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AIRBORNE PARTICLE COUNTERS AND HOW THEY WORK

Lighthouse Worldwide Solutions

Airborne Particle Counters

A particle counter is an instrument that detects and counts particles not visible to the naked eye. Particle counters operate on light scattering or light obscuration technology. A light source (typically a laser light) is used to illuminate the particle as it passes through the sensor. As the particle passes through, the laser scatters light.

Types Of Airborne Particle Counters

Particle counters are used to determine the air quality by counting and sizing the number of particles in the air. This information is useful in determining the number of particles inside a building or in the ambient air. It also helps to understand the cleanliness level in a controlled environment.

Cleanrooms are a typical environment that which airborne particle counters are used. Cleanrooms are used extensively in semiconductor device fabrication, biotechnology, pharmaceutics, aerospace, and other very sensitive fields to environmental contamination. Cleanrooms have defined particle count limits. Airborne particle counters are used to test and classify a cleanroom to ensure its performance is up to a specific cleanroom classification standard. Particle counter models come in different sizes for different applications.

Handheld particle counters – used in remote or some certification applications

Portable particle counters – used for cleanroom certification and can be used in particle monitoring systems

Remote particle counters – used in particle monitoring systems where product is made in sterile cleanrooms. Remote sensors are small and placed in critical locations to monitor for the duration of the process

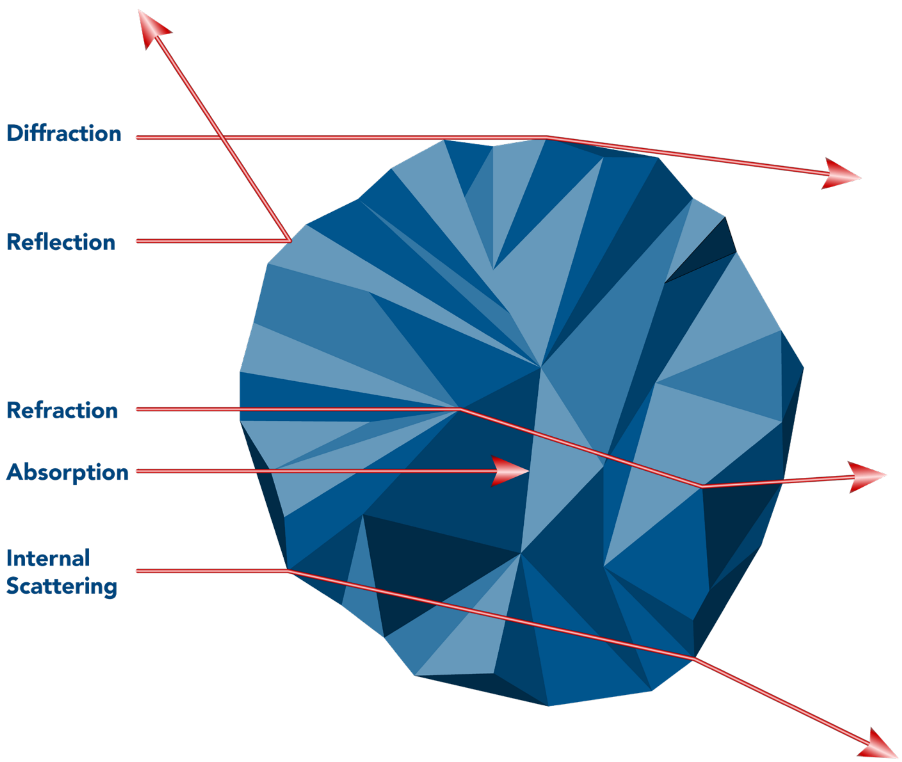
How light scatters on particles

The light scattering method is capable of detecting smaller-sized particles. This technique is based upon the amount of light that is deflected by a particle passing through the detection area of the particle counter.

This deflection is called light scattering. The typical detection sensitivity of the light scattering method is down to 0.05 microns or larger. However, the employment of the condensation nuclei counter (CNC) technique would allow a higher detection sensitivity in particle sizes down to the nanometer range. Most particle counters used in cleanrooms are typically in the 0.2µm to 10µm range for standard cleanroom applications.

Automobile industry applications range up to 100µm, where particle contamination in the spray paint booths can affect the paint finish quality.

