Room air conditioner on airborne bacteria (25 m^3 space)

KRCES - Bio. Test Report No.2018_0357

February 15, 2019

Approved by : Toshihiro Itoh

Toshihiro Itoh, Chief Director
Kitasato Research Center for Environmental Science
1-15-1, Kitasato, Minami, Sagamihara, Kanagawa 252-0329, Japan

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1. Test objective

Removal efficacy of the room air conditioners on airborne virus in a 25 m^3 test chamber was evaluated in this study. Evaluation method for removal efficacy was conducted in accordance with 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 : TOSHIBA CARRIER (THAILAND) CO., LTD.

Address : 144/9 Moo 5, Bangkadi, Industrial Park, Tivanon Road, Tambol Bangkadi, Amphur, Muang, Pathunthani 12000, Thailand

3. Test laboratory

Name: Kitasato Research Center for Environmental Science

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

4. Test period

January 16, 2019 ~ January 18, 2019

5. Test sample

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma) ・・・Photo1

2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer) ・・・Photo2

6. Test condition

Ⅰ. Natural reduction (control);

Time-dependent changes in virus count were monitored after the test virus suspension was splayed into the chamber where the test sample was turned off.

Ⅱ. Room air conditioner A (The air blower only)

Time-dependent changes in virus count were monitored after the test virus suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅲ. Room air conditioner A (The air blower and the test device)

Time-dependent changes in virus count were monitored after the test virus suspension was sprayed into the chamber where the sample (the air blower and the test device) was turned on.

Ⅳ. Room air conditioner B (The air blower only)

Time-dependent changes in virus count were monitored after the test virus suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)

Time-dependent changes in virus count were monitored after the test virus suspension was sprayed into the chamber where the sample (the air blower and the test device) was continuously operated for 30 seconds, and then turn off for 2 seconds.

Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)

Time-dependent changes in virus count were monitored after the test virus suspension was sprayed into the chamber where the sample (the air blower and the test device) was intermittently operated for 4 seconds, and then turn off for 6 seconds.

7. Test microorganisms

Virus : *Escherichia coli* phage φX-174 NBRC 103405 (=ATCC 13706-B1)

Size : approximately 30 nm

Host bacteria : *Escherichia coli* NBRC 13898 (= ATCC 13706)

8. Reagents, apparatus

1) Main reagents

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

2) Main apparatus

- Test chamber (25 m^3: 2.7×3.8×2.4 m, Amenity Technology)

- Circulation fan (BS-B-25, Yamazen)
- Laser particle counter (MODEL 3886, Kanomax Japan)
- Thermo-hygrometer (TR-72Ui, T&D)
- Nebulizer (Collison Nebulizer CN-31I、BGI)
- Glass impinger (specially ordered)
- Membrane filter (ϕ 0.22 μ m, Bottle Top Filter, TPP)
- Incubator (MIR-15 MIR-553, Sanyo)

9. Method

1) Test procedure

The test system was shown in Photos 3, 4 and Figs 5, 6. The test sample, the circulation fan, the laser particle counter, and the thermo-hygrometer were set in the test chamber. Two holes were made on one of the side panels of the test chamber. The nebulizer for spraying virus suspension was connected to one of the holes and the impinger for collecting airborne virus was connected to the other hole.

According to the test procedure described in Table 6, the virus suspension was sprayed with nebulizer for 15 minutes into the chamber while the circulation fan was operated. After 2 minute circulation of the air, the virus aerosol was collected into the impinger (time 0). The aerosol was collected after 60 and 120 minutes after the test sample was turned on.

As a control, the same test was performed under the condition that the test sample was turned off according to the procedure described in Table 5.

2) Preparation of test virus

The test virus was inoculated into the host bacterial suspension in nutrient broth which had been incubated at 36 ± 2 ℃ 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 ± 2 ℃, 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 10-fold with sterile ion-exchanged water for the test.

3) Spray of the virus suspension

The test virus suspension was sprayed into the test chamber with the nebulizer for 15 minutes at the 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 7.0 L/min.

4) Collection of airborne virus

The virus aerosol in the chamber was collected at 10 L/min for 5 minutes (total 50 L) to the glass impinger containing 20 mL of phosphate buffered saline added with 0.015% sodium thiosulfate.

5) Count of virus number

Ten-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 ± 2 °C for 18 hours. Plaques were counted to calculate the numbers of virus in 50 L of air was calculated.

6) Evaluation method for the removal 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 did not correspond to household air purifiers. Therefore, the evaluation of the removal 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 removal 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 sample 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 5.5×10^8 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. Residual virus ratios for the initial number at each time were shown in Table 3 and Fig 3. The residual virus ratios for the control were shown in Table 4 and Fig 4.

In this test, net LRV (reduction rate) of the test samples for airborne virus at 120 minutes were -0.17 (-47%) for test condition Ⅱ, 0.81 (84%) for the conditionⅢ, 0.04 (8%) for the condition Ⅳ, 1.40 (96%) for the condition Ⅴ and 0.92 (87%) for the conditionⅥ respectively.

11. Reference data

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

12. Comment

This test was referring to the method of JEM 1467. In attached document Annex D, "The evaluation test for removal efficacy on airborne virus" in Japan Electrical Manufacturers' Association standard 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.

In this study, the test sample showed certain degree of reduction effect but could not achieved 2.0 log reduction value even after being operated for 120min.

The difference between this standard and this test must be considered, as follows.

- The test samples in this test were not designed as air purifiers but air conditioners.

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

(Unit : CFU/50 L-air)

Test condition	Time (min)		
	0	60	120
Ⅰ. Control condition	400,000	53,000	40,000
Ⅱ. Room air conditioner A (The air blower only)	160,000	31,000	24,000
Ⅲ. Room air conditioner A (The air blower and the test device)	380,000	22,000	5,800
Ⅳ. Room air conditioner B (The air blower only)	330,000	36,000	30,000
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	810,000	21,000	3,200
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	460,000	26,000	5,500

Test sample :

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma)
2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer)

Test virus : *Escherichia coli* phage φX-174 NBRC 103405 (=ATCC 13706-B1)

Test space : 25 m^3

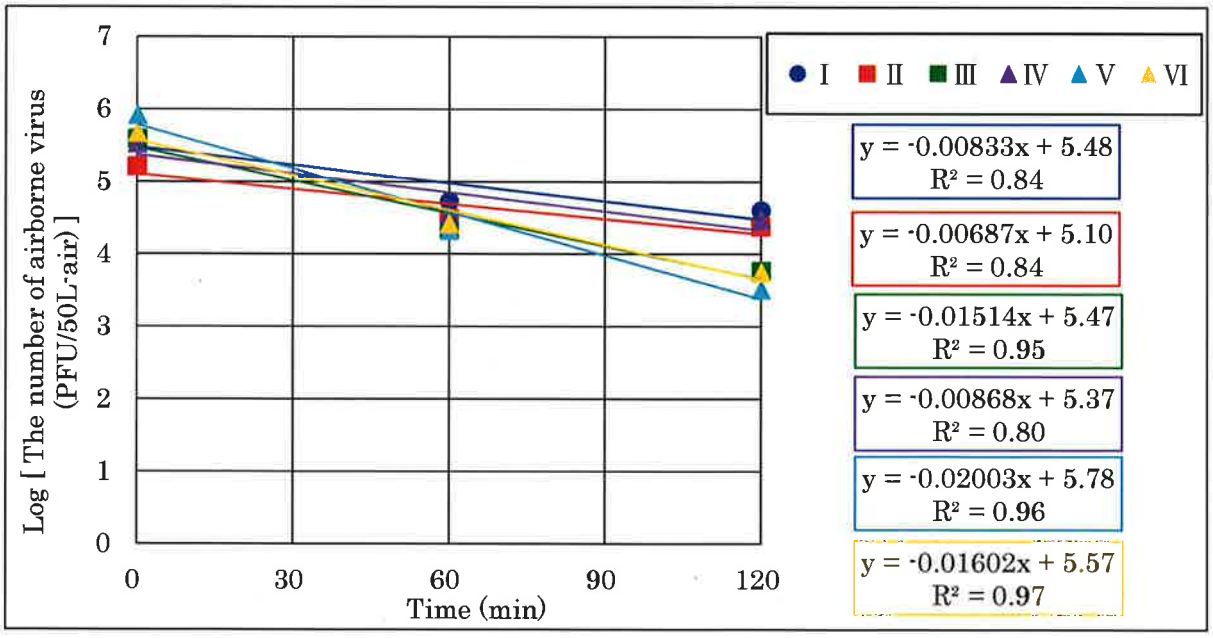

Fig 1. The number of airborne virus at each measurement time

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

Test condition	Inclination	Net inclination	Time (min)		
			0	60	120
I . Control condition	-0.00833				
II . Room air conditioner A (The air blower only)	-0.00687	0.00146	0.00	-0.08	-0.17
			(0%)	(-20%)	(-47%)
III. Room air conditioner A (The air blower and the test device)	-0.01514	-0.00681	0.00	0.40	0.81
			(0%)	(60%)	(84%)
IV. Room air conditioner B (The air blower only)	-0.00868	-0.00035	0.00	0.02	0.04
			(0%)	(4%)	(8%)
V. Room air conditioner B (Continuous operation of the air blower and the test device)	-0.02003	-0.01170	0.00	0.70	1.40
			(0%)	(80%)	(96%)
VI. Room air conditioner B (Intermittent operation of the air blower and the test device)	-0.01602	-0.00769	0.00	0.46	0.92
			(0%)	(65%)	(87%)

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

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

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

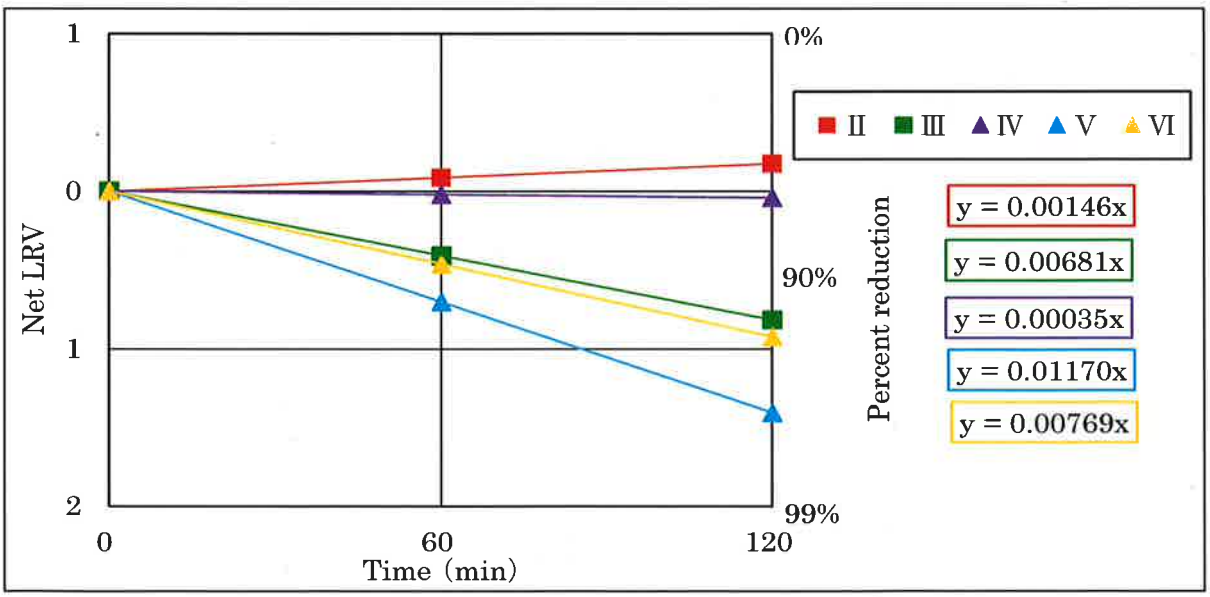

Fig 2. Net LRV and percent reduction at each measurement time

Table 3. Residual virus ratio for the initial number (%) at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	68	46	31	21	14	10
Ⅱ. Room air conditioner A (The air blower only)	100	72	53	38	28	20	14
Ⅲ. Room air conditioner A (The air blower and the test device)	100	49	24	12	6	3.0	1.5
Ⅳ. Room air conditioner B (The air blower only)	100	67	44	30	20	13	9
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	39	15	6	2.4	0.9	0.3
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	47	22	10	5	2.5	1.1

※Using slope of approximate expression as shown in Fig1 (number of airborne virus which change per minute, log value) the residual ratio was calculated according to equation ① and ②.

① Log reduction value = | Inclination | × Time (min)

② Residual rate (%) $= \dfrac{1}{10^{(\mathrm{LRV})}} \times 100$ (%)

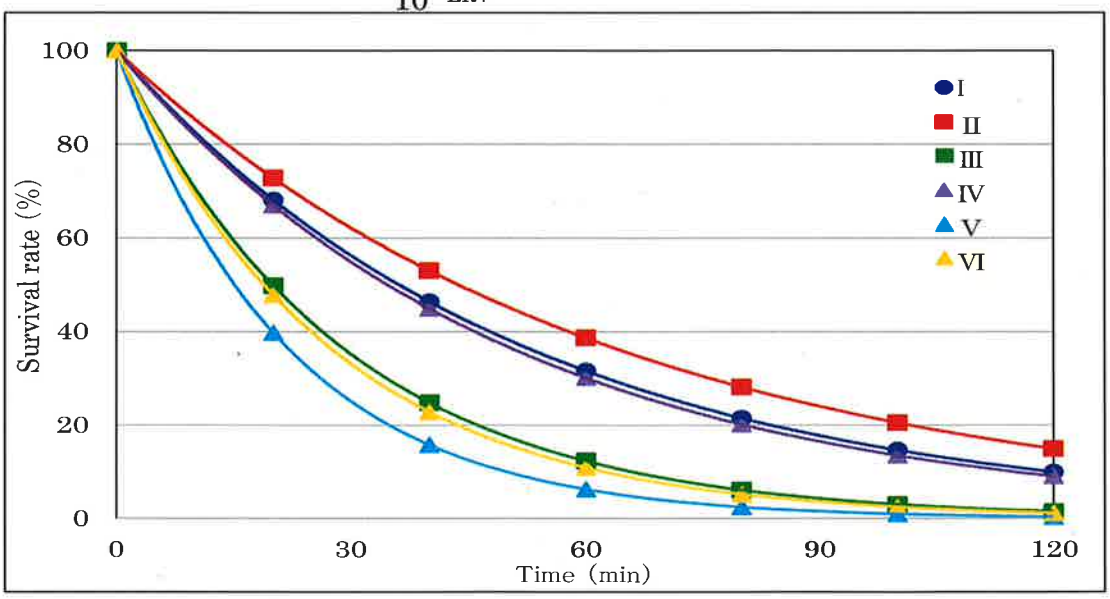

Fig 3. Residual virus ratio for the initial number (%) at each time

Table 4. The residual virus ratios with the sample for the control at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	100	100	100	100	100	100
Ⅱ. Room air conditioner A (The air blower only)	100	106	114	122	130	139	149
Ⅲ. Room air conditioner A (The air blower and the test device)	100	73	53	39	28	20	15
Ⅳ. Room air conditioner B (The air blower only)	100	98	96	95	93	92	90
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	58	34	19	11	6.7	3.9
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	70	49	34	24	17	11

※Using slope of approximate expression as shown in Fig1 (number of airborne virus which change per minute, log value) the residual ratio was calculated according to equation ① ,② and ③.

① Net inclination= Inclination of test condition− Inclination of control condition

② LRV= | Net Inclination | ×Time (min)

③ Residual rate (%) $= \frac{1}{10^{(\mathrm{LRV})}} \times 100$ (%)

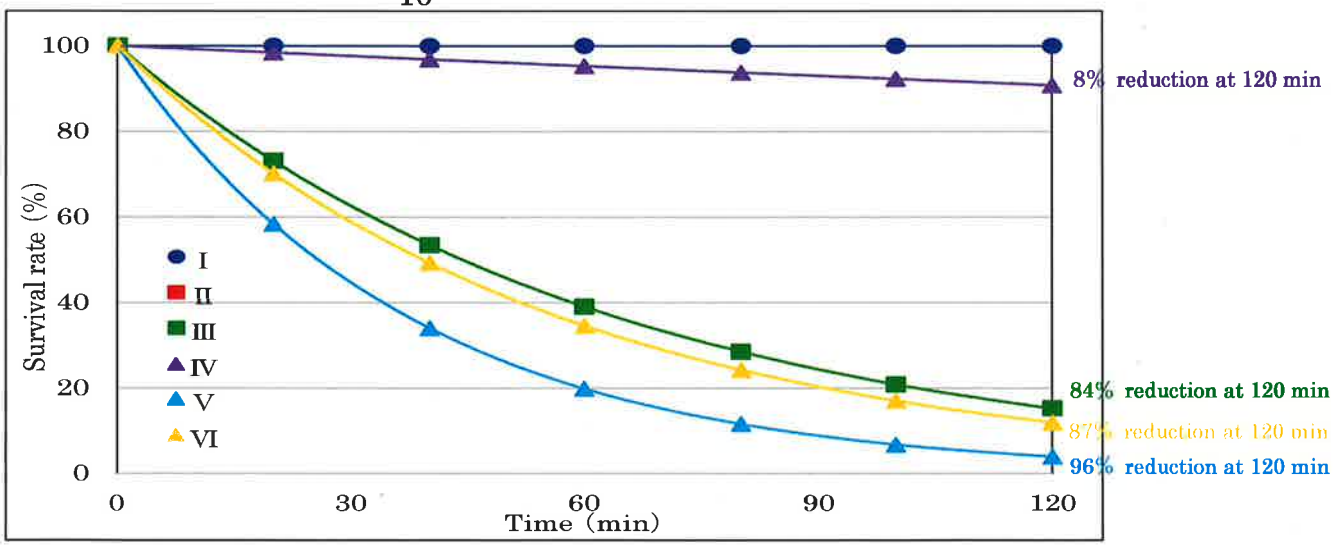

Fig 4. The residual virus ratios with the sample for the control at each time

Table 5. Test procedure (Control condition Ⅰ)

Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	→
Spray of virus	Nebulizer	15min → Dispersing bacteria for 2 min
Collect airborne virus	Impinger	5min (10L/min) 5min (10L/min) 5min (10L/min)

Table 6. Test procedure (Test condition Ⅱ～Ⅵ)

Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	→
Spray of virus	Nebulizer	15min → Dispersing bacteria for 2 min
Test sample	Air blower	→
	Test device	→
Collect airborne virus	Impinger	5min (10L/min) 5min (10L/min) 5min (10L/min)

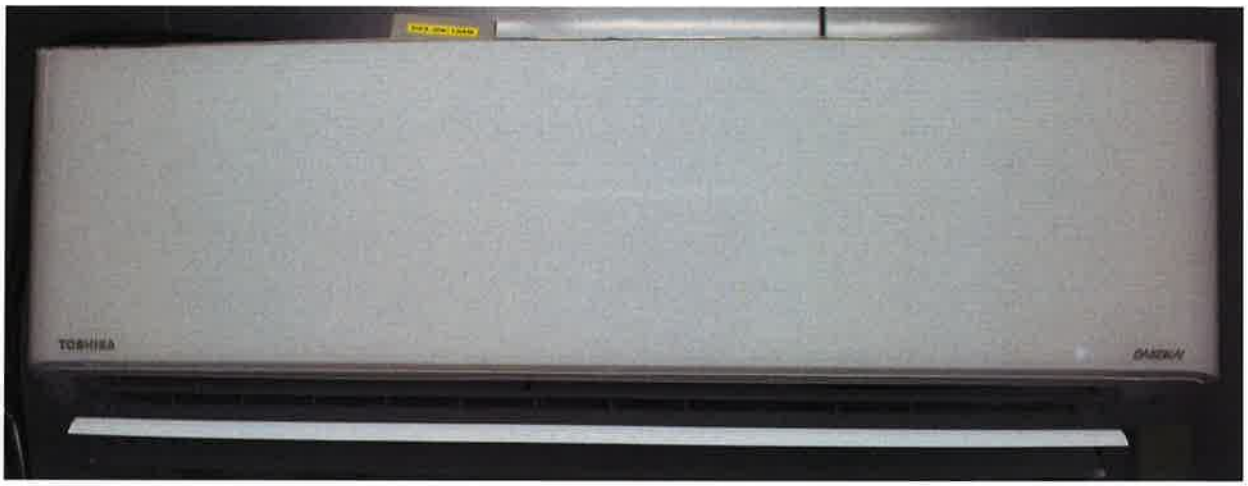

Photo 1. Room air conditioner A (Model No ; RAS-35PKVPG-ND)

Photo 2. Room air conditioner B (Model No ; RAS-13J2KCVRG-T)

Photo 3. 25 m^3 Test chamber (Room air conditioner A)

Photo 4. 25 m^3 Test chamber (Room air conditioner B)

