

# *Application Note*

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***Maintaining Validation  
and Calibration***

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# Validation, Calibration Assure Investigation Accuracy

*by Jim Akey, East Coast Sales Representative, Lighthouse Worldwide Solutions*

In 1984, I purchased a '77 charcoal gray, Datsun 280Z from a college buddy of mine. I was two years out of college, had a decent paying job, and had just purchased a really cool, fast car! What more could a young, single guy want? I think I washed that car on a weekly basis, kept it waxed, put in a killer stereo system, and loved to cruise around!

About a year later, my “baby” started running a little rough. I checked the spark plugs and found they looked good. I did notice that the car had gotten some dirt on it, so I washed the car and kept on driving. Shortly thereafter, I noticed some green fluid on the ground where I parked the car. I went to the auto store and got some of that “fix-a-leak” stuff that you pour into the radiator. It plugged the leak like a charm! There was no more radiator fluid on the ground. I was so happy that the car was no longer leaking; I just washed it and hit the road. Dang, that car sure looked good!

By now, you can probably guess where this story is leading. That’s right – it wasn’t a month or so later that the engine seized up. Could this have been prevented?

*Of course* it could have been prevented – with proper maintenance.

Having the correct instrument for the job requirement is vital to the ultimate success of the project. Imagine how difficult our daily tasks would be without these instruments? Or worse yet: What if an instrument appeared to be working but was giving us faulty or incorrect data?

A wide variety of scientific instruments are used on a regular basis to assist in our daily IAQ investigations. Moisture meters, temperature and relative humidity probes, infrared cameras, and particle counters all have a couple of things in common. First, they are invaluable assets for successful completion of our day-to-day jobs. Second, they all are finely tuned instruments that require scheduled maintenance and calibration.

Unfortunately, proper maintenance and calibration of our instruments are often overlooked, which can lead to inaccurate data being recorded and reported. As is often the case, the results of our investigations are used to assist our customers to have improved, healthier living conditions. Remember, there is always the possibility that our findings will end up in our judicial system. Let’s make sure that the data we are reporting is accurate!

“When conducting an investigation, you are building a chain, and it will only be as strong as its weakest link,” Jody Thomason, the director of product development at Aerotech Laboratories Inc., once said when discussing the importance of maintenance and calibration. He also said an investigator’s credibility could be called into question; if an investigator cannot maintain his instruments properly, what else might he or she be doing incorrectly?

## **Traceability**

The term “traceability” is often heard when describing electronic instruments and their associated calibrations. The voltmeter you are using is NIST-traceable. If the voltmeter is configured to read down to millivolts, then it was calibrated by a meter that is capable of reading in microvolts. The same goes for particle counters. They are calibrated against a particle counter with a lower minimum sensitivity.

I mentioned above that oftentimes, the findings from our investigations are used in a court of law. If readings from a particle counter are used as part of the investigation, then we had better be sure they are accurate. I don’t think the judge or opposition, when questioning the accuracy of these findings, would settle for “Jim Akey said the instrument is calibrated, so it must be!” This is one reason a valid calibration certificate should be kept on file for each instrument. What good is a calibration certificate if the methods used to calibrate the instrument are not recorded and traceable? Traceability means that each instrument used in the calibration of the instrument is recorded and has its own calibration certificate from the manufacturer. This chain leads back to instruments certified by the National Institute of Standards and Technology (NIST).

