ABB MEASUREMENT & ANALYTICS | WHITE PAPER

PUV3402 LED multiwave photometer

A new approach to online process photometry

The UV LED photometer with a design concept advantage.

Measurement made easy

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PUV3402 LED multiwave photometer

Introduction

The new ABB PUV3402 LED is a process UV photometer that is designed for online measurements in the UV region. This innovative photometer is based on the use of wavelength specific LED sources that are unique for this spectral region.

LED technology offers distinct advantages over a filter photometer, which has been the industry standard in process photometers for many years. The wavelength specific LED sources eliminate the need for filters and chopper motor.

This means that the LED photometer has no moving parts. The LED diodes also offer better performance with less zero drift than existing process photometers. These advantages correlate to a reduction in field maintenance.

Traditionally, process photometers have utilized narrow bandpass filters and a separate source to make chlorine measurements. With innovative ABB LED technology, the filters and source can be replaced by durable LED diodes. An LED, is a semiconductor device that emits visible light when electric current passes through it. The light is monochromomatic and occurs at a single wavelength.

There are many advantages to an LED photometer over a filter photometer, including less maintenance, no moving parts, and improved analyzer precision.

Analyzer principle of operation

Most laboratory spectroscopic measurements scan across a full spectrum with the use of a dispersive spectrophotometer. Process photometers are non-dispersive analyzers that eliminate a large amount of the spectral region. Discrete wavelengths are selected in photometer design to make the desired measurement. A reference wavelength is chosen in a region, where none of the stream components absorb.

A measure wavelength is then chosen in a region to maximize the measure component's absorbance, and minimize the absorbance of any other stream components.

Figure 1 below shows the UV spectrum of chlorine, along with the selected reference and measure wavelengths used. This graph depicts how process photometers work with only distinct spectral regions, as opposed to the entire spectrum.

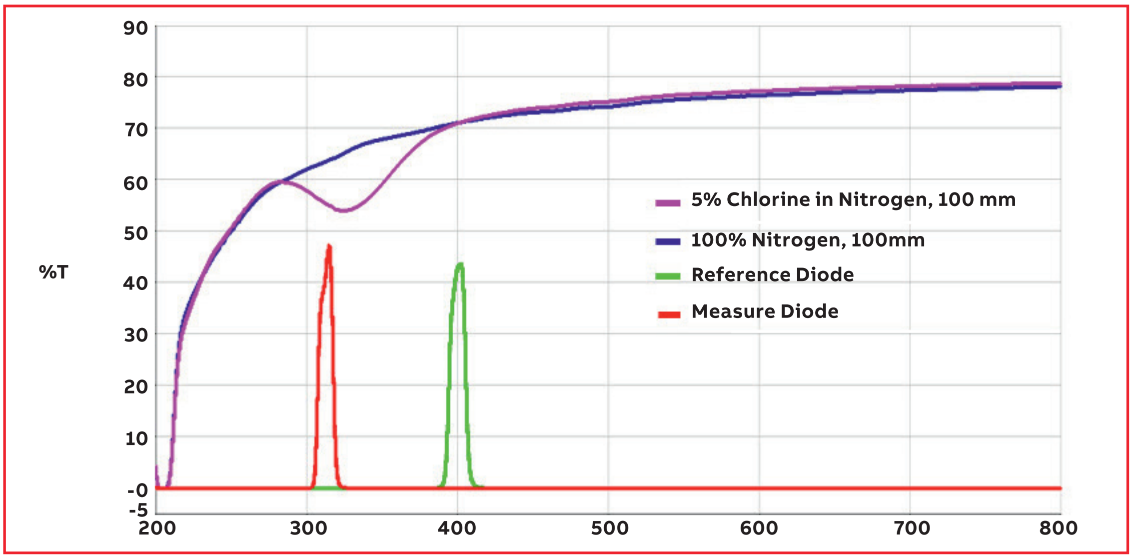

Figure 1 Chlorine absorption spectra and wavelength selection

A filter photometer has been one of the industry standards for continuous chlorine measurements for years. A photometer provides a fast and accurate measurement and is able to withstand the hazardous environments associated with chlorine. A schematic of a standard filter photometer can be seen in Figure 2 below.