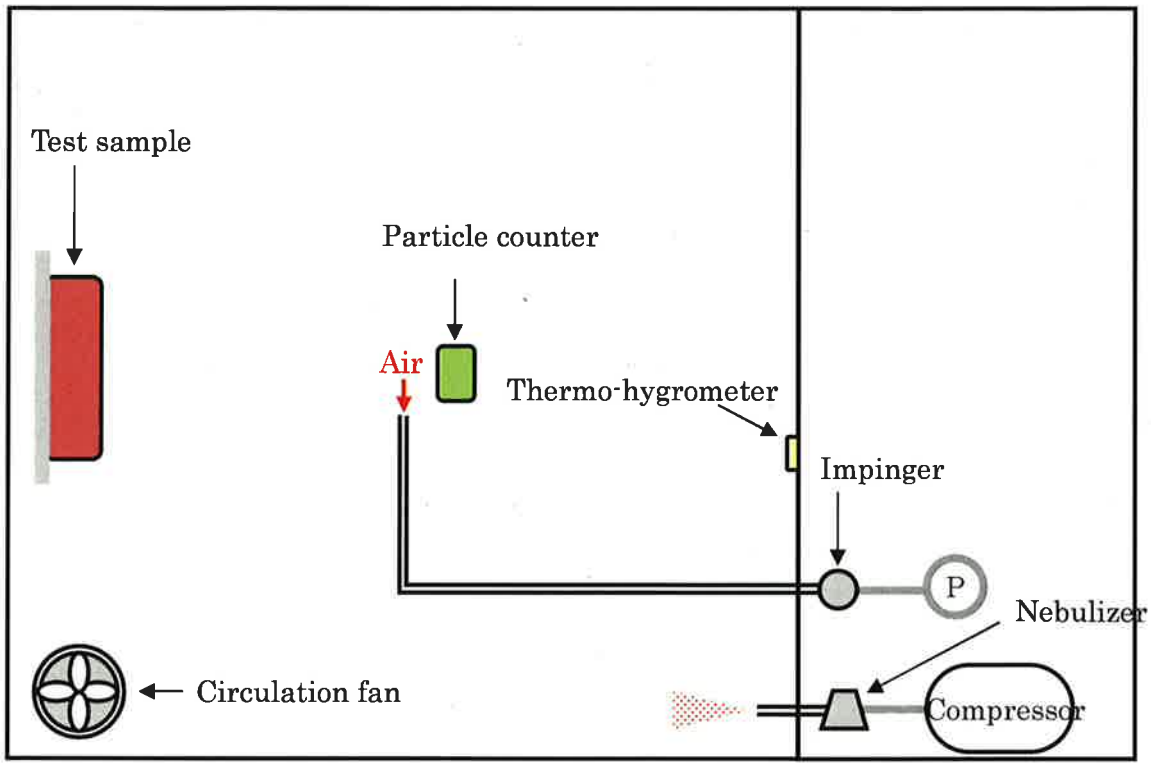

Fig 5. 25 m³ Test chamber (top view)

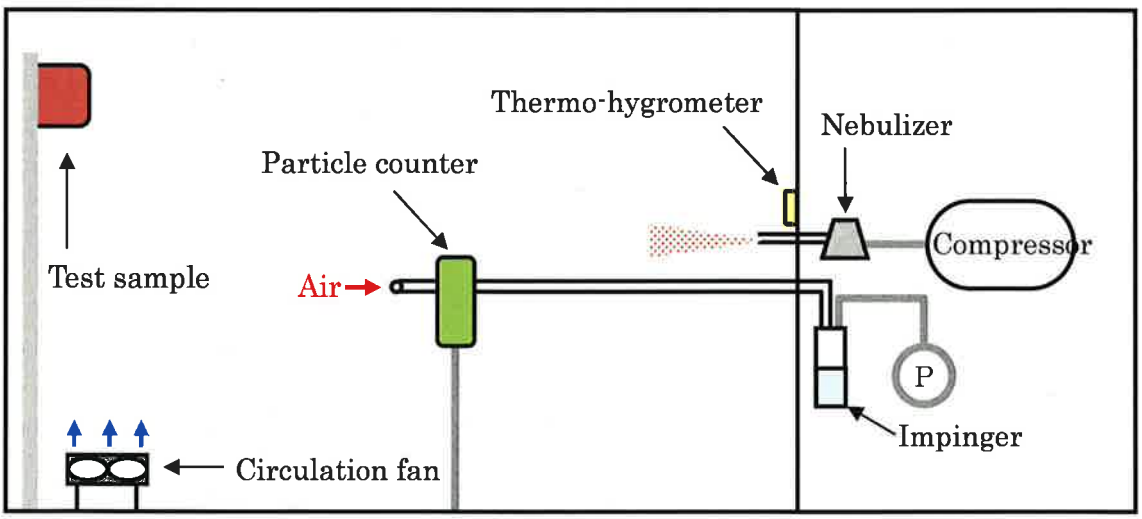

Fig 6. 25 m³ Test chamber (side view)

Referenced sheet

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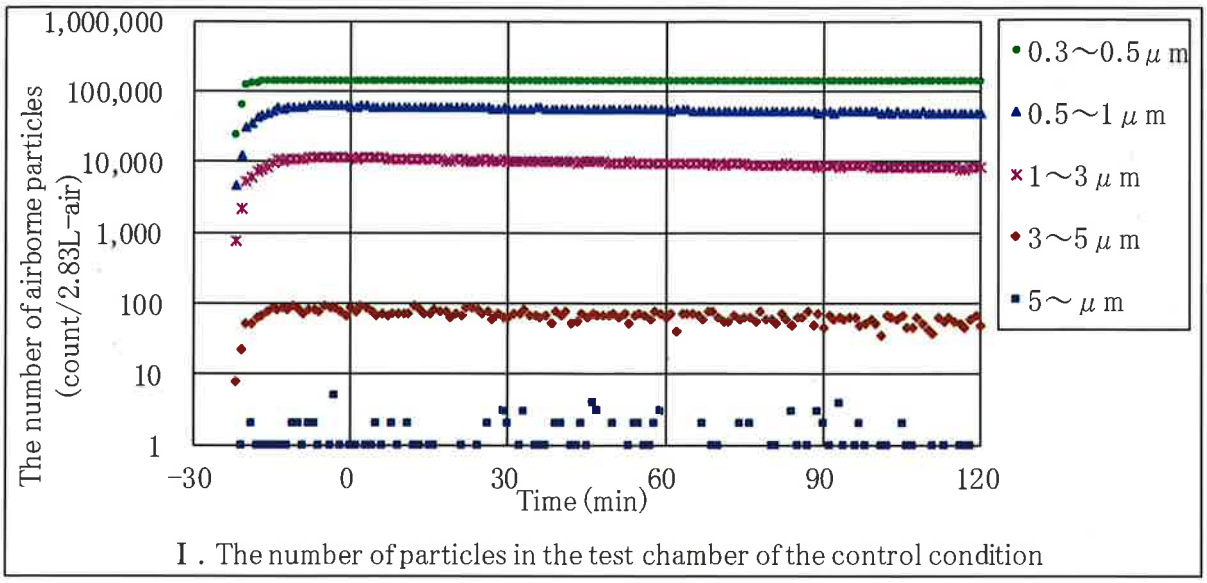
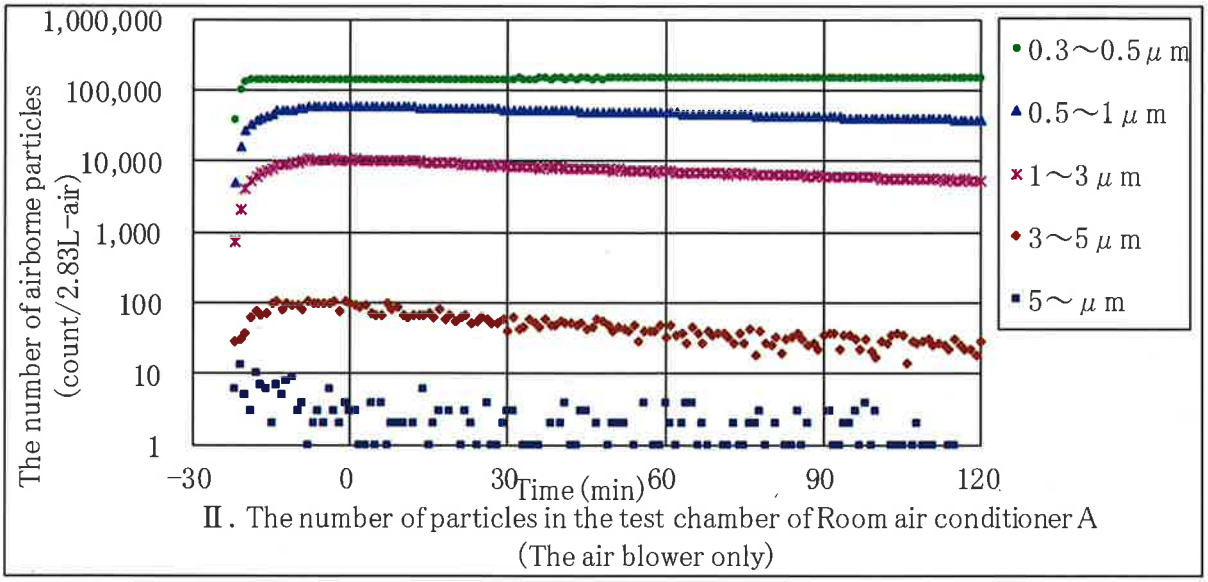
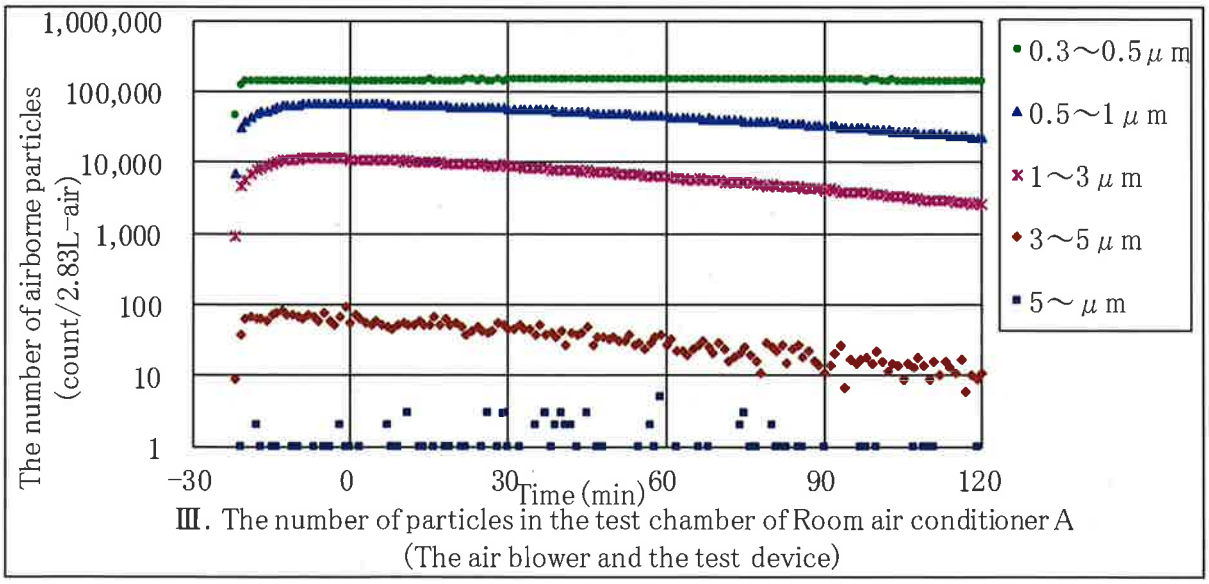


Ⅰ. The number of particles in the test chamber of the control condition



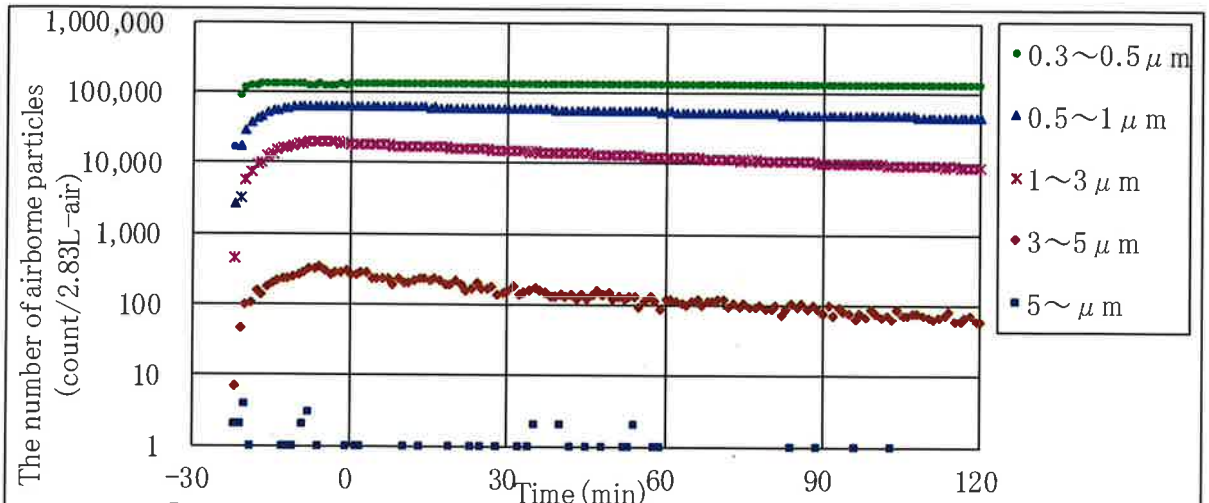
Ⅱ. The number of particles in the test chamber of Room air conditioner A
(The air blower only)



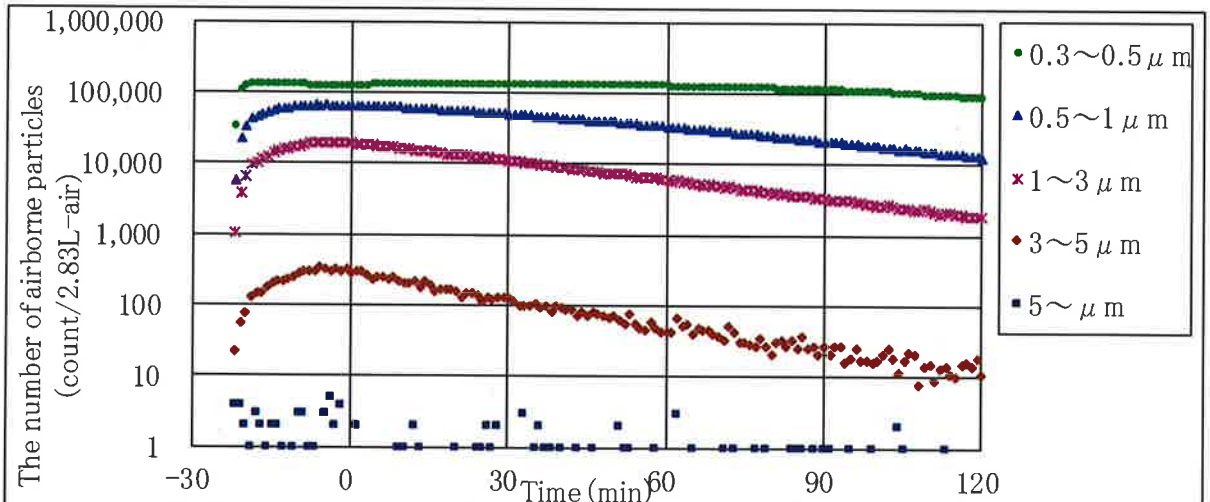
Ⅲ. The number of particles in the test chamber of Room air conditioner A
(The air blower and the test device)

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

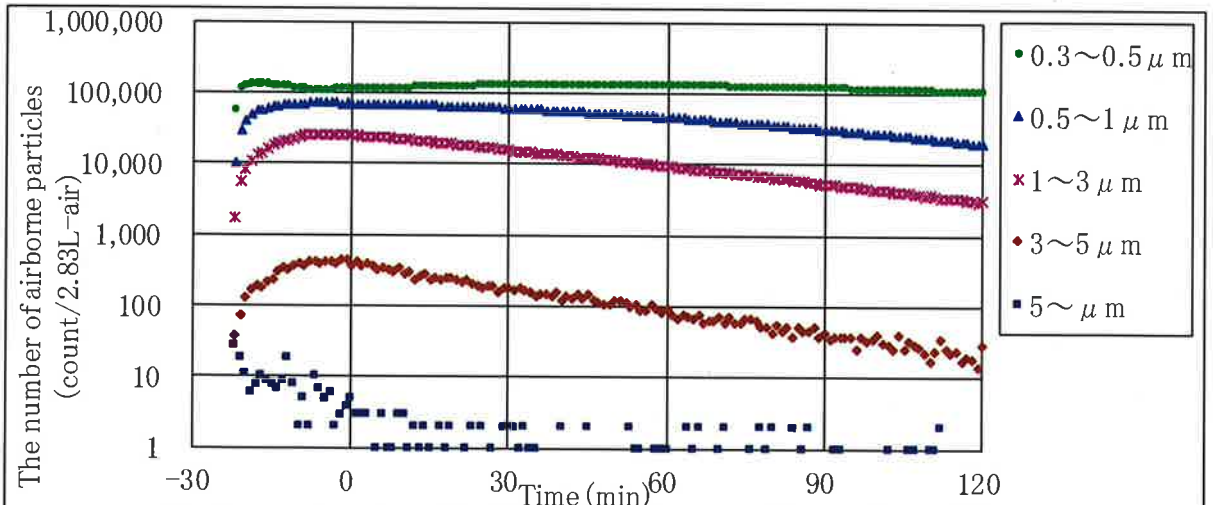
Referenced sheet



Ⅳ. The number of particles on the test chamber of Room air conditioner B
(The air blower only)



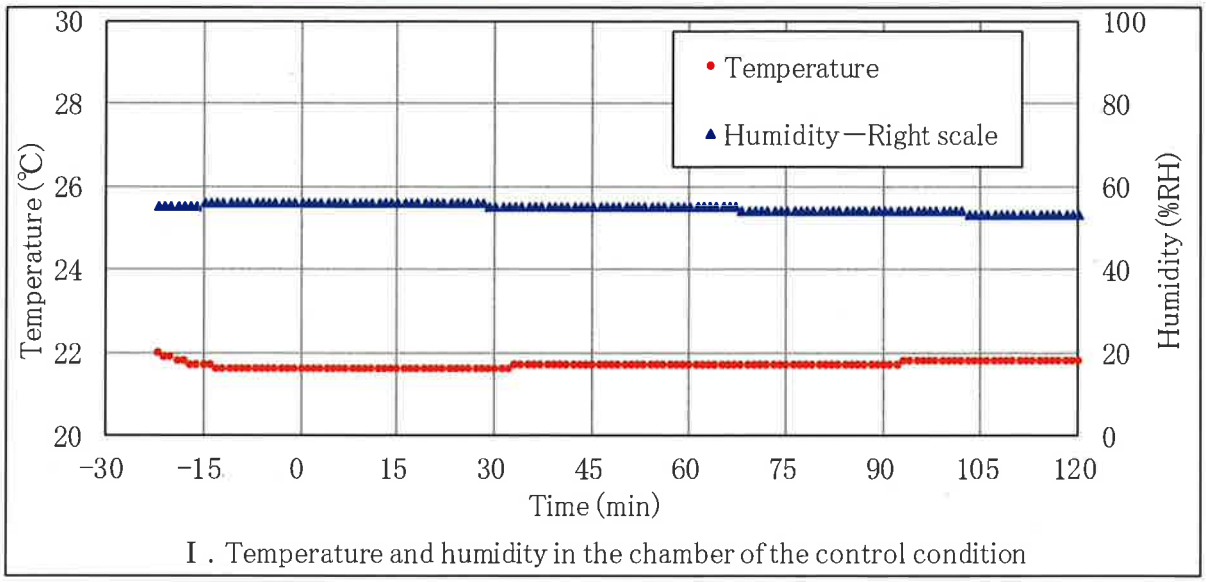
Ⅴ. The number of particles in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



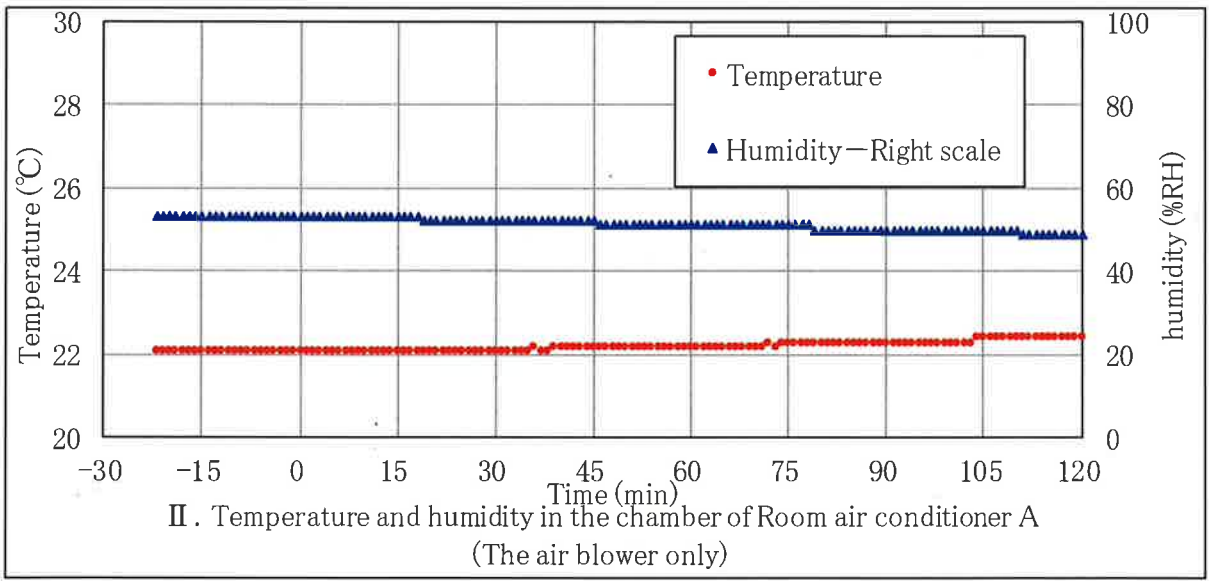
Ⅵ. The number of particles in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

