

**INSTITUTE OF  
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**Contamination Control Division  
Reference Document 011.2**

**IEST-RD-CC011.2**

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**A Glossary of Terms and  
Definitions Relating to  
Contamination Control**

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**INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY**

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Please note that in regard to references herein to Federal Standard 209 (FED-STD-209), Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones, the U.S. General Services Administration issued the following NOTICE OF CANCELLATION of FED-STD-209 on November 29, 2001: "Federal Standard 209E dated September 11, 1992 is hereby canceled and superseded by International Organization for Standardization (ISO) Standards. International Standards for Cleanrooms and associated controlled environments, ISO 14644-1 Part 1: Classification of air cleanliness; and ISO 14644-2 Part 2: Specifications for testing and monitoring to prove continued compliance with ISO 14644-1."

Copies of ISO Standards 14644-1 Part 1, and 14644-2 Part 2, may be obtained from the Institute of Environmental Sciences and Technology (IEST), 5005 Newport Drive, Suite 506, Rolling Meadows, IL 60008-3841. Phone: 1-847-255-1561, Fax: 1-847-255-1699, Website: [www.iest.org](http://www.iest.org), E-mail: [publicationsales@iest.org](mailto:publicationsales@iest.org).

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# A Glossary of Terms and Definitions Relating to Contamination Control IEST-RD-CC011.2

The terms and definitions included in this document generally have distinctive meanings within the context of contamination control. Terms having a more generic nature are not included in this document; their definitions as found in the *American Heritage Dictionary* are considered acceptable.

**abrasion resistance**

The ability of a surface of a material to resist abrasion while in use.

**accuracy**

The degree of agreement between the measured value of a quantity and the accepted value for that quantity.

**adhesion**

The force exerted across a surface of contact between liquids and solids, or solids and solids, that resists their separation.

**adsorber cell**

A modular container for an adsorbent (with provision for sealing to a mounting frame) that can be used singly or in multiples to build a system of any airflow capacity.

**aerosol**

A gaseous suspension of fine solid or liquid particles.

**aerosol, air-generated**

The aerosol that results when the pneumatic force of a high-velocity stream of air breaks up a specified room-temperature liquid into droplets.

**aerosol photometer**

An instrument that measures mass concentrations of aerosol by using the forward light-scattering principle. At a minimum, the instrument is capable of measuring aerosol concentrations of up to 100 mg/m<sup>3</sup>, and it has a threshold sensitivity capable of measuring 1 µg/m<sup>3</sup>.

**aerosol source material**

A specified liquid or solid, having known properties, that is transformed into an aerosol for challenge testing.

**airborne particles**

Particles suspended in moving or stationary air.

**airborne particulate cleanliness class**

A numerical designation that signifies a maximum allowable concentration of airborne particles of a specified particle size.

As established by *FED-STD-209*, the numerical value of a class is related to the concentration of particles in the size range of 0.5 µm and larger.

**airflow**

Movement of air in a given direction with respect to a specified reference plane or other designated physical reference.

The *rate* of airflow is expressed in terms of volume per unit time.

**airflow, parallel**

Unidirectional airflow, as demonstrated by a measured deviation of not more than 14 degrees from straight-line flow.

**airflow parallelism**

Unidirectionality of airflow, as determined in reference to measured dispersion that does not exceed 14 degrees from straight-line flow.

**airflow, uniform**

A unidirectional airflow pattern in which the

point-to-point readings are within  $\pm 20\%$  of the average airflow velocity for the total area of the unidirectional flow work zone.

**air ions**

Molecular clusters of about ten molecules or more (water, impurities, etc.) that are bound by polarization forces to a singly charged oxygen or nitrogen molecule.

**air resistance**

The loss of pressure caused by gas moving through the filter medium.

**anemometer**

An instrument for measuring airflow velocity.

**anemometer, hot-wire**

See *thermoanemometer*.

**anemometer, vane**

An instrument that measures the velocity of air by mechanically converting the momentum of the air into the rotation or deflection of a vane.

**anion**

A negatively charged atom or group of atoms.

**anisokinetic sampling**

The condition of sampling in which the mean velocity of the flowing air stream differs from the mean velocity of the air entering the inlet of the sampling probe.

Because of particle inertia, anisokinetic sampling can cause the concentration of particles in the sample to differ from the concentration of particles in the air being sampled.

**antimicrobial**

A compound or formulation used to retard the growth of or to kill microorganisms.

**antiseptic**

A substance that prevents or inhibits the growth of microorganisms without necessarily killing them.

**antistatic compound**

A chemical substance that is capable of neutralizing a surface charge.

**as-built cleanroom**

See *cleanroom, as-built*.

**aseptic processing**

Production activities that exclude all extraneous living matter, especially microscopic forms such as

bacteria and fungi, from the production units being assembled, filled, packaged, or built.

**as-found data**

Data showing the response of an instrument to known standards before adjusting or calibrating the instrument.

The term may also be applied to measured data indicating status or condition of a process or environment before any remedial or other required actions are taken.

**at-rest cleanroom**

See *cleanroom, at-rest*.

**bacteria**

One-celled, microscopic plantlike organisms lacking chlorophyll that multiply by fission. Bacteria typically measure from 0.2 to 50  $\mu\text{m}$  in diameter.

**bacterial spore**

A resistant body produced by a vegetative bacterial cell. These spores may be resistant to heat, ultraviolet light, and desiccation, and may remain dormant for extended periods of time.

**bactericide**

A substance or formulation capable of destroying bacteria.

**bacteriostat**

A compound or formulation that retards or prevents the growth of bacteria. Bacteriostats act reversibly; when they are removed, cells resume their normal growth patterns.

**basis weight**

The mass of a specified area of materials such as documentation forms or filter media; also referred to as *grammage*.

**bioburden**

A measure of the number of microorganisms resident on or within products and inanimate objects. A common synonym is *microcount*.

**box, wafer**

A carrier for wafers and cassettes that seals them from the outside environment.

**bypass**

The deliberate or nondeliberate diversion of air around a unit whose purpose is to filter that air.

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**calibrated equipment**

Test equipment that has been calibrated in accordance with the equipment manufacturer's recommendations or accepted industry practices.

**calibration**

Comparison of a measurement standard or instrument of unknown accuracy with another standard or instrument of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the unknown standard or instrument.

**cation**

A positively charged atom or group of atoms.

**certificate of compliance (conformance)**

A written statement, signed by a qualified person and accompanied by substantiating information, attesting that the items or services are in accordance with specified requirements.

**certification** (*see also validation and verification*)

The culmination of procedures leading to validation, expressed in the form of written evidence (certificate of compliance) that verification has been accomplished in accordance with specified testing procedures, such as *FED-STD-209* or *IEST-RP-CC006* (see pp. 30-32).

**CFU (colony-forming unit)**

An individual or an aggregate of many microbial cells which, when cultivated on solid media, will develop into a single visual colony.

**challenge aerosol**

An aerosol derived from the selected aerosol source material and used as the test challenge for filter medium testing.

Challenge aerosols may be produced by a variety of methods, the choice determining the aerosol type and particle size characteristics. Air-generated aerosols have a polydisperse nature, while thermally generated aerosols are monodisperse.

**dioctyl phthalate (DOP), air-generated aerosol**

An aerosol produced by forcing compressed air through DOP at room temperature.

The choice of the nozzle determines the mean diameter of the distribution of DOP droplets in the aerosol.

**dioctyl phthalate (DOP), gas-thermally generated aerosol**

An aerosol produced by injecting a regulated quantity of liquid DOP into a heated zone by pressure supplied by an inert gas.

**dioctyl phthalate (DOP), thermally generated aerosol**

An aerosol produced by condensing DOP vapor which has been evaporated from the liquid phase by the application of heat.

Aerosols so produced have a light-scattering mean diameter of approximately 0.3 micrometer and a geometric standard deviation of 1.4. *See also thermally generated aerosol.*

**challenge concentration**

The concentration (e.g., mg/m<sup>3</sup>) of an aerosol (number of particles per unit volume) or gas used to challenge a filter, adsorber, or other air cleaning device under conditions specified for testing such devices.

**channeling**

The disproportionately greater flow of gas through regions of lower resistance that may exist in a filter or gas-phase adsorber. Also, physical displacement of the filter medium or sorbent bed medium, which can result in regions of lower resistance.

Such discontinuities may be the result of nonuniform packing, segregation or inhomogeneity of constituent granules, displacement of granules resulting from direct impingement of high-velocity air, or other causes not characterized by mechanical leaks.

