GETTING DATA YOU NEED WITH PARTICLE MEASUREMENTS

APPLICATION NOTE ITI-075 (A4)

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Particles, large and small, are an important factor in maintaining good indoor air quality. Control measures, such as improved housekeeping, upgraded filters, or proper exhaust design, are usually straightforward actions. However, choosing the proper control depends on having the correct data for decision-making. Many instruments, employing various technologies, are currently available to provide this real time information. The question is “Which technology is right for my application?”

Photometers, optical particle counters (OPCs) and condensation particle counters (CPCs) all measure airborne particles in real time. Each technology has a unique sensitivity to specific particle characteristics such as size, mass and refractive index. Table 1 summarizes the basic performance differences. Note in particular the size range for each and the upper limit of the number concentrations between OPCs and CPCs. Table 2 summarizes typical applications for each measurement technology.

TABLE 1. Comparison Chart—Real Time Particle Measurement Technologies

	Photometer	OPC	CPC
Typical Size Range	0.1 to 10 µm	0.3 to 20 µm	0.02 to 1.0 µm
Measures Particle Mass	Yes	No	No
Measures Particle Size	No	Yes	No
Detects Single Particles	No	Yes	Yes
Typical Mass Concentration Range	0.01 to 100 mg/m^3	N/A	N/A
Typical Number Concentration, Upper Limit	N/A	2×10^6 Particles/ft^3 70 Particles/cm^3	1.5×10^{10} Particles/ft^3 500,000 Particles/cm^3

TABLE 2. Comparison Chart—Applications (Accepted Best Practice)

	Photometer	OPC	CPC
Indoor Air Quality - Conventional studies	Good	Good	Excellent
Indoor Air Quality - Ultrafine particle tracking	Poor	N/A	Excellent
Industrial Workplace Monitoring	Excellent	Poor	Excellent[1]
Outdoor Environmental Monitoring	Good	Good	Excellent[1]
Emissions Monitoring	Excellent	Poor	Good
Respirator Fit Testing	Excellent	Poor	Excellent
Filter Testing	Excellent	Excellent	Excellent
Clean Room Monitoring	Poor	Excellent	Excellent

[1] Health effects of ultrafine particles (below 0.1 µm) are not completely understood, though research suggests that they may cause the greatest harm. There are currently no established exposure limits or governmental regulations specifically addressing ultrafines.

Photometers

Often used for industrial workplace studies and emissions monitoring, photometers are well-suited for assessing human exposure to specific size fraction aerosols in real time. They use conventional light-scattering technology to closely estimate particulate mass concentrations.

The operation of a typical photometer is shown in Figure 1. A sample is drawn into the instrument by a continuously running pump. The size fraction of interest is aerodynamically "cut" from the air stream at the sample inlet using either an impactor or a cyclone. The size fractions of most interest are respirable, thoracic, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$.

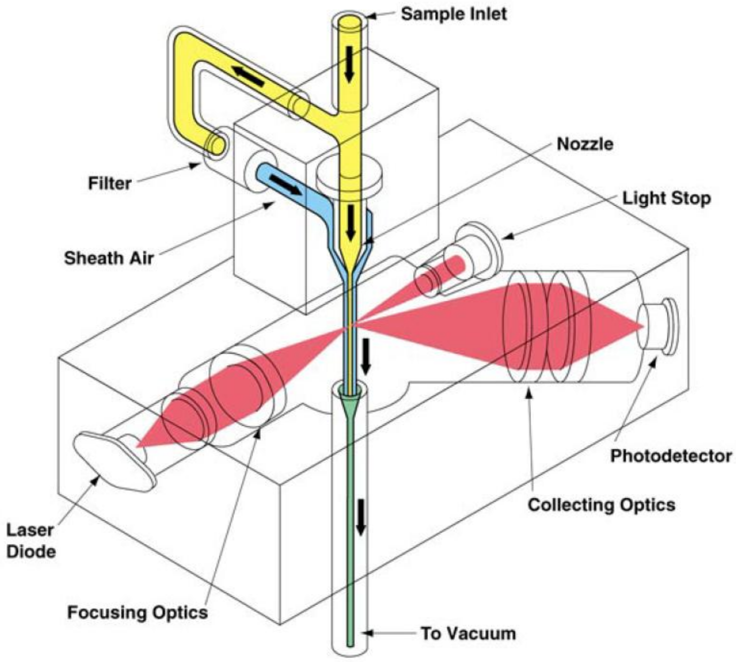

Figure 1
Flow Through a Photometer

The size-classified sample passes through a focusing nozzle and enters the photodetector sensing chamber. A laser diode emits light through a set of focusing optics. As light contacts the sample particles, it is scattered in all directions. A photodetector converts this light into a voltage, which is calibrated against a known aerosol mass concentration (mg/m^3). In some instruments, a portion of the sample is drawn from the main air stream, filtered and re-introduced as sheath air. The sheath air surrounds the particle sample to protect the instrument's optics from fouling.

