TECHNICAL PAPER

Vertex50
Ultra Pure Water Qualification

by Jason Kelly

03/09/2021

LIGHTHOUSE
WORLDWIDE SOLUTIONS

Technical Paper Liquid Particle Counter Technology

Qualification of the Vertex50 for UPW system online monitoring

Author Jason Kelly

Vice President of Services

Lighthouse Worldwide Solutions

Qualification of Vertex50 to measure and detect ≥50nm trends in UPW systems

The Vertex50 has TRUE sensitivity at 50nm has been qualified to measure and detect ≥50nm particles in Ultra-Pure Water Systems (UPW). UPW systems are used in many industries worldwide to provide high purity water. Ultrapure water is a commonly used term in the semiconductor industry to emphasize the fact that the water is treated to the highest levels of purity for all contaminant types, including organic and inorganic compounds; dissolved and particulate matter; volatile and non-volatile, reactive and inert; hydrophilic and hydrophobic; and dissolved gases.

Fig 1.0 Vertex50 online monitoring of UPW system

Qualification Setup and Scope

Scope

The Vertex50 LPC can detect particles down to 50nm. The range of measurement goes from 50nm to 200nm or in micron terms, the four size channels of the Vertex50 are as follows;

- 0.05µm
- 0.10µm
- 0.15µm
- 0.20µm

The Vertex50 has a flow rate of 100ml/minute and a sample rate of 5ml/min. The Vertex50 has a low False Count rate fewer than 0.02 Counts/ml compared to other LPC's. Low false count rates are key to detecting particles in the nanometer range, as false positives render the data unusable. It becomes challenging to determine if the counts are actual real counts or false counts. The LPC's photodetector can count interference from cosmic and terrestrial rays as false counts. So removing such false count interference improves the overall sensitivity of the Vertex50 data.

The scope of this qualification section below verifies the test setup is impartial to the results and is totally controlled. Therefore it does not influence the results with false positives or any other external influences.

UPW System Benchmarking Summary

The testing setup needs to be fully controlled, and the UPW output baseline needs consistency and the ability to deliver UPW to the test system. The filtration stages of the test setup ensure the UPW is filtered to 10nm. Control of the system is demonstrated in the first stage test, where the test system is taken from the baseline threshold of zero, and 50nm particles are introduced.

The Vertex50 sensor and flow cell are designed, so a partial sample flows over the laser at a focused point. Partial Flow Laser technology is used to detect particles in the ranges below 200nm due to the high intensity required by the laser to detect nm particles. Therefore the tradeoff means that counting efficiency is very low at 50nm since not all of the particles generated and flowing through the sensor will pass over the focal point of the laser. This does not mean that the LPC is low sensitivity in fact, the design of the Vertex50 makes it a high sensitivity LPC at the 50nm range. As outlined in figure 1 and figure 3 the Vertex50 detects and counts the 50nm particles passing through the flow cell at the focal point of the laser.

LPC's using Partial Stream Laser sensor designs combined with low noise and low false count generation are ideal for detecting particle events as demonstrated in the Clean to Dirty to Clean and Modulation Up and Down test results observed in fig 1 to fig 4 graphs.