**chemical compatibility**

The ability of a material to withstand chemical contact with minimal interaction.

**chemical degradation**

Changes in materials that occur when they come into contact with chemicals. Degradation may take such forms as swelling, loss of tensile strength, deformation, or loss of abrasion resistance.

**chemisorption**

Adsorption, especially when irreversible, by means of chemical (as opposed to physical) forces.

**chimney effect**

The vertical movement of a mass of gas or vapor caused by a difference in temperature.

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**class (airborne particulate)**

The cleanliness class, as defined by *FED-STD-209*.

**cleanability**

The level of cleanliness attainable when a material or a surface is subjected to a specified cleaning process.

**clean-air device**

A clean bench, clean work station, downflow module, or other equipment designed to control particulate air cleanliness in a localized working area and incorporating, as a minimum, a HEPA filter and a blower.

**clean-air device, laminar flow**

*This term is no longer in use. See clean-air device, unidirectional flow*

**clean-air device, unidirectional flow**

A clean work station or other device (other than a cleanroom or clean zone) that incorporates one or more HEPA or ULPA filters and one or more motor-blowers for the purpose of supplying unidirectional-flow clean air to a controlled work space.

**clean-air system**

A system designed to maintain the cleanliness of air in a cleanroom or clean zone at or below a specified airborne particulate cleanliness class.

**clean area**

*See clean zone.*

**cleaning agent**

A liquid that enhances the removal of contaminants from surfaces, by such mechanisms as dissolution, reducing surface tension, and neutralizing electrostatic charge.

Cleaning agents can also be disinfectants. To be acceptable for use in cleanrooms and other environmentally controlled areas, cleaning agents should be chemically and physically compatible with the process or product, or both, and should not themselves contribute measurably to the overall burden of contamination.

**clean island**

*See clean zone.*

**cleanliness level**

The established maximum allowable amount of contamination in a given area or volume or on a component.

**cleanroom**

A room in which the concentration of airborne particles is controlled and which contains one or more clean zones.

**cleanroom (facility), as-built**

A cleanroom (facility) that is complete and ready for operation, with all services connected and functional, but without production equipment or personnel within the facility.

**cleanroom (facility), at-rest**

A cleanroom (facility) that is complete and has the production equipment installed and operating, but is without personnel within the facility.

**cleanroom (facility), operational**

A cleanroom (facility) in normal operation with all services functioning and with production equipment and personnel, if applicable, present and performing their normal work functions in the facility.

**cleanroom, laminar airflow**

*This term is no longer in use. See cleanroom, unidirectional.*

**cleanroom, mixed airflow**

A hybrid cleanroom consisting of a combination of a unidirectional-airflow cleanroom and a nonunidirectional-flow cleanroom.

**cleanroom, nonunidirectional airflow**

A cleanroom in which airflows exist with a multiplicity of flow directions or multiple-pass circulation (eddies) or both.

**cleanroom, turbulent airflow**

*This term is no longer in use. See cleanroom, nonunidirectional airflow.*

**cleanroom, unidirectional-airflow**

A cleanroom in which airflows have generally parallel streamlines operating in a single direction and with uniform velocity over the cross section.

**cleanroom testing agency**

An organization that employs appropriately skilled technicians and specified instrumentation and methods to determine cleanroom cleanliness class.

The skill and experience level of the testing agency should be specified by the user or contracting agency.



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**clean work station**

A clean-air device such as a bench or similar enclosure, characterized by having its own supply of filtered air.

**clean zone**

A defined space in which the concentration of airborne particles is controlled to specified limits.

**collected volatile condensable material (CVCM)**

The mass that outgasses from a material and subsequently condenses on a collector, expressed as a percentage of the initial specimen mass. The measurement method is defined in *ASTM E-595*. (See also **total mass loss**.)

**collector**

A device, usually part of an exhaust system, for removing and retaining contaminants from air or other gases.

**condensation nuclei**

Small particles, normally within the size range from 0.001 to 0.1  $\mu\text{m}$  radius, upon which water vapor condenses in the atmosphere.

**condensation nucleus counter (sometimes referred to as a condensation particle counter)**

An instrument for counting airborne particles, in the nanometer size range and larger, by optically detecting droplets formed by condensation of a vapor upon the particles.

**conductive materials**

For the purpose of controlling static charge, conductive materials are generally considered to be those that have a surface resistivity less than  $10^5$  ohms/square or a volume resistivity of less than  $10^3$  ohm-cm.

A conductive material is not necessarily static dissipative. For example, a nonisotropic (e.g., laminated) material can be surface conductive, but not necessarily volume conductive.

**contaminant**

Any unwanted substance present in or on a material or any surface within a clean zone.

**contaminate**

To reduce the level of quality by the addition of contaminants.

**contamination**

The result of the addition of contaminants to a material or to any surface within a clean zone.

**contamination control**

Any organized effort taken to reduce the level of contamination.

**controlled environment**

An environment in which parameters such as temperature, pressure, humidity, contaminant level, and so forth are controlled within specified limits.

**correlation ratio**

The ratio of data obtained from two measurements.

The measurements may be from a single environment at different locations or from a single environment using two similar instruments.

**decay time**

The time interval between two specified values of a variable that decreases with time.

**decontamination**

The removal of contaminants present in or on a material.

**decontamination factor**

The ratio of the concentrations of contaminants before and after decontamination, cleaning, or treating.

**degradation**

Undesirable changes, physical or chemical or both, which take place when a material is exposed to certain solids, liquids, or gases or to harmful environmental conditions.

These may include swelling, dissolution, loss of physical strength, etc.

**designated leak**

A leak that should be detectable during scanning of a filter installation with a discrete-particle counter.

The designated leak is characterized by a designated number of counts, chosen to establish statistical probabilities related to its detection.

**desorption**

Any process by which absorbed or adsorbed materials are removed from the substrates on which they are sorbed. See **sorption**.

**differential pressure**

See **pressure, differential**.

### **diffusion, molecular**

A process of spontaneous intermixing of different substances, attributable to molecular motion and tending to produce uniformity of concentration.

### **dioctyl phthalate (DOP)**

A high-boiling organic liquid commonly used in the preparation of aerosols.

Although nearly always described as the dioctyl ester, the compound is actually the di-(2-ethylhexyl) ester of 1,2-benzenedicarboxylic acid (DEHP). *See also challenge aerosol.*

*Note: Recent research has indicated that there is a possibility that DOP may be carcinogenic under certain conditions. The user is advised to consult the applicable Material Safety Data Sheet prior to use of any aerosol source material. Alternatives are being investigated and developed.*

### **discrete-particle counter (DPC)**

An instrument, such as an optical particle counter or a condensation nucleus counter, capable of resolving responses from individual particles.

### **disinfectant**

An agent, chemical or physical, designed to reduce the population of microorganisms.

### **disperse system**

A two-phase system consisting of a dispersion medium and a disperse phase.

### **dispersion**

A general term for a system consisting of solid particles or liquid droplets suspended in a fluid.

### **dispersoid**

Solid or liquid matter in a disperse form.

### **DOP**

*See dioctyl phthalate.*

### **electret filter media**

Media made of fibers that carry electrical charge on their surfaces.

### **electromagnetic interference (EMI)**

Conducted or radiated electrical disturbances that can interfere with equipment operation; these disturbances occur anywhere in the electromagnetic spectrum, from less than 10 Hz to cosmic rays, including radio, light, and x-rays.

### **electrostatic charge control (ESCC)**

A system consisting of installations, materials, ac-

cessories, and procedures that maintains electrostatic effects below the hazard levels for a given product or process.

### **electrostatic damage**

Damage to a product caused by static electricity resulting from either 1) discharge from a charged conductor, 2) field induction, or 3) self discharge.

### **electrostatic discharge (ESD)**

The transfer of electrostatic charge between bodies that have different electrostatic potentials.

#### **electrostatic discharge control (ESDC)**

The limitation or elimination of the transfer of electrostatic charge.

### **electrostatic field**

- a) The space surrounding a charged object within which another charged object will be attracted or repelled.
- b) A voltage gradient between one electrostatically charged surface and another surface at a different electrostatic potential.

#### **electrostatic field detector**

Any device used to determine the presence of electrostatic charge.

### **electrostatic potential**

The potential difference (voltage) between a point and an agreed-upon reference point; usually the reference point is considered to be at infinity.

