# A Study on the Evaluation of Ventilation System for IAQ

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## ABSTRACT

Reinforcement of air-tightness and thermal insulation in the indoors leads to the decline in air-change rate. Moreover, due to increased chemical substances on furniture, the indoor air-quality becomes worse and may induce various health problems, namely the condition known as the Sick Building Syndrome(SBS).

Many tools and methods are being developed to improve indoor air-quality. In this paper, we suggest a ventilation system with an air-cleaning and heat-recovery unit in which the performance of the ventilation system was analyzed through a field study.

In the field study, the effects of the ventilation system on indoor air-quality under various conditions were measured and examined. As demonstrated in the field study, the ventilation-only mode or ventilation with air-cleaning mode in various settings proved the system to be effective in each case in terms of indoor air-quality and energy efficiency.

Key words: IAQ(Indoor Air Quality), ERV (Energy Recovery Ventilator), Field Study

## 1. INTRODUCTION

As most of our contemporaries spend a great amount of time inside buildings, demands and expectations on high indoor air quality continue to rise. Before such concerns took place, cases of significant deterioration in air-quality was detected due to insulation and high air-tightness in efforts to conserve energy. As a result, health-threatening diseases such as SBS(Sick Building Syndrome), SHS(Sick House Syndrome), and SSS(Sick School Syndrome) occurred, laying emphasis on the importance of improving such poor indoor air quality in today's indoor building plans.

In many countries, IAQ has already become a social concern, and various methods and studies on this issue are being conducted. In order to reduce indoor air pollutants, ventilation is recommended as the most effective method. Recently, Korea is also revising and enacting regulations to administrate and maintain IAQ under supervision of the government. These regulations are mainly about ventilation applications and building material grade.

Applying ventilation systems to improve IAQ is not only effective in removing dense pollutants but also in maintaining clean air indoors even after reconstruction, conservation, and repairs. However, there are cases in which ventilation plans are interrupted due to energy frugality, extreme sealing of houses, pollution in the surrounding environment, equipment issues, difficulty in securing trust, and installation restrictions.

Given such circumstances, We present the ERV system, which is a ventilation system invented

to effectively prevent energy loss while operating, equipped with an air-cleaner that can improve the level of indoor air pollution to a greater degree. In this paper, we introduce features of this ventilation system as well as the results from field studies.

## 2. A SUMMARY OF VENTILATION SYSTEM

### *2.1 "Ventilation System with Air cleaner" for residential settings*

Figure 1 shows an outline of "Ventilation System with Air cleaner". This system consists of one outdoor unit which supplies fresh air outside to the indoors. This outdoor unit has a heat exchange element, so it prevents energy loss regardless of the weather being winter or summer. And two indoor units clean the air indoor through circulation of the air indoor. These indoor units not only have dust filters but also a highly effective filter for removing HCHO/VOCs. Therefore, collecting dust and deodorizing is possible even when the ventilation mode is not operating. The system is able to operate separately on ventilation or as an air cleaner, but the two can also run together simultaneously. This simultaneous operation, which is the most effective for improving indoor air pollution and saving energy, is the main characteristic of this system. Also, it minimizes the space needed for installation and thus can fit in residential apartments. Specifications are explained in table.1

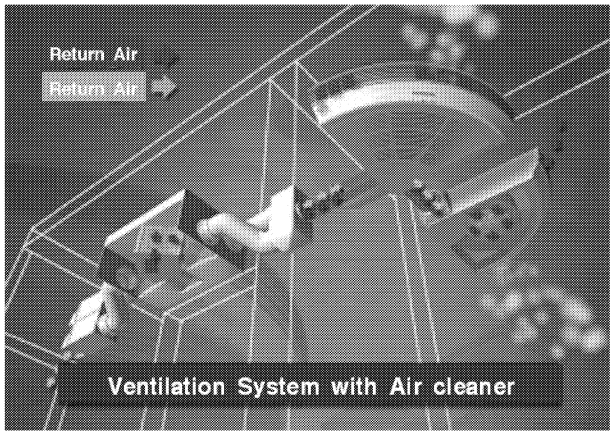


Figure 1 : Concept of "Ventilation System with Air cleaner"

Table 1 : Specification

| | Indoor unit (air cleaner) | Outdoor unit (ventilator) |
|---|---|---|
| Motor | BLDC (@ High durability) | BLDC (@ High durability) |
| Filter System | Pre, Dust, HCHO/VOCs | Pre, Dust |
| Control | Electronic remote control | Electronic remote control |
| Heat exchanger | - | Cellulous (@ High efficiency) |
| Sensor | $CO_2$//VOCs | |
| Fan | Sirocco | Sirocco |
| CMH | 90, 180 | 100 |

### *2.2 "Ventilation system" in non-residential settings*

Figure 2 shows an outline of a "Ventilation System" which we own in a non-residential environment. With its compact size and ability to be installed upside down, it is convenient to install inside of buildings. All components of the system are free from hazard materials. This also can operate without pre heating, which holds dangerous risks of fire even in extremely cold weathers.