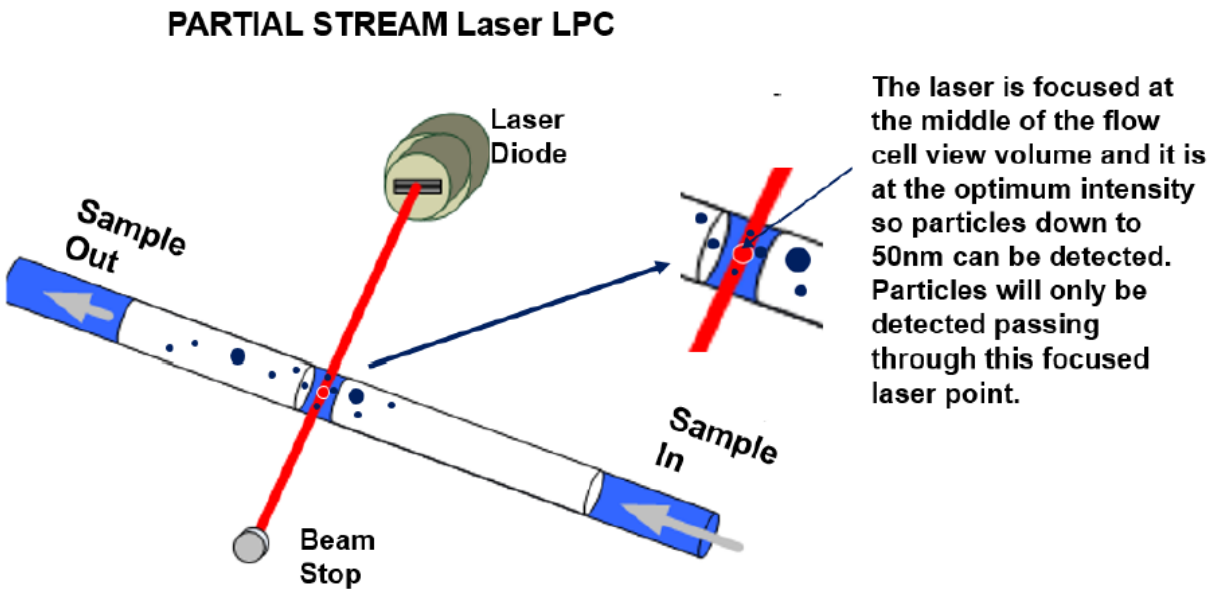


Figure 2.0 Example of Partial Stream LPC sensor

What can we understand so far?

In order to validate the TRUE sensitivity of the Vertex50, control of the test setup must be verified. The introduction of test particles must be controlled and within test concentrations. The system must also be free from other sources of particles. This ensures a robust and accurate test environment.

The test setup is controlled, and particle concentration introduction is immediately recorded by the Vertex50. The Vertex50 has high sensitivity at the 50nm size range, with Partial Stream Laser technology Counting Efficiency is low; however, in return, sizing is accurate and verifiable. Once the test setup is verified, the accuracy and counting efficiency of the Vertex50 can be tested. The calibration process must highlight the ability to successfully calibrate the Vertex50 for size accuracy and counting efficiency comparable to a reference instrument.

Section 2 on the following pages provides an overview of how the Vertex50 accuracy and counting efficiency is verified. This section requires traceable particles to be diluted and introduced into the Vertex50. Each size channel is then verified for sizing accuracy. For counting efficiency, the Vertex50 is compared to a Reference Instrument where both LPC's sample from the same sample source. For sizing criteria, the Vertex50 (UUT) must be within 5% of the reference standard. This process confirms the Vertex50 sizing accuracy and the counting accuracy. Understanding Partial Stream LPC sensor limitations helps to understand the sizing and CE testing requirements and expectations.

Vertex50 Calibration Validation Summary

The Calibration process of the Vertex50 runs through the range of particle channels and verifies the sizing accuracy, count accuracy as well as sensitivity, zero count, and dark count validation.

The calibration process introduces traceable reference particles into each channel. The traceable particle size is introduced at stage no.1 and introduced into the dilution system at stage no.3 where particle-free water is introduced through two post CLRW filtration stages (at stage no.2.). The diluted particles are then carefully controlled based on a dilution ratio, so the concentration is known. Each channel is tested individually.

