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CLEANROOM TECHNOLOGIES SOCIETY OF TURKEY

Performance Required for Air Shower and Effectiveness of Performance

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Abstract

Before entering into cleanroom, people will use Air Shower to clean up the body covered by clean garments. Air Shower is expected to protect cleanroom environment from particles and keep the room pressures. But it is saying once in a while, that Air Shower will contaminate cleanroom. We evaluated the expected performances and effectiveness of Air Shower, that was installed between test cleanroom and the gowning room as simulation. We confirmed that Air Shower will not contaminate the cleanroom and effective to remove particles, with verifying the cleanliness after air jet. And also establishing the protocol of interlocked doors and jet/clean up cycle is necessary.

Key words: Air Shower, Cleanroom, Contamination

1. Beginning

You are supposed to take an air shower before entering a CR from a GR. However, some point out that taking an air shower contaminates the CR unexpectedly. The purpose of taking an air shower is to clear off relatively large particles from bodies of cleanroom personnel (the effect of an air shower) and to prevent outside and inside of a CR from being cross- contaminated (like an air lock) as JACA Guidelines[1] says. Nevertheless, air showers being sold in the market do not have door locks, including interlock circuits, essential for the applications mentioned above or a clean-up function that purifies the inside of the air shower rapidly.
This study recreated the installation environment of an air shower, and verified the effectiveness of an air shower and operation method by assessing them based on the change of cleanliness and particle entrainment data of the inside of the air shower.

2. Airlocking Effect and Cleanliness of the inside of the Air Shower

An air shower is installed between a CR and GR to be used. General usage environment was recreated this time.

2.1 Experimental Equipment

We postulated that the size of the CR is 3.6mW*3.6mD*2.7mH and particle concentration has a grade B in GMP. Clean air (14 m²/min) was supplied to an air shower for maintaining overpressure with a HEPA Fan Filter Unit and clean air (15 m²/min) was supplied to an air shower for internal environment with a HEPA Fan Filter Unit. Rotations numbers were 50 times per hour. An air shower installed was our standard product. (Fig.1, Table.1) Experimental equipment used is in Fig.2.

Fig.1 Air Shower (DC motor type)

Table.1 Air Shower specification

Model	AAS-8016AMR
Air jet speed	25m/s (22m³/min)
Nozzles	30φ 22pcs (Including Pulsated Nozzle× 6pcs)
Clean- up air	15.6 m³/min Down laminar + Nozzles (with off-delay timer)
Power	560W
Electrical control	Door interlock Recorded voice speaker
Option	Particle Sensor (Clean Monitor)

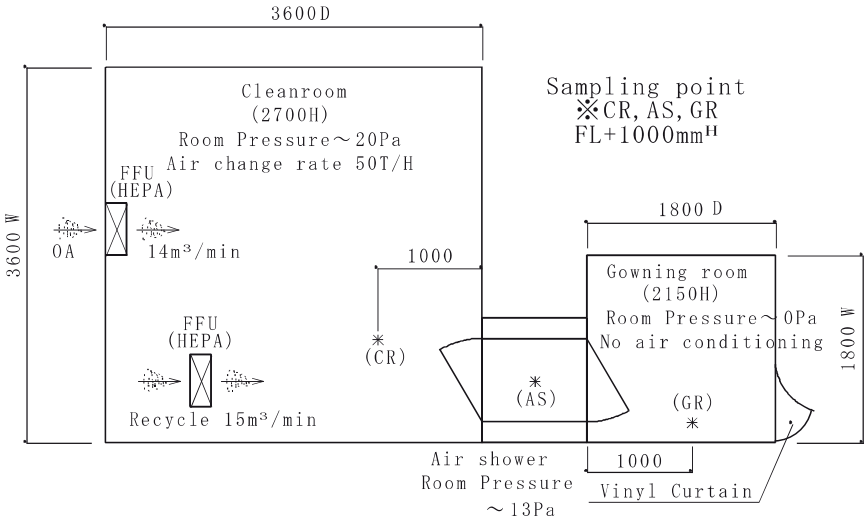

Fig.2 Layout of Air Shower and rooms

2.2 Experiment Method

After CR, air shower, and GR were contaminated up to around FS (Federal Sta. 209D) class 1,000,000 (ISO Class 9) by burning incense, the cleanliness of the air shower was measured in a process of time on condition that only the FFU in the CR was operated.