## Theory of Operation

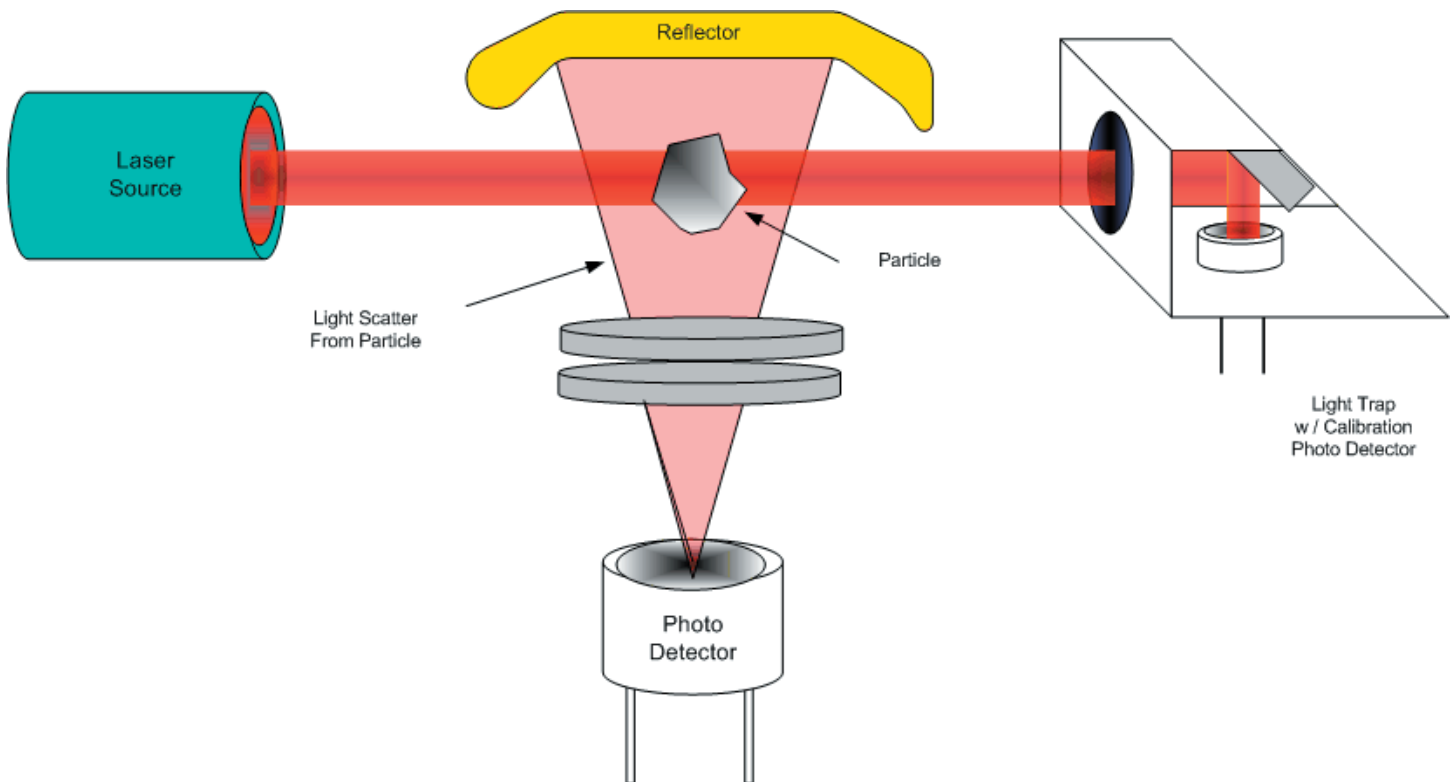
To emphasize the importance of maintenance and calibration, take for example the operation of a handheld particle counter. Air and the particulates in it are drawn into the counter by an internal pump at a controlled rate of flow – generally 0.1 cubic feet per minute. The air passes into the sensor area and through a tightly focused light beam created by a laser diode. The amount of light reflected from each particle is measured electronically. The larger the particle is, the larger the amount of reflected light. In this way, we can size and count the particles with amazing accuracy.

At this point, you may be thinking: That sounds pretty straightforward and simple, right? Let's look a little closer.

Particles that are visible to the unaided human eye start at around 30 microns, depending upon conditions such as ambient lighting, and the strength and clarity of the eye. Most handheld particle counters are capable of "seeing" particles 100 times smaller than that – 0.3 microns! One handheld counter has a minimum sensitivity of 0.2 microns, and generally, portable instruments have a minimum sensitivity of 0.1 microns. There is obviously some pretty impressive stuff happening inside particle counters!

The most important components of a particle counter are the optics and related electronics. Many things are happening simultaneously when a particle counter is operating. Inside the sensor, a light source (most commonly, a laser diode) is illuminating a flow nozzle. Directly opposite the laser is a light trap to absorb direct light. The flow nozzle directs the particles through the laser. As this happens, the particles scatter (or reflect) the light. This reflection is directed towards the photo detector by the light collection optics. This is demonstrated in Figure 1.