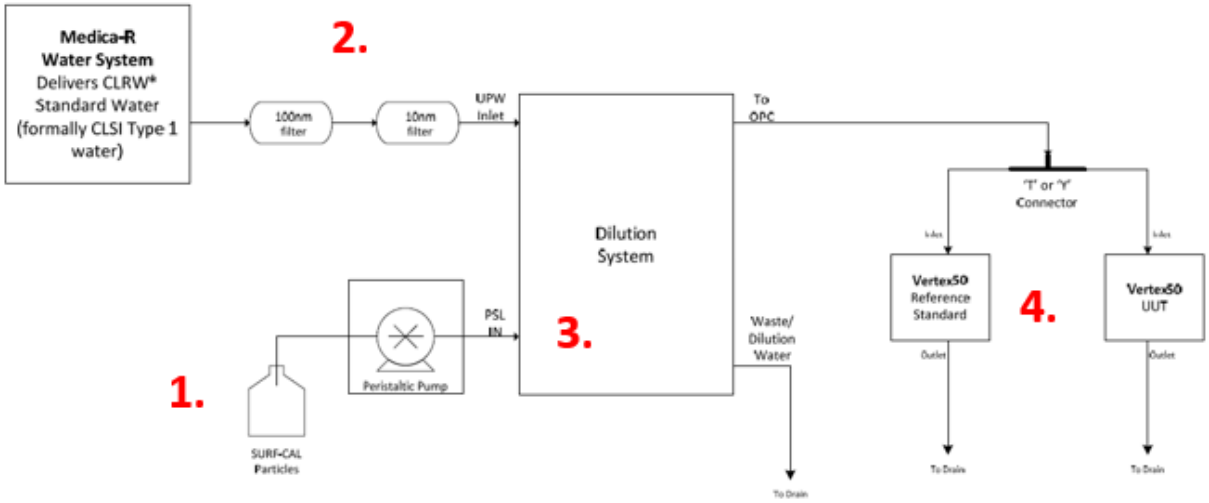


Figure 7.0 Process stages 1 to 4

Also known is the Counting Efficiency range of the Vertex50 (Unit under Test UUT) and also the Reference Standard Vertex50 CE. In stage no.4 the UUT and Reference Standard are compared together, and the ratio of counts are calculated to verify count accuracy.

All channel thresholds are adjusted on the UUT until counts are within ± 5% of the Reference Standard. Zero counts and dark noise must be validated so there are no false counts introduced.

What does the Vertex50 Calibration Validation tell us?

The Vertex50 calibration and verification tells us that the Vertex50 can detect particles in the size ranges;

- 50nm, 100nm, 150nm and 200nm
- 4 Sizing channels of the Vertex50

The CE is verified at 5% based on Partial Stream Laser LPC sensor detection ability. 5% of the sample will go through the focal point of the laser. This Ensures the sensitivity of the Vertex50 at these nano-size particle detection ranges. The Vertex50 will see ≥50nm particles.

Partial Stream Laser LPC sensor design enables the laser to be focused so it has more intensity to detect nano-sized particles. This laser focus is magnified at a focal point in the flow cell. Nano-sized particles that pass through this point will be detected down to 50nm. Remember, not all of the sample will pass through this focal point. But it enables the sensitivity of the sensor to be amplified without high laser power requirements that would fall outside of laser safety limits.

The Vertex50 verification also validates the sensor design eliminates false counts, and with the advanced photodetector design, dark noise is also extremely low, and there is no need for any algorithms to subtract dark noise. (Such algorithms can actually introduce false counts). Therefore the Vertex50 has high sensitivity with confidence.

How should the Vertex50 be used in UPW contamination detection?

The Vertex50 is designed for online monitoring and should be used as a watchdog that activates an alarm notification if the baseline of UPW systems drift from tolerance set-points. The Vertex50 can connect to LMS Express monitoring software so data trends, reports, automatic alarm messages and notifications can be issued. The overall system allows a fast response to be made if a contamination event were to occur.