High efficient fans and motors, optimum air flow designs, sound absorption systems help a ventilation system to be quiet, vibrate in low rates, and cause no other noises

When static pressure becomes low, constant RPM type tends to receive more air volume, resulting in louder noise and more power consumption than initially designed. However, this system can adjust fan speed even as static pressure becomes lower. High-efficient dust filter is basically installed to eliminate polluted outside air, and environmental deodorization filters can also be installed as an option. A sensor that automatically recognizes $CO_2$ concentration adjusts amount of the ventilation. Additionally, installing and connecting with several ventilation systems is possible, and connecting with the system's air conditioner, motor damper, humidifier, combination sensor,

and cleaning kits is also possible.

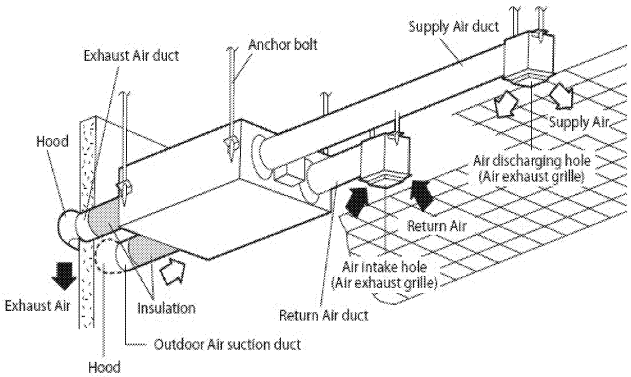


Figure 2 : Concept of "Ventilation System" in non-residential settings

Table 2 : Specifications

| Items | Details |
|---|---|
| Motor | BLDC<br>(@ High durability) |
| Filter System | Dust collection efficiency 60%<br>(@ High efficiency) |
| Control | Electronic control |
| Heat exchanger | Cellulous<br>(@ High efficiency) |
| Sensor | $CO_2$(option) |
| Fan | Sirocco |
| Capacity(CMH) | 250 ~ 2000 |

## 3. EVALUATION OF VENTILATION SYSTEM

### *3.1 "Ventilation System with Air cleaner" for Residential settings*

In order to evaluate the effects of this system, it was installed and tested in an apartment under three different operating conditions, which were ventilation only, air cleaning only, and ventilation with air cleaning. Figure 3 shows figure s of the installed system inside an apartment. One outdoor unit was installed on the porch, one indoor unit in the living room, and the other indoor unit in the master bed room, and they were measured in three modes. All measurements were taken twice and the average measure was recorded. Level of wind volume was on high. After measurements were taken, we compared the pollution concentration levels from before the experiment. Table 3 shows the measurement results in detail.

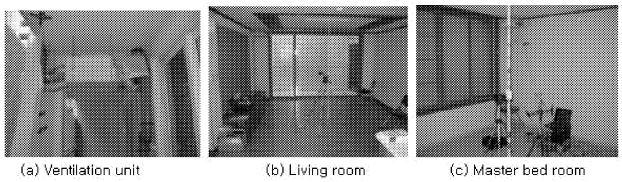


Figure 3 : "Ventilation System with Air cleaner" for measurement

Table 3 : Outline of measurement

| Items | Details |
|---|---|
| Evaluation | 2 apartment<br>( non-residence state 1.5 month passed after the construction) |
| Period | 2 weeks |
| Temperature Humidity | - Indoor: 24 ~ 26℃ / 30%<br>- Outdoor: 10 ~ 15℃ / 22~36% |
| Object of measurement | HCHO, VOCs, $CO_2$ , Temperature |
| Operating mode | - Air cleaning only,<br>- Ventilation only,<br>- Ventilation with Air cleaning,<br>- No ventilation |

### *3.2 "Ventilation system" in non-residential settings*

The system was installed in a school to measure its effectiveness. Variations of the pollution concentration in-class were measured. Size of the classroom was 352㎥ and the number of people in-class was 35. Installed ventilation capacity was 800CMH, in accordance to regulations.