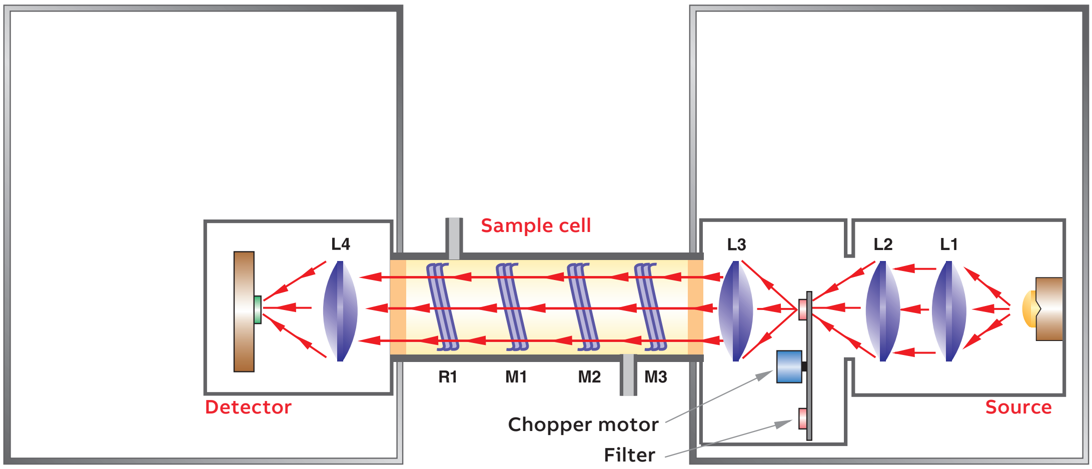

Figure 2 PUV3402 optical bench

A source emits light that absorbs across the entire UV region. The light from the source is focused by lenses L1 and L2. The signal is then passed through a rotating filter wheel, where the reference and measure filters are located. These narrow bandpass filters provide the discrete wavelengths needed for the measurement. The chopped signal is passed through another lens, L3, where the light is collimated and sent through the measurement cell. The signal is passed through a final lens, L4, which focuses the light onto the detector. The electronics of the analyzer perform an analog to digital conversion of the signals from the bandpass filters, and a microprocessor uses matrix algebra to calculate and report the measured component's concentration.

The new UV LED photometer builds on the same dependable photometer base described above to offer a simplified optical bench, as can be seen below in Figure 3.