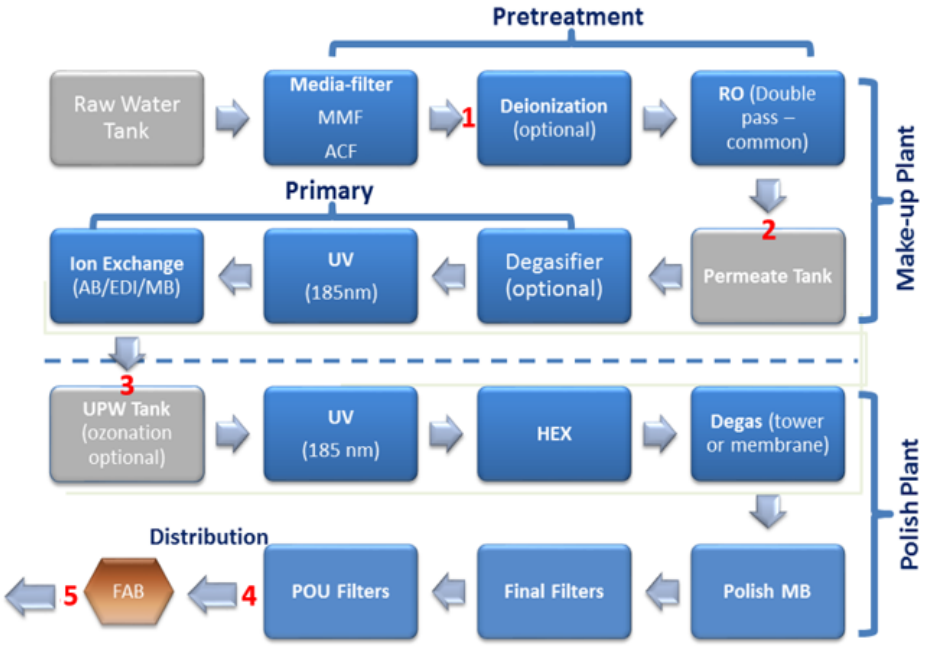


Fig 2.0 Semiconductor UPW system stages and particle monitoring

Recommended Monitoring Points

1 = 0.5µm (500nm) Particles using online real-time monitoring

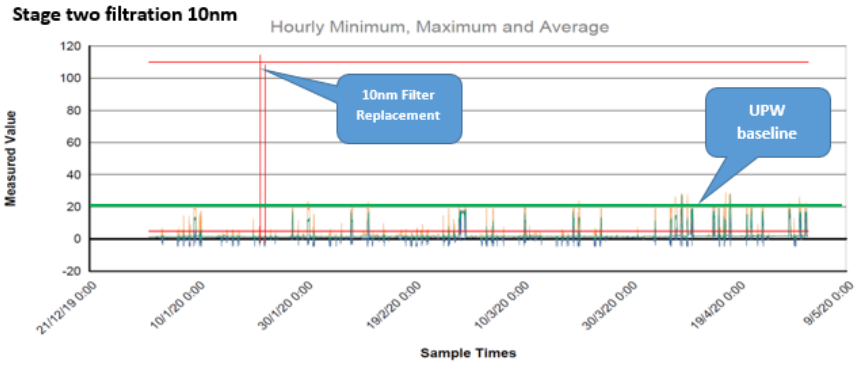
2 = 0.2µm (200nm) Particles using online real-time monitoring

3 = 0.1 µm (100nm) Particles using online real-time monitoring

4 = 0.05 µm (50nm) Particles using online real-time monitoring

5 = 0.05 µm (50nm) Particles using online real-time monitoring

UPW system data trend 6 Months



Vertex50 LPC's can be used at multiple locations along a UPW system to monitor filter performance, system efficiency and alert on any contamination events. This ensures that the product is processed using uncontaminated UPW. Improving product yield and quality. When connected to LMS Express al data points can be collected and visual trends can be displayed to verify the health of the UPW system in real-time. Filter replacements can be easily managed and overall run time of the UPW system can be enhanced

Figure 8.0 Application of Vertex50 Real Time Monitoring in a UPW system

Establishing UPW Real-Time Monitoring with LMS Express and the Vertex50

One of the main advantages of the high sensitivity of the Vertex50 is when it comes to online monitoring. With identified monitoring points along the UPW system, the water quality can be monitored in real-time when the Vertex50 sample points are connected to LMS Express monitoring software.