Figure 4 shows a plan of installation and a picture of the classroom after the system installed

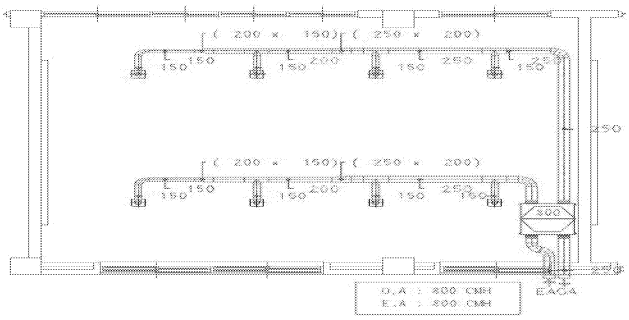

Figure 4 : An installation plan & picture

Table 4 : Outline of measurement

| Items | Details |
|---|---|
| Place | Elementary school in Busan |
| The number of persons | 35 |
| Measure time | AM 08:30 ~ PM 04:00 |
| Volume of classroom | 352 $m^3$ |

Table 5 : Regulation standard of educational institution

| Items | Limit | Subject | Method |
|---|---|---|---|
| $PM_{10}$ ($\mu g/m^3$) | 100 | Classroom (Within 3years from construction) | Light Transmission Method (TEOM air monitor) |
| $CO_2$ (ppm) | 1,500 | | NDIR Method (TSI8762-M-EU) |
| HCHO ($\mu g/m^3$) | 100 | | HPLC (Agilent 1100) |
| VOCs ($\mu g/m^3$) | 400 | | GC/MS (Perkinelmer ) |

## 4. RESULT OF EVALUATION

### *4.1 "Ventilation System with Air cleaner" for Apartment*

#### *4.1.1 Ventilation-only mode*

Before operating the system, levels of HCHO indoor was 0.241mg/$m^3$ which was about double the regulation levels of 0.12 mg/$m^3$. After the first round of operating the system on ventilation-only mode for 5 hours, levels of HCHO was measured at 0.063mg/$m^3$, a 74% reduction from before. In the second round, levels were at 0.176 mg/$m^3$ before and 0.125 mg/$m^3$ after, showing a 29% reduction. Reduction rates were less significant under low concentration environments.

In the case of VOCs, before the first round, levels of VOCs indoor was 3.018mg/$m^3$, about 6 times the regulation. After the first round of operating the system on ventilation-only mode for 5 hours, levels dropped 28% to 2.161mg/$m^3$.

In the second round, levels dropped from 2.206 mg/$m^3$ to 1.140 mg/$m^3$, showing a 48% reduction.

#### *4.1.2 Air cleaner-only mode*

After 5 hours of operating in the first round, levels of HCHO went from 0.363 mg/$m^3$, about three times the regulation, to 0.092 mg/$m^3$ with a 75% reduction rate.

After the second round, levels of HCHO decreased from 0.126 mg/$m^3$ to 0.054 mg/$m^3$, showing a reduction rate of 58%. Reduction rate of VOCs resulted in 66% and 55% respectively.

#### *4.1.3 Ventilation and Air cleaning mode operating simultaneously*

After the first round, HCHO concentration decreased from 0.221 mg/$m^3$ to 0.063mg/$m^3$, showing a removal rate of 72%. After the second round, levels decreased from 0.126 mg/$m^3$ to 0.054mg/$m^3$, a removal rate of 64%. VOCs removal rate resulted in 74% in the first round and 66% in the second.

