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Which Particle Counter is Best for You?
Measurement of Ultrapure Water (UPW) and Ultra Clean Fluids

The purity of water and chemicals used in the semiconductor industry has improved dramatically, creating near particle-free environments. The ITRS roadmap for the future shows continued decreasing line widths and a corresponding decrease in the critical particle size.

The increasing cleanliness of liquids and the decreasing critical particle size has caused a corresponding increase in particle counter capability and cost. It is therefore important to balance cost against features. The issue when purchasing a particle counter for ultrapure water or ultra clean fluids is whether the objective is to monitor only for alarming of extreme out-of-spec conditions or to monitor both for alarming as well as trend analysis. Today, particles are typically monitored at 0.05 microns in UPW and 0.065 microns in liquid chemicals. There are relatively few particles and it is not uncommon to encounter particle concentrations of these sizes at less than 1 particle/mL or even less than 0.2 particles/mL. The high sensitivity particle monitors required to detect these very small particles have a significant drawback in that they only examine a very small percentage of the total fluid flowing through their sample cells. The smaller the amount sampled, the less data you collect, and the longer it takes to gather sufficient data to be statistically significant.

Therefore, if the purpose of monitoring is for alarming purposes only, a lower flow particle counter such as the HSLIS M50e is adequate. But if the desire is to monitor data trends, then a higher flow counter such as the Ultra DI®50 is required.

Figure 1: HSLIS M50e low flow particle counter for alarming.

Monitoring for Alarming Only: HSLIS M50

Instruments with small sample volumes can be used to detect extreme out-of-spec problems. The HSLIS M50e (Figure 1) has a flow rate of 100 mL/min but only examines

0.25% of this flow. This results in a measurement sample volume of 0.25 mL/min. Various competitor products in the market examine even less, typically 0.1 mL/min. This sampling rate affects the length of time required to gather results and therefore the amount of sample monitored over a specific period.

Assuming the particulate concentration of the UPW is 0.5 particles/mL >0.05 microns, what size of sample is needed to collect meaningful data? In other words, what sample size is representative of the liquid tested? Sample size and analysis time are inextricably linked. If the analysis time is too short and very few particles are counted, then the sample-to-sample repeatability will be very poor. If the analysis time is too long, then the analyst will be blind to changes in the process between sample intervals. These concerns can be addressed with a simple examination of expected purity of the liquid chemical, the sample volume of the particle counter, and counting statistics. Counting statistics predicts the repeatability when a certain number of raw events are measured. The precision expected is the square root of the number of raw counts divided by the total number of raw counts.

Precision Percentage = √ (# raw counts) / # raw counts)

For example, if a 20% relative standard deviation is desired, then 20 counts must be measured during the sample interval (square root of 20 is 4.47 and divided by 20 = 22%). The conditions cited above (0.5 cts/mL concentration and a sample volume of 0.25 mL/mn) predict that we would need 160 minutes to detect 20 particles. It should be noted that only 40 mL of fluid would be examined during this entire time. Since the time interval is too long to be practical, the M50 is more suitable for alarming, rather than trending.

Cosmic Rays

Cosmic rays also affect results. Cosmic rays impact the detector about once per minute and are indistinguishable from particles due to the nature of the optical particle counter (i.e.: examining light scattering produced from particles). Although the particle counter anticipates and corrects for this, the measurement accuracy is affected especially for units with low sample volumes. This further deteriorates the quality of the data for low sample volume counters and effectively eliminates them from providing useful information for monitoring data trends.

Figure 2: Ultra DI high flow particle counter for trend analysis

Trend Analysis

Collecting repeatability data for trend analysis requires more raw counts per minute than low sample volume particle counters can provide. Counters with medium sample volumes of 1 to 10 mL/min can meet this need, however the Ultra DI50 (Figure 2) with a sample volume of 3.75 mL/min is in this category. In the example cited earlier, the time to measure 40 mL of fluid (for an average of 20 particles) is only 10 minutes with a Ultra DI50. This is contrasted to an alarming device such as the HSLIS M50 which requires 160 minutes to produce the same data (see the table below).

Particle Counter	Sample Volume	Time to Measure 1L Fluid	Time to Measure 40mL Fluid
Ultra DI50	3.75 mL/min	4.4 Hours	10.6 minutes
HSLIS M50	0.25 mL/min	2.8 Days	2 Hours 40 minutes
Competitors	0.1 mL/min	6.9 Days	6 Hours 40 minutes

Table 1: Sample volume rate differences between particle counters affects the time needed to measure a specific volume of fluid. If the particle concentration is 0.5 particles/mL, only 20 particles will normally be detected in a 40 mL volume.

Table 1 highlights the differences between the technologies available today. The ideal liquid monitoring strategy is to combine alarm devices such as the HSLIS M50 and higher precision monitors such as the Ultra DI50.

Conclusion

Before purchasing a particle counter it is important to understand the goal of particle monitoring. If the goal is to provide trend analysis and to be alerted in cases of out-of-spec conditions, then the particle monitor must not only have high sensitivity, but also a high sample volume. However, if the need is simply an alarm when the liquid conditions are extremely out-of spec, it is more economical to purchase a particle counter such as the HSLIS M50e, with a smaller sample volume.

Author

Ed Terrell is the Liquid Line Product Manager at Particle Measuring Systems and has a Bachelor's Degree in Mathematics. He has worked in the field of particle measuring for six years and has over 20 years experience in Chemical Analysis Instrumentation.

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