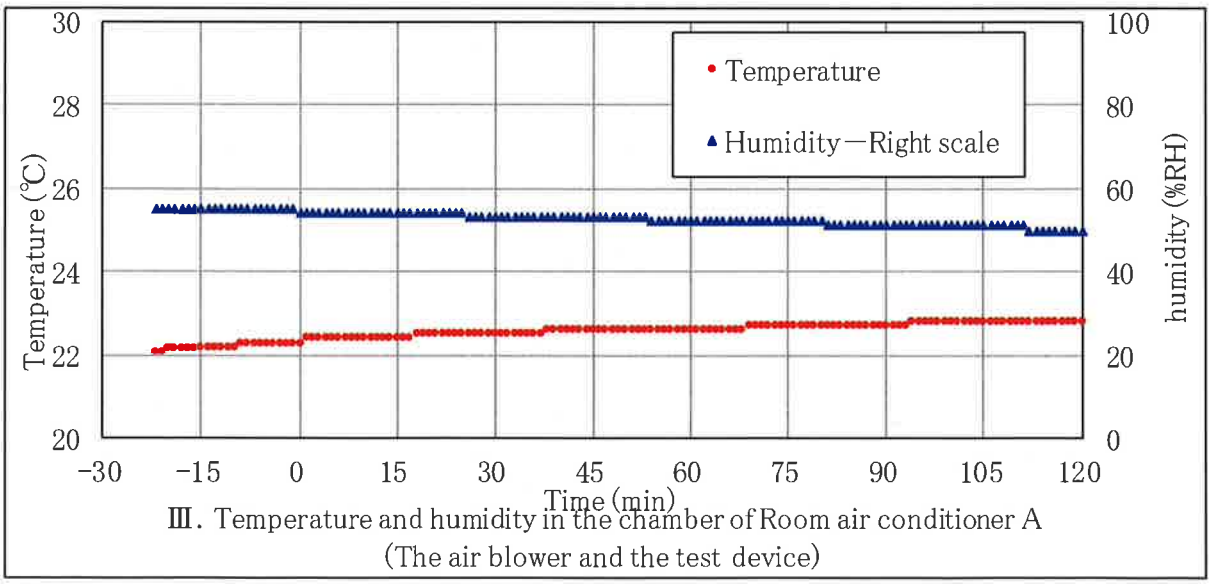
Referenced sheet



Ⅰ. Temperature and humidity in the chamber of the control condition



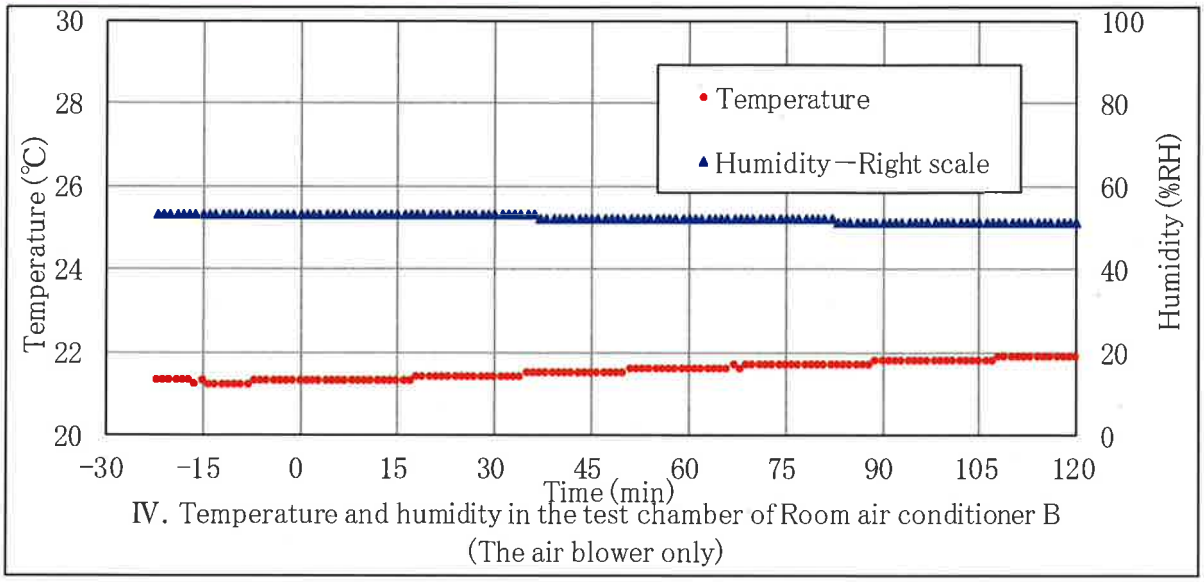
Ⅱ. Temperature and humidity in the chamber of Room air conditioner A
(The air blower only)



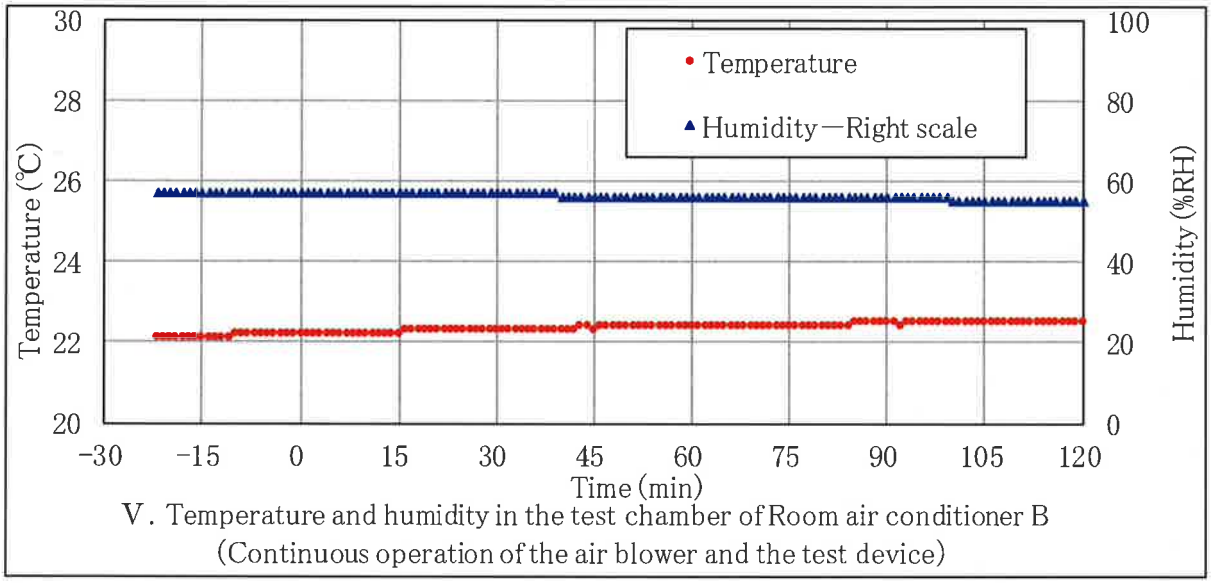
Ⅲ. Temperature and humidity in the chamber of Room air conditioner A
(The air blower and the test device)

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

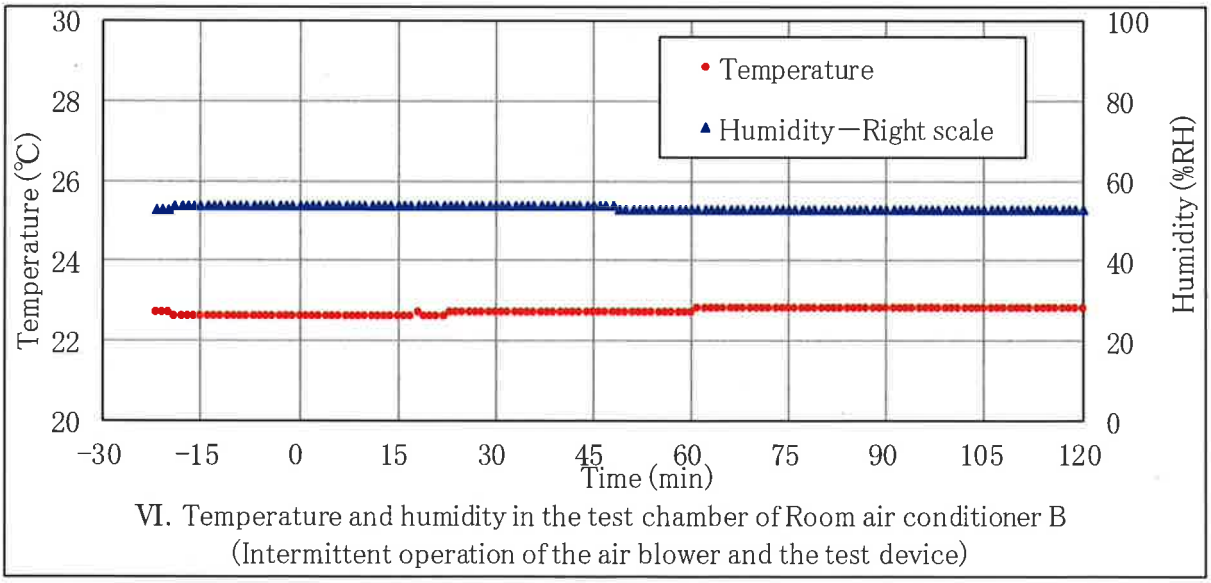
Referenced sheet



Ⅳ. Temperature and humidity in the test chamber of Room air conditioner B
(The air blower only)



Ⅴ. Temperature and humidity in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



Ⅵ. Temperature and humidity in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

Attachment

Annex D: The evaluation test of removal efficiency for airborne virus.

Standard of household air cleaner, JEM 1467, The Japan Electrical Manufacturers' Association

Result

The changes of number of airborne phage or influenza virus are shown in Fig 1. The inclination of the approximate equation represents the changes of number of airborne phage or influenza virus per minute (log). The changes of the logarithmic values in this case mean the digit changes of the number of phage or influenza virus. Accordingly, the log reduction of "② test device running" at t min corrected with that of "① natural reduction" at t min is the log reduction of the number of phage or influenza virus with time.

The approximate equation is as follows;

Natural reduction : $y=-a_1x+b_1$ ····· (D.1)

Test device running : $y=-a_2x+b_2$ ····· (D.2)

y : Log (the number of the airborne phage or influenza virus （ CFU / the values of the captured air)) x : The time of test device running (min))

The formulas Δy shows the logarithmic reduction value of airborne phage or influenza virus in the condition of natural reduction or running test device.

$\Delta y=t(a_2-a_1)$ ····· (D.3)

One digit decrease meant 90% reduction, and 2 digit decrease meant 99% reduction.

$$\left(1-\frac{1}{10^{\zeta}}\right)\times 100(\%) \quad \cdots\cdots \text{(D.4)}$$

ζ : The decreasing number of digits

In calculating the logarithmic reduction value, the values from the extrapolation of the approximate equation must not be used and the actual measured values at each time must be used.

Attachment

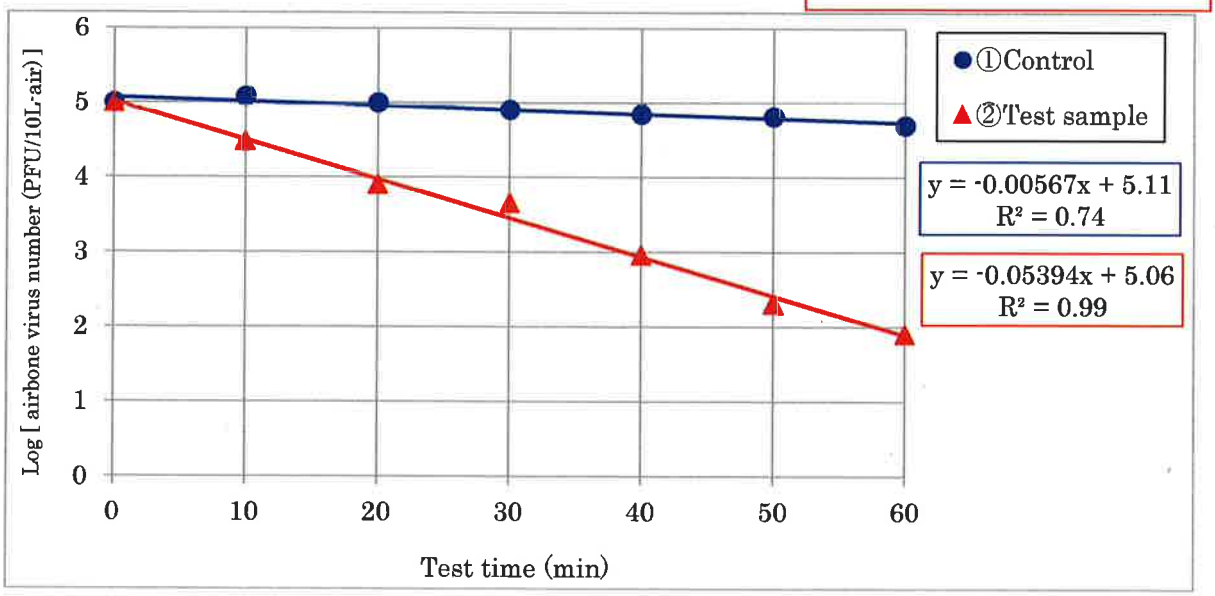


Fig D.1 Example of the results of removal efficiency evaluation test for airborne virus

Removal efficiency

When the logarithmic reduction value obtained from this examination is 2.0 or more, the air cleaner is considered as effective device for removing airborne virus.

2018_40356

To TOSHIBA CARRIER (THAILAND) CO., LTD.

Test Report

Evaluation test of the removal efficacy of the Room air conditioner on airborne fungal spores (25 m^3 space)

KRCES - Bio. Test Report No.2018_0356

February 15, 2019

Approved by : Toshihiro Itoh

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1. Test objective

Removal efficacy of the room air conditioners on airborne fungal spores in a 25 m^3 test chamber was evaluated in this study. Evaluation method for removal 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 : TOSHIBA CARRIER (THAILAND) CO., LTD.

Address : 144/9 Moo 5, Bangkadi, Industrial Park, Tivanon Road, Tambol Bangkadi, Amphur, Muang, Pathunthani 12000, Thailand

3. Test laboratory

Name: Kitasato Research Center for Environmental Science

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

4. Test period

January 1, 2019 ~ January 23, 2019

5. Test sample

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma) ・・・Photo1

2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer) ・・・Photo2

6. Test condition

Ⅰ. Natural reduction (control);

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was splayed into the chamber where the test sample was turned off.

Ⅱ. Room air conditioner A (The air blower only)

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅲ. Room air conditioner A (The air blower and the test device)

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was sprayed into the chamber where the sample (the air blower and the test device) was turned on.

Ⅳ. Room air conditioner B (The air blower only)

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was sprayed into the chamber where the sample (the air blower and the test device) was continuously operated for 30 seconds, and then turn off for 2 seconds.

Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)

Time-dependent changes in fungal spores count were monitored after the test fungal spores suspension was sprayed into the chamber where the sample (the air blower and the test device) was intermittently operated for 4 seconds, and then turn off for 6 seconds.

7. Test fungus

Penicillium citrinum NBRC 6352 (Spore), Size : approximately 3 μm

8. Reagents, apparatus

1) Main reagents

- Potato Dextrose Agar (Nissui、hereinafter called PDA)
- Sodium chloride (Wako, special grade, for physiological saline)
- Sodium thiosulfate (Wako, 1st grade)
- Aerosol OT (Wako, for chemistry)

2) Devices and apparatus

- Test chamber (25 m^3 : 2.7×3.8×2.4 m, Amenity Technology)
- Circulation fan (BS-B-25, Yamazen)
- Laser particle counter (MODEL 3886, Kanomax Japan)
- Thermo-hygrometer (TR-72Ui, T&D)

- Nebulizer (Collison Nebulizer CN-31I、BGI)
- Glass impinger (specially ordered、hereinafter called impinger)
- Membrane filter (ϕ 0.45 μ m, mixed cellulose ester, A045R047A, Advantec)
- Incubator (MIR-153, MIR-553, Sanyo)

9. Method

1) Test procedure

The test system was shown in Photos 3, 4 and Figs 5, 6. The test sample, the circulation fan, the laser particle counter, and the thermo-hygrometer were set in the test chamber. Two holes were made on one of the side panels of the test chamber. The nebulizer for spraying fungal spores suspension was connected to one of the holes and the impinger for collecting airborne fungal spores was connected to the other hole.

According to the test procedure described in Table 6, the fungal spores suspension was sprayed with nebulizer for 15 minutes into the chamber while the circulation fan was operated. After 2 minute circulation of the air, the fungal spores aerosol was collected into the impinger (time 0). The aerosol was collected after 60 and 120 minutes after the test sample was turned on.

As a control, the same test was performed under the condition that the test sample was turned off according to the procedure described in Table 5.

2) Preparation of the test fungus

Cryopreserved test fungi were applied to PDA and incubated for 2 weeks at 27 ± 2℃. Spores were scraped off and suspended in sterile ion-exchanged water and filtrated through cotton wool. The fungal count was adjusted to 10^8 CFU/mL for the test.

3) Spray of the fungal spores suspension

The test fungal spores suspension (10^8 CFU/mL) was sprayed into the test chamber with the nebulizer for 15 minutes at the liquid flow 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 6.5 L/min.

4) Collection of airborne fungal spores

The air in the chamber was sampled at 10 L/min for 5 minutes (total 50 L) to the impinger containing 20 mL of sterilized saline with 0.015 % sodium thiosulfate to collect the airborne fungal spores (fungal spores aerosol).

5) Count of fungal spore numbers

Ten-fold dilutions of the each collected spore suspension were prepared with 0.005 % dioctyl sodium sulfosuccinate in sterilized saline. One mL of the each dilution or the original suspension was mixed with PDA medium to make an agar plate. Ten mL of the suspension of the collected fungal spore suspension in the impinger were filtered through the membrane filter. The resultant filter was transferred onto the surface of PDA medium. These medium were incubated at 27 ± 2℃ for 1 week. After the incubation, colony numbers were counted and the numbers of fungal spores in 50 L of air were calculated.

6) Evaluation method for the removal 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 did not correspond to household air purifiers, and besides, the fungal spores were used instead of virus in this test. Therefore, the evaluation of the removal efficacy was performed using the method described below.

The approximate equation was calculated based on the time-dependent changes of airborne fungal spores (logarithmic representation) and the inclination of the approximate equation was obtained. This inclination represents an amount of change in the number of fungal spores 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 removal efficacy of airborne fungal spores was determined based on net LRV.

The efficacy of the test sample was evaluated using the following formulae.

※1 Net inclination =

Inclination of test sample 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

Fungal spore counts of the sprayed suspension was 6.8×10^8 CFU/mL. The numbers of airborne fungal spores 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 fungal spores at each measurement time, and were shown in Table 2 and Fig 2. Residual fungal spore ratios for the initial number at each time were shown in Table 3 and Fig 3. The residual fungal spore ratios for the control were shown in Table 4 and Fig 4.

In this test, net LRV (reduction rate) of the test samples for airborne fungal spores at 120 minutes were 1.30 (94%) for test condition Ⅱ, 2.01 (99.0%) for the conditionⅢ, 1.20 (93%) for the condition Ⅳ, 2.30 (99.4%) for the conditionⅤand 2.38 (99.5%) for the conditionⅥ respectively.

11. Reference data

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

12. Comment

This test was referring to the method of JEM 1467. In attached document Annex D, "The evaluation test for removal efficacy on airborne virus" in Japan Electrical Manufacturers' Association standard 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.

In the test conditions Ⅰ and Ⅳ, the test sample showed certain degree of reduction effect but could not achieved 2.0 log reduction value even after being operated for 120min. On the other hand, in the test conditions Ⅲ, Ⅳ and Ⅴ, the log reduction value was more than 2-dight, and removed efficacy of the test sample against airborne fungi was recognized.

The two major differences between this standard and this test must be considered, as follows.

1) The test samples in this test were not designed as air purifiers but air conditioners.
2) The target microorganisms used in this test were bacteria instead of viruses.

