Designation: E 2088 – 00

Standard Practice for Selecting, Preparing, Exposing, and Analyzing Witness Surfaces for Measuring Particle Deposition in Cleanrooms and Associated Controlled Environments[1]

This standard is issued under the fixed designation E 2088; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice is intended to assist in the selection, preparation, exposure, and analysis of witness surfaces for the purpose of characterizing particle deposition rates in cleanrooms and associated controlled environments, particularly for aerospace applications.

1.2 Requirements may be defined in terms of particle size distribution and count, percent area coverage, or product performance criteria such as optical transmission or scatter. Several choices for witness surfaces are provided.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 The values stated in SI units are to be regarded as the standard.

2. Referenced Documents (Note 1)

2.1 *ASTM Standards:*

E 1216 Practice for Sampling for Surface Particulate Contamination by Tape Lift[2]

F 24 Method for Measuring and Counting Particulate Contamination on Surfaces[3]

F 50 Practice for Continuous Sizing and Counting of Airborne Particles in Dust-Controlled Areas and Clean Rooms Using Instruments Capable of Detecting Single Sub-Micrometer and Larger Particles[2]

F 312 Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters[4]

2.2 *ISO Standard:*

ISO 14644-1 Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness[5]

2.3 *Government Standards:*

Fed-Std-209 Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones[6]

MIL-STD-1246 Product Cleanliness Levels and Contamination Control Program[6]

NOTE 1—The Institute of Environmental Sciences and Technology has several Recommended Practices which may also be useful.

3. Terminology

3.1 *Definitions:*

3.1.1 *bidirectional reflectance distribution function (BRDF)*—the scattering properties of light reflected off surfaces, expressed as the ratio of differential outputs of radiance divided by differential inputs of radiance. Surface contaminants scatter the incident radiation in all directions and with variable intensities. The BRDF is a method to quantify the spatial distribution of the scattered energy.

3.1.2 *cleanliness level*—an established maximum allowable amount of contamination in a given area or volume, or on a component.

3.1.3 *cleanroom*—an environmentally conditioned area in which temperature, humidity, and airborne contaminants are controlled by design and operation. High-efficiency particulate air (HEPA) filters or better are usually required to achieve the air cleanliness level. Air particulate cleanliness is classified in accordance with FED-STD-209 or ISO 14644-1.

3.1.4 *contaminant*—unwanted molecular and particulate matter that could affect or degrade the performance of the components upon which they reside.

3.1.5 *contamination*—a process of contaminating.

3.1.6 *contamination control*—organized action to control the level of contamination.

3.1.7 *controlled area*—an environmentally controlled area, operated as a cleanroom, but without the final stage of HEPA (or better) filters used in cleanrooms.

3.1.8 *critical surface*—any surface of an item or product which is required to meet established cleanliness level requirements.

[1] This practice is under the jurisdiction of ASTM Committee E-21 on Space Simulation and Applications of Space Technology and is direct responsibility of Subcommittee E21.05 on Contamination.

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[2] *Annual Book of ASTM Standards*, Vol 15.03.

[3] Discontinued; see *1993 Annual Book of ASTM Standards*, Vol 15.03.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

3.1.9 *demonstrated equivalence*—the condition in which a method of measurement has passed a series of tests to show that it gives equivalent results to those of a standard measurement.

3.1.10 *environmentally controlled area*—cleanrooms, controlled areas, good housekeeping areas, and other enclosures that are designed to protect hardware from contamination. Cleanliness is achieved by controlling air purity, temperature, humidity, materials, garments, and personnel activities.

3.1.11 *fiber*—a particle >100 µm in length with a length to diameter ratio of ten or more.

3.1.12 *image analysis*—the measurement of size, shape, number, position, orientation, brightness, and other parameters of small objects using the combination of a microscope, an imaging sensor, and a dedicated computer system. Image analysis can be used to perform particle counts or measure particle dimensions automatically, with far greater accuracy than manual techniques.