The UPW system can be actively monitored with alarm notifications issued when the water quality becomes high. Useful data can be gathered from a monitoring system.

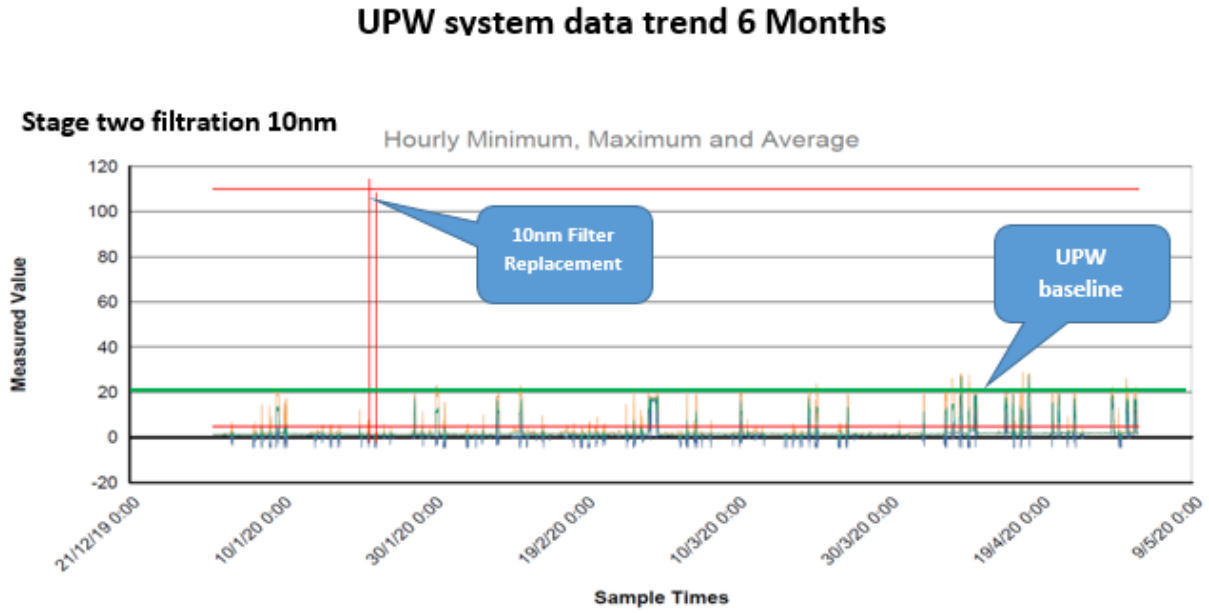


Figure 9.0 Example of Monitoring System data trend

The data above was gathered from the filtration stage at 10nm, and the trend shows historical data where high counts were observed. On inspection, the filters needed replacement, and on inspection of other historical data it was determined that an active filter replacement program was to be initiated. Filter replacement will occur every 6 months during planned UPW service schedules. By using the monitoring system and by reviewing data trends, planned service events were enacted that improved product yield by preventing unplanned downtimes.

Return of Investment

The Vertex50 Monitoring System ensured UPW performance and highlighted user control of the UPW system. With real-time monitoring, the UPW system performance can be tracked, and any events that could impact product yield can be notified so immediate action can be taken.

Over the course of a very short period, the ROI of a Vertex50 Monitoring System would be repaid based on the savings made in product yield uptime and performance and productivity increases for the facility.

If you are interested in a Vertex50 Monitoring system for your UPW system, contact us at sales@golighthouse.com for a system demo or pricing, including installation and validation costs.