Table 1. The number of airborne fungal spores at each measurement time

(Unit : CFU/100 L-air)

Test condition	Time (min)		
	0	60	120
Ⅰ. Control condition	330,000	190,000	120,000
Ⅱ. Room air conditioner A (The air blower only)	380,000	37,000	6,800
Ⅲ. Room air conditioner A (The air blower and the test device)	400,000	12,000	1,400
Ⅳ. Room air conditioner B (The air blower only)	410,000	43,000	9,300
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	840,000	19,000	1,500
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	1,000,000	31,000	1,500

Test sample :

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma)

2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer)

Test fungus : *Penicillium citrinum* NBRC 6352 (Spore)

Test space : 25 m^3

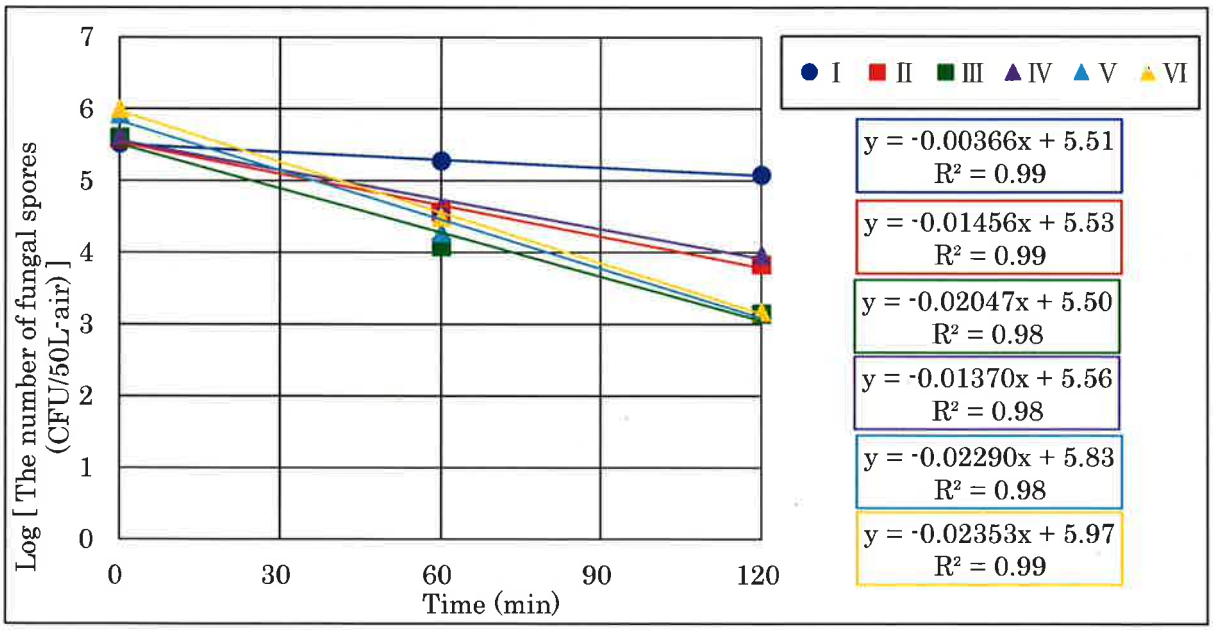


Fig 1. The number of airborne fungal spores at each measurement time

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

Test condition	Inclination	Net inclination	Time (min)		
			0	60	120
Ⅰ. Control condition	-0.00366				
Ⅱ. Room air conditioner A (The air blower only)	-0.01456	-0.01090	0.00	0.65	1.30
			(0%)	(77%)	(94%)
Ⅲ. Room air conditioner A (The air blower and the test device)	-0.02047	-0.01681	0.00	1.00	2.01
			(0%)	(90%)	(99.0%)
Ⅳ. Room air conditioner B (The air blower only)	-0.01370	-0.01004	0.00	0.60	1.20
			(0%)	(74%)	(93%)
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	-0.02290	-0.01924	0.00	1.15	2.30
			(0%)	(92%)	(99.4%)
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	-0.02353	-0.01987	0.00	1.19	2.38
			(0%)	(93%)	(99.5%)

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

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

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

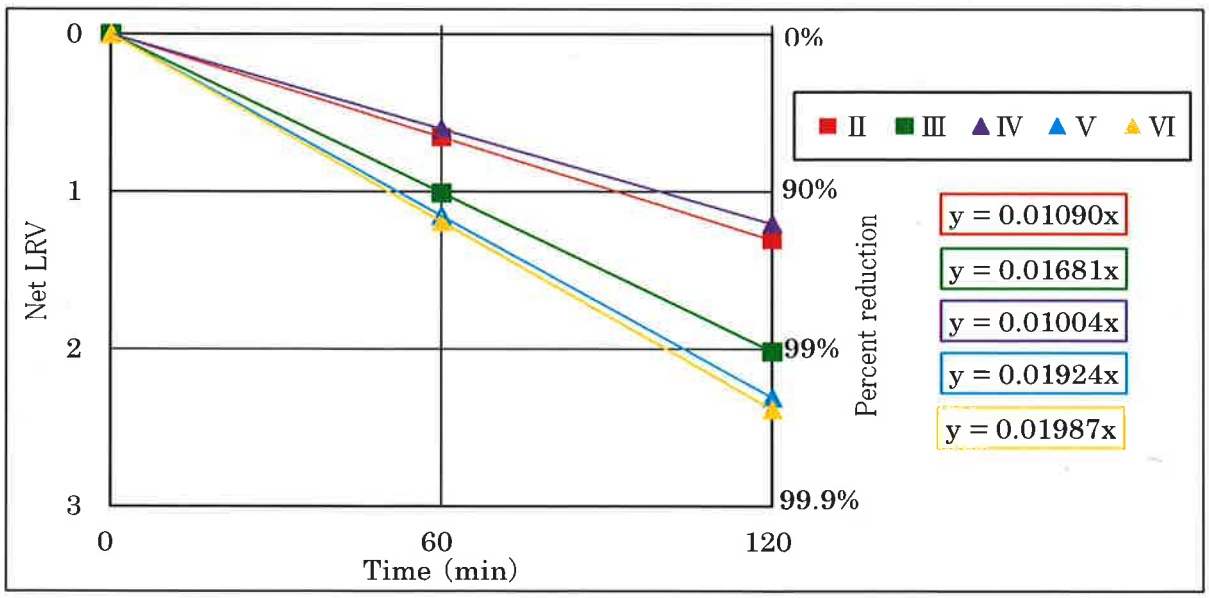


Fig 2. Net LRV and percent reduction at each measurement time

Table 3. Residual fungal spore ratio for the initial number (%) at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	84	71	60	50	43	36
Ⅱ. Room air conditioner A (The air blower only)	100	51	26	13	6.8	3.4	1.7
Ⅲ. Room air conditioner A (The air blower and the test device)	100	38	15	5.9	2.3	0.8	0.3
Ⅳ. Room air conditioner B (The air blower only)	100	53	28	15	8.0	4.2	2.2
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	34	12	4.2	1.4	0.5	0.1
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	33	11	3.8	1.3	0.4	0.1

※Using slope of approximate expression as shown in Fig1 (number of airborne fungal spores which change per minute, log value) the residual ratio was calculated according to equation ① and ②.

① Log reduction value = | Inclination | × Time (min)

② Residual rate (%) $= \frac{1}{10^{(LRV)}} \times 100$ (%)

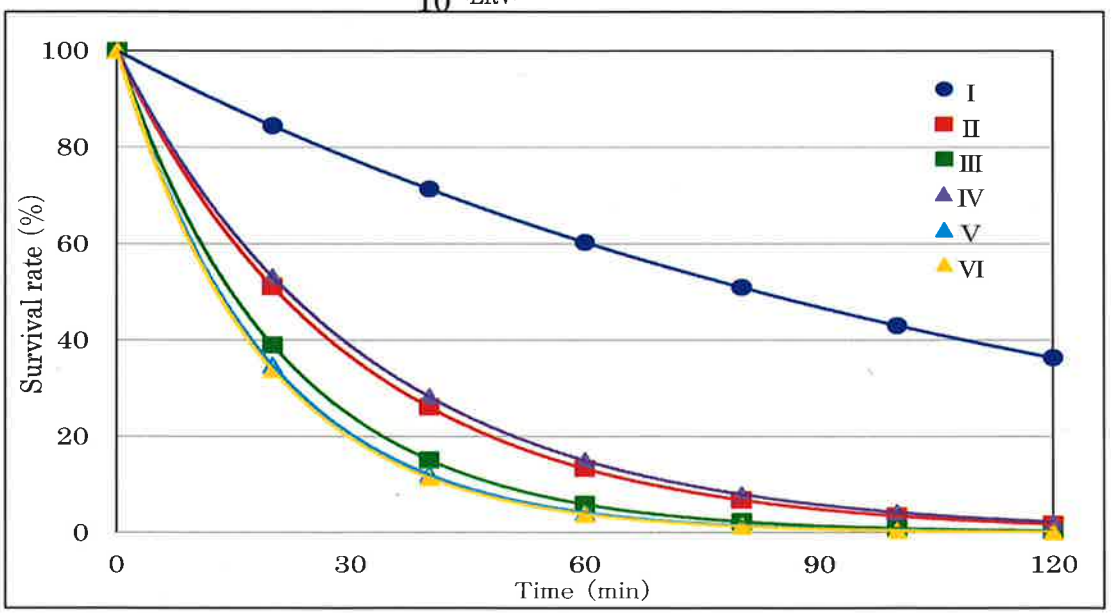


Fig 3. Residual fungal spore ratio for the initial number (%) at each time

Table 4. The residual fungal spore ratios with the sample for the control at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	100	100	100	100	100	100
Ⅱ. Room air conditioner A (The air blower only)	100	60	36	22	13	8.1	4.9
Ⅲ. Room air conditioner A (The air blower and the test device)	100	46	21	9.8	4.5	2.0	0.9
Ⅳ. Room air conditioner B (The air blower only)	100	62	39	24	15	9.9	6.2
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	41	16	7.0	2.8	1.1	0.4
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	40	16	6.4	2.5	1.0	0.4

※Using slope of approximate expression as shown in Fig1 (number of airborne fungal spores which change per minute, log value) the residual ratio was calculated according to equation ① ,② and ③.

① Net inclination= Inclination of test condition− Inclination of control condition

② LRV= | Net Inclination | ×Time (min)

③ Residual rate (%) $= \frac{1}{10^{(LRV)}} \times 100$ (%)

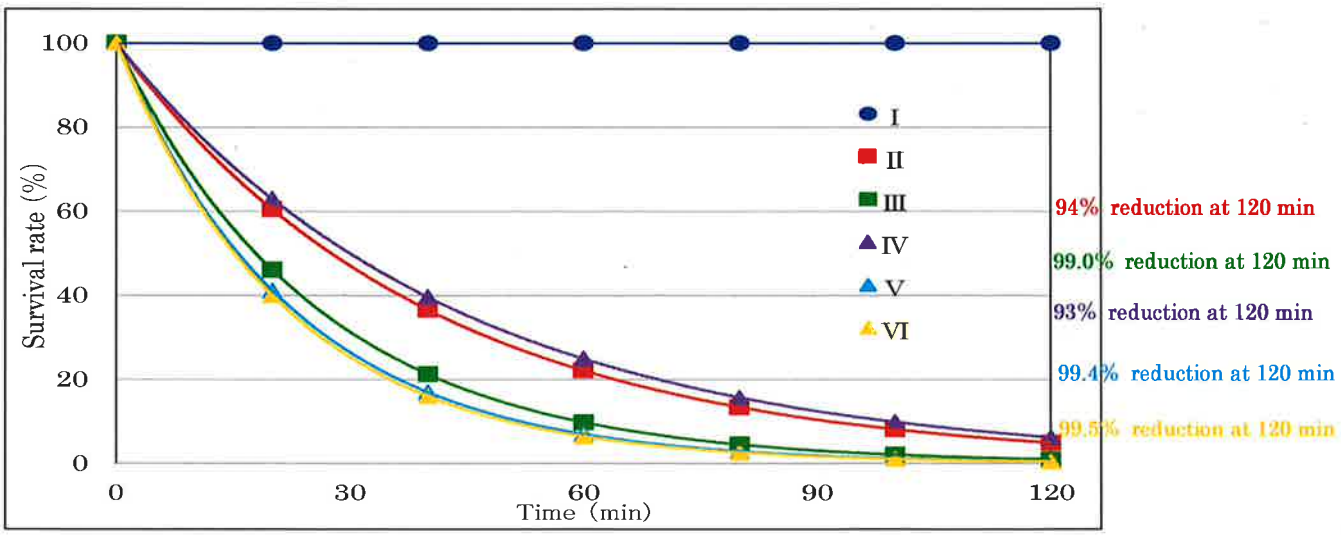


Fig 4. The residual fungal spore ratios with the sample for the control at each time

Table 5. Test procedure (Control condition I)

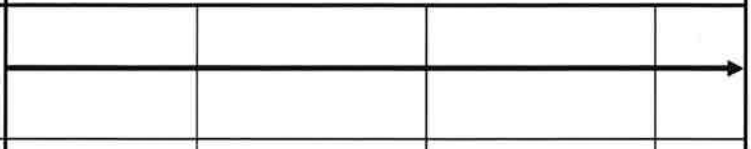
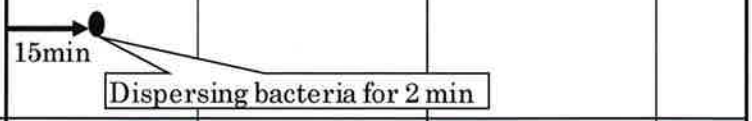
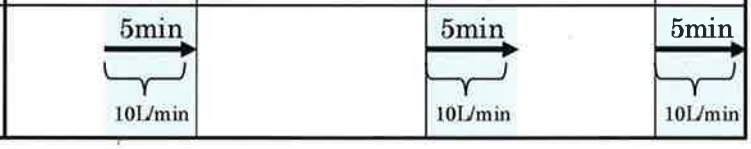
Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	
Spray of fungal spores	Nebulizer	
Collect airborne fungal spores	Impinger	

Table 6. Test procedure (Test condition II～VI)

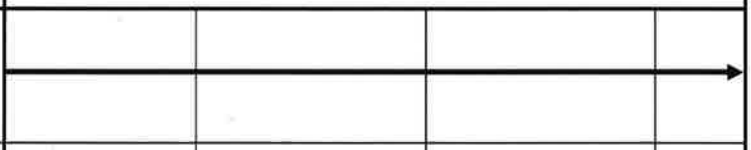
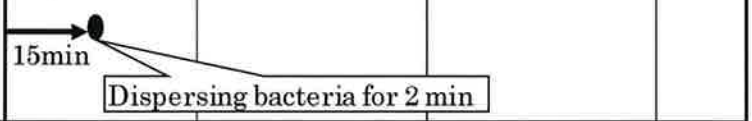
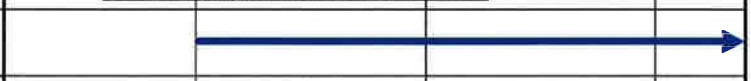
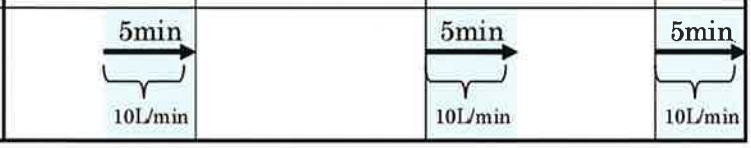
Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	
Spray of fungal spores	Nebulizer	
Test sample	Air blower	
	Test device	
Collect airborne fungal spores	Impinger	

Photo 1. Room air conditioner A (Model No ; RAS-35PKVPG-ND)

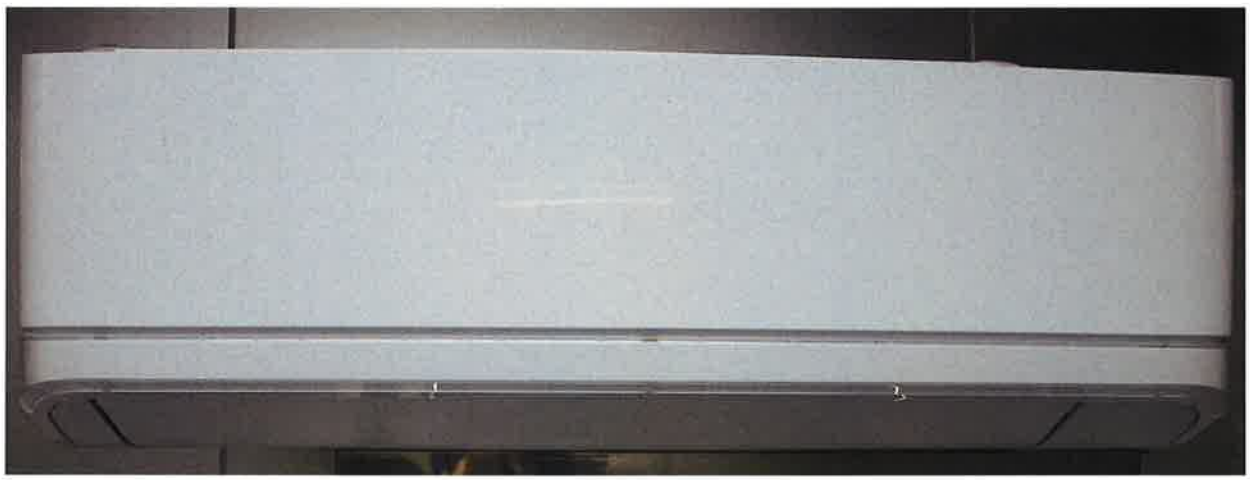


Photo 2. Room air conditioner B (Model No ; RAS-13J2KCVRG-T)

Photo 3. 25 m^3 Test chamber (Room air conditioner A)

Photo 4. 25 m^3 Test chamber (Room air conditioner B)

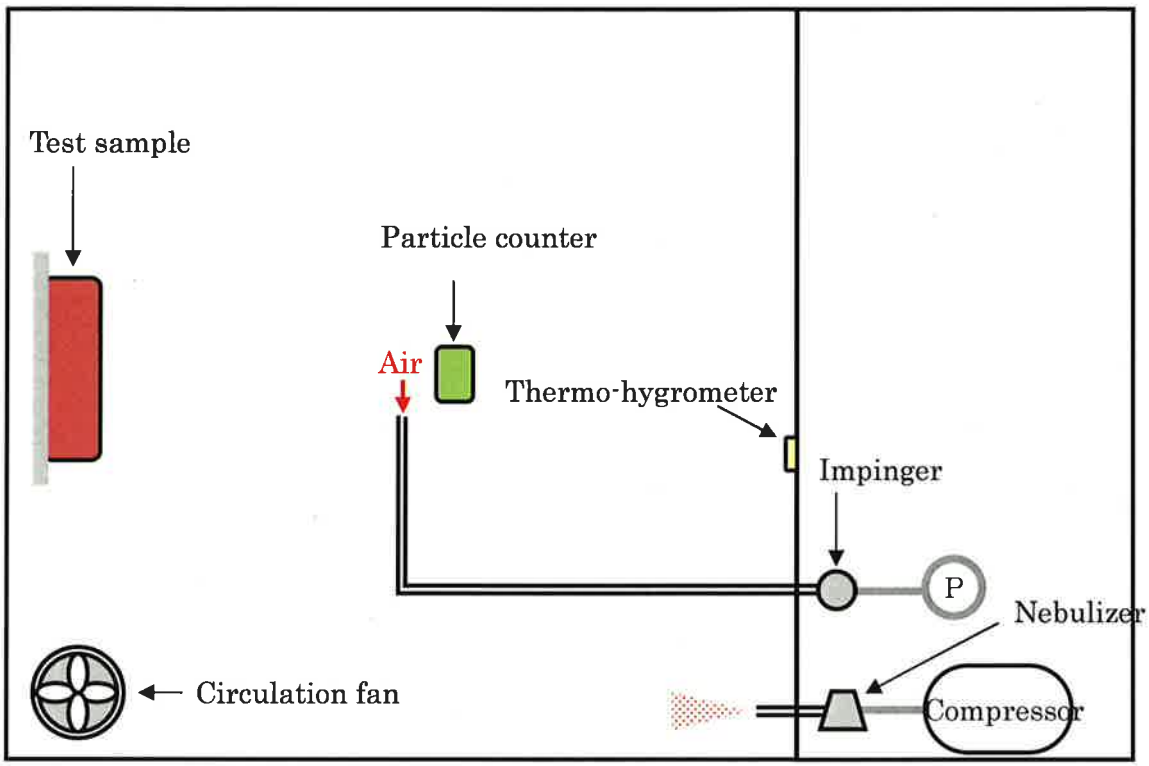


Fig 5. 25 m³ Test chamber (top view)

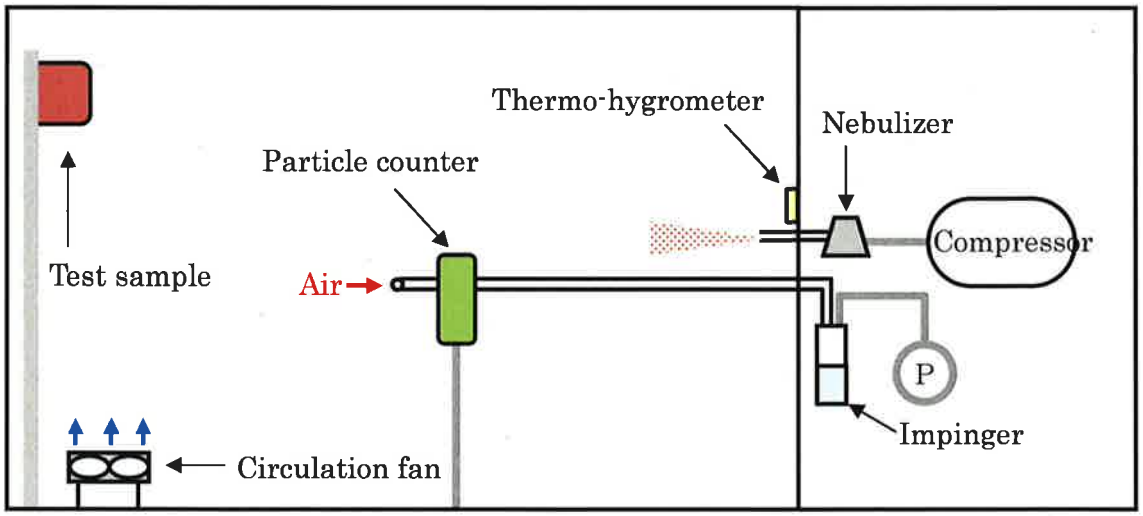


Fig 6. 25 m³ Test chamber (side view)

