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Common Terminology used in Particle Counting

This paper defines the most common terminology used in particle counting.

Accumulative (Cumulative) Counts The summed or total counts for all particles in the specific channel as well as particles in the larger channels.

Aerosol Particles suspended in air or water-vaporized air.

Brownian Motion This is the random movement of small particles due to collisions with molecules. Generally, Brownian motion influences particles equal to or smaller than 0.1 micron (µm) diameter.

Capillary A transparent, small-diameter conduit through which sample fluid passes. Laser light passes through the capillary and illuminates the fluid to scatter light from particles. Commonly, the capillary's shape is a cylinder, made from glass or sapphire, and the diameter is about 0.7 mm (700 µm).

Channel A predefined storage bin designed for specific particle sizes. Channels are calculated by measuring a particle's scattered light and creating thresholds, which correlate the amount of particle scatter to the particle size. Example: particle counters display common channels as 0.2 µm or 0.3 µm.

Class (i.e.: Cleanroom Class*)* Cleanrooms or clean environments are often categorized in classes that define the quality of a cleanroom. Using the (obsolete) *FS-209e* standard, a cleanroom class was expressed as the maximum number of 0.5 µm particles per cubic foot; in the ISO standard, a cleanroom class is expressed as the maximum number of 0.1 µm particles per cubic meter.

Coherent Light This is a beam of light whose photons have the same optical properties (wavelength, phase, and direction). Coherent light is essential for particle detection because particles illuminated by different light sources will size differently.

Coincidence Loss When two or more particles are within a light source (e.g. laser) at the same time, a particle counter may not differentiate between the two particles and instead, assume there is one large particle present. This is called *coincidence loss* and is characterized by a distribution shift in particle data.

Counting Efficiency This is a measure of a particle counter's ability to accurately count the particles as they pass through the sample volume.

DC Light Liquid particle counters use lasers to illuminate the optical flow cell, chemical, and particles. DC light is a measure of the amount of background scatter.

Differential Counts The number of particle counts placed into a particular sizing channel. Specifically, only those particles greater than a channel's threshold, but less than the next channel's threshold, are considered differential counts. Although the definition appears similar to *raw* counts, differential counts can be displayed as normalized or raw particle counts.

Extinction Describes techniques for particle counting based on backlighting the viewing volume and analyzing the shadows cast by particles.

Federal Standard 209e (FS-209e) A US Government regulation that defined how cleanrooms were classified. FS-209e provided standards based upon particles in a volume of space with limits set for particles measuring 0.5

microns in 1 cubic foot. The FS-209e regulations became obsolete in 1999 and were replaced by International Organization for Standardization (ISO) regulations. ISO standards can accommodate particle sizes to 0.1 microns in 1 cubic meter.

Facility Net Particle Measuring Systems' software that collects data from particle counters, environmental sensors, or process-control systems. This data is useful for characterizing the operation of a facility, and the software is an elemental part of a facility monitoring system (FMS).

FMS An acronym for Facility Monitoring System, which is a system of computer hardware, software, and cables that monitors and controls all particle-counting equipment in a facility.

HEPA Filter An acronym for High Efficiency Particulate Air filters. HEPA flters remove 99.99% of particles at 0.3 µm.

Index of Refraction A complex number (a + bi), with the real numbers *a* and *b* describing how much light slows down, and the imaginary value *i* describing how strongly the material absorbs light. Typically, particle counters require index of refraction contrast between the particle and media is necessary for light scattering.

IQ/OQ/PQ Common acronyms for procedures used in pharmaceutical processes
IQ - Installation Qualification. Methods for instrumentation and testing installations.
OQ - Operational Qualification. Methods for how the instrumentation or test fixtures should operate.
PQ - Performance Qualification. Methods for how the instrumentation and test fixtures actually perform while under simulated tests.

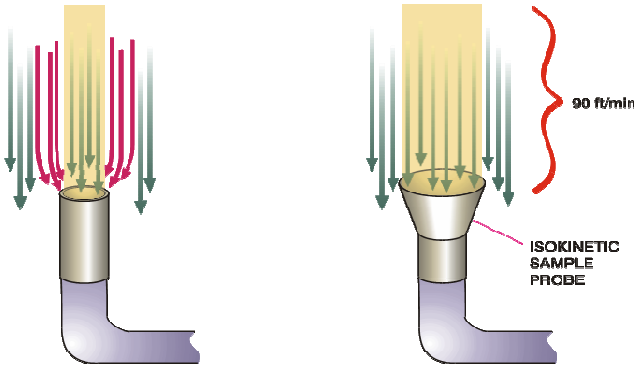
ISO (International Organization for Standardization) The world's largest developer of technical standards. The ISO defines procedures for testing, reliability, repeatability, and documentation. These procedures allow equal and fair trade between countries and provide governments with a technical base for health, safety, and environmental legislation.