2.3 The Result of the Experiment and consideration

The result is shown in Fig.3. Both of the doors of the air shower were closed and the clean-up function was not operated in this experiment.

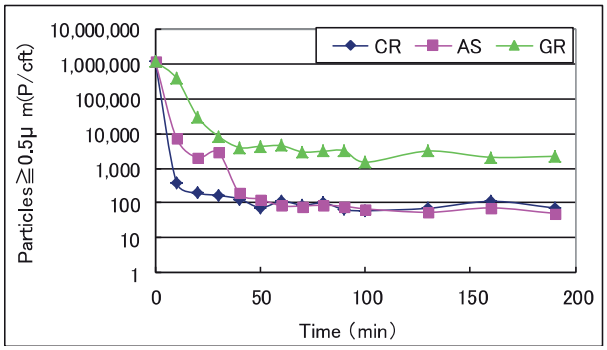

Fig.3 Particle concentration at no operation of Air Shower

The cleanliness of the CR changed from FS class 1,000,000 (ISO Class 9) to FS class 100 (ISO Class 5) in about one hour. The cleanliness of the inside of the air shower became similar to that of the CR in the cleanliness although it was time-consuming. The reason for that is because the overpressure made the air inside the CR travel through clearance of the doors of the air shower and into the air shower. The overpressure in the CR was set up at 20Pa this experiment. If both of the doors of the air shower were closed, the pressure inside the air shower became 13Pa. The pressure difference was 7Pa. The pressure difference and the area of crevices of the doors determined the inflow. The inflow into the air shower was 2.0 m²/min. It is thought that the inflow was relatively large as general doors were used in this experiment. It is thought that when general doors are used, stopping air circulation inside the air shower can cause no problems after cleaning up inside the air shower for a few minutes and it is possible to save energy.

3. The Effect of Closing or Opening the Doors on the Cleanliness

Hinged doors are generally used for an air shower with manual doors. The effect of closing or opening the doors on the cleanliness of each room was assessed as air among an air shower, CR, and GR is circulated when doors are closed and opened.

3.1 Experiment Method

The door of the GR was opened and closed (opened for 2 seconds, closed for 2 seconds) with the cleanliness of the GR (FS Class 100,000 (ISO Class 7)), CR (FS Class 100 (ISO Class 5)), and air shower stable. During the time, particle concentration inside the air shower was measured by a high-flow particle counter (28.3L/min) every 6 seconds. After that, the change in the cleanliness was measured in two situations. Firstly, the cleanliness of the inside of the air shower and CR when the door of the CR was opened and closed with the clean-up function of the air shower ceased (air-circulation fan stoppage). Secondly, the

cleanliness of the inside of the air shower and CR when the door of the CR was opened and closed with the air shower cleaned up.

3.2 The Result of the Experiment and Consideration

The change in the cleanliness when the clean-up function of the air shower was not operated is shown in Fig.4. Also, the change in the cleanliness when the clean-up function of the air shower was operated is shown in Fig.5.