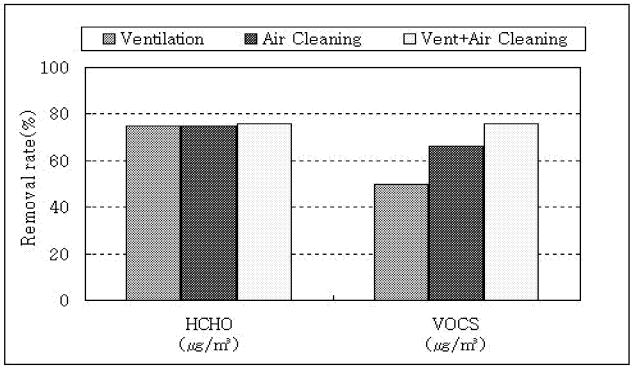


Figure 5 : A comparison of average removal rate

*4.2 "Ventilation System" for the classroom*

The system was installed in a classroom for evaluation under variable pollution levels indoors. Before operating, levels of $CO_2$ in the classroom were measured at 2400ppm on average, and 3312ppm at maximum. This concentration is much higher than the stated 1500ppm according to the school health act. Under the regulation, ventilation measures per person is to meet 21.6㎥/h. Therefore the total ventilation amount required for 35 persons is about 800CMH. Figure 6 shows the state of $CO_2$ concentration in the middle of operation. During operation of 800CMH ventilator, level of $CO_2$ was maintained below1500ppm. Figure 7 shows the removal effect of PM10, HCHO, VOCs.
The rates were reduced by PM10 26%, HCHO 38%, VOCs 49%, which resulted in measures satisfying regulations set by the school health act.

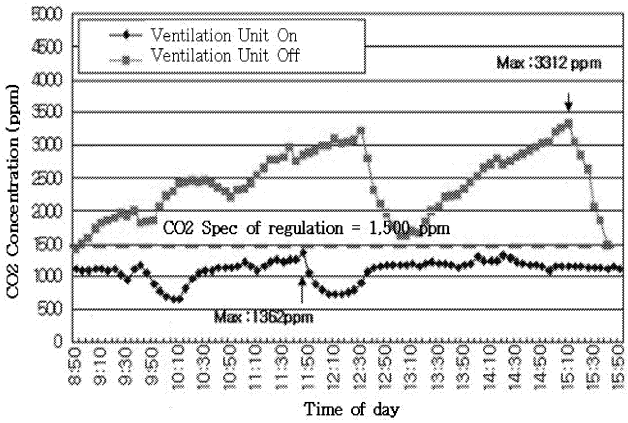

Figure 6 : Variation of $CO_2$ concentration

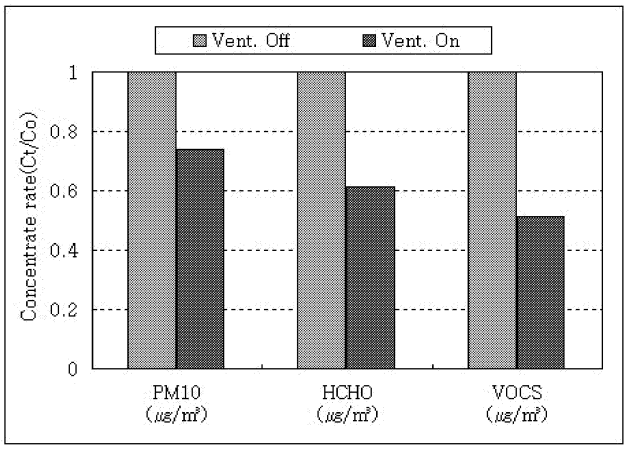

Figure 7 : Variation of pollutant concentration

## 5. CONCLUSION

*5.1 "Ventilation System with Air cleaner" for residential settings*

The study resulted in the following results.

1) After 5 hours of operating in the Ventilation-only mode, the reduction rate in HCHO was 52% on average, and 75% at maximum. The reduction rate in VOCs was 38% on average, and 48% at maximum.
2) After 5 hours of operating in the Air-cleaner-only mode, the reduction rate in HCHO was 66% on average, and 75% at maximum. The reduction rate of VOCs was 61% on average, and 66% at maximum.
3) After 5 hours of operating in ventilation and air cleaning mode combined, the reduction rate of HCHO was 68% on average, and 72% at maximum. The reduction rate of VOCs was 68% on average, and 72% at maximum.

Overall, ventilation and air cleaning mode combined proved to be the most effective for removing pollutant materials. When a dilution with ventilation and filtering pollutant material with air cleaning is performed, it is the most effective for improving indoor pollution. Samsung Electronics' Ventilation System with Air Cleaner can provide the best solution for improving indoor air quality in residences.

*5.2 "Ventilation System" for non-residential settings*

The study resulted in the following results.

(1) There was a significant difference in levels of $CO_2$ depending on whether the ventilation system was operating or not. When levels were measured according to the number of persons(21.6㎥/h per one person) as the ventilator system operated, the results showed that the system was effective in maintaining the $CO_2$(1500ppm) levels indoors.
(2) When the ventilator system was operated, it decreased the concentration of PM10 by 10%, HCHO by 38%, VOCs by 49%, meeting the regulations of the school health act

Ventilation amount which estimated at 21.6㎥/h per one person is applicable in the school place. The ventilation system can supply appropriate levels of ventilation in the indoors. Namely it is capable of maintaining air quality at a desirable level by operating the ventilation system.

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