### **enthalpy**

A thermodynamic property of a substance defined as the sum of its internal energy plus the quantity  $Pv/J$ ; where  $P$  represents pressure of the substance,  $v$  represents its volume, and  $J$  represents the mechanical equivalent of heat; formerly called total heat and heat content.

### **entrance plane**

A plane perpendicular to the unidirectional airflow located immediately upstream of a specified region (typically the work area unless otherwise specified) and having the same dimensions of the cross section of the clean zone perpendicular to the direction of the airflow.

### **ESD-protective material**

Material generally classified by resistivity as either conductive or static-dissipative; materials capable of dissipating, avoiding, or shielding electrostatic occurrences.

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**exposure time**

The period of time during which a product is in direct contact with the air in a cleanroom.

**fiber**

A solid object usually defined as having an aspect ratio of at least 10:1.

**filter**

A device used to remove particulate matter or impurities from a fluid (gas or liquid) flowing through it.

**filter, controlled-pore**

A filter of various plastics or metals having a structure of controlled range of pore size; sometimes referred to as a membrane or molecular filter.

**filter, extended-medium**

A filter having a medium in a form that employs pleats, bags, socks, or other shapes to increase the effective surface area available for filtration within a defined filter cross section.

**filter, high-efficiency particulate air (HEPA)**

A throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.97% (that is, a maximum particle penetration of 0.03%) for 0.3- $\mu\text{m}$  particles of thermally generated DOP or specified alternative aerosol.

**filter, mechanical**

Any device that removes particles from a fluid by the mechanisms of impaction, settling, screening, inertia, diffusion, or any combination thereof.

**filter, membrane**

A filter, generally thin and manufactured from polymeric plastics or from metal, the open structure of which is comprised of pores or capillaries in a controlled range of sizes.

**filter, ultralow-penetration air (ULPA)**

A throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.999% (that is, a maximum particle penetration of 0.001%) for particles in the size range of 0.1 to 0.2  $\mu\text{m}$ , when tested in accordance with the methods of *IEST-RP-CC007* (see pp. 30-32).

**filter flow resistance**

Resistance to fluid flow offered by a filter medium, the pressure difference required to give unit flow of a fluid of unit viscosity through a unit cube of filter medium. *See also* **resistance**.

**filter medium**

A permeable material that separates solid particles or liquid droplets from a fluid passing through it.

**finding**

Buckles, belts, closures, bindings, and other attachments to apparel.

**finger cot**

A covering or sheath for a finger.

**flora**

The types of microbiological organisms found in an environment.

**flowmeter**

An instrument for measuring the rate of flow of a fluid moving through a pipe or duct.

A flowmeter is calibrated to indicate volume rate of flow or mass rate of flow.

**fogging**

A process involving conversion of a liquid to an aerosol mist, generally for purposes of coating a surface with a uniform deposition of the liquid material.

One example of fogging is its use for decontamination purposes, in which case the decontaminant is dispensed in the form of an aerosol.

**fumigation**

A process of decontamination in which the decontaminant is administered in gaseous, smoke, or aerosol form at ambient pressure.

**fungi**

Nonphotosynthetic microorganisms possessing cell walls and usually growing as a mass of branching, interlacing filaments known as mycelia.

The mycelial forms are called molds, and the nonmycelial forms are called yeasts. Fungi are usually larger than 0.4  $\mu\text{m}$  in size.

**fungicide**

A substance that is capable of destroying fungi.

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**fungistat**

A substance that retards or prevents the growth of fungi.

The effects of fungistats are reversible; when the fungistats are removed, the fungi resume their normal growth patterns.

**garments, cleanroom**

Specially designed items of clothing that are worn to prevent or reduce the dispersion of contaminants that may be shed or released by personnel.

Examples of such apparel include jumpsuits, footwear, shoe covers, gloves, and head covers.

**gas chromatograph**

An instrument used for quantitative analysis of extremely small quantities of organic compounds.

Its operation is based upon the adsorption and partitioning of a gaseous phase within a column filled with solid or liquid phases, or both.

**generated particles**

Particles that were not previously present on the surface of a substrate, e.g. wipers, but are generated and released in response to mechanical energy imparted to that surface.

**glove**

A covering for the hand, having separate sections for each of the fingers and the thumb, and often extending part way up the arm.

**gowning system**

A set of specified articles of apparel and accessories, together with specifications governing their donning, use, removal, reprocessing or replacement, and storage, as well as specifications related to the way in which they interface with equipment, fixtures, and facilities.

**grammage**

See **basis weight**.

**Gram-negative bacteria**

Bacteria that do not retain the purple color of the crystal violet dye when treated with Gram's staining technique.

**Gram-positive bacteria**

Bacteria that retain the purple color of the crystal violet dye when treated with Gram's staining technique.

**Gram's staining technique**

A method for staining and classifying bacteria, developed by Dr. Hans C.J. Gram.

**gravimetric analysis**

A standard analytical technique used to determine the mass of a specified material, and commonly used to quantify the amount of nonvolatile residue in a solvent.

In this application, the contaminated surface is rinsed with a solvent, the solvent is evaporated, and the mass of the substance remaining is determined. This residue, the NVR, is expressed as mass per unit area of surface.

**ground**

An electrically conducting connection to the earth or to another conducting body that serves in place of the earth.

**ground lead**

Conductive cabling or a similar device used as a wrist strap or other form of grounding system.

In a wrist strap system, the lead connects the cuff with a ground. In a foot strap system, the lead may connect the body-contacting portion to the ground-contacting portion.

**ground path**

The total system of connecting leads, straps, and surfaces between the body being controlled and a ground.

**ground straps**

A skin-contacting wrist, leg, or ankle strap that rapidly and safely dissipates personnel electrostatic charges to the ground and equalizes electrostatic levels of personnel with that of the work surface. The strap may contain a current-limiting resistor for safety.

**HEPA (high efficiency particulate air) filter**

See **filter**, HEPA.

**heterogeneous dioctyl phthalate (DOP)**

An aerosol having the approximate light-scattering mean droplet-size distribution as follows:

- 99+% less than 3.0  $\mu\text{m}$
- 50+% less than 0.7  $\mu\text{m}$
- 10+% less than 0.4  $\mu\text{m}$

*Note: Recent research has indicated that there is a possibility that DOP may be carcinogenic under*

*certain conditions. The user is advised to consult the applicable Material Safety Data Sheet prior to use of any aerosol source material. Alternatives are being investigated and developed.*

### **hot spots (electrically charged)**

Charged islands formed on material when conductive additives, such as topical antistats, are not evenly distributed. Another form of hot spot may occur in some apparel constructions when conductive filaments become broken and are no longer in electrical contact with each other.

Product damage due to ESD could result from these isolated areas of electrical potential.

### **housekeeping, cleanroom**

Maintenance or cleaning performed to preserve the specified cleanliness of a cleanroom.

### **housekeeping maintenance, cleanroom**

Functions performed to preserve the specified cleanliness of a cleanroom or clean zone.

### **impaction**

Physical contact of particles with other surfaces in response to the application of an external force. The term is occasionally used synonymously with impingement.

### **impactor**

A sampling device capable of removing particles from a gaseous suspension using the principle of impaction (impingement).

A "cascade impactor" refers to a specific instrument that employs several impactions in series to collect particles of successively smaller sizes.

### **impingement**

A sampling procedure whereby particles are removed from a gaseous suspension by forcibly directing the flowing gas against a collection surface.

#### **impingement, dry**

Impingement in which the particle-collecting surface is a solid or a solid coated with an adhesive.

#### **impingement, wet**

Impingement in which the particle-collecting surface is a liquid or is located beneath the surface of a liquid bath.

### **impregnated carbon**

Activated carbon to which one or more ingredients

have been added to enhance the adsorption of selected molecular species from air or other gases.

### **inches of water gauge (w.g.)**

See **water gauge**.

### **induction leak test**

See **leak test, induction**.

### **in-place leak test**

See **leak test, in-place**

### **insulative material**

A material having a surface resistivity of at least  $10^{12}$  ohms/square, or  $10^{10}$  ohm-cm volume resistivity.

### **ionic contamination**

Contamination in the form of atoms having electrical charge.

Common examples include singly charged atoms (ions) from Group IA (such as sodium and potassium) and Group VIIA (such as fluorine and chlorine) of the periodic table.

### **isoaxial**

A condition of sampling in which the direction of the airflow into the sampling probe inlet is the same as that of the unidirectional airflow being sampled.