Most photometers are calibrated against a standard test dust, commonly referred to as Arizona Road Dust. This calibration is a good approximation for most ambient aerosols. Because optical measurements are dependent upon particle size and material properties, there may be times in which a custom calibration would improve the accuracy for a specific aerosol.

Optical Particle Counters

Optical particle counters measure particle size and number concentration by detecting the light scattered from individual particles. They were traditionally used for clean room monitoring, but have more recently found application in filter testing, outdoor environmental monitoring, and indoor air quality studies.

Single particles are drawn through a focused laser beam and produce a flash of light, as illustrated in Figure 2. The intensity of the scattered light is a complex function of the diameter, shape and refractive index of the particle as well as light wavelength and geometry of the optical detector. A photodetector measures the amount of light that each particle scatters and records a count for each calibrated size range or bin.

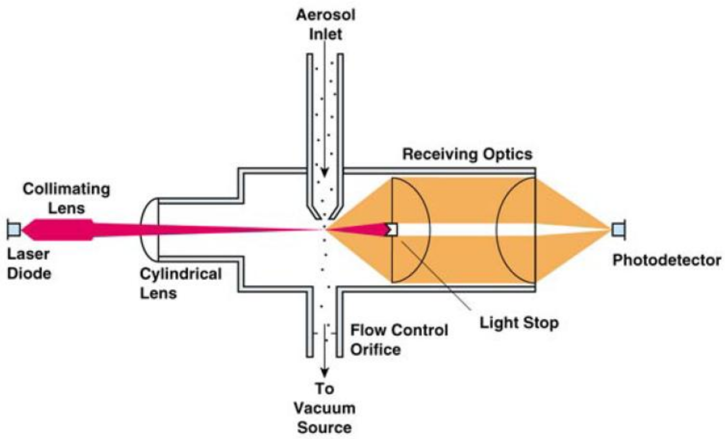

Figure 2
Flow Through an Optical Particle Counter

The measured size range is typically 0.3 to 20 µm diameter, and the number concentration is limited to a maximum of 2,000,000 particles/ft^3 (70 particles/cm^3). OPCs are calibrated with perfectly uniform, spherical polystyrene latex bead particles of known refractive index. The measured size of an unknown particle is therefore the “light-scattering equivalent size” as compared to the known calibration particle. The actual physical size may be quite different from this.

Condensation Particle Counters

Condensation particle counters, sometimes referred to as condensation nuclei counters, are specialized instruments that first enlarge very small particles to an optically detectable size. They excel at counting particles in size ranges that are invisible to OPCs and photometers. CPCs are used for a variety of applications ranging from respirator fit testing to environmental air pollution studies to basic research. They are particularly well-suited for tracking indoor pollutants to their source.

As depicted in Figure 3, particles are continuously drawn into the instrument and passed through a warm alcohol vapor. The mixture then flows through a condenser section where the alcohol vapor condenses onto the particles and “grows” them into larger droplets. The individual droplets then pass through the focal point of a laser beam, producing a flash of light. Each light flash is counted as one particle.

The measured size range is typically from below 0.02 to above 1.0 µm diameter. Number concentration ranges from zero to more than 500,000 particles/cm^3 (15,000,000,000 particles/ft^3). The concentration measurement does not depend on the size or material properties of the particle.

All three types of instruments—photometers, optical particle counters, and condensation particle counters—have their place in IAQ investigations. Matching the appropriate technology with your particular application will provide the data you need to understand and improve your building's air quality. Photometers, which measure mass concentration, provide the necessary data to compare against air quality standards and guidelines. OPCs give additional understanding of particle number concentrations and size ranges of the mid-sized particles to help identify the probable source and health impact. Finally, CPCs offer insight into the ultrafine particles that are now emerging as an important new IAQ metric that may play a significant role in the health and comfort of building occupants.

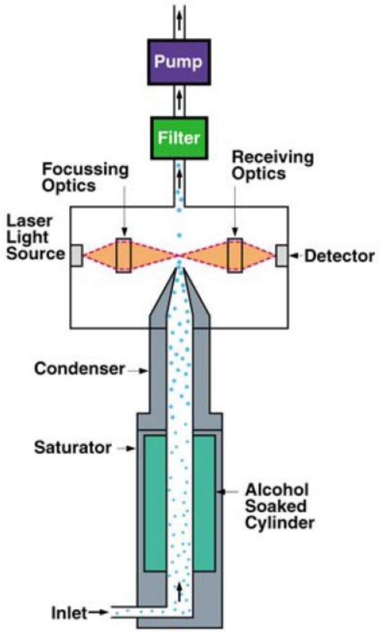

Figure 3
Flow Through a Condensation Particle Counter

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