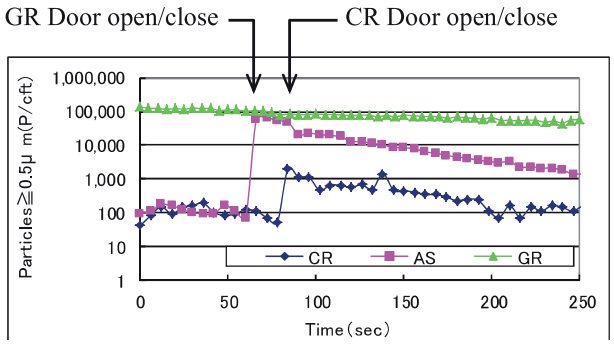

Fig.4 Particle concentration without clean-up cycle

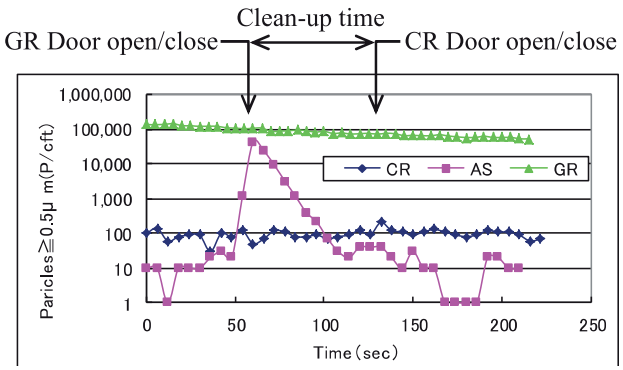

Fig.5 Particle concentration with clean-up cycle

Either closing or opening the door of the GR caused the inside of the air shower to be nearly as contaminated as the GR. Closing or opening the door of the CR in this condition can cause the CR to be contaminated. (the cleanliness around the door of the CR rose by more than one figure.)

However, if the air shower is cleaned up, the cleanliness inside the CR became lowered than standard cleanness. The door of the CR needs to be locked until the air shower is completely cleaned up. Clean-up method needs to be reviewed to shorten lockout time and cleanliness management by a timer for managing the lockout time or particle counter for monitoring the CR is essential.

4. Clean-up Performance of Air Shower

It is reviewed to restore the cleanliness of the inside of the air shower contaminated by the circulation of polluted air, happening when the door of the GR is opened and closed, and dust removing. Representative air flow patterns for the clean-up compared this time are shown in Table.2 and Fig.6.

Table.2 Types of Clean-up air flow

No.	Sources of Clean-up air flow	Air volume (m^3/min)
1	Down laminar flow from ceiling	12.8
2	Down laminar + Air jet nozzles	15.2
3	Air jet nozzles	7.0
4	Nothing (Blower stopped)	0