This voltage is converted to represent the particle size in microns. The number of particles is then displayed in the particle channel sizes on the particle counter display. The data can be sent to a software system that shows the size and number of counts.

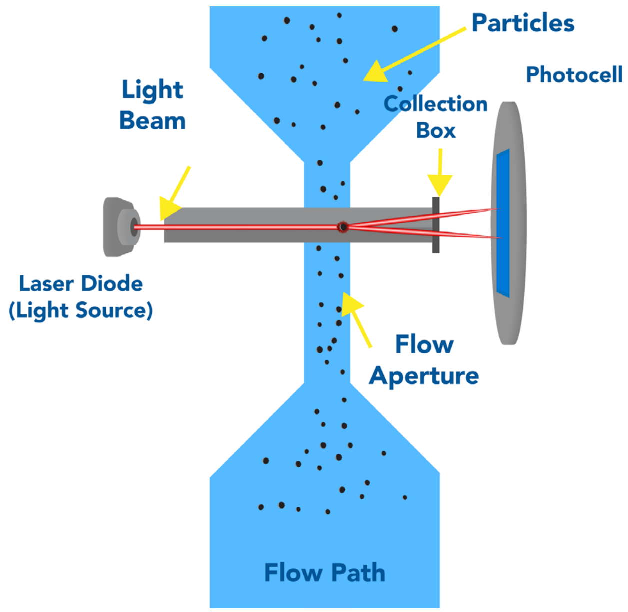


How light energy is converted into an electronic signal (Pulse)

As we can see here, the air sample is pulled through the particle counter via the sample inlet and vacuum.

In a particle counter, the air sample passes through the sensor, where particles reflect laser light. This scattered light energy is picked up by a photodetector which converts this light energy into a voltage proportionate to the size of the particle and the magnitude of light energy scattered.

The proportion of light scattered is directly proportionate to the size of the particle.



How Particles are detected by a Particle Counter?

In a cleanroom environment, HEPA filters are typically installed in the ceiling. A particle counter is used to verify that the air coming from these filters is clean and that contamination levels in the cleanroom due to people and processes, and equipment are acceptable levels based on Cleanroom Standards such as ISO 14644-1. A sample probe called an isokinetic sample probe (ISP) is used to ensure laminar flow conditions are maintained as the air sample is pulled in through the particle counter. Maintaining the flow rate of the particle counter is critical to accurate particle count data. Flow is part of the sensor calibration, and we can say that the flow is tuned into the sensor and has a role to play in light scattering and particle "dwell time" which will be explained later.