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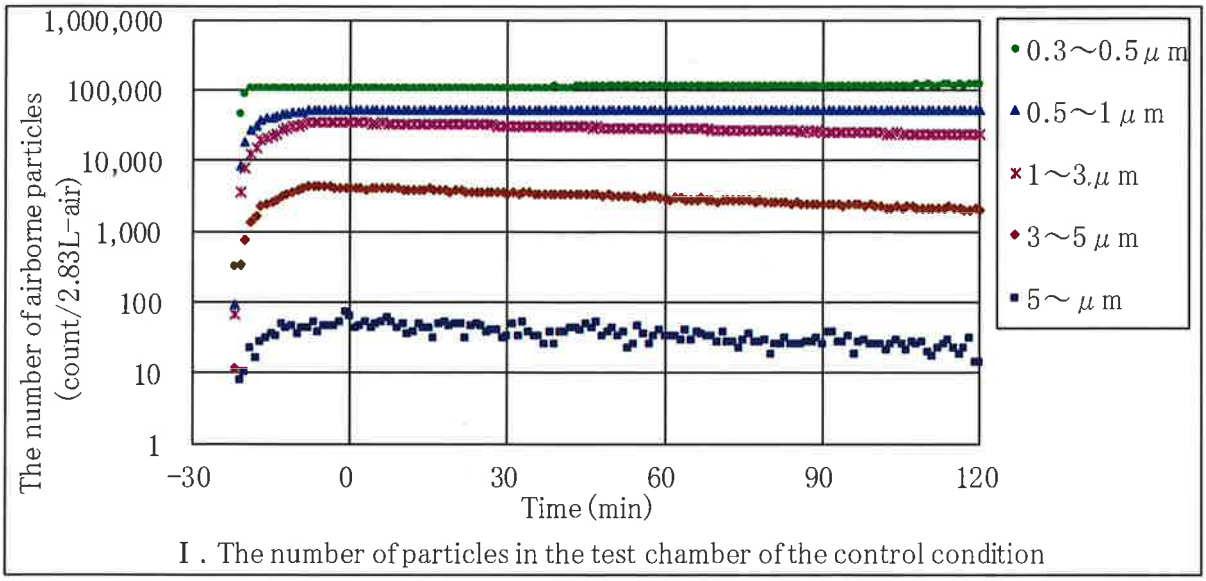
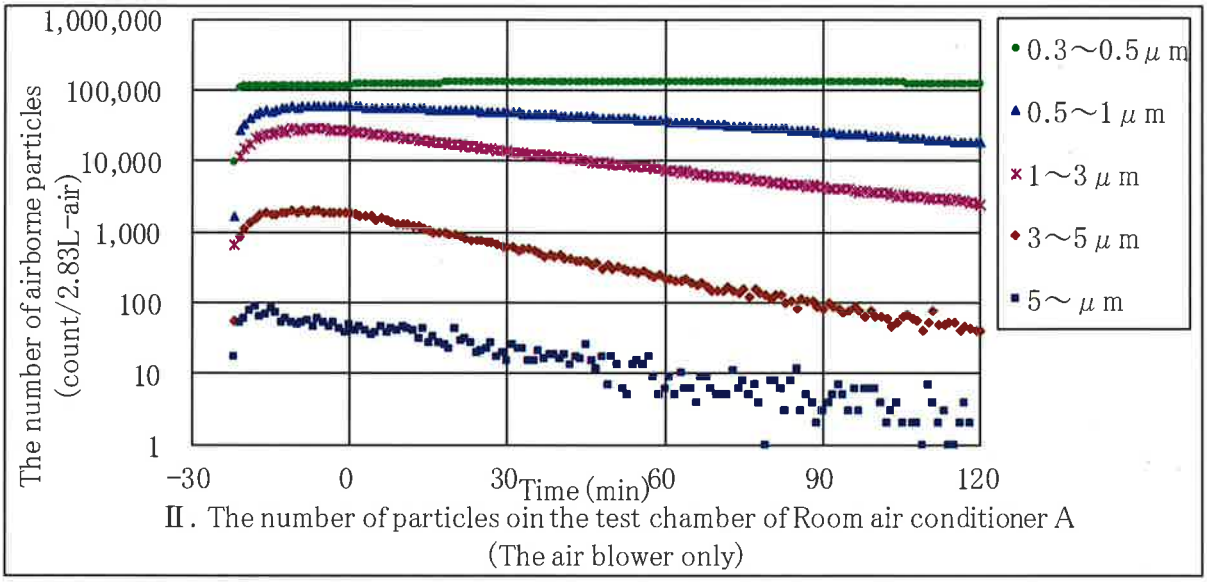
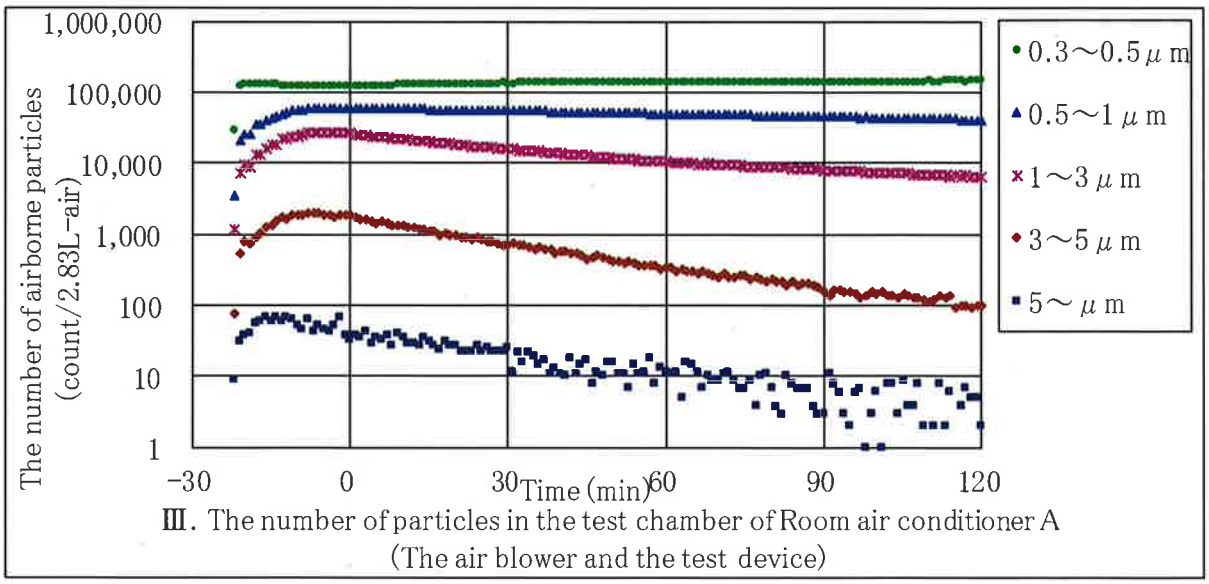


Ⅰ. The number of particles in the test chamber of the control condition

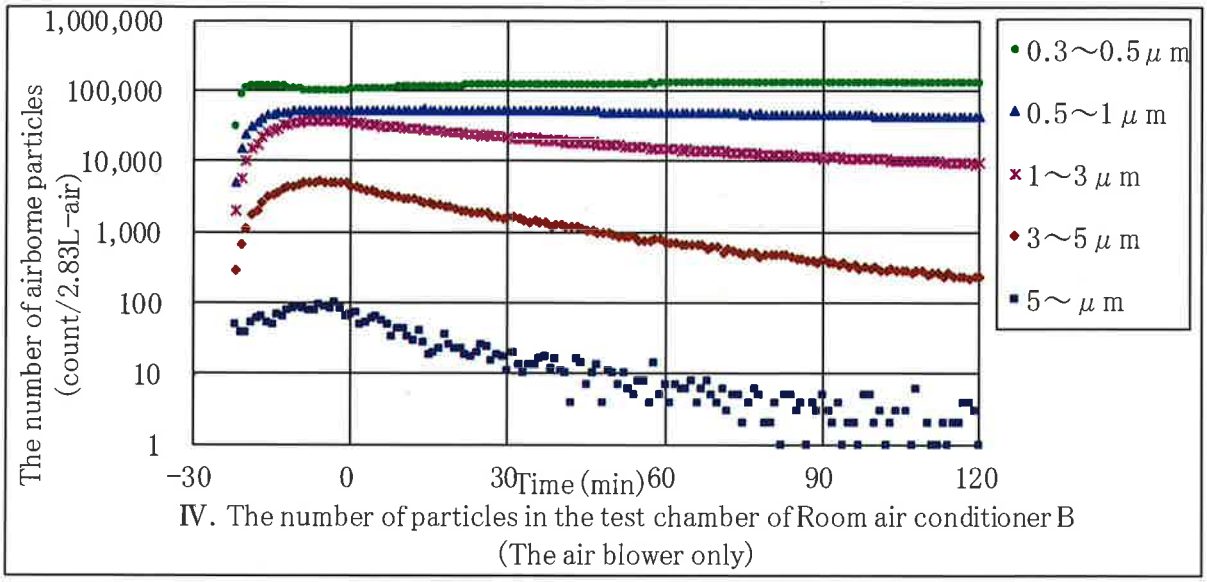


Ⅱ. The number of particles oin the test chamber of Room air conditioner A
(The air blower only)

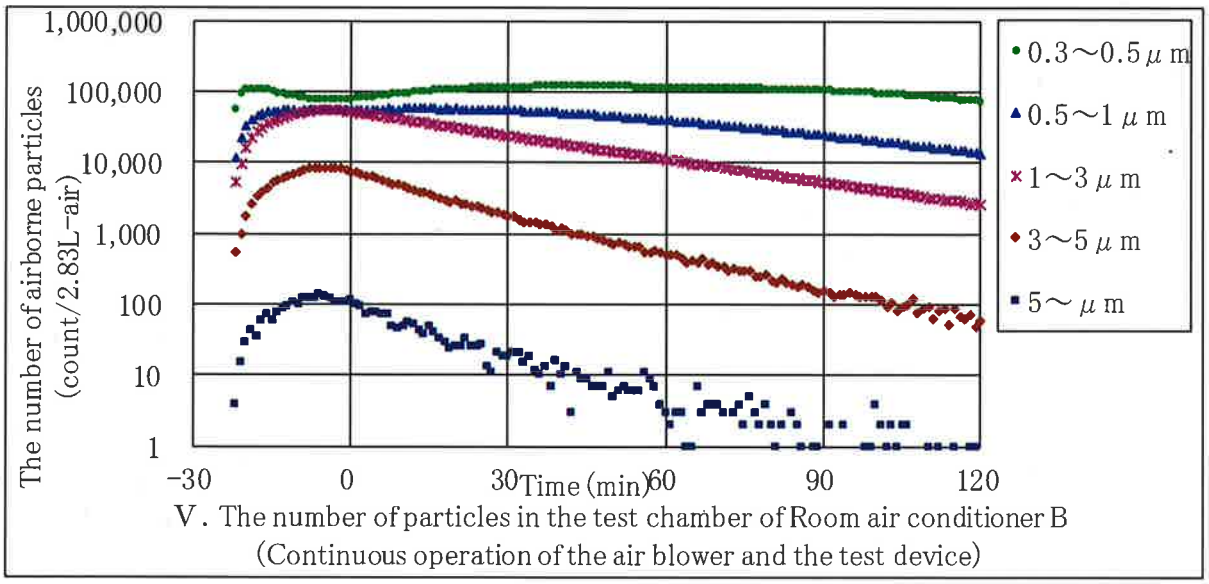


Ⅲ. The number of particles in the test chamber of Room air conditioner A
(The air blower and the test device)

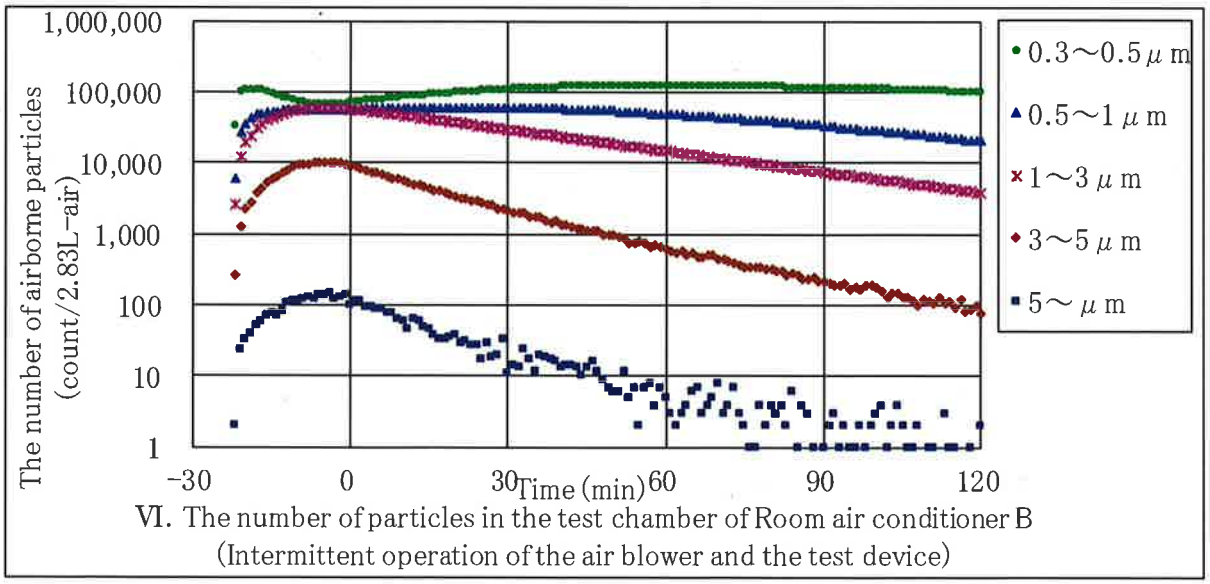
＊Measured by a laser particle counter (MODEL 3886, Kanomax Japan)



Ⅳ. The number of particles in the test chamber of Room air conditioner B
(The air blower only)



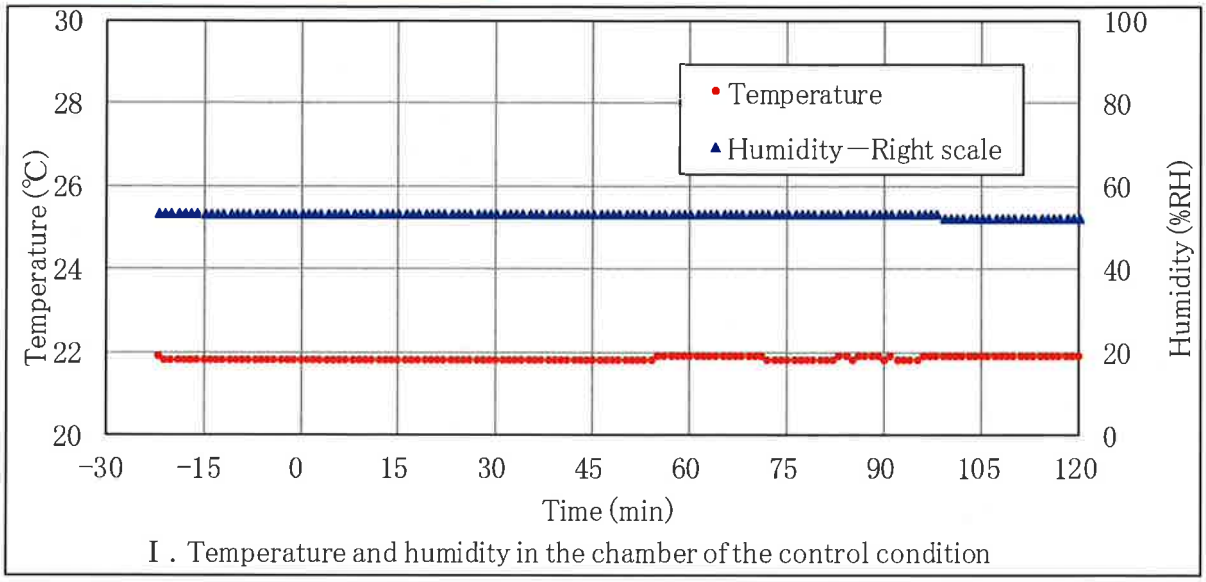
Ⅴ. The number of particles in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



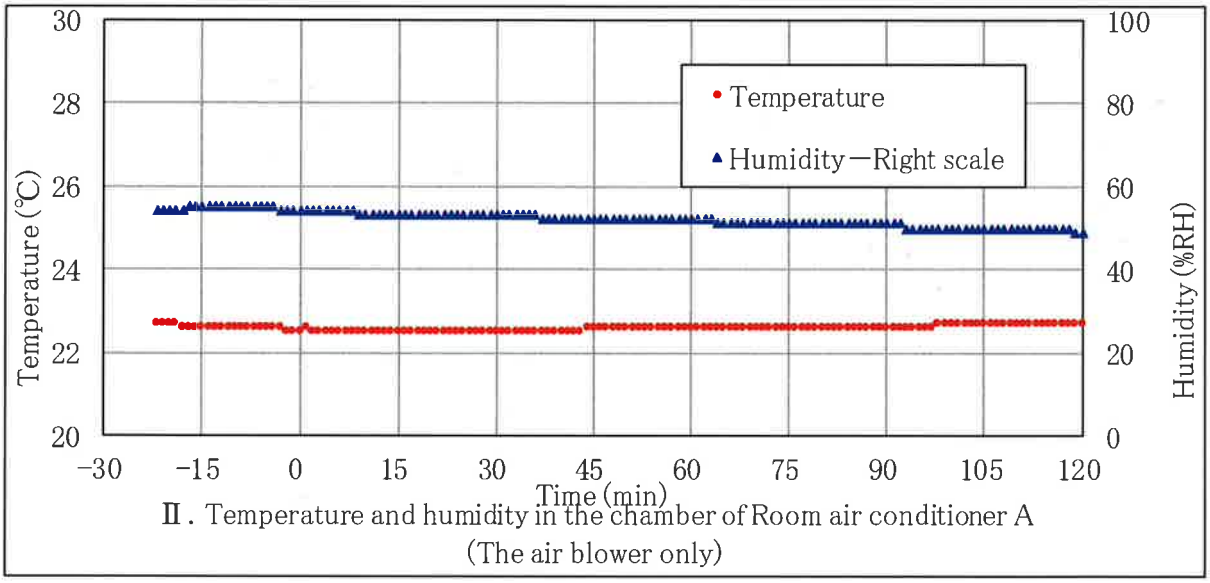
Ⅵ. The number of particles in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

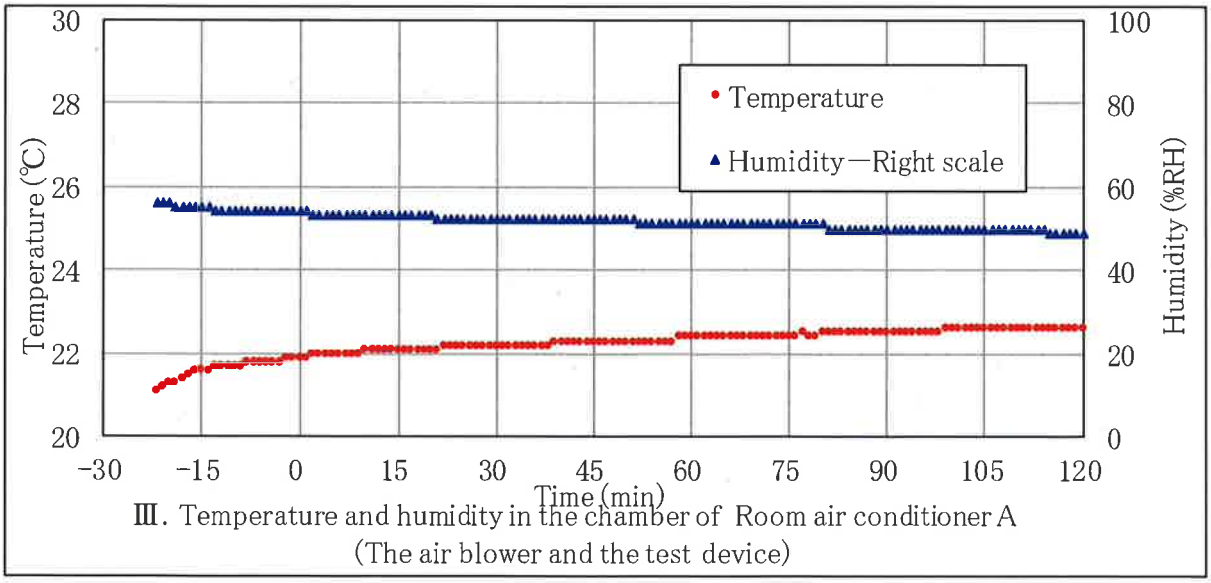
Referenced sheet



Ⅰ. Temperature and humidity in the chamber of the control condition



Ⅱ. Temperature and humidity in the chamber of Room air conditioner A
(The air blower only)



Ⅲ. Temperature and humidity in the chamber of Room air conditioner A
(The air blower and the test device)