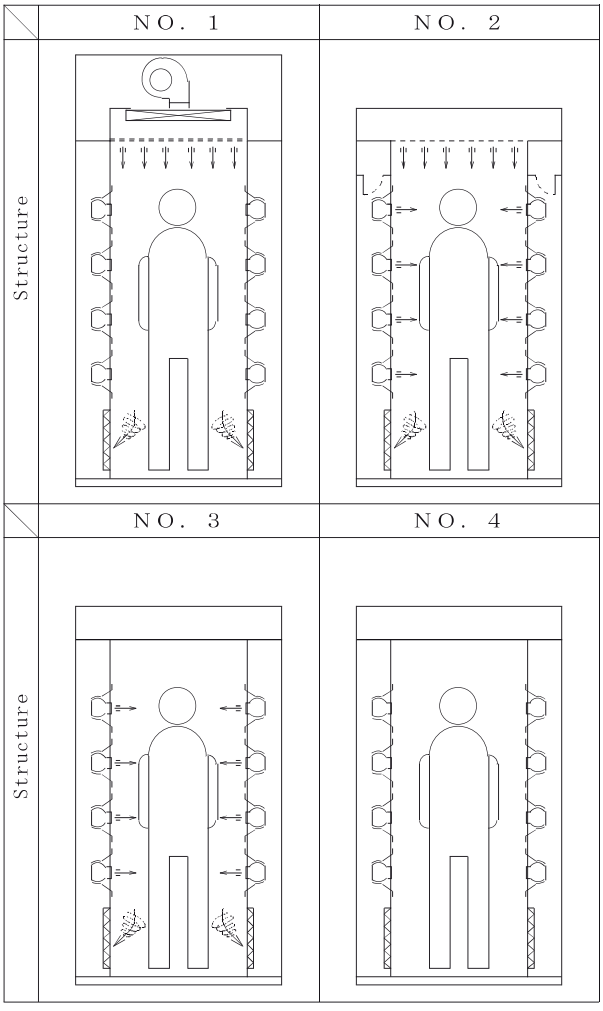

Fig.6 Types of Clean-up air flow

4.1 Experiment Method

After the inside of the air shower was contaminated (around FS Class 500,000 (ISO Class 8.7)) by supplying outdoor air, an air flow pattern for the

clean-up was operated. The change in the cleanliness was measured by a high-flow particle counter every 6 seconds.

4.2 The Result of the Experiment and Consideration

The result of measurement is shown in Fig.7.

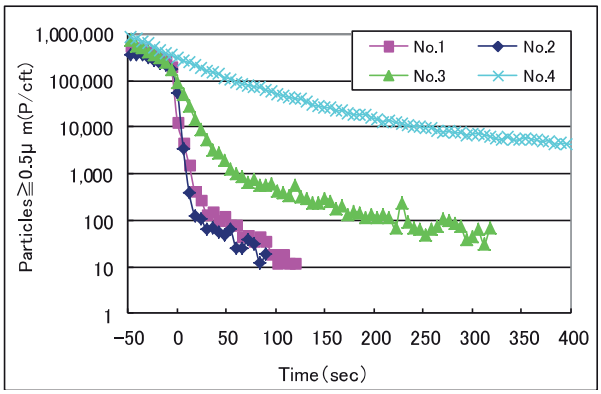

Fig.7 Comparison of clean-up performances

Downflow System, including No.2, takes around 18 seconds to reach FS Class 1000 (ISO Class 6) and takes 30 to 40 seconds to reach FS Class 100. (ISO Class 5) Also, the air flow pattern with a nozzle, which reduced RPM (revolutions per minute) of a jet-fan, takes more than 40 seconds to reach FS Class 1000. Downflow System is useful for an air flow pattern for the clean-up that requires high cleanliness.

5. Dust Removal performance by an Air Jet

The experiments above were performance tests for air locking. This experiment is to review how much an air jet can have an effect on the cleanliness of the inside of the air shower, removing the dust.

5.1 Experiment Method

After a subject changed into a dust-free garment in the GR (FS Class 100,000 (ISO Class 8)), he/she entered the air shower and exposed oneself to the air-jet. The position was standing at attention. The dust-free garment he/she was wearing had been cleanly cleaned. The dust-free garment that was exposed to FS Class 500,000 (ISO Class 8.7) for one hour and 3 types of general work clothes were compared. In addition, only subjects wearing a general work cloth beat the dust off their clothes rotating themselves. (once every 15 seconds.) That was also included in the experiment conditions.

5.2 The Result of the Experiment and Consideration

The result of measurement is shown in Fig.8 and Fig.9.