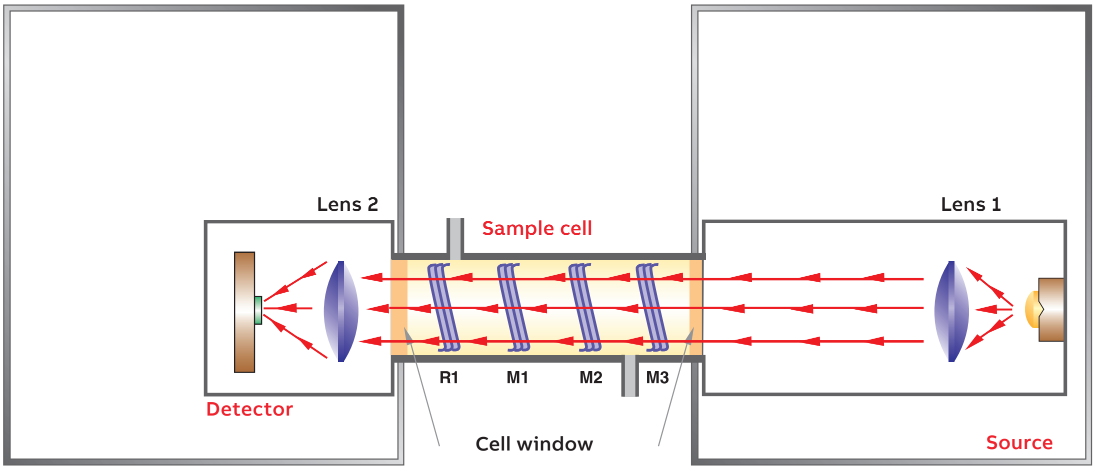

Figure 3 PUV3402 LED optical bench

For the online measurement in an UV LED photometer, an assembly of four separate UV diodes are used. Each diode emits light at a distinct wavelength. Two of the diodes have a reference wavelength, and the other two diodes are selected as the measure wavelength. The diode assembly is programmed so that it sequentially pulses a signal through L1. This pulse supplies the analyzer with the required chopped signal, thus eliminating the need for a chopper motor and two lenses. This also means that the UV LED photometer has no moving parts. L1 sends a collimated signal through the measurement cell. Cell windows are located on either side of the cell. The design of the UV LED photometer completely isolates the sample cell from all other parts of the analyzer, which is especially helpful for corrosive chlorine applications. L2 focuses the signal leaving the measurement cell onto the detector. The analyzer then ratios this pulsed signal and converts it from analog to digital. The micro-processor uses this digital signal to calculate the component concentration.

Figure 4 UV LED photometer

PUV3402 LED

Deuterium sources are one of the industry standards for UV photometers. These source types produce a good quality signal in the UV region, however, their initial burn-in time, drift rate, and life span are limiting factors. Figure 5 below shows a 36 hour stability run from a photometer using a deuterium source for a 0 to 500 ppm chlorine measurement with 100 % nitrogen in the sample cell. This test was done during the initial start-up of the analyzer. Over a 24 hour period, the zero drift rate for this analyzer is 8 % of the full scale range. This drift rate does improve to 1 % of the full scale range over time. However, this source burn-in time can be days or even weeks.

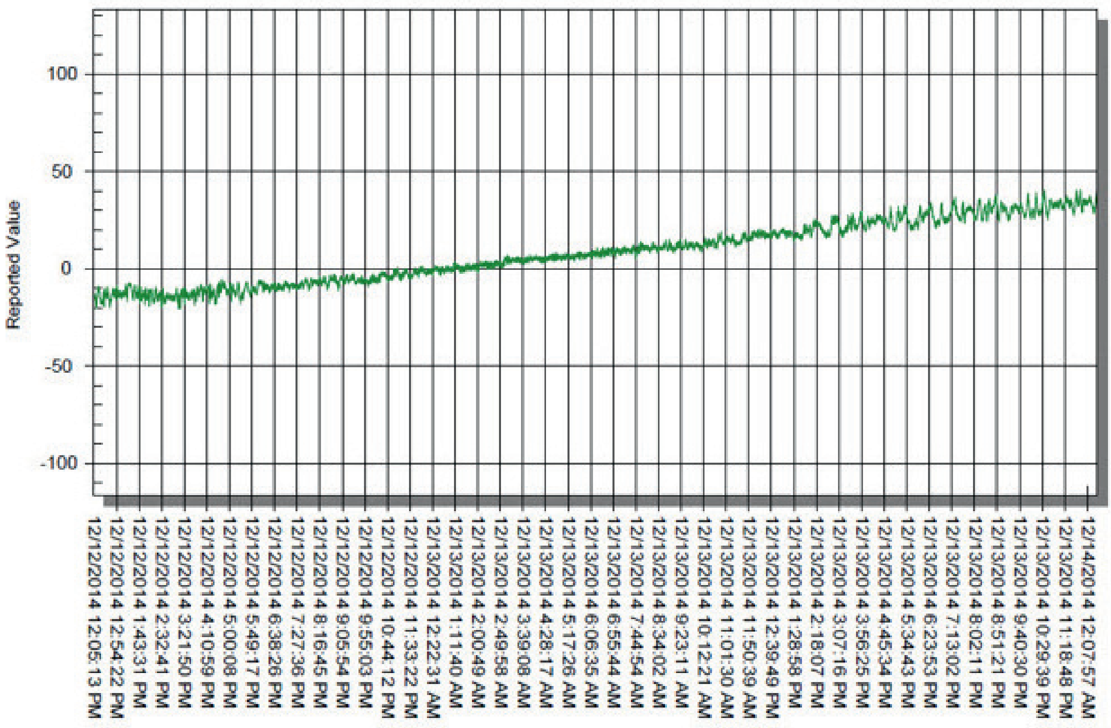

Figure 5 PUV3402 Initial zero drift

The LED diode assembly has been shown to have a much smaller zero drift rate for chlorine applications versus a classic deuterium source. There is also virtually no source burn-in time. Figure 6 shows a 48 hour stability run of a UV LED photometer designed for a trace level chlorine application.

