



Designation: E2088 – 06 (Reapproved 2021)

Standard Practice for Selecting, Preparing, Exposing, and Analyzing Witness Surfaces for Measuring Particle Deposition in Cleanrooms and Associated Controlled Environments¹

This standard is issued under the fixed designation E2088; 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 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents (Note 1)

2.1 *ASTM Standards:*²

E1216 Practice for Sampling for Particulate Contamination by Tape Lift

F24 Test Method for Measuring and Counting Particulate

Contamination on Surfaces

F312 Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

2.2 *ISO Standard:*³

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

2.3 *Government Standards:*

Fed-Std-209 Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones⁴

IEST-STD-CC1246 Product Cleanliness Levels and Contamination Control Program⁵

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.

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

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Although Fed-Std-209 has been cancelled, it still may be used and designations in Fed-Std-209 may be used in addition to the ISO designations.

⁵ Available from Institute of Environmental Sciences and Technology (IEST), Arlington Place One, 2340 South Arlington Heights Road, Suite 100, Arlington Heights, IL 60005-4516, <http://www.iest.org>.

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.

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 that uses black glass witness surfaces and measures particle scatter in parts per million.⁶

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 measuring particle deposition, or fallout, in cleanrooms and other controlled environments. It is based on the use of a witness surface

⁶ The Euramark Model 255 PFO photometer has been found to be satisfactory. The sole source of supply of the apparatus known to the committee at this time is Euramark, 834 East Rand Rd., Unit 6, Box 823, Mt. Prospect, IL 60056. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.