**Figure 1**



Each time a particle passes through the laser, the amount of light reflected is measured by the electronic pulse it generates. These voltage pulses are proportional in amplitude to the particle's size. The counter detects the pulse's peak height and counts the number of pulses, thus sizing and counting the particles. In multiple channel particle counters, bins are established for the different particle sizes. The instrument compares the pulse height to the voltage thresholds for each bin to ensure proper placement (sizing) and counting.

The sensor output and counter thresholds are measured in volts. Simply put, calibration is the process of determining what voltage corresponds to a particle size, and setting the voltage thresholds in the counter.

## **Calibration and Maintenance**

Now that we know how a particle counter operates, let's look into why periodic maintenance and calibration are so vital. As I mentioned, the optics portion of the particle counter is very important. Remember, the key components of the sensor are the laser diode, the light collection optics (mirror), the flow nozzle and the detector.

As the internal vacuum pump is drawing air into the sensor, particles are introduced into the sensor area. What happens when the pump finishes the count cycle and shuts off? Particles remain in the instrument. Over time, these particles build up, collecting on the laser diode and mirror.

Have you ever looked in a mirror that is really dirty? Your reflection is distorted, and you can't see yourself clearly. When the mirror inside the particle counter becomes coated with particles, the same thing happens. Not all of the light is reflected back towards the detector, and incorrect sizing of particles occur.

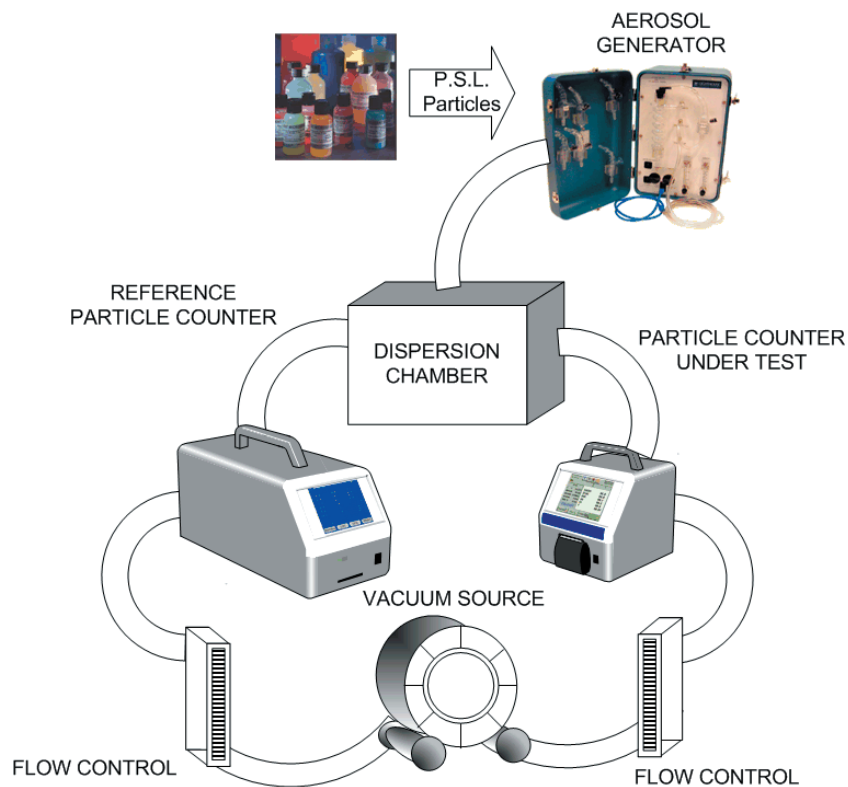
Have you ever been in a musty attic or basement and seen a light bulb with dirt and grime all over it? It does not emit much light, does it? The same thing will happen if large amounts of particles settle on or around the laser diode.

The same amount of light is not illuminating the particles as when the instrument was originally calibrated. Regular use of the purge or "zero count filter" will assist in keeping the sensor area free of particles. Contact the manufacturer of your particle counter if you are unsure how to use the filter properly.

Annual calibrations are extremely important for particle counters and the many other types of electronic instruments that we use. Most particle counters are calibrated to the JIS B9921 and ASTM F 328-98 standards. There are a number of key specifications that are addressed during calibration per the aforementioned standards; these are counting efficiency, size accuracy, zero count and flow rate.