3.1.13 *micrometre* (µm)—a unit of measurement equal to one millionth of a metre, or approximately 39 millionths of an inch, for example, 25 µm is approximately 0.001 in. The term "micron" has been used but is not a recommended SI unit.

3.1.14 *nonvolatile residue* (NVR)—soluble material remaining after evaporation of a filtered volatile fluid or precipitate from a gas phase, usually reported in milligrams per unit area (or volume).

3.1.15 *particle deposition*—the settling of airborne particles onto surfaces resulting from electrostatic or dynamic conditions, or both, in cleanrooms or other controlled environments.

3.1.16 *particle fallout* (PFO)—a standard particle deposition method used by the European aerospace community which uses black glass witness surfaces and measures particle scatter in parts per million.[7]

3.1.17 *particle size*—(*1*) the apparent maximum linear dimension of a particle in the plane of observation, as observed with an optical microscope; (*2*) the equivalent diameter of a particle detected by automatic instrumentation. The equivalent diameter is the diameter of a reference sphere having known properties and producing the same response in the sensing instrument as the particle being measured; (*3*) the diameter of a circle having the same area as the projected area of a particle, in the plane of observation, observed by image analysis; (*4*) the size defined by the measurement technique and calibration procedure.

3.1.18 *particulate contamination*—discrete mass of solid matter, size often measured in micrometres (µm), which adversely affects critical surfaces of component and hence system performance.

3.1.19 *percent area coverage* (PAC)—fraction of the surface that is covered by particles, reported in percent as total particle projected area divided by total area of the surface.

3.1.20 *precision cleaning*—cleaning of hardware surfaces approved by established facility methods or methods specified or provided by the customer with verification to a specified cleanliness level.

3.1.21 *visibly clean*—absence of particulate or molecular contaminants when viewed from a specified distance with normal (or corrected to normal) vision with a specified illumination level.

3.1.22 *witness surface* (WS)—a contamination-sensitive material used instead of direct evaluation of a specific surface when that surface is either inaccessible or is too sensitive to be handled.

3.1.22.1 *optical witness surface* (OWS)—witness surface from which contaminants may be analyzed by optical methods.

3.1.22.2 *particle witness surface* (PWS)—witness surface from which particulate contaminants may be analyzed by standard optical or electron microscopic methods.

4. Summary of Practice

4.1 Particle deposition in controlled environments is determined by collecting particles on a clean witness surface for a specified period of time or operational activity, then retrieving the witness surface and quantifying the particle population collected.

4.2 Witness surfaces (WS) are typically surfaces that lend themselves to traditional microscopic or image analysis techniques for sizing and counting particles on the surface, but may be an optical surface that is evaluated on the basis of the change in its optical properties or may be a witness surface that best represents the surface material of interest which is subsequently evaluated by extracting a sample from the surface and sizing and counting particles removed from the witness surface.

4.3 This practice does not address real time particle deposition measurements involving particle counters on site with continuous recording over a specified period of time.

5. Significance and Use

5.1 This practice provides a standard approach to mesuring particle deposition, or fallout, in cleanrooms and other controlled environments. It is based on the use of a witness surface to collect particles that deposit from the surrounding environment and subsequently sizing and counting the particles by conventional methods. Several options are introduced, with limitations and guidelines for selecting the best choice for the intended application.

5.2 This practice is applicable across numerous industries including aerospace, microelectronics, and pharmaceuticals.

6. Selecting Witness Surfaces

6.1 Considerations for selecting WS include available methods of analysis, precision and accuracy required, size of particles of concern, actual material of critical surfaces of concern, and cost. Preferably, the WS should be a surface material which best represents the actual critical surface and should be analyzed using the method which best represents the actual performance characteristics of interest. Additionally, certain surfaces may become charged, especially in dry environments, and this charging can effect the particle deposition. If WS are to monitor a vacuum environment they must be made of low-outgassing, vacuum-compatible materials and held securely in vacuum-compatible, low-particle shedding holders.

[7] The Euramark Model 255 PFO photometer has been found to be satisfactory.