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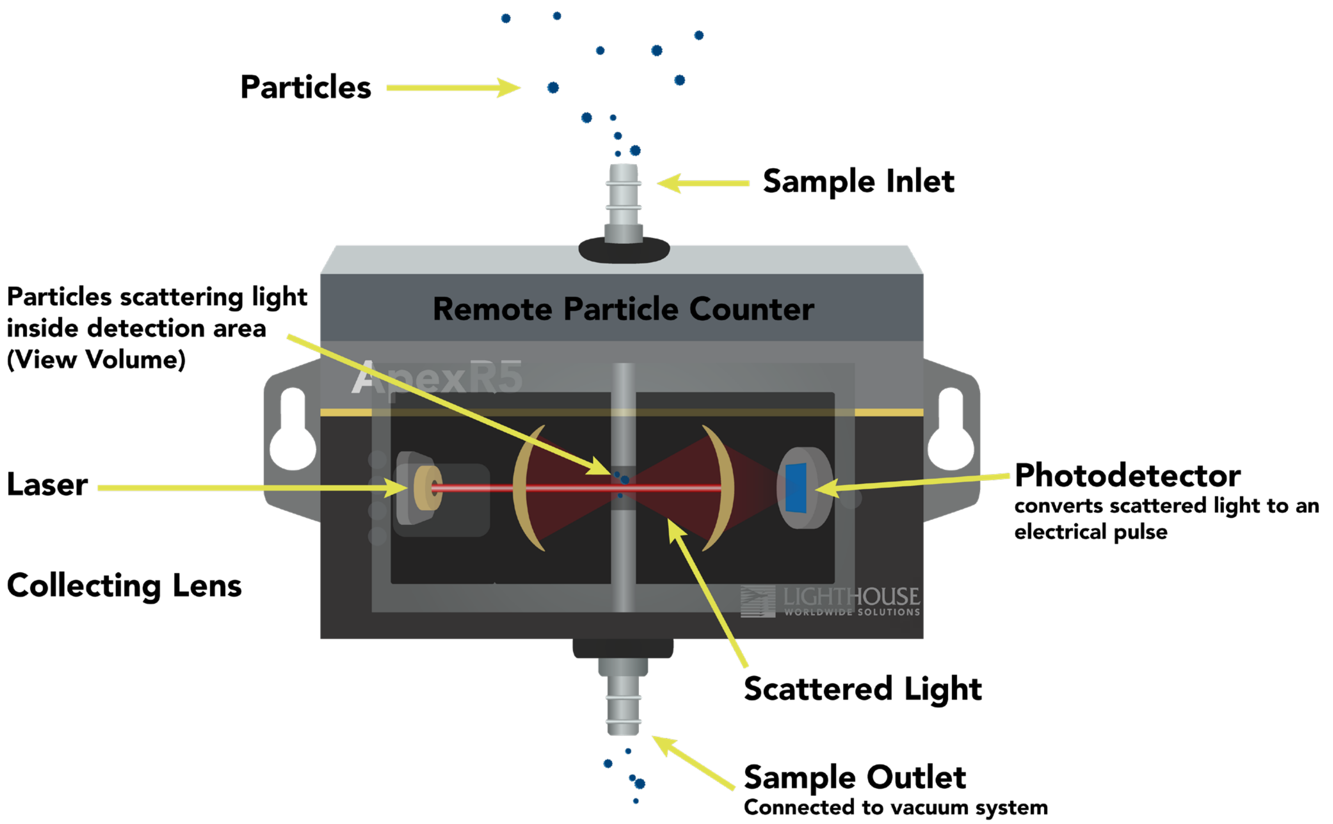
Looking at the diagram below, the particle is pulled into the particle sensor at a specified velocity (the fixed flow rate of the particle counter). The particle passes through laser light and scatters light inside the particle sensor, and a photodetector picks up this light energy. The photodetector converts this light energy into an electrical pulse. The magnitude of this pulse is proportional to the size of the particle and the amount of light scattered. It is important to note that different types of particles have different refractive indices. This means the composition of the particle will reflect light differently.



Dwell Time

When the particle is in the view volume, the dwell time in the view volume also determines the amount of light energy scattered. If the velocity of the particle counter is too high (outside of tolerance), then the dwell time is shorter than expected – less light energy is scattered. Therefore the photodetector picks up less energy and converts the lower light energy into a smaller particle size. Hence, the higher flow rate (particle velocity) causes a sizing error, and the particle is seen as a smaller one by the particle counter. The inverse is true if the flow rate is lower than specified the particle would be sized larger than it actually is.

Particle Counter Laser 1

The particle counter laser is the light source used to illuminate the particles passing through the view volume inside the sensor. The laser light needs to be at a certain magnitude (power) to successfully illuminate the minuscule particles the particle counter is rated to detect.