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

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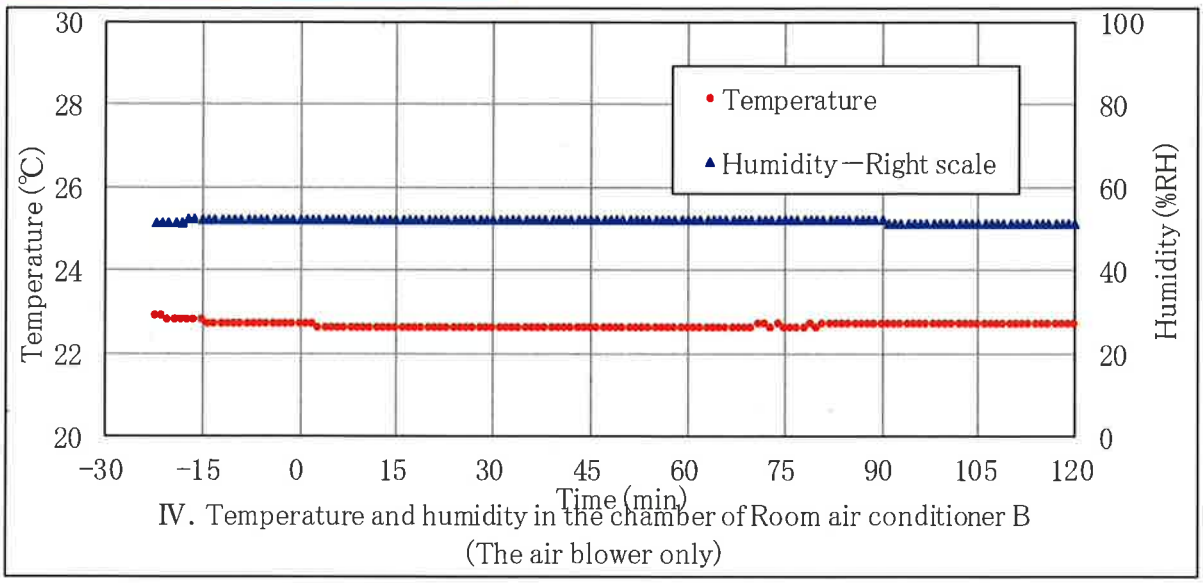
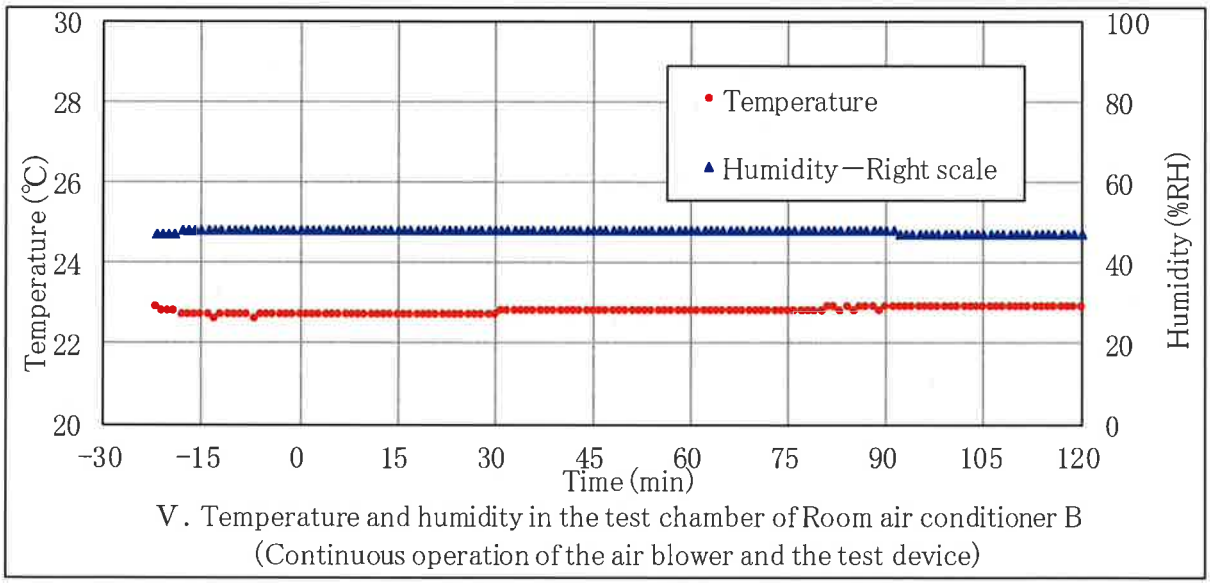
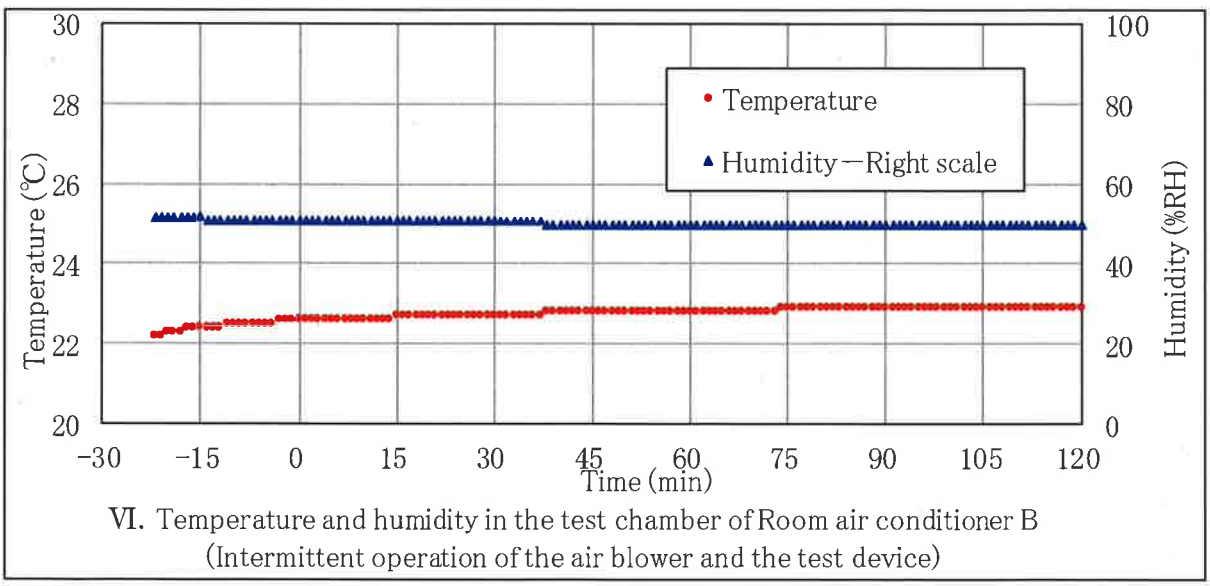


Ⅳ. Temperature and humidity in the chamber of Room air conditioner B
(The air blower only)



Ⅴ. Temperature and humidity in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



Ⅵ. Temperature and humidity in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

Attachment

Annex D: The evaluation test of removal efficiency for airborne virus.

Standard of household air cleaner, JEM 1467, The Japan Electrical Manufacturers' Association

Result

The changes of number of airborne phage or influenza virus are shown in Fig 1. The inclination of the approximate equation represents the changes of number of airborne phage or influenza virus per minute (log). The changes of the logarithmic values in this case mean the digit changes of the number of phage or influenza virus. Accordingly, the log reduction of "② test device running" at t min corrected with that of "① natural reduction" at t min is the log reduction of the number of phage or influenza virus with time.

The approximate equation is as follows;

Natural reduction : $y=-a_1x+b_1$ ····· (D.1)

Test device running : $y=-a_2x+b_2$ ····· (D.2)

y : Log (the number of the airborne phage or influenza virus （ CFU / the values of the captured air)) x : The time of test device running (min))

The formulas Δy shows the logarithmic reduction value of airborne phage or influenza virus in the condition of natural reduction or running test device.

$\Delta y=t(a_2-a_1)$ ····· (D.3)

One digit decrease meant 90% reduction, and 2 digit decrease meant 99% reduction.

$$\left(1-\frac{1}{10^{\zeta}}\right)\times 100(\%) \quad \cdots\cdots \text{(D.4)}$$

ζ : The decreasing number of digits

In calculating the logarithmic reduction value, the values from the extrapolation of the approximate equation must not be used and the actual measured values at each time must be used.

Attachment

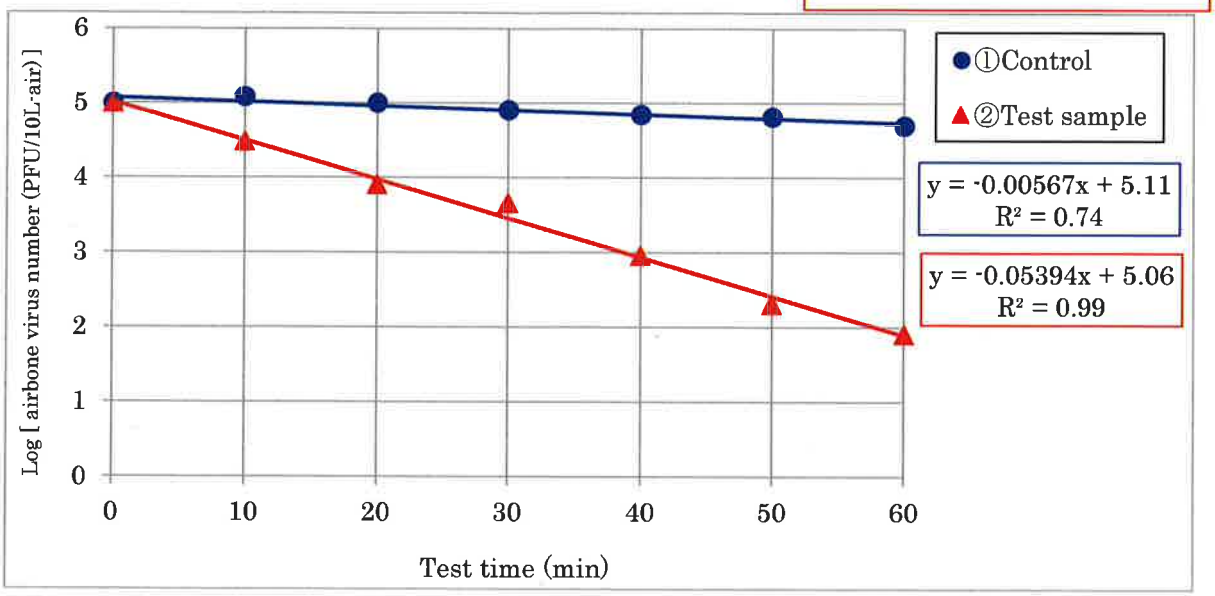


Fig D.1 Example of the results of removal efficiency evaluation test for airborne virus

Removal efficiency

When the logarithmic reduction value obtained from this examination is 2.0 or more, the air cleaner is considered as effective device for removing airborne virus.

1. Test objective

Removal efficacy of the room air conditioners on airborne bacteria in a 25 m^3 test chamber was evaluated in this study. Evaluation method for removal 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 : TOSHIBA CARRIER (THAILAND) CO., LTD.

Address : 144/9 Moo 5, Bangkadi, Industrial Park, Tivanon Road, Tambol Bangkadi, Amphur, Muang, Pathunthani 12000, Thailand

3. Test laboratory

Name: Kitasato Research Center for Environmental Science

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

4. Test period

January 15, 2019 ~ January 18, 2019

5. Test sample

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma)・・・Photo1

2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer)・・・Photo2

6. Test condition

Ⅰ. Natural reduction (control);

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was splayed into the chamber where the test sample was turned off.

Ⅱ. Room air conditioner A (The air blower only)

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅲ. Room air conditioner A (The air blower and the test device)

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was sprayed into the chamber where the sample (the air blower and the test device) was turned on.

Ⅳ. Room air conditioner B (The air blower only)

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was sprayed into the chamber where only the air blower of the test sample was turned on.

Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was sprayed into the chamber where the sample (the air blower and the test device) was continuously operated for 30 seconds, and then turn off for 2 seconds.

Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)

Time-dependent changes in bacteria count were monitored after the test bacterial suspension was sprayed into the chamber where the sample (the air blower and the test device) was intermittently operated for 4 seconds, and then turn off for 6 seconds.

7. Test bacteria

Staphylococcus aureus NBRC 12732, Size : approximately 0.5 μm

8. Reagents, apparatus

1) Main reagents

- Tryptic Soy Agar (Difco、hereinafter called TSA)
- Sodium chloride (Wako, special grade, for physiological saline)
- Sodium thiosulfate (Wako, 1st grade)

2) Devices and apparatus

- Test chamber (25 m^3 : 2.7×3.8×2.4 m, Amenity Technology)
- Circulation fan (BS-B-25, Yamazen)
- Laser particle counter (MODEL 3886, Kanomax Japan)
- Thermo-hygrometer (TR-72Ui, T&D)
- Nebulizer (Collison Nebulizer CN-31I、BGI)

- Glass impinger (specially ordered、hereinafter called impinger)
- Membrane filter (ϕ 0.45 μ m, mixed cellulose ester, A045R047A, Advantec)
- Incubator (MIR-153, MIR-553, Sanyo)

9. Method

1) Test procedure

The test system was shown in Photos 3, 4 and Figs 5, 6. The test sample, the circulation fan, the laser particle counter, and the thermo-hygrometer were set in the test chamber. Two holes were made on one of the side panels of the test chamber. The nebulizer for spraying bacterial suspension was connected to one of the holes and the impinger for collecting airborne bacteria was connected to the other hole.

According to the test procedure described in Table 6, the bacterial suspension was sprayed with nebulizer for 15 minutes into the chamber while the circulation fan was operated. After 2 minute circulation of the air, the bacterial aerosol was collected into the impinger (time 0). The aerosol was collected after 60 and 120 minutes after the test sample was turned on.

As a control, the same test was performed under the condition that the test sample was turned off according to the procedure described in Table 5.

2) Preparation of test bacteria

Cryopreserved test bacteria were pre-cultured and then sub-cultured for 21 hours at 36 ± 2 ℃ on TSA. Colonies formed on TSA were scraped off and suspended in sterilized ion-exchange water. Bacterial count of the suspension was adjusted to about 10^9 CFU/mL for the test.

3) Spray of the bacterial suspension

The test bacterial suspension (10^9 CFU/mL) was sprayed into the test chamber with the nebulizer for 15 minutes at the 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 7.0 L/min.

4) Collection of airborne bacteria

The air in the chamber was sampled at 10 L/min for 5 minutes (total 50 L) to the impinger containing 20 mL of sterilized saline with 0.015 % sodium thiosulfate to collect the airborne bacteria (bacterial aerosol).

5) Count of bacterial numbers

Ten-fold dilutions of the each collected bacterial suspension were prepared with saline. One mL of the each dilution or the original suspension was mixed with TSA medium to make an agar plate. Ten mL of the suspension of the collected bacterial suspension in the impinger were filtered through the membrane filter. The resultant filter was transferred onto the surface of TSA medium. These media were incubated at 36 ± 2 ℃ for 43 hours. After the incubation, colony numbers were counted and the numbers of bacteria in 50 L of air were calculated.

6) Evaluation method for the removal 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 did not correspond to household air purifiers, and besides, the bacteria were used instead of virus in this test. Therefore, the evaluation of the removal efficacy was performed using the method described below.

The approximate equation was calculated based on the time-dependent changes of airborne bacteria (logarithmic representation) and the inclination of the approximate equation was obtained. This inclination represents an amount of change in the number of bacteria 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 removal efficacy of airborne bacteria was determined based on net LRV.

The efficacy of the test sample was evaluated using the following formulae.

※1 Net inclination =

Inclination of test sample 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

Bacterial count of the sprayed suspension was 2.5×10^9 CFU/mL. The numbers of airborne bacteria 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 bacteria at each measurement time, and were shown in Table 2 and Fig 2. Residual bacteria ratios for the initial number at each time were shown in Table 3 and Fig 3. The residual bacteria ratios for the control were shown in Table 4 and Fig 4.

In this test, net LRV (reduction rate) of the test samples for airborne bacteria at 120 minutes were 0.17 (32%) for test condition Ⅱ, 0.73 (81%) for the conditionⅢ, 0.12 (24%) for the condition Ⅳ, 1.35 (95%) for the conditionⅤand 0.90 (87%) for the conditionⅥ respectively.

11. Reference data

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

12. Comment

This test was referring to the method of JEM 1467. In attached document Annex D, "The evaluation test for removal efficacy on airborne virus" in Japan Electrical Manufacturers' Association standard 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.

In this study, the test sample showed certain degree of reduction effect but could not achieved 2.0 log reduction value even after being operated for 120min.

The two major differences between this standard and this test must be considered, as follows.

1) The test samples in this test were not designed as air purifiers but air conditioners.
2) The target microorganisms used in this test were bacteria instead of viruses.

Table 1. The number of airborne bacteria at each measurement time

(Unit : CFU/50 L-air)

Test condition	Time (min)		
	0	60	120
Ⅰ. Control condition	1,900,000	770,000	520,000
Ⅱ. Room air conditioner A (The air blower only)	2,500,000	990,000	460,000
Ⅲ. Room air conditioner A (The air blower and the test device)	3,800,000	460,000	190,000
Ⅳ. Room air conditioner B (The air blower only)	1,500,000	540,000	310,000
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	2,700,000	270,000	33,000
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	1,600,000	250,000	55,000

Test sample :

1) Room air conditioner A (Model No; RAS-35PKVPG-ND, Device; DSK9 with plasma)

2) Room air conditioner B (Model No; RAS-13J2KCVRG-T, Device; BF1-13K with ionizer)

Test bacteria : *Staphylococcus aureus* NBRC 12732

Test space : 25 m^3

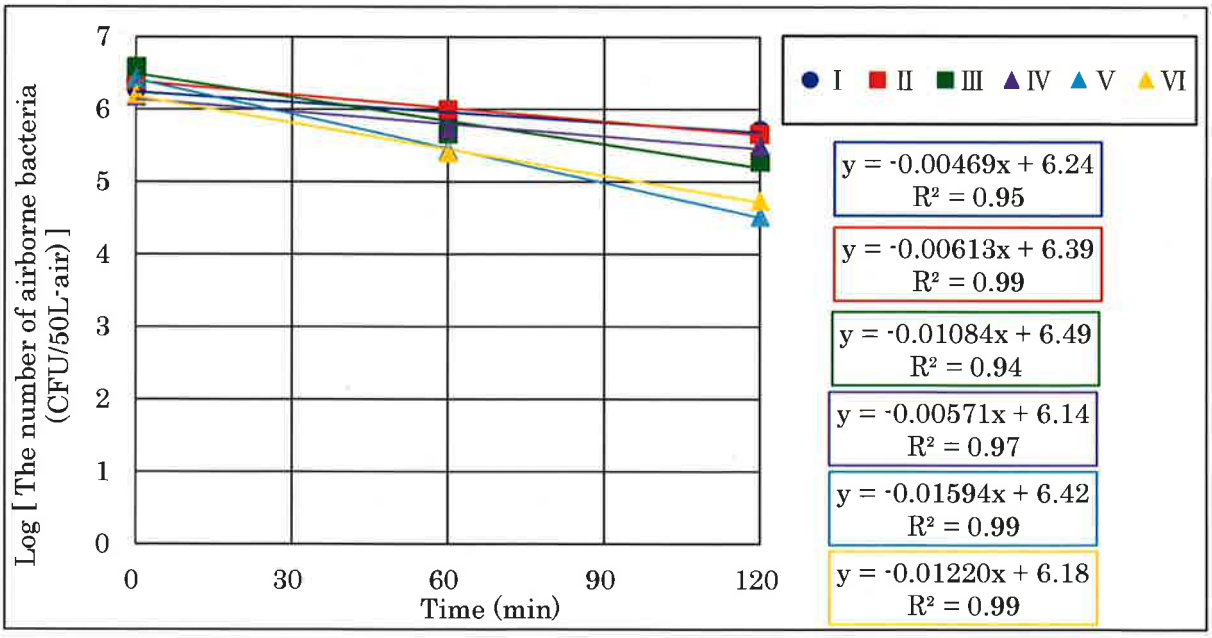


Fig 1. The number of airborne bacteria at each measurement time

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

Test condition	Inclination	Net inclination	Time (min)		
			0	60	120
Ⅰ. Control condition	-0.00469				
Ⅱ. Room air conditioner A (The air blower only)	-0.00613	-0.00144	0.00	0.08	0.17
			(0%)	(16%)	(32%)
Ⅲ. Room air conditioner A (The air blower and the test device)	-0.01084	-0.00615	0.00	0.36	0.73
			(0%)	(56%)	(81%)
Ⅳ. Room air conditioner B (The air blower only)	-0.00571	-0.00102	0.00	0.06	0.12
			(0%)	(12%)	(24%)
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	-0.01594	-0.01125	0.00	0.67	1.35
			(0%)	(78%)	(95%)
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	-0.01220	-0.00751	0.00	0.45	0.90
			(0%)	(64%)	(87%)

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

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

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

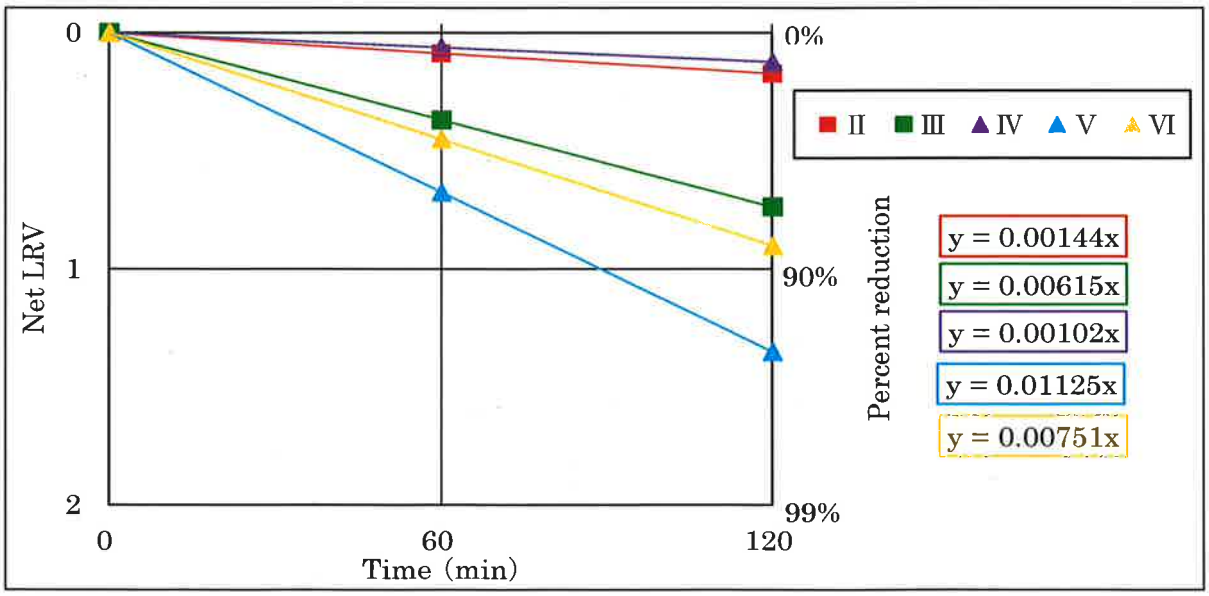


Fig 2. Net LRV and percent reduction at each measurement time

Table 3. Residual bacterial ratio for the initial number (%) at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	80	64	52	42	33	27
Ⅱ. Room air conditioner A (The air blower only)	100	75	56	42	32	24	18
Ⅲ. Room air conditioner A (The air blower and the test device)	100	60	36	22	13	8.2	5.0
Ⅳ. Room air conditioner B (The air blower only)	100	76	59	45	34	26	20
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	47	23	11	5.3	2.5	1.2
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	57	32	18	10	6.0	3.4

※Using slope of approximate expression as shown in Fig1 (number of airborne bacteria which change per minute, log value) the residual ratio was calculated according to equation ① and ②.

