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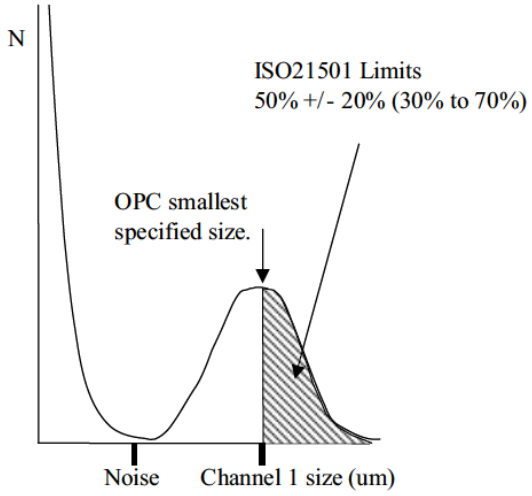
Prior to ISO 21501 (first released in May 2007), it was not required counting efficiency to be checked at each calibration interval. Which raise the question, would equipment designed before that date comply…?

Counting Efficiency

Airborne particle counters typically feature a number of size channels into which particle counts are binned, each channel being calibrated to count particles greater than a specific particle size. Particle sizes are typically expressed in microns (µm). The term "counting efficiency" primarily refers to the ability of the airborne particle counter to count particles at a specified size. Typically, calibration involves passing a continuous stream of standard, mono-sized particles through the particle counter sensor, which results in a stream of electrical pulses, each pulse being proportional to the size of each particle. The mono-sized standard particles produce a distribution of pulse heights, the median of which is typically regarded as the appropriate channel calibration threshold for that size. Therefore, in the real world a particle exactly the same size as a given channel would have a 50% probability of being counted (see Figure 2a). As a result, particle counters calibrated in this manner are said to have a counting efficiency of 50%. Note however that this does not mean that the OPC will only count half of the particles in the real world.

ISO 21501 makes use of the specification for counting efficiency accepted in the JIS B 9921 standard. This states that the counting efficiency should be 50% ±20% (i.e. between 30% and 70%) in the first channel (Figure 2a). Additionally, particles of between 1.5 X to 2.0 X the channel 1 particle size should be counted with an efficiency of 100% ±10% (i.e. between 90% and 110%) in the first channel (Figure 2b.)



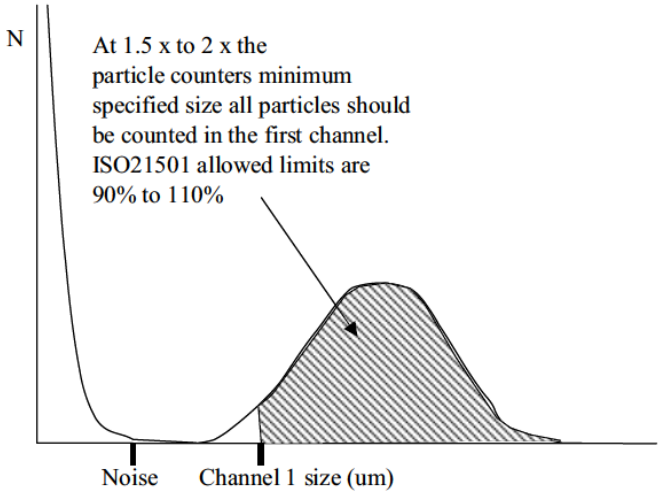


Figure 2a: The 50% calibration point **2b: Verifying 100% efficiency at a higher size**

The governing factor of the CE numbers is the Particle Size settings which are established during particle size/channel calibration, wherein calibrated particles of specific sizes relative to the nominal channel sizes are introduced into the counter and the particle size responses measured using pulse height analysis.

Using a pulse height analyser (PHA) the median response of the calibration reference particle size distributions are calculated back to the nominal channel size which determines the specific channel threshold size setting for a particular channel size.

This size setting is the point from which all particles and larger (cumulative counts) are counted in any given size channel. The particle size calibration procedure is perhaps the most important aspect of the calibration as it determines the PASS/FAIL result in As Found Size Error (±10%) or instrument accuracy. A 'FAIL' result in As Found Size Error will indicate undercounting (positive number error) or overcounting (negative number error). The CE results are solely a consequence of the particle size calibration, furthermore Counting Efficiency cannot be adjusted to meet the 50% ±20% and 100% ±10% limits imposed by ISO21501-4:2018. The results of the CE test cannot be used by the end user (for example Count Correction, e.g. a 50% CE does not mean the 0.50µm counts should be multiplied by 2 to obtain the correct counts).

The 100%CE results are derived from counts obtained in the 0.50µm channel using 1.0µm particles so the 1.00µm counts in the 0.50µm size channel will always be somewhere in the region of 100%. Again, this is of little benefit to the end user. Failure of a CE limit does not necessarily mean failure of particle size error. In other words, Counting Efficiency (50% ±20%, 100% ±10%) is **not** a measure of particle size error failure nor does it have any bearing on the latter.

Our argument is that if Size calibration is normal (no significant change between calibrations), distribution peaks look normal (not distorted), sensor noise is normal there's a 99.9% chance of passing counting efficiency.