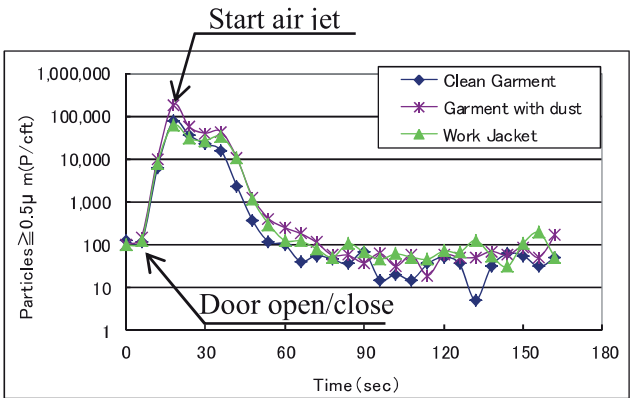

Fig.8 Comparison of particles generated by air jet from garments

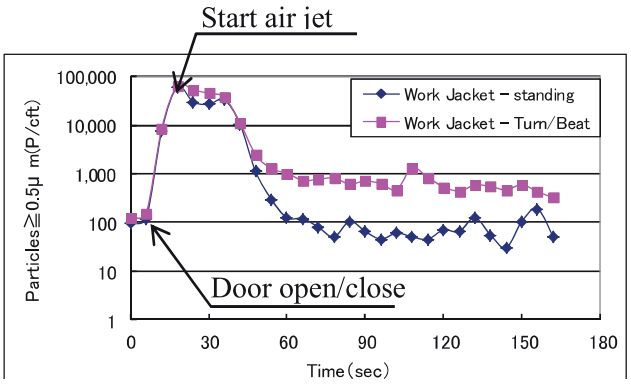

Fig.9 Comparison of particles generated by air jet from work jacket with or without action

When a human with any of the clothes above exposed oneself to the air-jet in the air shower, the cleanliness did not dramatically drop for around the first 18 seconds. Although it can be thought that a human influenced the air flow pattern, it can be also thought that fine particles that had stuck to the clothes while changing into the clothes in the GR are removed while exposing oneself to the air-jet. Furthermore, the clothes each subject was wearing did not influence the change in the cleanliness very much. In addition, dust being generated while removing dust did not raise particle concentration in the air shower. The amount of dust generation (on the clothes) from using the air-jet can be considered to be even smaller than the ratio for removing dust by an air volume of the air-jet. It is estimated that dust removal performed by the air-jet lasts around the first 10 seconds considering this measurement data and data from past experiments. [2]

While beating the dust off the general work cloth and exposing oneself to the air-jet simultaneously, the cleanliness of the air shower was maintained at around FS Class 1000 (ISO Class 6) as much dust was generated from wearing the cloth. However, there was no significant difference between beating the dust off the dust-free garment rotating oneself simultaneously and doing that standing at attention, although there is no data relevant to this. That is to say that beating the dust off the general work cloth continuously cannot clean up the inside of the air shower.

Around 10-19 seconds are enough for using the air-jet in an air shower like in this paper. After that, the air shower needs to be cleaned up rapidly by changing the air flow pattern for the clean-up. It is thought that audio guidance (voice unit) for instructing movements while using the air-jet and for instructing the subject to wait while cleaning up is also useful for removing dust and cleaning up.

6. Summary

Only closing and opening the door of the GR can raise particle concentration of the inside the air shower, including the air-lock, as high as the GR. Closing and opening the door of the CR without cleaning up the inside contaminates the CR. In addition, removing dust by an air-jet cannot raise particle concentration of the inside the air shower. Monitoring the cleanliness of the inside of the air shower is needed considering the interlock door of the air shower to effectively use the air shower without contaminating the CR. Establishing a standard behavioral sequence as well as carefully controlling time needed for using the air-jet time and for cleaning up are required. The detailed recommendations are as follows.

① The clean-up function is essential and Downflow System is recommended for shortening time for the clean-up.

② In terms of preventing the CR from being contaminated and preventing cross-contamination, door locks and interlock (for preventing simultaneous opening) circuit are needed.

③ A particle counter for monitoring the cleanliness of the inside of the air shower needs to be built in the air shower or timer circuits for regularly measuring clean-up time inside the air shower and setting clean-up time are needed to check if the inside of the air shower has been cleaned up.

④ Personnel who entered the air shower can raise the effectiveness of the air shower rather than audio guidance (voice unit) to recognize the air-jet is in waiting mode or it is cleaning up the air shower.

⑤ Making the clean-up function be automatically ceased when it is confirmed that clean-up has been complete is effective in terms of low energy consumption as well as airtight performance of the door.

It is confirmed that adjusting the specifications and operation method of the air shower can be beneficial.

Reference

[1] JACA Standard No.44-2006
「The structure of the air shower and performance guidance」
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