Particle Counter Photo Detector 2

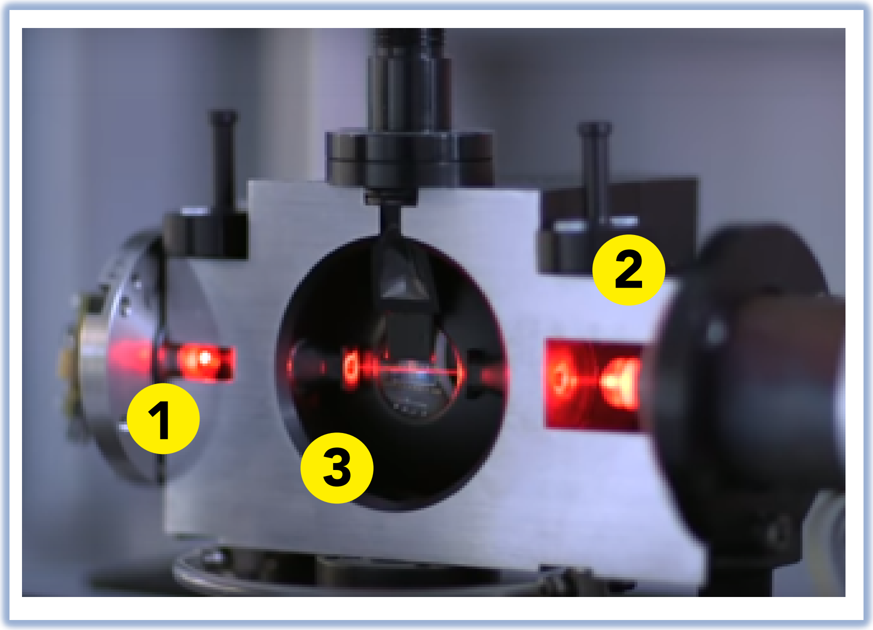
The particle counter photodetector converts the scattered light into a voltage. This voltage is passed through the particle counter's digital circuitry, and the magnitude of the voltage determines the size range the particle will fall into. Remember, scattered light is proportional to the size of the particle.

Particle Counter View Volume 3

The view volume is the space where the laser and the sample flow path converge. The flow path is narrowed down from the sample inlet to a fine sheath of air that passes through the laser.
The alignment of the laser and the flow path is critical to particle counter accuracy. In calibration counting efficiency testing can detect if this alignment is out by comparing the counting ratio to that of a reference particle counter which has a higher sensitivity.

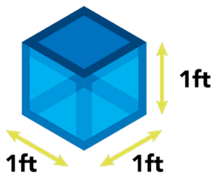
Particle Counter Flow Rate

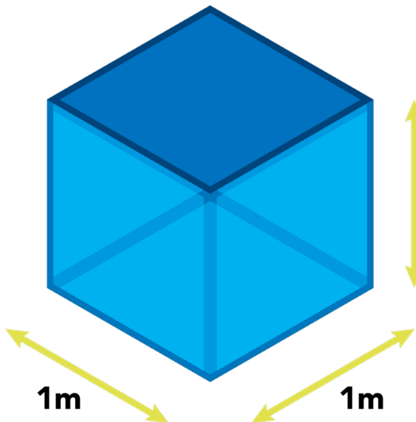
As the particle passes through the view volume, the flow velocity must be maintained within the specified flow rate of the particle counter. This velocity is an essential factor and is some of the reasons isokinetic probes and high-pressure gas diffusers were designed and implemented.



Sample Volume

The sample sizes taken for monitoring purposes using automated systems will usually be a function of the sampling rate of the system used. It is not necessary for the sample volume to be the same as that is used for the formal classification of cleanrooms and clean air devices.





The Zero Count Filter

The Zero Count filter is used to verify that the sensor is clean from any particles. At the end of a standard sample, the internal vacuum is turned off when the sample is completed. The air sampled could contain particles that may be recirculated and counted the next time the particle counter is used.

To prevent this, it is recommended to purge the sensor using a zero count filter. This purging may take a few sample cycles, and ISO 21501-4 has criteria for zero counting in its standard; however, the particle counter should clean up in a few sample cycles.

Summary

There are three main types of particle counters, but they all work in similar ways. Particle counters need airflow through the inlet and use a light source to illuminate particles that pass through the view volume; when the light strikes a particle, the light is then scattered, which is converted into a signal by the photodetector telling the particle counter what size the particle is and what channel to count the particle on. These are the principles in which an airborne particle counter work. To learn more about particle counting technology visit our Knowledge Center.

Maximum Concentration Limits (Particles m³ of air)

ISO Classification Number (n)	0.1µm	0.2µm	0.3µm	0.5µm	1.0µm	5.0µm
ISO 1	10	d	d	d	d	e
ISO 2	100	24	10	d	d	e
ISO 3	1,000	237	102	35	d	e
ISO 4	10,000	2,370	1,020	352	83	e
ISO 5	100,000	23,700	10,200	3,520	832	d, e, f
ISO 6	1,000,000	237,000	102,000	35,200	8,320	293
ISO 7	c	c	c	352,000	83,200	2,930
ISO 8	c	c	c	3,520,000	832,000	29,300
ISO 9	c	c	c	35,200,000	8,320,000	293,000

NOTES