RESEARCH OF TEST METHOD FOR CLEANROOM GARMENT AIRBORNE PARTICLE FILTRATION EFFICIENCY

Author: Jianhua Huang, President, Shanghai Chenlong Static Technology Co., Ltd.
Co-author: Ming Xu, Deputy director, Shanghai Hi-clean Static Test Technology Center
Co-author: Xiang Shao, Shanghai Chenlong International Trade Co., Ltd.

Abstract:

Filtration efficiency is the key index to evaluate the cleanliness property of cleanroom garment. In this article, the author tries to compare the different test methods from China, United States, Europe, and Japan in terms of it. The author will also try to make a deep research for test principle of textiles filtration efficiency which regulated in Chinese National Standard GB/T 24249-2009 *Antistatic Fabric For Cleanroom Garment System*.

1. Preface

Cleanroom, is one space for blocking airborne particles and microbe which would be harmful to production. Cleanroom garment, is one kind of special designed garment to obstruct particles and microbe generated from human body and reduces the contamination in cleanroom. To meet the technical safety requirements of cleanroom, the cleanroom garment should not produce particles, meanwhile, it can block particles and microbe generated from human body effectively. In this article, the author will focus on the test method for blocking (filtrating) airborne particles of cleanroom garment, that is said the cleanroom garment filtration efficiency of airborne particles.

2. About the airborne particles filtration efficiency of textile

The following chart is quoted from *Cleanroom and Air Conditioning of Pharmaceutical Factory*, to illustrate the generated particles from human body who dress the different garments in working area （particles size ≥0.5μm）.

Chart 1

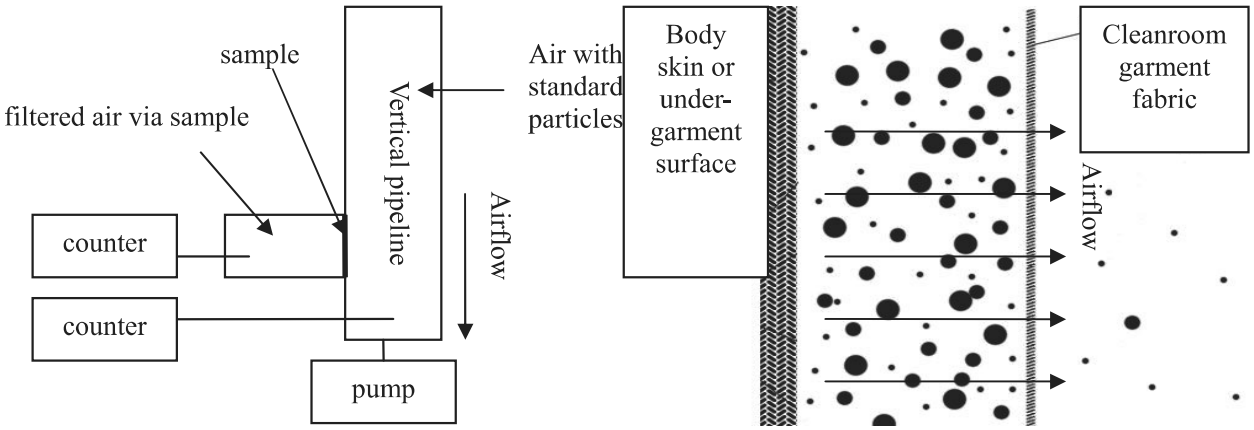
Activity	particles generated from common garment （number/p・sec）	particles generated from cleanroom coverall （number / p・sec）
sitting	5×10^3	1.2×10^2
head moves around	10.5×10^3	1.9×10^2
stepping	48.7×10^3	9.3×10^2

From this table, we can clearly see the effectiveness of cleanroom garment to block the particles. Cleanroom garment is just like one filter, which wrapped particles inside the garment, follows the filter and block, fewer particles would escape to outer space. As a result, the purpose of testing cleanroom garment is to confirm the particle filtration efficiency and the percentage of controlled particles.

3. Test methods for airborne particles filtration efficiency from main technical standards

1) VDI - Guideline 3926 is an instructional paper for filter testing from The Association of German Engineers. Fasten the sample onto the vertical pipeline, put the standard particles from the top of pipeline, and calculate the particles density both in the pipeline and back of the sample based on the certain airflow, then get the data of material filtration efficiency.