### **isokinetic sampling**

The condition of isoaxial sampling in which the mean velocity of the air entering the sampling probe inlet is the same as the mean velocity of the unidirectional airflow at that location.

### **isokinetic test aerosol generator (formerly isokinetic smoke generator)**

An air-generated source of a visible aerosol connected to a length of tubing and fitted with a valve capable of metering the flow of the aerosol to match the flow direction and velocity of the surrounding air within  $\pm 1.5$  m/min (5 ft/min).

The outlet of the tubing should not exceed 6.4 mm (0.25 in.) in diameter.

### **laminar airflow**

*This term is no longer in use. See **unidirectional airflow**.*

### **laminar flow**

Streamline flow within a fluid (such as air) near a solid boundary (such as a duct wall), characterized by an upper-limit Reynolds number.

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**laminar flow clean-air device**

This term is no longer in use. See **clean-air device**, **unidirectional flow**.

**laminate**

A material formed by bonding together two or more layers in order to achieve an effect not otherwise attainable from each of the component layers separately.

**Laskin nozzle**

A nozzle used as part of a system to generate a heterogeneous aerosol, such as DOP, that utilizes a source of compressed gas (see **air-generated DOP and heterogeneous dop**).

**latent heat**

Change of enthalpy during a change of state, usually expressed in J/kg (Btu/lb).

With substances, latent heat is absorbed or rejected at constant temperature at any pressure.

**laundryability**

The ability of an article such as a glove or garment to be laundered to a specified level of cleanliness.

**leak, adsorber**

A gap or void in the adsorbent, gaskets, or metal framework that allows unfiltered air to bypass the adsorber and enter the cleanroom or clean zone.

**leak, air filter**

A gap or void in the medium, gaskets, or framework of a filter that allows unfiltered air to bypass the filter and enter the cleanroom or clean zone.

**leak test, induction**

A procedure for evaluating the potential for particle intrusion into a clean zone or clean-air device by induction through unsealed construction joints, through structural penetrations for piping or utilities, or by backstreaming from openings in the work space boundaries.

**leak test, in-place**

A leak test performed on installed components, either individually or in banks.

Two basic types of in-place testing are: 1) gross testing, which is designed to challenge all parts of the installation, including possible bypass of the bank; and 2) shrouded testing, in which selected portions of the bank are isolated so that only a limited area is subjected to the challenge aerosol or gas at any one time, thereby limiting the total

quantity of challenge aerosol or gas presented to the bank.

**leak-tightness**

The condition of a component, unit, or system where leakage through the pressure boundary is less than a specified value at a specified differential pressure.

**liquid-borne particle cleanliness**

The level of cleanliness specified by the maximum allowable number of particles in a specified size range per unit volume of liquid.

**makeup air**

Air that is introduced into a recirculated air system to ventilate, pressurize, and replace exhaust air.

**margin**

An unperforated area at the side, at the end of, or around the perforated area of a perforated sheet or screen.

**mass concentration**

Concentration expressed in terms of mass per unit volume of gas or liquid.

**mechanical leak**

The measure of the direct leakage through metal parts of the cell or its gasket due to manufacturing defects, bypassing of the sorbent because of settling of the sorbent in the bed, or inadequate cell design.

The results are reported as percent refrigerant penetration.

**medium (plural, media)**

The filtering material in a filter.

**microbiological clean area**

A defined space with a filtered air supply that is designed to accommodate the performance of activities for which the control of viable particles is essential.

**micrometer ( $\mu\text{m}$ )**

A unit of measurement of length, equal to one-millionth of a meter (approximately 0.00003937 inch).

**minienvironment**

An environment that provides localized control of airborne contaminants by means of an enclosure designed to isolate product-handling areas from personnel and the surrounding room environment.

Four basic types of minienvironments are: microenvironment, tool-in-a-box, tunnel, and ducted flow.

### **mixed-airflow cleanroom**

See **cleanroom, mixed airflow**.

### **molecular diffusion**

The mixing of different substances when subjected to a concentration gradient.

The phenomenon originates with molecular motion and tends to produce a uniform concentration.

### **monitoring**

The routine determination of airborne particle concentrations, as well as other relevant parameters, in cleanrooms and clean zones.

### **most-penetrating particle size (MPPS)**

The size of the particles that achieve maximum penetration of the filter medium.

Particles that are smaller or larger than the most penetrating size exhibit a lower rate of penetration; the reduced penetration of the smaller particles is due to diffusion mechanisms, while for the large particles it is due to interception and inertial effects.

The most penetrating particle size is a function of the structure of the filter medium, the velocity of the airflow through the filter, and the physical and chemical nature of the particles.

### **mounting frame**

The structure to which a filter unit is clamped and sealed.

### **noncorrosive, nonstaining**

Terms applied to substances that have a minimal effect on the integrity or appearance of surfaces with which they come in contact.

### **nonionic**

A term used to describe materials that do not possess a net electrical charge.

### **nonunidirectional airflow**

Airflow that does not qualify as unidirectional because it has a multiplicity of flow directions or multiple-pass circulation (eddies), or both.

### **nonunidirectional airflow cleanroom (or clean zone)**

A cleanroom or clean zone that is characterized by random, turbulent airflow vectors throughout the work zones.

### **nonvolatile residue (NVR)**

Any solid or liquid phase remaining after the evaporation of a volatile liquid from a solution.

NVR is generally expressed in units of mass per unit

volume of liquid; if the volatile liquid was used to remove soluble contamination from a specific area of surface, the NVR units may be expressed as mass per unit area.

### **nonvolatile residue (NVR) deposition rate**

The deposition of nonvolatile residue as a function of time.

Standard rates are expressed in units of

mg/0.1 m<sup>2</sup>/month or mg/ft<sup>2</sup>/month.

### **numerical aperture**

A measure of the light-gathering and resolving power of a microscope objective.

### **offset voltage**

A voltage produced on an isolated conductive plate, in an ionized environment, when an unequal number of positive and negative ions exist on the plate.

### **operational cleanroom (facility)**

See **cleanroom, operational**.

### **organic vapors**

Vapors that emanate from solid or liquid organic materials.

They are typically the result of outgassing from the material or they are the product of a chemical reaction, such as combustion.

### **outgassing**

The liberation of a gas from any material other than by change of state.

### **owner (as the term applies to cleanrooms)**

The company or organization that has the ultimate responsibility for achieving established strategic and fiscal objectives through operation of the cleanroom. See also **user**.

### **particle**

An object that is solid, liquid, or both, usually between 1 nanometer and 1 millimeter in size.

### **particle burden**

The number of particles in the relevant size range per unit area of surface.

### **particle concentration**

The number of particles per unit volume of fluid.

### **particle count**

The number of particles detected (or reported) in a given volume of fluid.

### **particle counter, airborne**

An instrument for continuous counting of airborne particles larger than a given threshold size. The sensing means may be optical, electrical, aerodynamic, etc.

### **particle counter, optical**

An instrument that measures particle scattering or extinction of light to report the count and size of discrete particles suspended in a fluid stream passing through the light.

### **particle deposition**

The portion of the transient particle population that does not remain airborne, typically with respect to a specified period of time, under the influence of ambient airflow conditions, air and surface temperatures, and localized electrostatic charges.

### **particle diameter, arithmetic mean**

The arithmetic mean diameter  $d_g$  of a collection of particles given by the equation:

$$d_g = (N_1d_1 + \dots + N_nd_n) / (N_1 + \dots + N_n) \text{ or} \\ d_g = \Sigma(Nd) / \Sigma N, \text{ where}$$

$d_g$  is the arithmetic mean particle diameter,

$N_n$  is the number of particles of size  $n$ ,

$d_n$  is the size of particles in size group  $n$ , and

$N$  is the total number of particles.

### **particle diameter, mass median**

A measure of median particle diameter based on the particle mass.

For the mass median, one-half of the particle mass is contributed by particles with a size smaller than the mass median size, and one-half by particles larger than the mass median size.

### **particle fallout**

Those particles that have fallen out of a parcel of air due to gravitational effects and are deposited upon horizontal surfaces.

### **particle size**

The apparent maximum linear dimension of a particle in the plane of observation, as observed with an optical microscope, or 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.

### **particle size distribution**

The relative mass or number of particles present in a series of discrete subdivisions of the overall range of designated particle sizes.

### **particles, airborne**

See *airborne particles*.

### **particulate**

An adjective referring to particles, e.g., particulate matter.

