Cleanroom Garment & Vendor Selection: Recommended Practices

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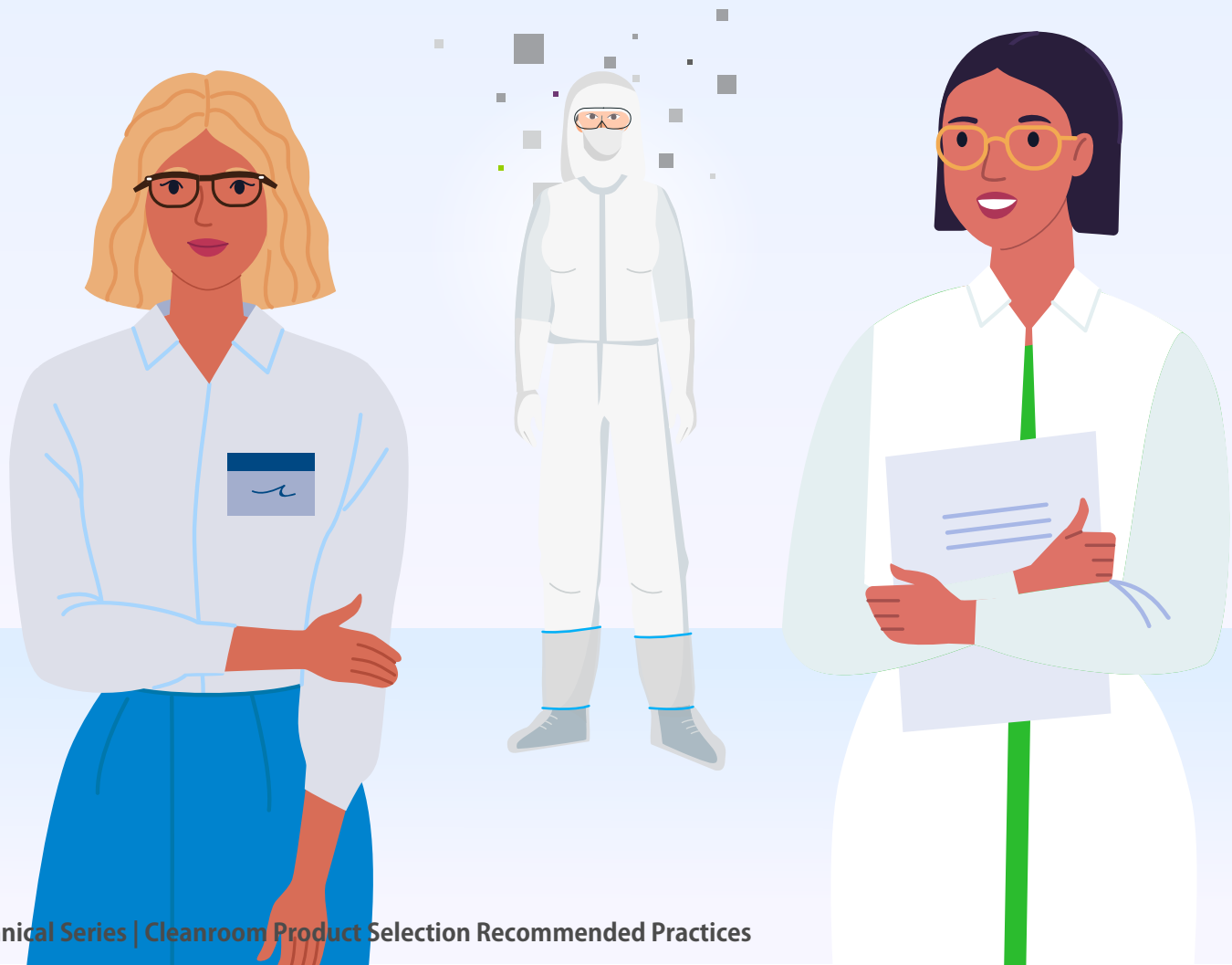
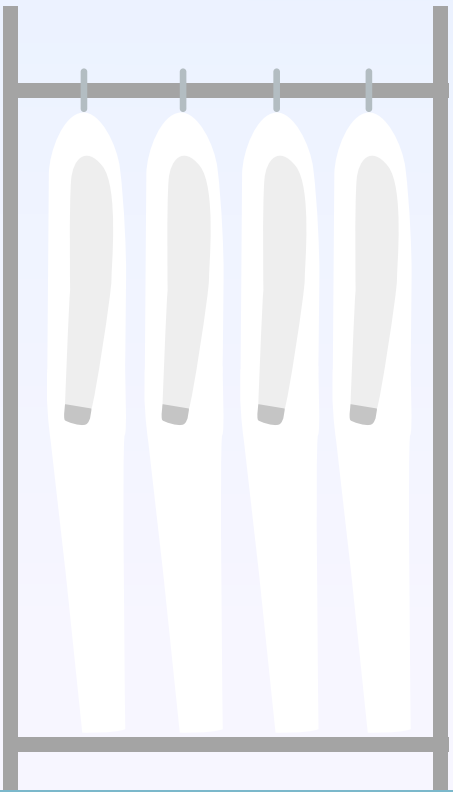


Effectively Maintain Air Cleanliness Classification and Protect Your Processes

The primary purpose of a cleanroom garment is to trap operator-generated particles. Encapsulating or creating a "bubble" around the operator would be most effective. However, this severely limits operator functionality. Instead, cleanroom and facility managers must specify the appropriate garment that traps particles to effectively maintain the air cleanliness classification of the cleanroom and protect the processes performed there.