Diagram 1 Diagram 2



VDI 3926 airflow of device　　airflow of cleanroom garment

The highlighted point of this method is to place the sample parallelized with airflow direction. Theoretically, when human body dresses garment, the airflow inside the garment is vertical and outward to garment fabric. The main parameters for this test:

Chart 2

Sample area	Particle density	Velocity of airflow	particles
150 cm²	25 mg/㎡	5 cm/S	silicon dioxide，0.3μm

2) Japan Synthetic Textile Inspection Institute Foundation: Kaken test method for textile filtration efficiency. To simulate the real environment of airflow into the garment, low velocity of airflow is applied. The main parameters for this test:

Chart 3

Sample area	Velocity of airflow	Counter model	Airflow volume
491 cm^2	0.0961 cm/sec	Mat One 237B	0.0472 L/sec

In 2006, the author got the data as follows:

Chart 4

Sample particles	Sample 1	Sample 2	Sample 3	Sample 4
0.5 ~ 1μm	97.7	93.8	96.0	94.0
1 ~ 3μm	98.4	95.1	97.1	95.6
3 ~ 5μm	99.1	96.9	98.4	96.6
> 5μm	99.8	97.8	99.1	98.6

As for the low rate of airflow, although those four samples have different warp, weft density, and construction, the result data are steady at 95% level.

3) TSI 3160 is one kind of famous device for filtration efficiency test. It is known for the accurate test result. But it is designed for filter materials, no test report related to textiles. In this machine, the test sample area is too small for textiles to evaluate, it has no stable repeated test results because textiles are heterogeneous materials. The main parameters for this test:

Chart 5

Sample area	Airflow volume	Particles
100 cm^2	0.0833～1.6667 L/sec	sodium chloride，DOP，DES and oily substances 0.015～0.8 μm

4) IEST-RP-CC003.3 is now well known for its application and testing of cleanroom garment. As for the

filtration efficiency, 'A section of garment fabric is clamped in a holder and controlled, particle-challenged air is passed through it at a controlled pressure drop across the fabric face. The ability of the fabric to filter particles generated by the wearer is determined by testing the air on both sides of the fabric with an automatic particle counter.' The main parameters for this test:

Chart 6

Sample area	Airflow volume	Sampling airflow	Particles	Pressure difference
491 cm^2	Max 14.2 L/sec	0.0472 L/sec	Atmospheric particles	1cm water coloumn（98Pa）

4. GB/T 24249 airborne particles filtration efficiency test

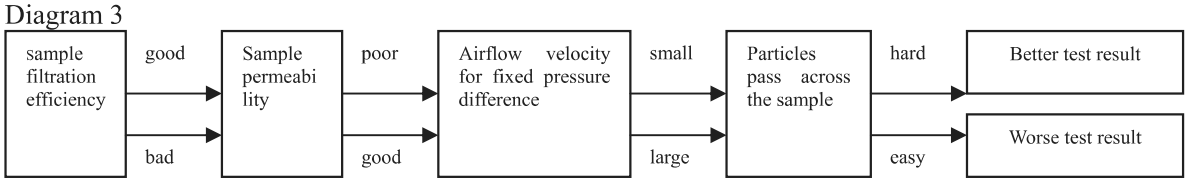
GB/T 24249 is the first active Chinese national standard related to cleanroom textiles. In this standard, the developers refer to lots of technical materials as well as diversified experiments for establishing test method and device of textile airborne filtration efficiency. The main principles for designing it are as follows:

Chart 7

Principles	Test method	Parameter
repeatability	Larger sample area can remain repeatability of test data for heterogeneous materials	Sample area 491cm^2
Data steadiness	Standard particles have more stable property than atmospheric particles	PSL standard particle
Trustworthy data	Single size controlled particles can avoid test interference compared with using non size controlled particles	0.5μm、1μm standard particle
Real environment simulation	Simulate real airflow direction inside of cleanroom garment	Airflow vertical pass through sample surface
Easy ranking	Constant air pressure, not constant airflow	pressure difference 98Pa

It's better to rank test data by using constant air pressure.