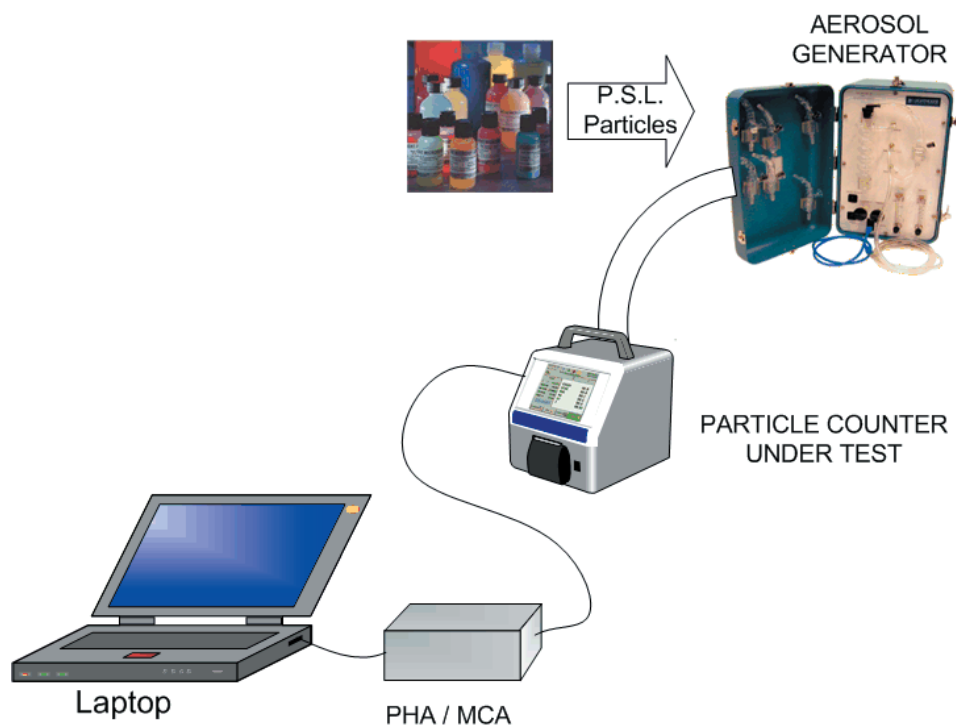
A common counting efficiency measurement test that is often run to ensure correct sizing and counting is shown in Figure 2 below. Using a diluted PSL (Poly Styrene Latex spheres) solution, the aerosol generator will atomize a near mono-dispersed aerosol. The near mono-dispersed aerosol is run through a dispersion chamber where the aerosol is given more time to dry and to mix. This step provides a more even distribution. The aerosol stream is split into two even flow streams and fed into both the instrument under test and the standard instrument. The sample tubes from the dispersion chamber to the particle counters are the same length to assure even airflow. The number of particles counted by the test instrument is then compared to the number of particles counted by the reference counter.