IEST Recommended Practice

IEST-RP-CC003: Garment Considerations for Cleanrooms and Other Controlled Environments provides guidance on the performance, construction, and testing of both single-use and reusable cleanroom garments. Additionally, IEST-RP-CC003 provides specific laundering guidance for reusable garments and addresses the responsibility of the cleanroom laundry service and the end user. This Recommended Practice is currently in review to add critical information regarding cleanroom arc thermal, flame-resistant garments constructed of Nomex fabric and sewing thread. This new garment RP will be available in 2023.



Performance Criteria

There are several fabric performance specifications used in the manufacturing of cleanroom garments.

Moisture Vapor Transfer Rate
The moisture vapor transfer rate (MVTR) measures filtration efficiency and relates to wearer comfort. Operators prefer a breathable fabric for comfort which translates to a high MVTR for the fabric. However, fabrics with a high MVTR are less effective at containing operator-generated particles. See ASTM E96 for this standardized test methodology.

Bacterial Filtration Efficiency
The bacterial filtration efficiency and particle filtration efficiency tests predict the ability of the cleanroom garment to entrain particles shed by the operators. The best test result is 99.999% efficiency, but most fabrics do not achieve this test result as most cleanroom operators prefer a breathable fabric that is more comfortable, but less effective in containing operator-generated particles. See ASTM F2101 for the filtration efficiency test methodology and IEST-RP-CC003 for the air permeability test methodology.

ESD
Some cleanroom fabrics have a carbon-yarn grid or stripe to impart static dissipative properties that prevent unwanted particle migration due to electro-inductive forces in the cleanroom.

Microbial Resistance
Some reusable fabrics have a durable, non-migrating antimicrobial and a Teflon shield to reduce microbial breakthrough and assist in liquid repellency.

Garment Construction
IEST-RP-CC003 addresses the style of construction of cleanroom garments, including the yarn used for the seams of cleanroom garments. The yarn must be polyester and silicone free and must be manufactured in a silicone-free environment. Silicone is an airborne molecular contaminant that can cause product defects in many cleanroom applications (e.g. Aerospace, SEMI). The seams in all reusable cleanroom garments should be double needle, flat felled seams. This type of seam encapsulates the cut edges of the fabric, preventing particle shedding when the garment is worn. The seams in all single-use cleanroom garments should be bound seams. This type of seam also encapsulates the cut edges of the fabric, preventing particle shedding when the garment is worn. The construction of cleanroom garments should minimize the number of seams and all other components, such as zippers, snaps and straps, and must be cleanroom compatible, and in some cases also gamma compatible, if the garment will undergo a sterilization process.

Specification Process: Challenges and Solutions

The selection of cleanroom garments should be based on the air cleanliness classification (e.g. ISO 3,4,5) of the cleanroom and the operations performed in the cleanroom. The operation should consider the specific tasks and environmental conditions. For example, is it a wet process, high-temperature exposure, or ESD-sensitive area? Is the floor a solid surface or raised grid? Considering all inputs on the front end will ensure that the most appropriate garment system is specified. Controlled environments are all unique—do not limit your selection to the "off the shelf" laundry rental program. Taking a "one size fits all approach" might not be the best solution for your specific application.

One of the challenges is that garments that are the most effective at entraining particles are also hot and uncomfortable to wear. Balancing operator comfort with garment filtration efficiency is an ongoing challenge. That is why active participation from the operator level is key in the selection process. Some facilities provide hospital scrub-type undergarments and lower their thermostats to help keep operators happy, and particle counts low. Operators need to be involved in the selection process, so they understand the "why."

Testing Methods

The cleanroom garment laundries perform a Helmke Tumble test on laundered reusable cleanroom garments to provide documented evidence of compliance with the cleanroom laundering specifications stated in IEST-RP-CC003. This test method determines if the garment is releasing fiber. Manufacturers of single-use cleanroom garments also perform a Helmke Tumble test to provide documented evidence of the suitability and cleanroom compatibility of their products. When the Helmke Tumble test is performed as described in this RP and the test result achieves IEST Category 1 particle cleanliness (<1200 particles 0.5um and greater per cubic foot minute), the end user can be assured that the cleanroom garment will protect the product and process from operator-generated particles. The vendor(s) selected for cleanroom garments should supply the end user with fabric and Helmke Tumble test results.
Garments are also tested on their effectiveness at trapping particles over the life of the garment. This is described in the filtration efficiency test. As garments are repeatably laundered, the rigorous wash, and extract and drying process opens the initially tight weave pattern, thereby permitting particles to migrate from the operator into the environment. It is suggested that your laundry track the number of cycles per garment. Scheduled air particle filtration tests are needed to determine when each garment needs to be retired because it is no longer compliant with the specification of the new garment.
In addition to testing for cleanliness levels, single-use garments (including facewear, headwear, bodywear and footwear) can also be evaluated on:

- Basis weight, according to IEST-RP-CC003
- Tensile strength, according to ASTM D5034
- Elongation, according to ASTM D2261
- Hydrostatic pressure, according to GB/T 4744-1997
- Coefficient of friction, according to ASTM D1894

Jan Eudy is an independent Cleanroom and Contamination Control consultant as well as Fellow, Past President and Senior Faculty Instructor of the Institute of Environmental Science and Technology.

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References:
Standards references: ISO 14644-1 and ISO 14644-2; ASTM F2101; ASTM D5034; ASTM D2261; GB/T 4744-1997; ASTM D1894; ASTM E96
IEST RPs references: IEST-RP-CC003