### **particulate cleanliness level, fluid**

A cleanliness ranking system based on the number of particles, equal to or larger than specified sizes, that are present in a unit volume of fluid (gas or liquid).

### **particulate percent area coverage**

The fraction of the surface that is covered by particles, reported as total particle projected area divided by total surface area.

### **pathogen**

A microorganism capable of causing disease.

### **penetration**

The ratio of the number of particles in fluid exiting a filter to the number of particles in a given volume of the fluid entering the filter, normally expressed as a percentage for a specified particle size range.

### **observed penetration**

Penetration as calculated from observed counts for limited testing.

### **true mean penetration**

The penetration that would be calculated from the averages of observed upstream and downstream counts, if tests were repeated indefinitely.

### **UCL and LCL penetration**

The 95% upper confidence limit (UCL) penetration and 95% lower confidence limit (LCL) penetration values statistically calculated from the observed counts.

There is 95% confidence that the true mean penetration is between the UCL and LCL penetrations.

### **penetrometer**

An instrument for determining penetration characteristics of very high-efficiency filtration media and filter units, using thermally generated challenge aerosol in accordance with MIL-STD-282.



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**percent elongation**

The percent increase in the dimension of the material in the direction of stress at the point of failure.

**permeability**

A quantitative measure of the ability of a material to transfer mass (solid, liquid or gaseous) through its pores and/or capillaries under the influence of a pressure gradient.

**photometer**

See **aerosol photometer**

**plenum chamber**

An enclosed, positive-pressure section of a gas supply system, designed to ensure even distribution of flow.

Examples include: a) the point of origin for air distribution in air-conditioning and ventilation, and b) the supply source for a filtration system to create even distribution of the gas to each filter unit.

**pod**

A type of box designed to interface with an I/O device so that the outside of the pod is never introduced into the minienvironment.

**precision**

The closeness of agreement between values obtained by repeated measurements of the same quantity under the identical conditions; also known as *repeatability* or *reproducibility*.

**prefilter**

A cleaning unit installed upstream of another unit to protect the latter from high concentrations of contaminants.

Prefilters are usually less efficient—and less expensive—than the units they protect.

**prep area (decontamination area)**

A cleanroom or clean zone in which preliminary cleaning or other preparatory procedures are performed before entry into the operational cleanroom.

The prep area typically is less clean than the operational cleanroom.

**pressure, differential**

The difference in pressure between two points of a system, which may be separated by a solid or fluid barrier.

**pressure, gauge**

The amount by which the total absolute pressure exceeds the ambient atmospheric pressure.

**pressure, static**

The pressure exerted by a fluid at rest or, if the fluid is in motion, the pressure it exerts perpendicular to its direction of flow.

**pressure, total**

The sum of static pressure and velocity pressure at the point of measurement.

**pressure, velocity**

The impact pressure associated with the velocity of a flowing fluid.

It is related to the kinetic energy per unit volume of the flow.

**primary surface**

A surface that is in direct contact with the product.

**probing or scanning**

A method for locating leaks in HEPA and ULPA filters, whereby the inlet of the sampling probe of an aerosol photometer or a discrete-particle counter is moved in a series of parallel slightly overlapping strokes across the test area, at a distance of approximately 2.5 cm (1 in.) from the filter face, and at a rate based on the leak penetration to be detected and the upstream concentration of the challenge aerosol.

**processing, garment**

Procedures performed to meet cleanliness and usability specifications for apparel and accessories.

**production and support equipment**

Equipment, tools, and devices whose primary function is to perform designated operations on products and materials, or to provide support to those operations, within a controlled environment.

Production and support equipment may include items such as filters, conveyors, computers, CRTs, jigs, work tables, and desks located in cleanrooms, clean zones, or clean air devices.

**pyrogen**

A substance capable of producing a fever. Common pyrogens are endotoxins, a class of lipopolysaccharides that comprise the outer wall of Gram-negative bacteria and are themselves by-products of cell metabolism.

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**radio frequency interference (RFI)**

Noise that disrupts desired instrument signals.

As a general rule, interference is restricted to the radio frequency spectrum of 10 kHz to 10 GHz.

**recirculated air**

The portion of the cleanroom air supply that has been recirculated by the air-handling equipment.

**Recommended Practice**

A published document that provides technical guidance, philosophy, or preferred procedures regarding a given topic.

**releasable particles**

Particles present on the surface of a substrate that are readily releasable therefrom by wetting it with a liquid, but without imparting mechanical energy to the substrate.

**residence time**

The finite period of time during which a material is contained within a handling or processing system, wherein components of the material may be subjected to change.

Calculation of the time of contact is based on the time required for the volume of fluid to completely traverse the medium. The time required for the fluid to traverse the medium is a function of the flow rate of the fluid and the physical parameters of the system.

**residual activity**

Residue, which may or may not be active, that remains on surfaces after treatment with an antimicrobial substance.

**residue**

Any substance remaining on a surface after the surface has been cleaned.

**resistance, filter**

The pressure drop across a filter under known conditions of flow, temperature, etc., commonly expressed in units of: Pascals ( $N/m^2$ ), mm water gauge, inches w.g., or psi ( $lb/in.^2$ ).

**resolution, particle size**

The capability of a particle sizing device to discriminate between particles that are similar in size.

The resolution is expressed as the ratio of the minimum size differential required to indicate a size change to the size of the particle being measured.

**Reynolds number**

A nondimensional value indicating the transition from laminar to turbulent flow in contained fluid systems.

It is based upon fluid density, viscosity, and velocity, and the cross-sectional dimensions of the fluid flow system.

**retention**

The measure of a material's ability to hold, without mechanical loss, the fluid that it has sorbed.

**reusability**

The capability of a product to be used more than once and to be cleaned to a definable level of cleanliness.

**roughing filter**

A prefilter with high efficiency for large particles and fibers and low efficiency for smaller particles.

**sampling**

A process consisting of the withdrawal or isolation of a fractional part of a whole.

In air or gas analysis, the separation of a portion of an ambient atmosphere with or without the simultaneous isolation of selected components.

**sampling, continuous**

Sampling without interruptions throughout an operation or for a predetermined time.

**sampling, instantaneous**

Sampling for a period of time that is negligible in comparison to the duration of the operation or to the total period of time being studied.

**sampling, intermittent**

Sampling successively for a limited period of time throughout an operation or for a predetermined period of time.

The duration of sampling periods and of the intervals between are not necessarily regular and are not specified.

**sanitizer**

A substance that reduces the number of microbial contaminants to a level considered to be safe.

**scale division**

On a photometer with numbered major scale divisions (0, 1, 2, 3, 4, 5), the term **one scale division** indicates the interval between consecutive numbered divisions.

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**scanning**

See **probing**.

**secondary surface**

A surface that is not in contact with the product, but which indirectly affects the product.

**sensible heat**

The heat absorbed or emitted by a body when its temperature is changed; in contrast with **latent heat**, the heat interchange associated with a change of state but without change in temperature.

**sensor**

A device designed to respond to a physical stimulus (as temperature, illumination, and pressure, etc.) and transmit a resulting signal for interpretation, or measurement, or for operating a control.

**separator**

A corrugated strip (usually of aluminum alloy, but may be of other materials such as plastic-coated aluminum, plastic, or kraft paper) used to separate the pleats in separator-style HEPA and ULPA filter media and to form channels between the pleats for the purpose of directing the flow of the filtered air.

**sequential counting system**

A system that uses a single detector to determine the concentrations of the test aerosol, both upstream and downstream of the filter medium, by alternating the sampling locations of the detector.

**settling velocity**

The terminal rate of fall of a particle through a fluid as induced by gravity or other external forces.

**shedding**

The release and generation of particles from a surface in response to the application of mechanical stress.

**shelf life**

The estimated length of time that a product or formulation can be stored before it loses its effectiveness.

**significant surface**

Any surface, of an item or product, that is required to meet established cleanliness level requirements.

**simultaneous counting system**

A system that uses a pair of detectors to simultaneously determine the concentrations of the test

aerosol both upstream and downstream of the filter medium.

**single-particle counter**

See **discrete-particle counter**.

**soap test**

A procedure used to evaluate low-rate air leakage through a small opening.

A soap solution is applied to the low-pressure side area where the suspected leak is located. Any leakage will result in formation of an easily visible soap bubble at the exact location of the leak.

In this procedure, a soap solution is applied to locations of potential leakage.

