

3M™ Protective Coverall Linting Data Revision 1: Initial Issue

Purpose

The purpose of this technical data bulletin is to provide information about the suitability of 3M™ Protective Coverall products for use in environments where low-linting properties are an important consideration.

Introduction

When materials shed particles it is known as “linting.” A garment with a high linting propensity sheds more particles than one with low linting propensity. Linting can be an important factor to consider during garment selection, particularly for particle controlled environments.

Environments that are typically concerned with linting levels include cleanrooms; microelectronics manufacturing; pharmaceutical applications; and industries such as food, beverage and biotechnology. In some industries, garments may be used for personal protection but can also be used to protect the cleanroom environment from particles generated by the operators. Those involved in product selection should be aware that current American National Standards Institute (ANSI), European Conformity (CE) or International Standards Organization (ISO) standards for protective clothing performance requirements do not call up any test methods to test this aspect of the protection. For example, an ANSI 103-2010 American National Standard for Classification and Performance Requirements for Chemical Protective Clothing Category 5 coverall must pass the whole suit total inward leakage test but there is no testing done to see how the suit performs as a barrier against outward leakage.

In addition, the linting test described in this technical data bulletin is not an in-use test so it only looks at the particles shed from the garment itself. Product suitability should always be based on a risk assessment by a competent person. Linting test data may be useful during this process for certain applications.

Definitions

For the purpose of this technical data bulletin the following definitions taken from ISO 14644-1 Cleanroom and associated controlled environments – Part 1: Classification of air cleanliness¹ will be used.

Cleanroom – room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which the other relevant parameters, e.g. temperatures, humidity, and pressure, are controlled as necessary.

Particle – solid or liquid object which, for purposes of classification or air cleanliness, falls within a cumulative distribution that is based upon a threshold (lower limit) size in the range from 0.1 micron to 5 micron.

Particle size – diameter of a sphere that produces a response, by a given particle-sizing instrument, which is equivalent to the response produced by the particle being measured.

Classification of Cleanrooms

Many operations that are sensitive to airborne particles are conducted in controlled environments such as cleanrooms, which have various levels of cleanliness. These cleanrooms are typically classified according to ISO 14644-1. This ISO standard classifies cleanrooms in terms of airborne particle concentrations of particles in the size range of 0.1 to 5 micrometers (μm). Table 1¹ shows the ISO cleanroom classifications and maximum airborne particle concentration limits. An ISO Class 1 cleanroom is the cleanest environment while a Class 9 cleanroom is the least clean of the ISO cleanroom classes.

Table 1 — Selected airborne particulate cleanliness classes for cleanrooms and clean zones

ISO classification number (N)	Maximum concentration limits (particles/m ³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) in 3.2)					
	0,1 μm	0,2 μm	0,3 μm	0,5 μm	1 μm	5 μm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1,000	237	102	35	8	
ISO Class 4	10,000	2,370	1,020	352	83	
ISO Class 5	100,000	23,700	10,200	3,520	832	29
ISO Class 6	1,000,000	237,000	102,000	35,200	8,320	293
ISO Class 7				352,000	83,200	2,930
ISO Class 8				3,520,000	832,000	29,300
ISO Class 9				35,200,000	8,320,000	293,000

NOTE: Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level.

3M has consulted with experts from Holdstock Technical Services who have experience in testing and evaluating materials intended for use in cleanrooms and other particle controlled environments. In their report, Holdstock Technical Services notes that: "...standards that specify the construction and design of cleanrooms only refer to apparel in qualitative terms..."² ISO cleanroom standards (ISO 14644-1¹) define 9 classes of cleanroom. However, there is no formal documentation relating the ISO cleanroom classes to the apparel cleanliness classification.

The Holdstock report goes on to explain that "...in principle it is possible to wear any garment in a cleanroom, the requirement being that the design of the cleanroom shall be such that any particles generated by the garment shall be removed or diverted away from sensitive areas within the cleanroom...nevertheless it is good practice to use 'low-linting' garments in order to reduce the burden on particle filtration or removal systems."²

On that basis, it is not possible to define a garment as sufficiently "low-linting" to be suitable for a particular application or recommend its suitability for a particular class of cleanroom. However, Holdstock Technical Services aims to provide an expert opinion as to whether the garments in question "can reasonably be described as 'low-linting'"² and give "some indication of possible acceptance for different applications" based on the test data provided by 3M.

In some cases, only Institute of Environmental Sciences and Technology (IEST) Category I garments may be acceptable in cleanrooms. The Holdstock report suggests that "it is reasonable to say that Category II or III garments are unlikely to be accepted for ISO Class 1, 2 and 3 cleanrooms, but they may be acceptable in cleanrooms of ISO Class 4 to 9"². Further definitions of IEST cleanliness categories follow.