ISO 14644 The procedures and protocols outlined in ISO-14644 are defined:

- ISO 14644-1: Classification of air cleanliness (cleanroom classes ISO 1, ISO 2, etc.)
- ISO 14644-2: Specifications for testing and monitoring to prove continued compliance with ISO 14644-1
- ISO 14644-3: Test methods for meeting ISO 14644 air cleanliness classifications
- ISO 14644-4: Procedures for design, construction and start-up of clean process facilities.
- ISO 14644-5: Operations of clean process facilities (cleanrooms or clean environments)
- ISO 14644-6: Vocabulary used in the procedures
- ISO 14644-7: Procedures for separate clean devices (clean air hoods, glove boxes, isolators and mini-environments)
- ISO 14644-8: Classification of airborne molecular contamination
- ISO 14644-9: Classification of surface particle cleanliness

Isokinetic Sampling Techniques for collecting airborne particles in which the collector is designed so the velocity at its face is the same as the velocity of the air stream. Isokinetic sampling is only important for larger, less easily deflected particles.

Specifically, if the collector's sampling velocity is too high (shown right), particles larger than about 2 µm fail to adhere to the normal flow lines and are captured; this is known as *positive sampling*. In the isokinetic case, only particles within the collector's sampling region are captured. If the



collector's sampling velocity is too low (not shown), positive pressure above the collector forces larger particles to bypass capture; this is known as *negative sampling*.

Light Scattering Occurs due to a change in the index of refraction. The amount of scattered light is proportional to the particle size.

Maximum Concentration Specification Defines a limit when many particles simultaneously traverse a light beam and the particle counter cannot accurately account for the distinct sizes. This specification is usually determined as the point when the particle losses exceed 5-10 %. This is also known as coincidence loss.

Minienvironment Similar to a miniature cleanroom and include air-filtering mechanisms, robotics for handling product, and an interface for process monitoring.

MPPS An acronym for Most Penetrating Particle Size and, defines the particle that is most likely to penetrate a filter media. When used as a term in filter efficiencies, the HEPA filters are rated with an MPPS at 0.3 µm and ULPA filters are rated with a MPPS at 0.12 µm.

Normalized Counts These are the particle counts existing in a sample volume. If the *raw* counts are known, divide them by the volume sampled and the answer will be defined as particles per volume (e.g. particles per cubic-foot or particles per cubic-meter).

Nominal Size The nominal size of a particle relates to a theoretical size that may vary from the actual size. For instance, if a particle distribution starts just below 0.3 microns and ends just above 0.3 microns, we say the nominal size is 0.3 microns.

OPC An acronym for optical particle counter.

Photodetector A device that detects light and converts the light into electrical pulses. These electrical pulses correlate to particle sizes; specifically, a larger particle scatters more light than a smaller particle, so the electrical pulse will be much larger.

PSL An acronym for Polystyrene Latex Spheres. Used for calibration particle counters.

Pulse Height Analyzer (PHA) A device that collects electrical pulses and correlates them to relative particle sizes.

Raw Counts The actual number of particles in a specific size channel.

Resolution Defines an instrument's ability to differentiate particles that are very close in size to one another.

Sample Interval A settable time limit to gather and analyze particle content. Particle counter manufacturers often suggest minimum sample intervals equal to one minute and maximum sample intervals equal to ten minutes.

Sample Media This is the air, liquid, or gas that contains particles and is analyzed by a particle counter.

Sample Volume A fixed amount of media passing through a particle counter, at a specific rate, and analyzed for particulate matter.

Saturation Commonly referenced when describing *maximum concentration specifications*. Saturation occurs when too many particles are present within a sample volume, so the instrument cannot accurately size the particles. When this occurs, the maximum concentration specification is met, and the instrument starts to erroneously count 5-10% (minimum) of the particles passing through the sample volume.

Sensitivity A particle counter's sensitivity is the smallest particle it can detect.

Sizing Error The difference between measured particle size and the actual particle size.

Spectrometer A type of particle counter that uses only the center, most-uniform section of the laser beam, which provides high accuracy, high resolution, and an improvement in signal-to-noise ratios.

ULPA Filter ULPA is an acronym for Ultra Low Particulate Air. These filters remove 99.9995% of particles at 0.12 µm.

Volumetric Commonly used to describe particle counters that examine the entire sample, as opposed to sampling only a small portion.

Zero-Count A value that states, in the absence of particle contamination, the background noise is sufficiently low enough and generate a minimal amount of particle counts.

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Steve Kochevar has a B.S. in Electrical Engineering from the University of Colorado. In 1994, he joined Particle Measuring Systems as a Field Engineer, responsible for instrument calibration, integration, customer support, and training. In 1999, after gaining experience with customer applications and product development, he assumed a role in Applications Engineering. His first responsibilities were to develop a new particle spectrometer and a particle counter that could be used for the newly-developing 300mm semiconductor processes. In the past couple of years, he co-authored Chapter 42, of the Semiconductor Manufacturing Handbook and edited The Basic Guide to Particle Technology. In addition to applications engineering and writing, he has lectured in the US, Europe, and Asia

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