**solution**

A homogeneous mixture of two or more materials, typically in the form of a single phase in a liquid.

**solvent**

A substance that dissolves another to form a solution.

**sorbency**

A collective term describing the tendency of a swab or wiper to hold liquids, whether by absorption (within its capillaries or pores) or by adsorption (a surface phenomenon).

**sorbent**

A liquid or solid medium in or upon which materials are retained by absorption or adsorption.

**sorber bed**

A layer of sorbent contained between two perforated sheets spaced at a specified distance. Also, the assembly of perforated and nonperforated members that comprises the volume into which the sorbent is packed.

**sorber cell**

A modular container for a sorbent (with provision for sealing to a mounting frame) that can be used singly or in multiples to build a system of any airflow capacity.

**sorption**

A general term—applicable to wipers, swabs, and other sorbent materials—which comprises both *absorption* (within capillaries and pores) and *adsorption* (a surface phenomenon) without differentiating between them.

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**specification, design**

A concise document defining technical requirements in sufficient detail to form the basis for a product or process.

When appropriate, the design specification also includes the procedures used to determine whether the requirements are satisfied.

**specification, performance**

A concise document that provides the requirements for a product's performance.

The performance specification includes, as appropriate, the procedures and references required for testing and certification of the product.

**sporicide**

A substance or formulation capable of destroying bacterial spores.

**standard air**

Air at 50% relative humidity, with a temperature of 21°C (69.8°F), and pressure of 760 mm Hg (29.92 in. Hg).

**standard air density**

Air having a density of approximately 1.201 kg/m<sup>3</sup> (0.075 lb/ft<sup>3</sup>; that is, standard air with a specific volume of 0.832 m<sup>3</sup>/kg (13.33 ft<sup>3</sup>/lb).

**standard leak penetration**

The leak penetration that would be detected by a discrete-particle counter with a standard sample flow rate of 28.3 L/min (1.0 ft<sup>3</sup>/min) when the sampling probe is stationary over the leak.

**standard mechanical interface (SMIF)**

The connecting plate that mates with the bottom of a pod or carrier.

**static-dissipative garments**

All body coverings specifically designed or treated to prevent buildup of electrostatic charge.

**static-dissipative materials**

Materials having a surface resistivity between 10<sup>5</sup> and 10<sup>12</sup> ohms/square, or between 10<sup>3</sup> and 10<sup>10</sup> ohm-cm volume resistivity.

**static electricity**

An electrical charge at rest.

The electrical charge is due to the transfer of electrons within a body (polarization) or from one body to another.

**sterile**

Free from bacteria or other microbiological life.

**sterilization**

A physical or chemical process that completely destroys or eliminates all forms of microbial life.

**stiffness**

Resistance to bending when flexural stress is applied.

**strength**

The combined properties of tensile strength, elongation, and modulus of materials that relate to the ability to resist stress.

**surface contaminant**

Any unwanted substance present in or on a surface.

**surface finish**

Characteristic properties of the surface of a material; e.g., features such as adhesiveness, abrasiveness, hardness, coefficient of friction, and the propensity to contribute particles.

**surface resistivity**

An inverse measure of the conductivity of a material, equal to the ratio of the potential gradient to the current per unit width of the surface, with the potential gradient measured in the direction of current flow in the material.

Surface resistivity is numerically equal to the surface resistance between two electrodes forming opposite sides of a square of the material. The size of the square is irrelevant over a wide range of sizes. Surface resistivity is expressed in units of ohms per square ( $\Omega/\square$ ).

**swab**

A head or bud of material, usually but not necessarily sorptive, attached to the end of a slender handle.

Swabs are used for applying liquids to surfaces and for removing solids and liquids from surfaces.

**temperature control zone**

A cleanroom, or portion thereof, in which temperature is uniquely controlled.

**tensile strength**

The maximum stress a material can withstand when subjected to stretching.

**thermally generated aerosol**

An aerosol generated by condensation of a vapor evaporated from a high-boiling liquid such as dioctyl phthalate (DOP) or equivalent.

The vapor condensation occurs as a result of the presence of heterogeneous or homogeneous nuclei

under controlled conditions, so that the resulting aerosol is nearly monodisperse. The light-scattering mean diameter is approximately 0.3  $\mu\text{m}$  and the geometric standard deviation of the particle size distribution is no more than 1.4. *See also challenge aerosol, dioctyl phthalate (DOP), thermally generated aerosol.*

**thermoanemometer (hot-wire anemometer)**

An instrument that measures the velocity of air by sensing the change in the electrical resistance of a heated element cooled by the airflow.

**thickness, filter medium**

The dimension perpendicular to the plane of the filter medium.

**through bolt**

A bolt or other fastener which passes through the sorbent bed.

**tool in a box**

A minienvironment in which the enclosure covers the entire tool.

**topical antistat**

Any of various chemical agents that, when applied to surfaces of insulative materials, will reduce the ability of those surfaces to accumulate electrostatic charge.

Topical antistats usually function by increasing the surface lubricity of the material. One such agent, an ionic hygroscopic antistat, exhibits a secondary effect by which surface conductivity is increased; if the surface of the material is properly grounded, any triboelectric charge produced is delocalized and is slowly bled off.

**total mass loss**

The mass that outgasses from a material, expressed as a percentage of the initial mass of the specimen. (*See ASTM E595.*)

**toxic**

Poisonous, causing an adverse reaction.

**triboelectric charging**

The generation of electrostatic charges that results when two objects in intimate contact are separated. Substantial charge can be caused by contact and separation of two materials or by rubbing two objects together.

**triboelectric test**

Any test of the charge transfer between objects.

Triboelectric tests are frequently employed to determine the propensity for ESD damage due to triboelectric charging.

**tunnel**

A minienvironment in which an enclosure separates the tools and wafer-handling robot aisle from the general cleanroom; or, an enclosed single-wafer track for transport into and between tools.

**turbidity**

The cloudiness of a liquid resulting from the presence of finely divided suspended material.

**U descriptor**

The maximum allowable concentration (particles per cubic meter of air) of ultrafine particles.

The U descriptor serves as an upper confidence limit or as the upper limit for the location averages, or both, as appropriate. U descriptors are independent of airborne particulate cleanliness classes and may be specified alone or in conjunction with one or more airborne particulate cleanliness classes.

**ULPA (ultralow-penetration air) filter**

*See filter, ULPA.*

**ultrafine particles**

Particles in the size range from approximately 0.02  $\mu\text{m}$  to the upper limit of detectability of the discrete-particle counter.

**unidirectional airflow**

Air that flows in a single pass in a single direction through a cleanroom or clean zone with generally parallel streamlines. Formerly referred to as *laminar airflow*.

**uniform airflow**

*See airflow, uniform.*

**user (as the term applies to cleanrooms)**

A production or operational organization whose primary function is to produce a product or achieve defined objectives from a facility. (*See also owner.*)

**validation (see also certification and verification)**

Establishment, by means of a specified testing program, that a system or facility under test is capable of performing as intended.

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**vegetative organisms**

Microbial cells that are actively multiplying.

**verification** (*see also certification and validation*)

The procedure for determining compliance of air in a cleanroom or clean zone to a specified airborne particulate cleanliness class limit or U descriptor; also, the *result* of determining such compliance.

**viable particle**

A particle capable of reproduction; a living organism.

**viricide**

A substance or formulation capable of destroying viruses.

**virus**

An obligate intracellular parasite, typically in the size range of 0.01 to 0.1  $\mu\text{m}$ , that can infect and cause disease in man, animals, plants, and insects.

**volatile condensable material (vcm)**

Gaseous products released from materials under certain conditions of temperature and pressure. The gases may subsequently condense when changes in one or both of these conditions favor condensation.

**volume resistivity**

An inverse measure of the conductivity of a material, equal to the ratio of the potential gradient to the current density, where the potential gradient is measured in the direction of current flow in the material. Units are expressed in ohm-centimeters ( $\Omega\text{-cm}$ ).

**wall effect**

Partial bypass of the gas flow past the sorbent, along an unbaffled metal-to-sorbent interface.

**water gauge**

A means of designating pressure or differential pressure in terms of the height of an equivalent column of water, commonly expressed as inches w.g. in the English system (1 inch w.g. = 0.036 psi).

**water repellency**

The ability of a filter medium to resist wetting.

**wiper**

A piece of fabric or cloth designed for cleaning and removing liquids from critical surfaces.