① Log reduction value = | Inclination | × Time (min)

② Residual rate (%) $= \dfrac{1}{10^{(LRV)}} \times 100$ (%)

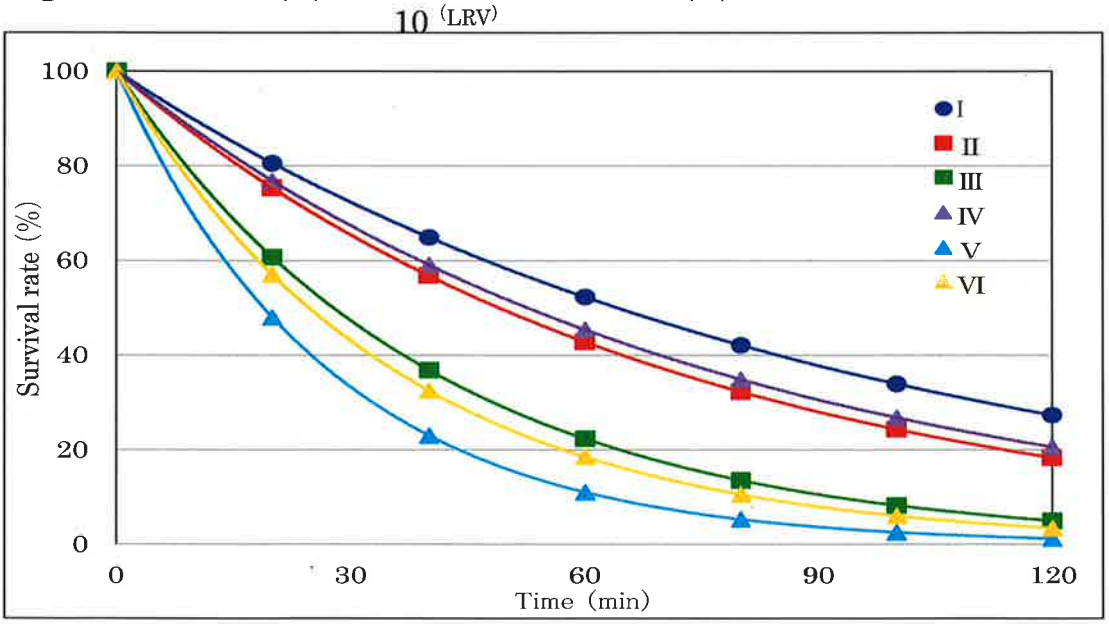


Fig 3. Residual bacterial ratio for the initial number (%) at each time

Table 4. The residual bacteria ratios with the sample for the control at each time

Test condition	Time (min)						
	0	20	40	60	80	100	120
Ⅰ. Control condition	100	100	100	100	100	100	100
Ⅱ. Room air conditioner A (The air blower only)	100	93	87	81	76	71	67
Ⅲ. Room air conditioner A (The air blower and the test device)	100	75	56	42	32	24	18
Ⅳ. Room air conditioner B (The air blower only)	100	95	91	86	82	79	75
Ⅴ. Room air conditioner B (Continuous operation of the air blower and the test device)	100	59	35	21	12	7.4	4.4
Ⅵ. Room air conditioner B (Intermittent operation of the air blower and the test device)	100	70	50	35	25	17	12

※Using slope of approximate expression as shown in Fig1 (number of airborne bacteria which change per minute, log value) the residual ratio was calculated according to equation ① ,② and ③.

① Net inclination= Inclination of test condition− Inclination of control condition

② LRV= | Net Inclination | ×Time (min)

③ Residual rate (%) $= \frac{1}{10^{(LRV)}} \times 100$ (%)

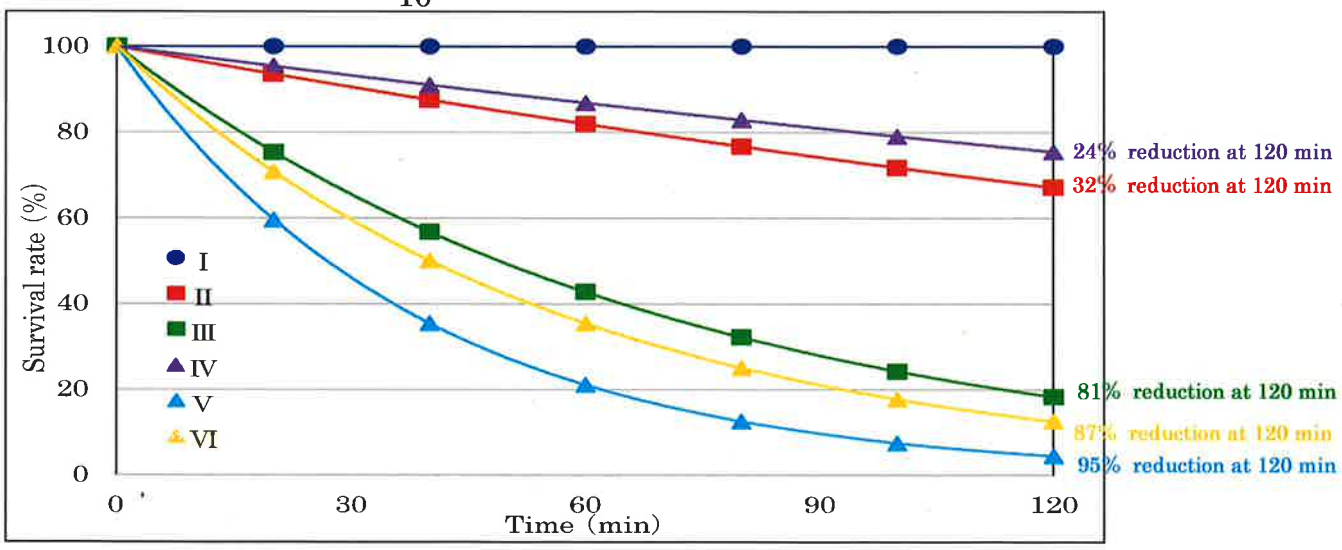


Fig 4. The residual bacteria ratios with the sample for the control at each time

Table 5. Test procedure (Control condition Ⅰ)

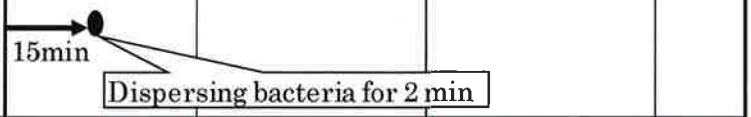
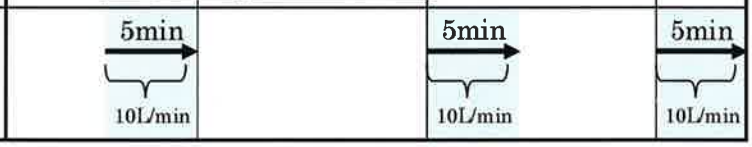
Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	
Spray of bacteria	Nebulizer	
Collect airborne bacteria	Impinger	

Table 6. Test procedure (Test condition Ⅱ～Ⅵ)

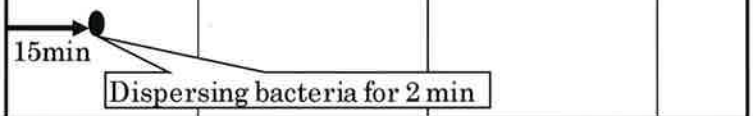
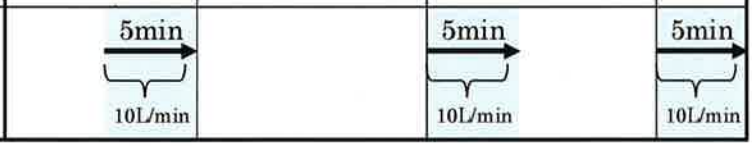
Test condition	Equipment	Time (min) 0 60 120
To make homogeneous air in the chamber	Circulation fan	
Spray of bacteria	Nebulizer	
Test sample	Air blower	
	Test device	
Collect airborne bacteria	Impinger	

Photo 1. Room air conditioner A (Model No ; RAS-35PKVPG-ND)

Photo 2. Room air conditioner B (Model No ; RAS-13J2KCVRG-T)

Photo 3. 25 m^3 Test chamber (Room air conditioner A)

Photo 4. 25 m^3 Test chamber (Room air conditioner B)

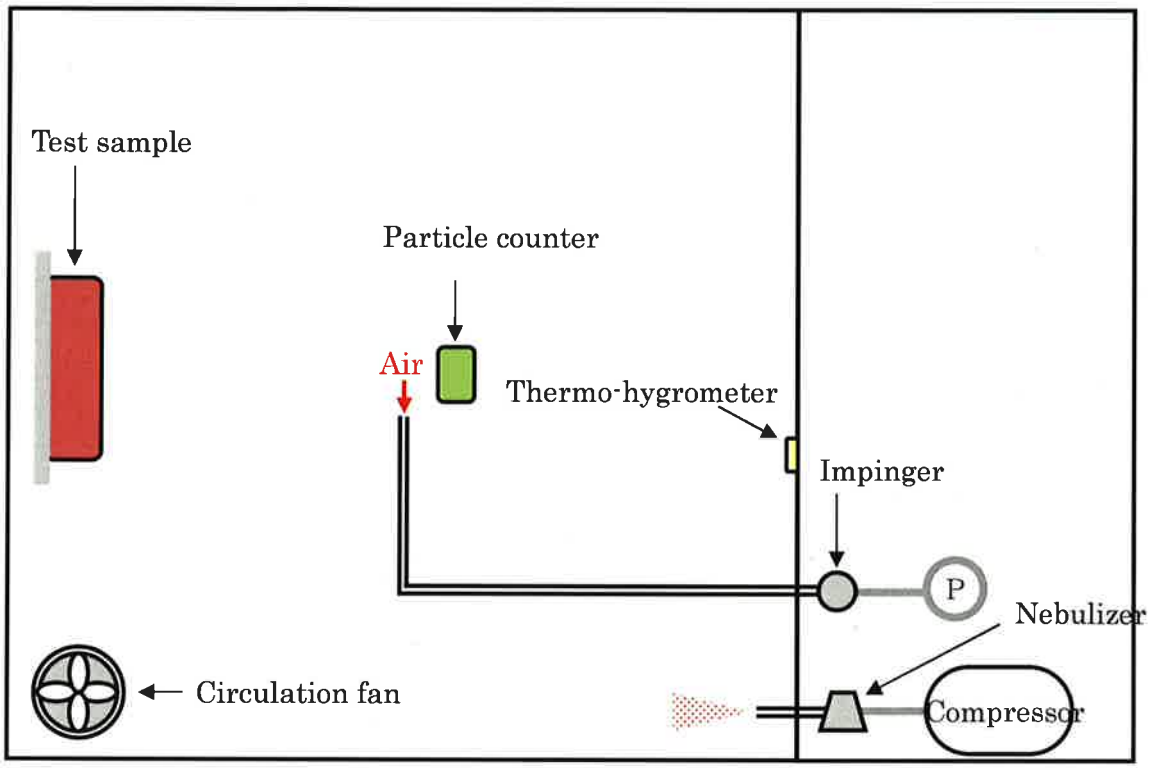


Fig 5. 25 m³ Test chamber (top view)

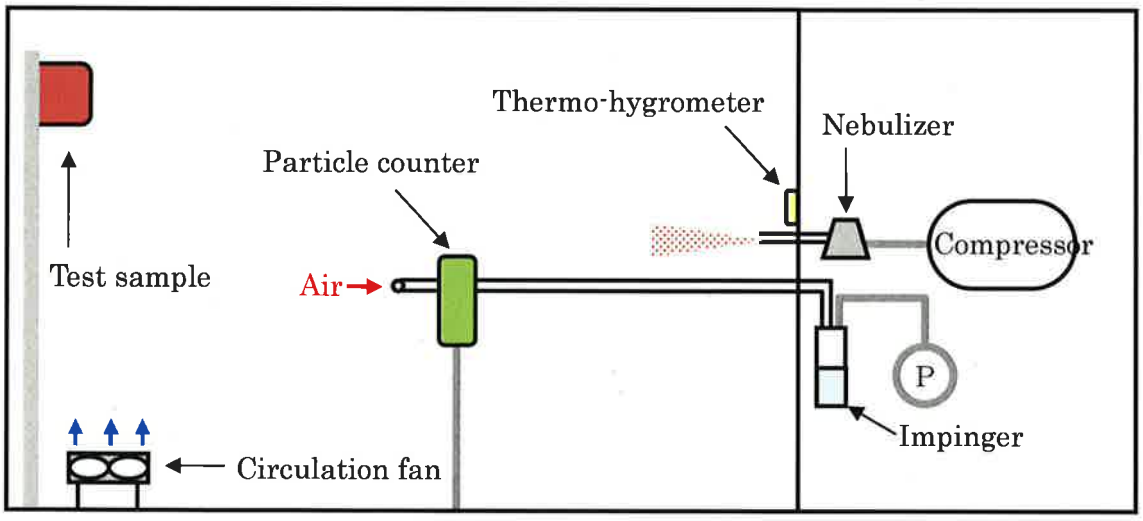
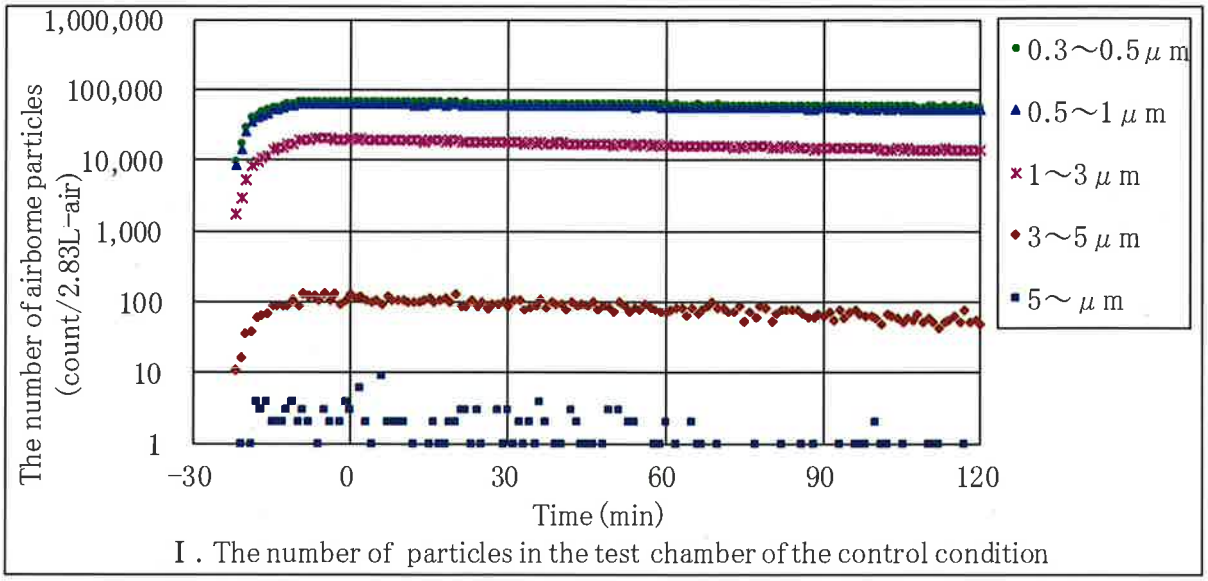
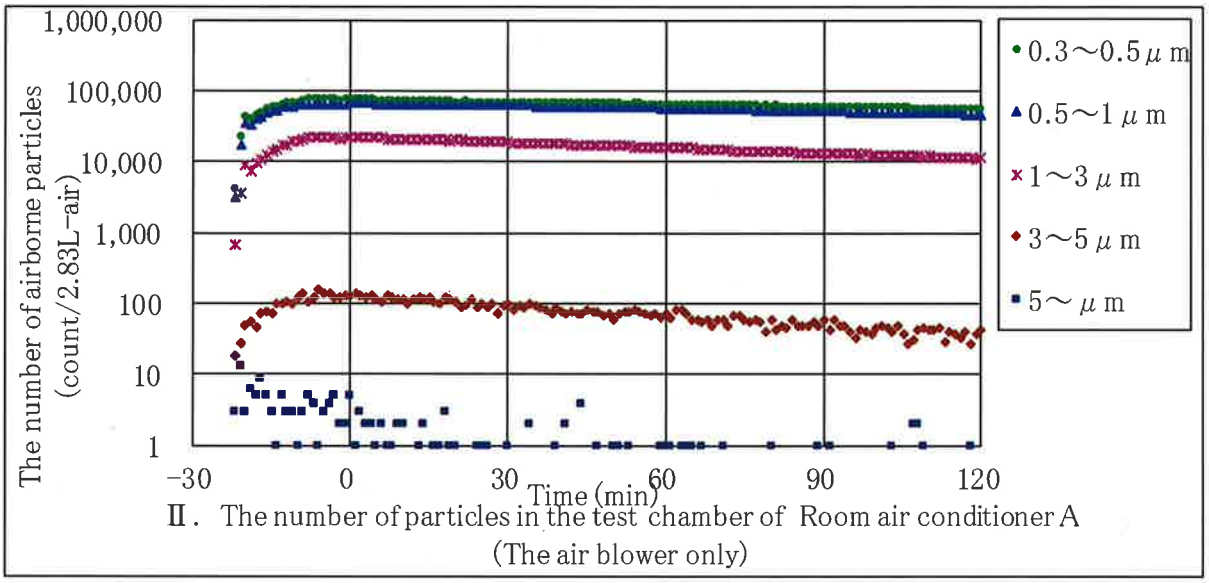


Fig 6. 25 m³ Test chamber (side view)

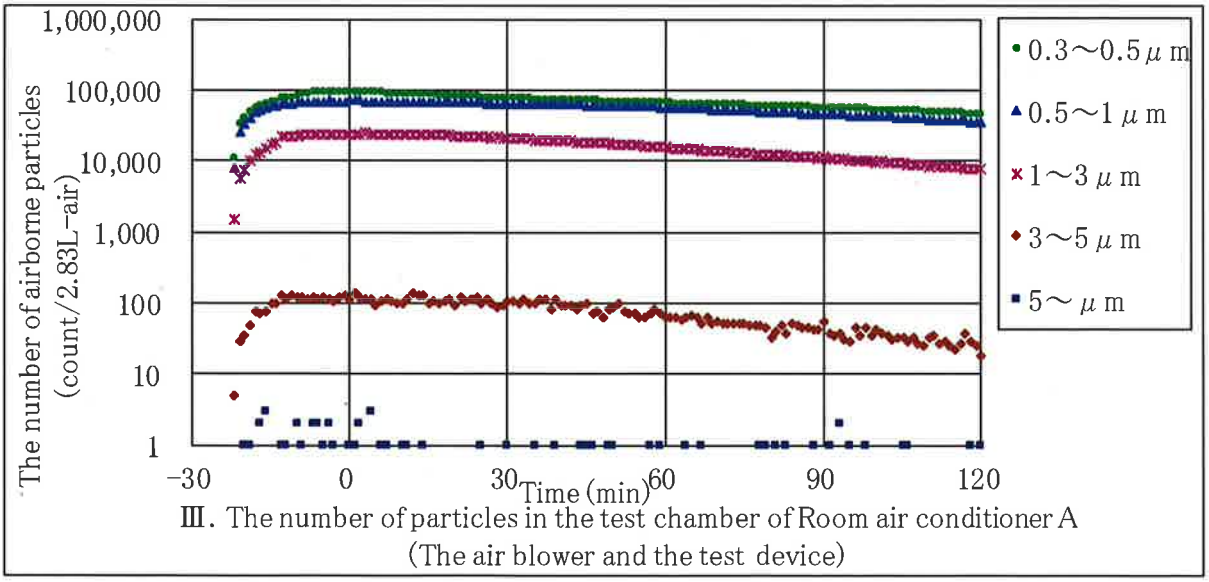
Referenced sheet



Ⅰ. The number of particles in the test chamber of the control condition



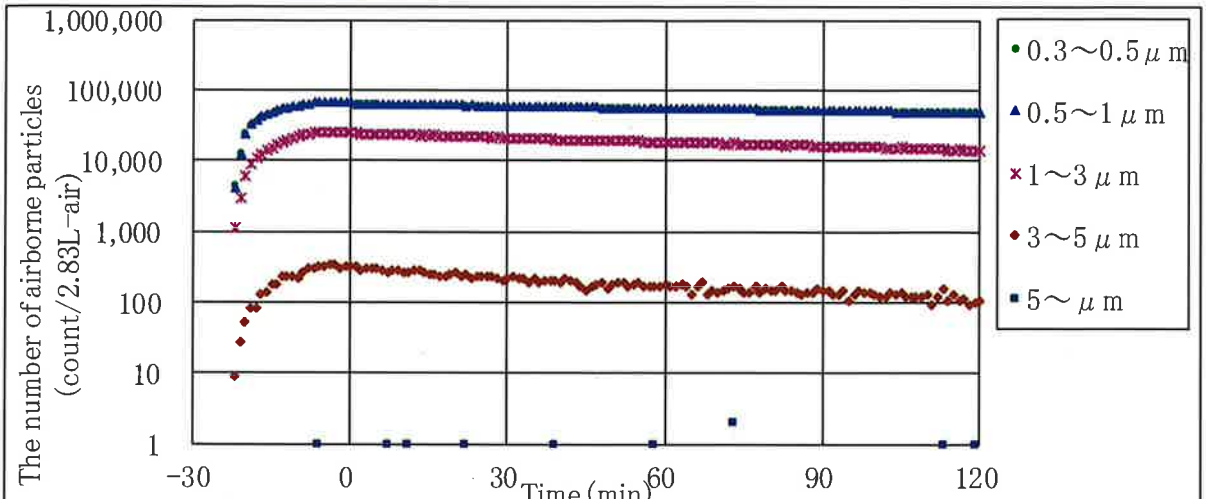
Ⅱ. The number of particles in the test chamber of Room air conditioner A
(The air blower only)