Test Methods

To assess linting propensity, garment manufacturers typically use the "Helmke Drum Test." This method aims to quantify the number of particles "dislodged from a garment through the application of mechanical energy under dry conditions as a means of simulating particle shedding from the surface of the garment."³

The procedure involves "placing the test material into a stainless steel drum"³ which is rotated at a rate of 10 rpm, connected to a sampling tube which is connected to an automatic laser particle counter. Particle counts are recorded at one minute intervals for a period of 10 minutes. The number of counts per minute for each particle channel (0.3, 0.5, 1.0 and 5.0 μm) is reported (after the subtraction of the background counts), and these results are used to determine average particle emission rates the test procedures described in IEST Recommended Practice RP-CC003.3: Garment System Considerations for Cleanrooms and Other Controlled Environments (Appendix B2.3)⁴.

As with all laboratory tests, the data obtained may not be representative of real usage situations, and do not account for wearer and workplace factors. As such, it should only be used as an indicative guide. It should also be noted that IEST-RP-CC003.3 guidelines have been the subject of disagreement among some committees.

Cleanliness Classification of Garments

IEST-RP-CC003.3 defines a cleanliness classification system which is summarized in Table 2 below. The classification system is based on the Helmke Drum Test. The table lists acceptable particle emission rates (particles/min) for each category based on a medium size coverall (average area for both sides of 5.99 m²). Category I garments have the lowest particle shed requirements and are the “cleanest.”

Table 2³

Coverall	Emission rate for particles $\geq 0.3\mu\text{m}$	Emission rate for particles $\geq 0.5\mu\text{m}$
Category I	< 2,000	< 1,200
Category II	2,000 – 20,000	1,200 – 12,000
Category III	20,000 – 200,000	12,000 – 120,000

3M Product Data

The 3M™ Protective Coveralls 4510, 4540+ and 4565 have been tested according to the Helmke Drum Test. A summary of the data is provided in Table 3. Please note that these test results relate to the tested sample set only. While test data may be used as an indicator of relative product performance, they may not be representative across a wider sample range or of real usage situations. The data do not form part of a formal ANSI or CE approved product claim. 3M™ Protective Coveralls not discussed have not been tested and should not be considered for cleanroom applications.

3M™ Protective Coverall 4565

Results for the five 3M™ Protective Coveralls 4565 fell well within IEST Category II, with two of the samples achieving Category I. Based on these results, 3M protective coveralls 4565 are likely to be acceptable for use in ISO Class 4 – 9 cleanrooms, and may just be considered for ISO Class 1 – 3 cleanrooms depending on requirements. The Holdstock Technical Services report supports this conclusion.

3M™ Protective Coverall 4510 & 3M™ Protective Coverall 4545

Results for both of these protective coveralls fell within IEST Category II. So both products are likely to be considered acceptable for use in ISO Class 4 – 9 cleanrooms. The Holdstock Technical Services reports support this conclusion and confirm that it is reasonable to describe the 3M™ Protective Coverall 4510 and 3M™ Protective Coverall 4545 as low-linting, but not necessarily for all applications.

3M™ Protective Coverall 4540+

In the $\geq 0.3\mu\text{m}$ size range, all the results for the 3M™ Protective Coverall 4540+ fall into Category II. For particles $\geq 0.5\mu\text{m}$, the results are mostly Category III. Average particle count results are generally higher for 3M protective coverall 4540+ than the fully laminated products, but this is to be expected because the material from which the breathable panel is constructed typically has a higher linting propensity than a laminated material. The Holdstock Technical Services report concludes that the 3M protective coverall 4540+ may still reasonably be described as low-linting in the context of some applications, and may be suitable for use in ISO Class 4 – 9 cleanrooms. This product should not be considered for use in cleanrooms ISO Class 1 – 3.

Summary

Table 3

Garment	IEST RP-CC003.3 Cleanliness Category	Likely to be suitable for use in ISO Class 1–3 Cleanrooms	Likely to be suitable for use in ISO Class 4–9 Cleanrooms	Low Average Particle Emission Rate for 1 - 5 μm
4565	I - II	Yes	Yes	Yes
4510	II	No	Yes	No
4545	II	No	Yes	No
4540+	III	No	Yes	No

References:

1. EN ISO 14644-1:1999: Cleanrooms and associated controlled environments. Classification of air cleanliness.
2. P. Holdstock, “Report R0065: Interpretation and statement of opinion on a test report,” *Holdstock Technical Services*, (04/08/2010).
3. Procedure Number: STP0008 REV 03, *Nelson Laboratories*.
4. IEST-RP-CC003.3, *Institute of Environmental Sciences and Technology Recommended Practice*.

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