**work zone**

The space or volume within the cleanroom that is designated for contamination-controlled operations, and for which testing is required.

The spatial limits of the work zone volume are defined by an entrance plane and an exit plane normal to the airflow (where there is unidirectional airflow).

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## ABBREVIATIONS AND ACRONYMS— ORGANIZATIONS AND AGENCIES

**AAAR**

American Association for Aerosol Research

**AABC**

Associated Air Balance Council

**AAMI**

Association for the Advancement of Medical Instrumentation

**AATCC**

American Association of Textile Chemists and Colorists

**ACGIH**

American Conference of Governmental Industrial Hygienists

**ACS**

American Chemical Society

**AFNOR**

Association Française de Normalisation (French Association for Standardization) (France)

**AFS**

American Filtration Society

**AGS**

American Glovebox Society

**AIA**

Aerospace Industries Association of America

**AIChE**

American Institute of Chemical Engineers

**AIHA**

American Industrial Hygiene Association

**AMCA**

Air Movement and Control Association

**ANSI**

American National Standards Institute

**ARI**

Air-Conditioning and Refrigeration Institute

**ASCCA**

Associazione per lo Studio ed il Controllo della Contaminazione Ambientale (Italy)

**ASE**

Agence Spatiale Européenne (France) (*see also* ESA)

**ASHRAE**

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

**ASME**

American Society of Mechanical Engineers

**ASPEC**

Association pour la Prévention et l'Étude de la Contamination (France)

**ASTM**

American Society for Testing and Materials

**AWMA**

Air & Waste Management Association

**AWS**

American Welding Society

**BSI**

British Standards Institution (England)

**CBER**

Center for Biological and Environmental Research

**CCE**

Commission des Communautés Européennes;  
*also*

**CEC**

Commission of the European Communities  
(Belgium)

**CEN**

Comité Européen de Normalisation (European Committee for Standardization) (Belgium)

**CENELEC**

Comité Européen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardization) (Belgium)

**CETA**

Controlled Environment Testing Association

**CGA**

Compressed Gas Association

**CMAI**

Chinese Ministry of Aerospace Industry  
(People's Republic of China)

**CSA**

Canadian Standards Association (Canada)

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**DIN**

Deutsches Institut für Normung (German Institute for Standardization) (Germany)

**DOD**

U.S. Department of Defense

**DOE**

U.S. Department of Energy

**DRES**

Defence Research Establishment, Suffield (Canada)

**EIA**

Electronic Industries Association

**EOS/ESD**

Electrical Overstress/Electrostatic Discharge Association

**EPA**

(U.S.) Environmental Protection Agency

**ESA**

European Space Agency (France) (*see also* ASE)

**FDA**

U.S. Food and Drug Administration

**FME&R**

Factory Mutual Engineering and Research Corporation

**FPS**

Fine Particle Society

**FS**

Filtration Society (England)

**GSA**

General Services Administration

**ICBO**

International Conference of Building Officials (U.S.)

**ICCCS**

International Confederation of Contamination Control Societies (Switzerland)

**ICCE**

International Cleanroom Control Engineering (Belgium)

**IEEE**

Institute of Electrical and Electronics Engineers

**IEST**

Institute of Environmental Sciences and Technology

**IES, IESNA**

Illuminating Society of North America

**IPA**

Industrial Perforators Association

**ISA**

Instrument Society of America

**ISHM**

International Society for Hybrid Microelectronics (U.S.)

**ISO**

International Organization for Standardization (Switzerland)

**ISPE**

International Society of Pharmaceutical Engineers (U.S.)

**JACA**

Japan Air Cleaning Association (Japan)

**JSA**

Japanese Standards Association (Japan)

**MSFC**

Marshall Space Flight Center

**NASA**

National Aeronautics and Space Administration

**NCWM**

National Conference on Weights and Measures

**NEBB**

National Environmental Balancing Bureau

**NELAC**

National Environmental Laboratory Accreditation Conference

**NFPA**

National Fire Protection Association

National Fluid Power Association

**NIH**

National Institutes of Health

**NIST**

National Institute of Standards and Technology

**NRC**

(U.S.) Nuclear Regulatory Commission



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**NSF**

National Sanitation Foundation

National Science Foundation

OINL

Organisation Internationale de Metrologie Légale  
(International Organization of Legal Metrology)  
(France)

**OSHA**

Occupational Safety and Health Administration

**PDA**

Parenteral Drug Association

**PS**

The Parenteral Society (England)

**R<sup>3</sup>-Nordic**

Nordic Association for Contamination Control  
(Sweden)

**SAA**

Standards Association of Australia (Australia)

**SAE**

SAE International (*formerly* Society of  
Automotive Engineers)

**SEE**

Society of Environmental Engineers (England)

**SEMI**

Semiconductor Equipment and Materials  
International (U.S.)

**SGR or SRRT**

Schweizerische Gesellschaft für Reinraumtechnik  
(Swiss Society for Contamination Control)  
(Switzerland)

**SKI**

Swiss Institute for Public Health and Hospitals  
(Switzerland)

**SMACNA**

Sheet Metal and Air Conditioning Contractors'  
National Association

**SRRT**

Schweizerische Gesellschaft für Reinraumtechnik  
(*see also* SGR) (Switzerland)

**SWKI**

Swiss Association of Heating and Air  
Conditioning Engineers (Switzerland)

**UL**

Underwriters Laboratories, Inc.

**USDA**

United States Department of Agriculture

**USP**

United States Pharmacopeial Convention

**VDI**

Verein Deutscher Ingenieure (Society of German  
Engineers) (Germany)

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## ABBREVIATIONS AND ACRONYMS RELATING TO CONTAMINATION CONTROL

<b>AA</b> atomic absorption	<b>ESD</b> electrostatic discharge
<b>ACCTD</b> air cleaner coarse test dust	<b>EtO</b> ethylene oxide (sterilizing agent)
<b>ACFDT</b> air cleaner fine test dust	<b>FMS</b> facility monitoring system
<b>AC/HR</b> air changes per hour	<b>FTIR</b> Fourier transform infrared (spectroscopy)
<b>AMD</b> aerodynamic mean diameter (of particles)	<b>GLP</b> good laboratory practice
<b>BOD</b> biological oxygen demand	<b>GMP</b> good manufacturing practice
<b>CFC</b> chlorofluorocarbon	<b>GSD</b> geometric standard deviation
<b>CGLP</b> current good laboratory practice	<b>HCFC</b> hydrochlorofluorocarbon
<b>CGMP</b> current good manufacturing practice	<b>HEPA</b> high-efficiency particulate air (filter)
<b>CIP</b> clean in place	<b>HPLC</b> high performance liquid chromatography
<b>CNC</b> condensation nucleus counter	<b>HVAC</b> heating, ventilating, and air conditioning
<b>COD</b> chemical oxygen demand	<b>ICP</b>
<b>CPC</b> condensation particle counter	<b>ICPMS</b> inductively coupled plasma mass spectroscopy
<b>CV</b> coefficient of variation	<b>I/O</b> input/output
<b>CVCM</b> collected volatile condensable material	<b>LALL</b> Low-angle laser light scattering
<b>dB</b> decibel	<b>LC</b> liquid chromatography
<b>DOS</b> dioctyl sebacate	<b>LCE</b> locally controlled environment (containment)
<b>DPC</b> discrete-particle counter	<b>LCL</b> lower confidence limit
<b>ESCA</b> electron spectroscopy for chemical analysis	<b>LSMD</b> light-scattering median diameter
	<b>MCA</b> multichannel analyzer (PHA)

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**MCP**  
microbe-containing particle