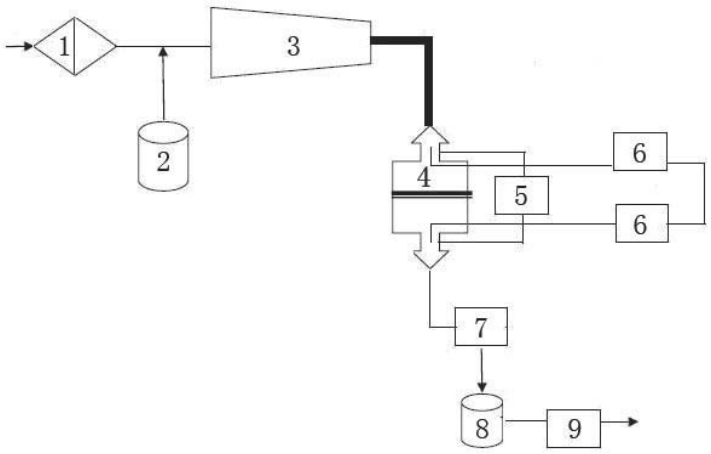
Diagram 3



In GB/T24249, put the sample inside the vertical ventilated pipeline, pump the air with standard particles and pass through sample surface, count the particle numbers both upstream and downstream the sample surface under controlled pressure, then use the formula to calculate and get the result:

Sample particle filtration efficiency = (particles number upstream - particles number downstream) / particles number upstream × 100%, the following chart explains the principle.

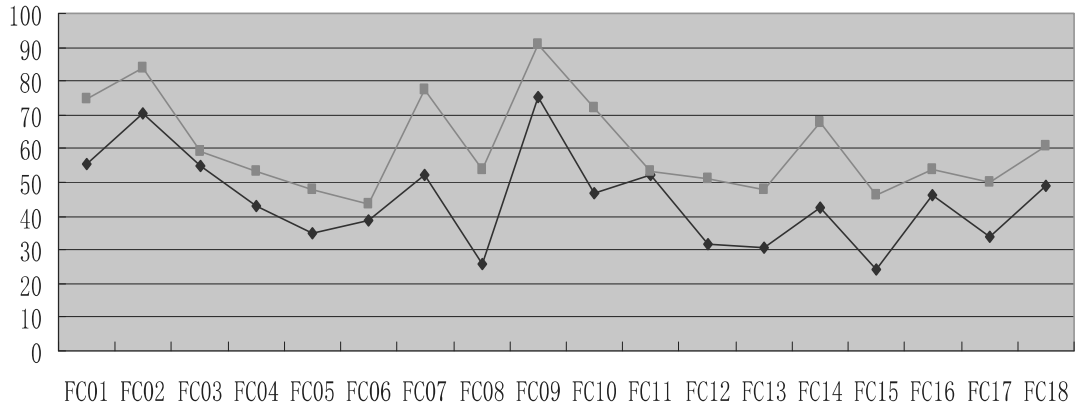
Diagram 4



1——High Efficiency Particulate Air Filter;
2——Monodisperse aerosol generator，atomized PSL;
3——homogenized transferring pipeline;
4——sample clamp;
5——Pressure meter;
6——Particle counter ， sampling airflow 0.0472L/sec;
7——Flow regulator;
8——Pump;
9——Ventilation filter，level F

The following chart is to explain the reliability of test result.

Diagram 5



Remarks: Ordinate represents filtration efficiency; Abscissa represents sample number. The curve above represents filtration efficiency of 1μm standard particle; the curve below represents filtration efficiency of 0.5μm standard particle.

We can find two disciplines based on the experiment.

1. Different samples have different filtration efficiency, samples could be clearly classified in accordance with their filtration efficiency.

2. One sample would have different filtration efficiency by applying different diameter standard test particles. The bigger the particles, the better the filtration efficiency. Two curves have almost same change rate, and without intersection. We can also read that there are two samples have the most effective particle filtration efficiency, FC09 and FC02. They are plain weave with high warp and weft density. Besides that, FC09 is finished with film, it has more advanced particle filtration efficiency.

5. Conclusion:

GB/T 24249 is one kind of test method for evaluating airborne particle filtration efficiency with visible repeatability, stability, accuracy, and easy to classify different products level.

Reference:

1. GB/T 24249 Antistatic Fabric For Cleanroom Garment System
2. Cleanroom and Air Conditioning of Pharmaceutical Factory

3. VDI-Guideline 3926 Testing of Filter Media for Cleanable Filters
4. IEST-RP-CC003.3 Garments Required in Cleanrooms & Controlled Environments