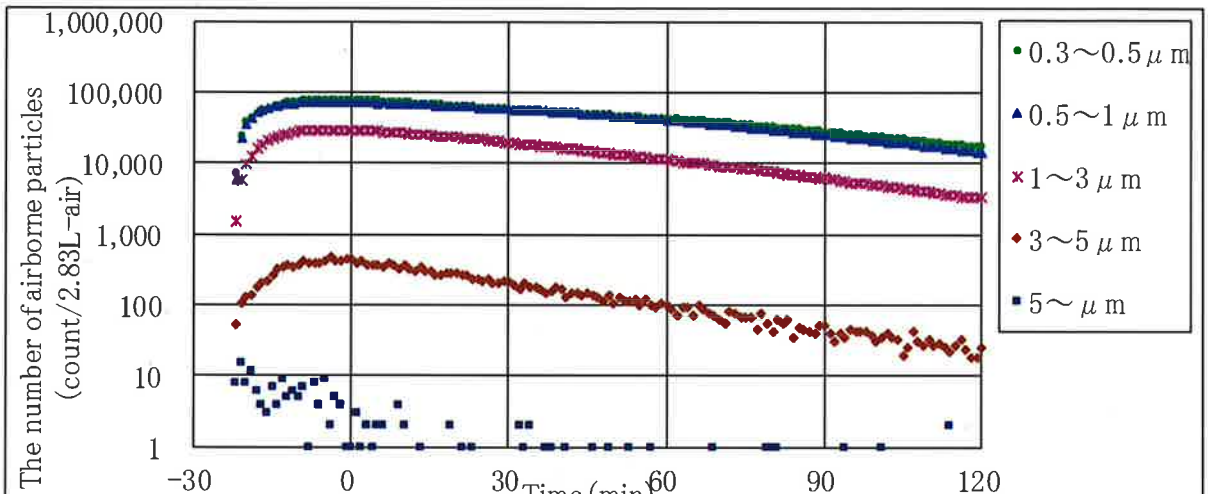
Ⅲ. The number of particles in the test chamber of Room air conditioner A
(The air blower and the test device)

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

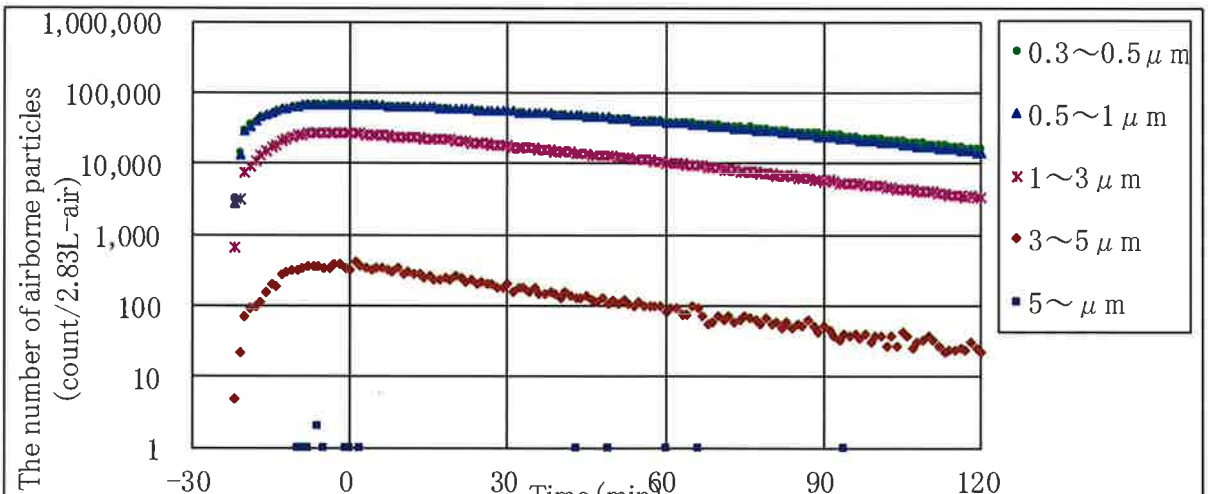
Referenced sheet



Ⅳ. The number of particles in the test chamber of Room air conditioner B
(The air blower only)



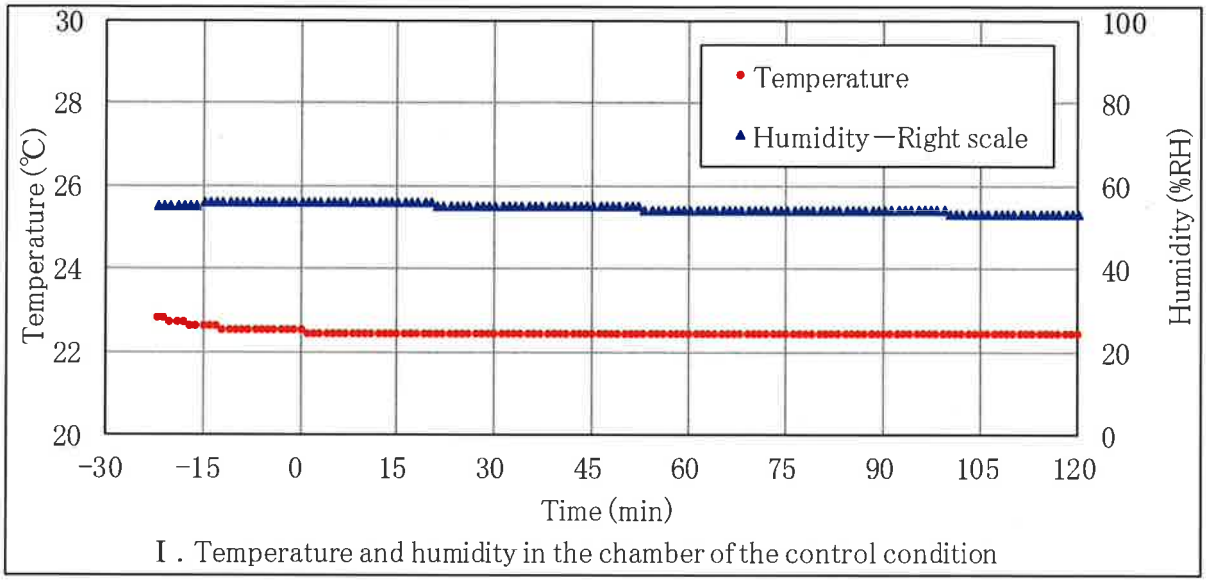
Ⅴ. The number of particles in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



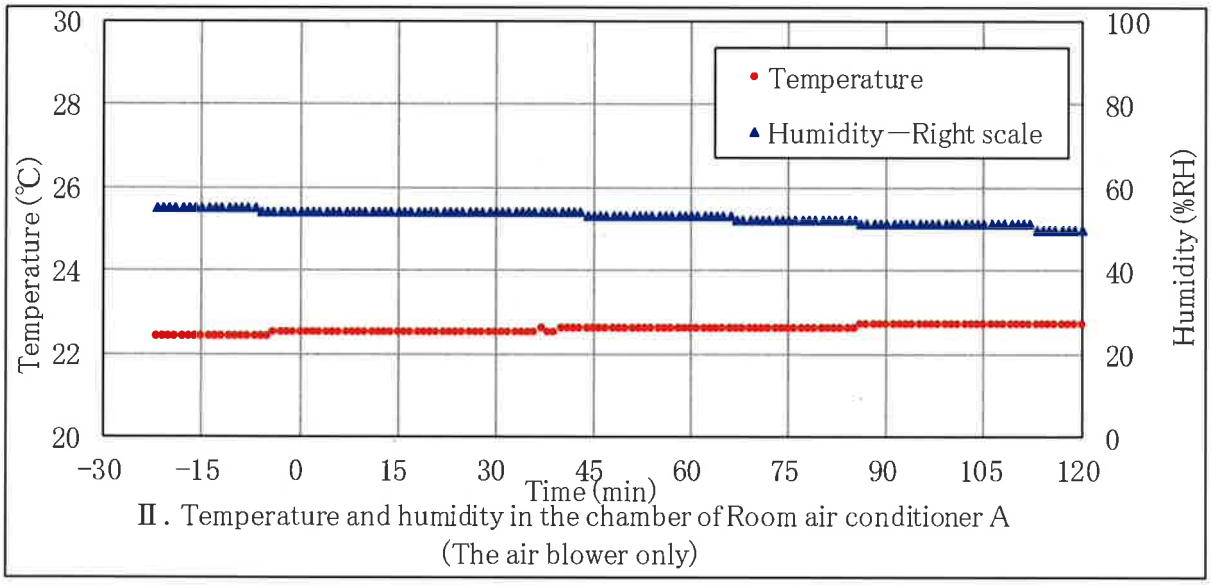
Ⅵ. The number of particles in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

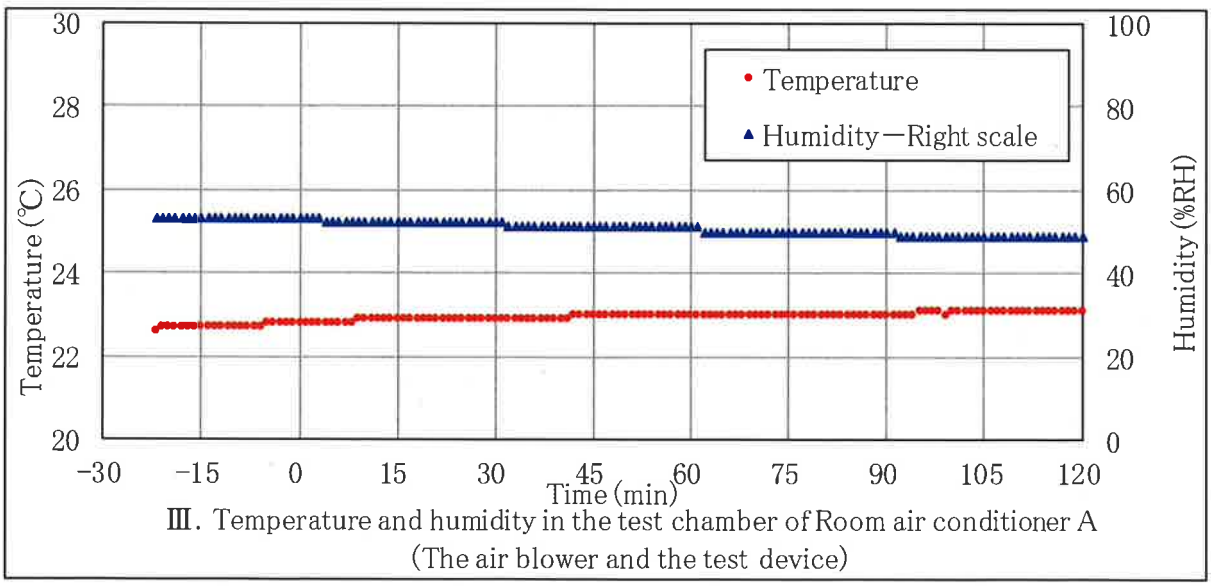
Referenced sheet



Ⅰ. Temperature and humidity in the chamber of the control condition



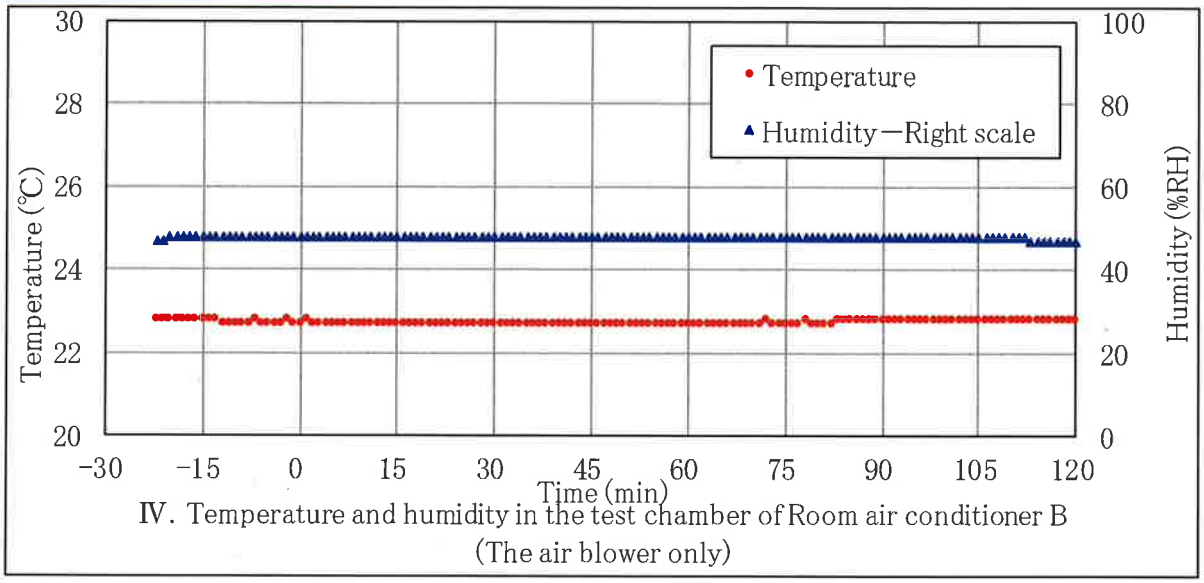
Ⅱ. Temperature and humidity in the chamber of Room air conditioner A
(The air blower only)



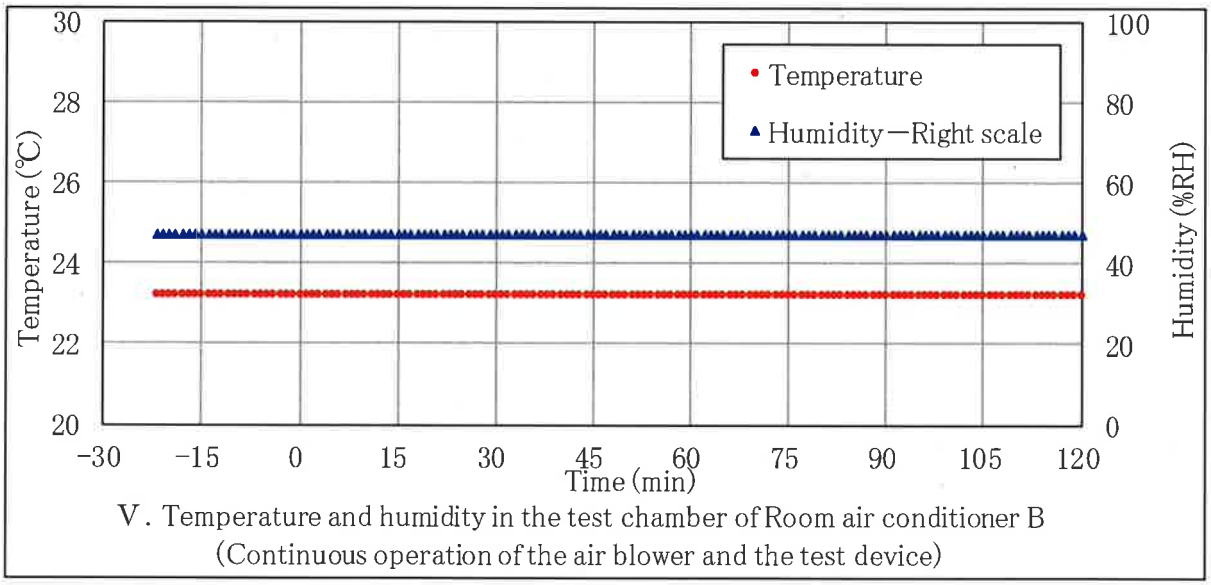
Ⅲ. Temperature and humidity in the test chamber of Room air conditioner A
(The air blower and the test device)

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

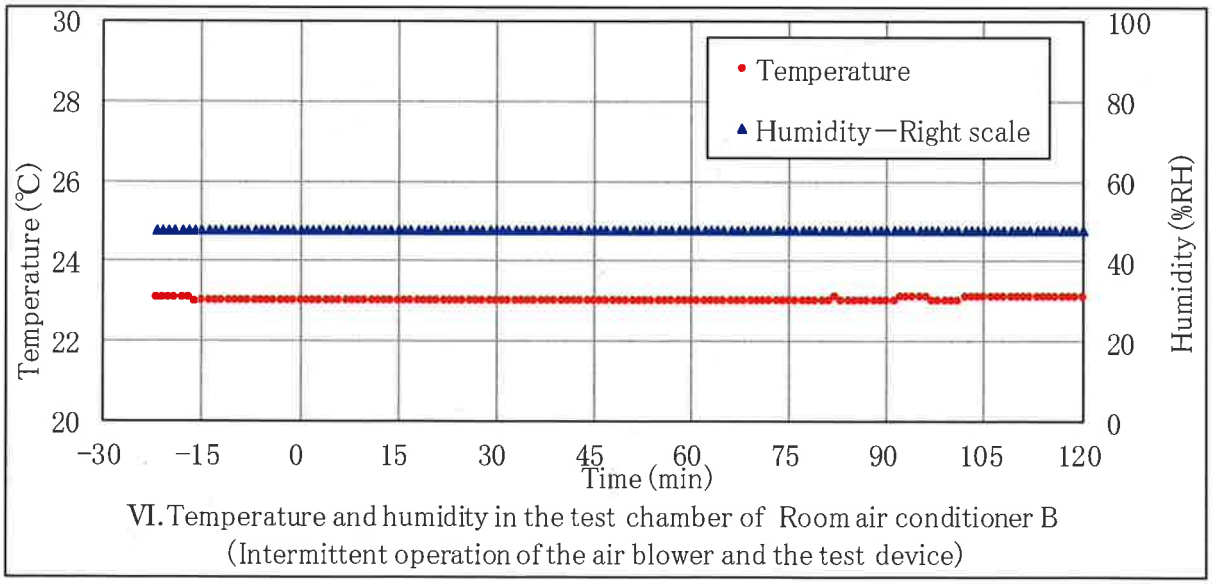
Referenced sheet



Ⅳ. Temperature and humidity in the test chamber of Room air conditioner B
(The air blower only)



Ⅴ. Temperature and humidity in the test chamber of Room air conditioner B
(Continuous operation of the air blower and the test device)



Ⅵ. Temperature and humidity in the test chamber of Room air conditioner B
(Intermittent operation of the air blower and the test device)

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

Attachment

Annex D: The evaluation test of removal efficiency for airborne virus.

Standard of household air cleaner, JEM 1467, The Japan Electrical Manufacturers' Association

Result

The changes of number of airborne phage or influenza virus are shown in Fig 1. The inclination of the approximate equation represents the changes of number of airborne phage or influenza virus per minute (log). The changes of the logarithmic values in this case mean the digit changes of the number of phage or influenza virus. Accordingly, the log reduction of "② test device running" at t min corrected with that of "① natural reduction" at t min is the log reduction of the number of phage or influenza virus with time.

The approximate equation is as follows;

Natural reduction : $y=-a_1x+b_1$ ····· (D.1)

Test device running : $y=-a_2x+b_2$ ····· (D.2)

y : Log (the number of the airborne phage or influenza virus （ CFU / the values of the captured air)) x : The time of test device running (min))

The formulas Δy shows the logarithmic reduction value of airborne phage or influenza virus in the condition of natural reduction or running test device.

$\Delta y=t(a_2-a_1)$ ····· (D.3)

One digit decrease meant 90% reduction, and 2 digit decrease meant 99% reduction.

$$\left(1-\frac{1}{10^{\zeta}}\right)\times 100(\%) \quad \cdots\cdots \text{(D.4)}$$

ζ : The decreasing number of digits

In calculating the logarithmic reduction value, the values from the extrapolation of the approximate equation must not be used and the actual measured values at each time must be used.

Attachment

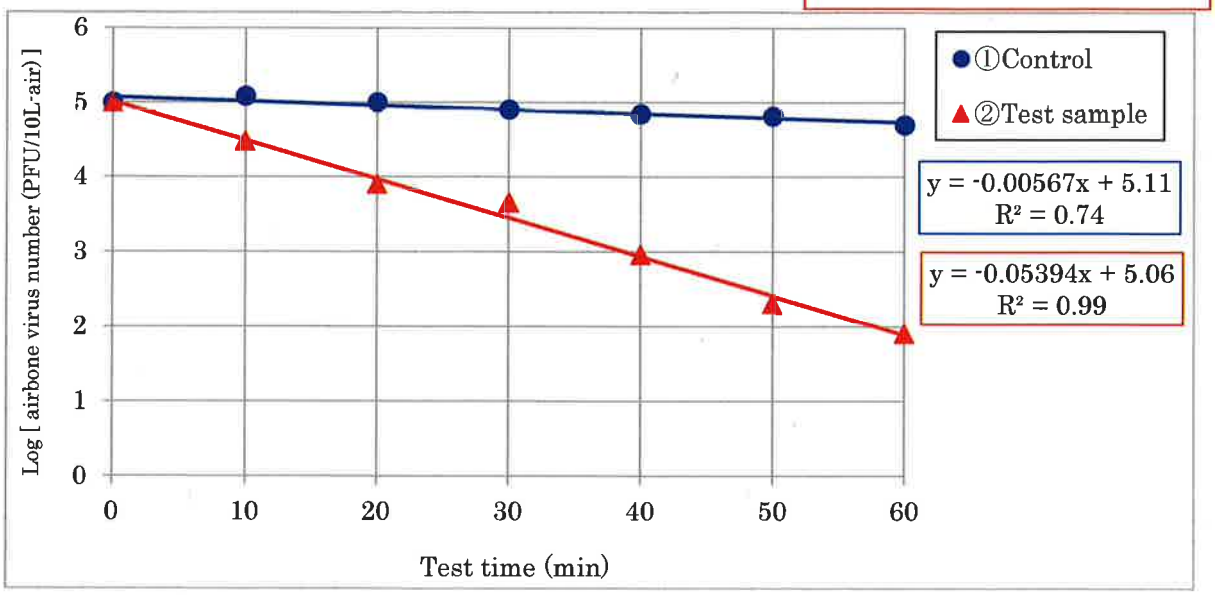


Fig D.1 Example of the results of removal efficiency evaluation test for airborne virus

Removal efficiency

When the logarithmic reduction value obtained from this examination is 2.0 or more, the air cleaner is considered as effective device for removing airborne virus.