**MIMS**  
membrane introduction mass spectroscopy

**MMD**  
mass median diameter (of particles)

**MS**  
mass spectroscopy

**MSDS**  
material safety data sheet

**NTU**  
nephelometric turbidity unit

**NVR**  
nonvolatile residue

**ODP**  
ozone depleting potential

**ODS**  
ozone-depleting substance

**OEL**  
occupational exposure limit

**OPC**  
optical particle counter

**PCS**  
photon correlation spectroscopy

**PEL**  
permissible exposure limit (OSHA)

**PHA**  
pulse height analyzer (MCA)

**ppb**  
parts per billion

**ppm**  
parts per million

**PSL**  
polystyrene latex (spheres)

**PWP**  
particles per wafer (per) pass

**QELS**  
quasi-elastic light scattering

**RFI**  
radio frequency interference

**RMS**  
root-mean-square

**RO**  
reverse osmosis

**SAL**  
sterility assurance level

**SD**  
standard deviation

**SEM**  
scanning electron microscope

**SI**  
Système International d'Unités (International System of Units)

**SIP**  
sterilize in place

**SMIF**  
standard mechanical interface

**SPC**  
statistical process control

**SPM**  
scanning probe microscopy

**TLV**  
threshold limit value

**TNTC**  
too numerous to count

**TOC**  
total organic carbon

**UCL**  
upper confidence limit

**UF**  
ultrafiltration

**ULPA**  
ultralow penetration air (filter)

**UV**  
ultraviolet

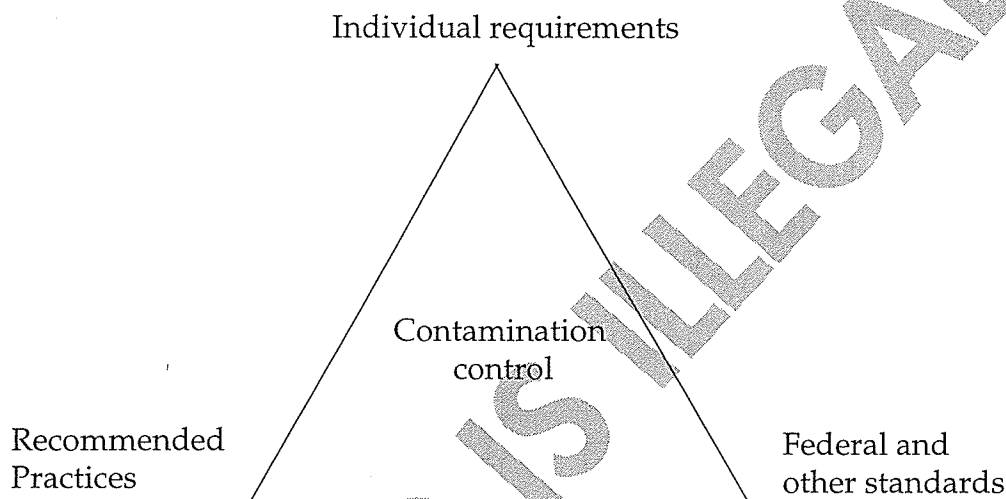
**VCM**  
volatile condensable material

**XPS**  
x-ray photoelectron spectroscopy

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## IEST RECOMMENDED PRACTICES

The use of Recommended Practices of the Institute of Environmental Sciences and Technology is a key factor in establishing and maintaining a comprehensive program of contamination control. Two other factors must also be taken into account: 1) the body of relevant documents extant, including those of the United States Government (such as *Federal Standard 209E*) and other professional organizations (such as ASTM and SEMI), and 2) the individual requirements of the various processes and products in the user's application. No one of these three factors is sufficient unto itself. Each is related to the others and depends on the others to make up a complete program. To use a graphical analogy, the three factors can be thought of as vertices of a triangle illustrating their interactive relationship in contamination control:



The installations, hardware, accessories, and techniques which support processes and products must be regulated to prevent or reduce contamination. The extent to which this contamination must be controlled is defined by the requirements of each individual process or product. When a program of contamination control is implemented in a comprehensive fashion—that is, by giving consideration to all three factors composing the triangle—the yields, reliability, and conformance to specification of process and product are improved.

The Institute of Environmental Sciences and Technology encourages the application of its Recommended Practices and encourages their integration into a comprehensive program of contamination control.

Recommended Practices result from the efforts of various Working Groups within the Institute of Environmental Sciences and Technology. These Working Groups are composed of persons from the technical community who volunteer their time and expertise. The chairmen of the Working Groups conduct the activities of the groups in accordance with guidelines set forth in the Institute's *Policy for Working Groups*. This procedure was established to assure a high level of technical content and to maintain appropriate representation on the Working Groups by both users and suppliers.

On pages 31 and 32, the Recommended Practices are listed both in numerical order and by subject areas reflecting various aspects of contamination control. The subject areas and their constituent Recommended Practices are continually being revised and augmented through the activities of the Contamination Control Division of the Institute.

For further information on the Standards and Practices program of the Contamination Control Division, contact the Institute of Environmental Sciences and Technology at 940 East Northwest Highway, Mount Prospect, Illinois 60056; telephone (847) 255-1561; fax (847) 255-1699.

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## IEST RECOMMENDED PRACTICES AND REFERENCE DOCUMENTS

*IEST-RP-CC001—HEPA and ULPA Filters*

*IEST-RP-CC002—Laminar-Flow Clean-Air Devices*

*IEST-RP-CC003—Garment System Considerations for Cleanrooms and Other Controlled Environments*

*IEST-RP-CC004—Evaluating Wiping Materials Used in Cleanrooms  
and Other Controlled Environments*

*IEST-RP-CC005—Gloves and Finger Cots Used in Cleanrooms and Other Controlled Environments*

*IEST-RP-CC006—Testing Cleanrooms*

*IEST-RP-CC007—Testing ULPA Filters*

*IEST-RP-CC008—Gas-Phase Adsorber Cells*

*IEST-RP-CC012—Considerations in Cleanroom Design*

*IEST-RP-CC013—Equipment Calibration or Validation Procedures*

*IEST-RP-CC015—Cleanroom Production and Support Equipment*

*IEST-RP-CC016—The Rate of Deposition of Nonvolatile Residue in Cleanrooms*

*IEST-RP-CC018—Cleanroom Housekeeping—Operating and Monitoring Procedures*

*IEST-RP-CC020—Substrates and Forms for Documentation in Cleanrooms*

*IEST-RP-CC021—Testing HEPA and ULPA Filter Media*

*IEST-RP-CC022—Electrostatic Charge in Cleanrooms and Other Controlled Environments*

*IEST-RP-CC023—Microorganisms in Cleanrooms*

*IEST-RP-CC024—Measuring and Reporting Vibration in Microelectronics Facilities*

*IEST-RP-CC026—Cleanroom Operations*

*IEST-RD-CC009—Compendium of Standards, Practices, Methods, and Similar Documents Relating to  
Contamination Control*

*IEST-RD-CC011—A Glossary of Terms and Definitions Relating to Contamination Control*

## SUBJECT AREAS OF IEST RECOMMENDED PRACTICES AND REFERENCE DOCUMENTS

When the content of a particular Recommended Practice (RP) pertains to more than one subject, that Recommended Practice is listed under all relevant subjects.

<u>Subject</u>	<u>RP Title</u>	<u>RP Number</u>
Clean air	<i>HEPA and ULPA Filters</i>	001
	<i>Laminar-Flow Clean-Air Devices</i>	002
	<i>Testing Cleanrooms</i>	006
	<i>Testing ULPA Filters</i>	007
	<i>Gas-Phase Adsorber Cells</i>	008
	<i>The Rate of Deposition of Nonvolatile Residue in Cleanrooms</i>	016
	<i>Testing HEPA and ULPA Filter Media</i>	021
Cleanrooms and clean environments	<i>Testing Cleanrooms</i>	006
	<i>Considerations in Cleanroom Design</i>	012
	<i>The Rate of Deposition of Nonvolatile Residue in Cleanrooms</i>	016
	<i>Cleanroom Housekeeping—Operating and Monitoring Procedures</i>	018
	<i>Electrostatic Charge in Cleanrooms and Other Controlled Environments</i>	022
	<i>Microorganisms in Cleanrooms</i>	023
	<i>Measuring and Reporting Vibration in Microelectronics Facilities</i>	024
	<i>Cleanroom Operations</i>	026
Chemicals and supplies	<i>Garment System Considerations for Cleanrooms and Other Controlled Environments</i>	003
	<i>Evaluating Wiping Materials Used in Cleanrooms and Other Controlled Environments</i>	004
	<i>Gloves and Finger Cots Used in Cleanrooms and Other Controlled Environments</i>	005
	<i>Substrates and Forms for Documentation in Cleanrooms</i>	020
Equipment	<i>Laminar Flow Clean Air Devices</i>	002
	<i>Testing Cleanrooms</i>	006
	<i>Gas-Phase Adsorber Cells</i>	008
	<i>Equipment Calibration or Validation Procedures</i>	013
	<i>Cleanroom Production and Support Equipment</i>	015
Terms	<i>A Glossary of Terms and Definitions Relating to Contamination Control</i>	011
Literature	<i>Compendium of Standards, Practices, Methods, and Similar Documents Relating to Contamination Control</i>	009

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