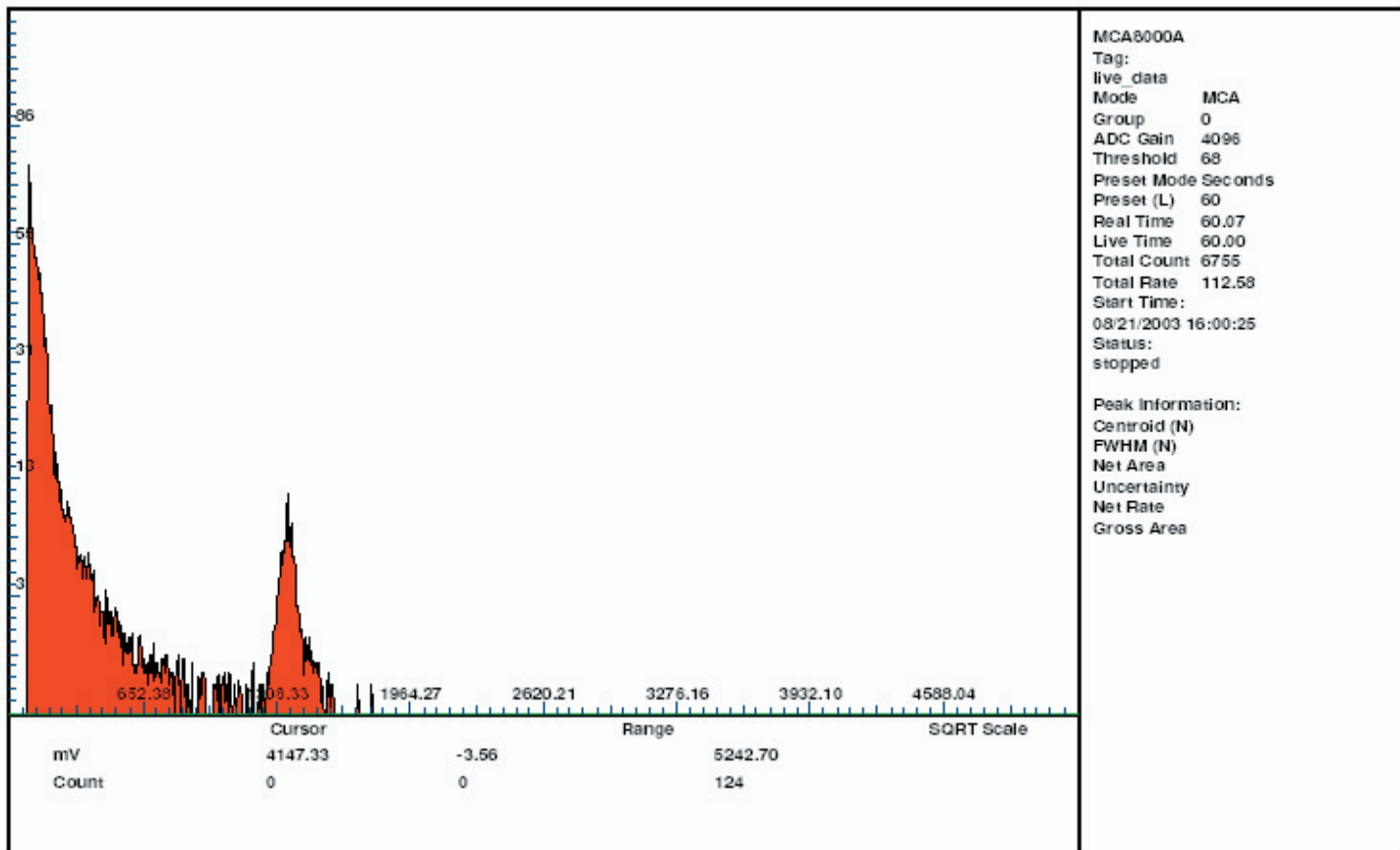
**Figure 2: Comparison to a Standard**



Size calibration or verification is another test run to ensure correct counting. Figure 3 shows a typical test setup. Using a diluted PSL solution, the aerosol generator will atomize a near mono-dispersed aerosol. The mono-dispersed aerosol is run through the instrument under test directly from the aerosol generator. The pulse height analyzer software will count and display the distribution of particles.

**Figure 3: Calibration With Spheres**





**Figure 4: Distribution Curve**

A distribution curve will display that will distinguish the background electronic noise from the actual particle pulses. A typical distribution curve is shown in Figure 4.

Zero count verification and flow rates are also checked during calibrations, as well as internal filter replacement. During calibration, many manufacturers perform any applicable upgrades to the instrument. The overall “health” of the instrument is inspected, much like a tune-up for your motor vehicle.

## Conclusion

Speaking of the vehicle whose story started this article...

The mechanic could not even start the car to perform diagnostics. He informed me that because the engine was so badly damaged, repair would require a complete engine rebuild. The cost of the rebuild was something like \$3,200. Of course, I didn't have that kind of money, so I ended up selling the car to that mechanic. I often wonder what would have happened if I had properly maintained the vehicle.

You have spent many hours and a large sum of your hard-earned dollars to equip yourself with the available tools and instruments that make you successful. Unless you really enjoy the experience of purchasing new instruments, you should take a little time and have the proper maintenance performed on the tools of your trade.

*Jim Akey is responsible for inside sales with the state-of-the-art manufacturing facility of Lighthouse Worldwide Solutions (www.golighthouse.com), a recognized leader in the design and manufacturing of aerosol particle counters. Akey holds a bachelor's degree in business and has 18 years experience within the electronics and scientific instrumentation fields. He has participated in numerous IAQ investigations. A presenter at the National Air Duct Cleaners Association's technical seminars, he is an active member of the Indoor Air Quality Association.*

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