This stability test was done on a 0 to 1000 ppm chlorine measurement with 100 % nitrogen in the sample cell. Again, this data was taken at the initial start-up of the analyzer. Over a 24 hour period, the drift rate on the UV LED photo-meter is less than 0.5 % of the full scale range. This is an 8x improvement over the initial deuterium source drift rate.

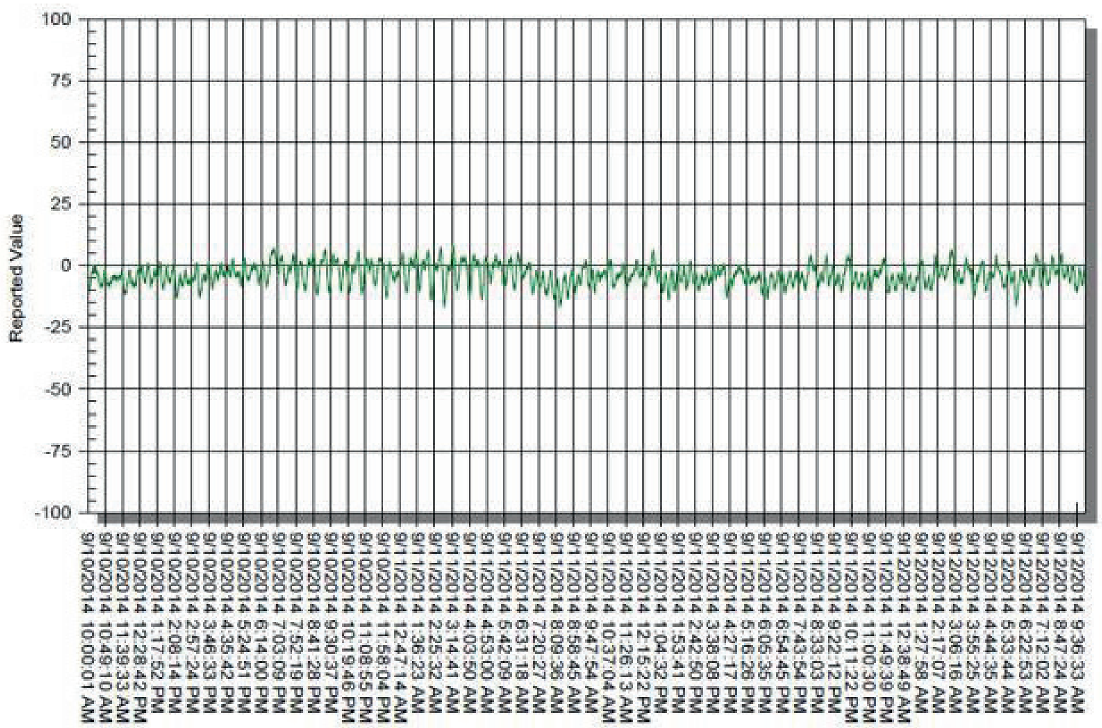

Figure 6 PUV3402 LED Initial zero drift

LED technology provides high precision and less maintenance

The improvement in zero drift translates to a more precise chlorine measurement and a longer time interval between calibrations. One of our customer sites has reported going from daily calibration frequency to a weekly one. The life span of the diode assembly is 4 times longer than that of a deuterium source, which means that there will be less analyzer down time due to routine maintenance.

The diode source assembly offers the same amount of precision that can be found in filter photometers with deuterium sources. During initial development, a traditional filter photometer with a deuterium source was calibrated on a 200 ppm chlorine sample. A separate 100 ppm chlorine sample was then placed in the sample cell, and the analyzer read 100 ppm. The source and filter wheel were replaced in the analyzer with a UV LED diode assembly. The same 100 ppm chlorine sample read 99 ppm.

The single beam, fixed wavelength principal of the UV LED photometer has many advantages as a design concept. Since both the reference and measure wavelengths pass through the same optical path, any obstructions of the cell windows are compensated. This same principle also counteracts diode and detector aging, and minimizes the effect of particulates and bubbles in the sample cell.

The UV LED photometer can make measurements in the liquid or vapor phase, and the sample cell is completely isolated from the analyzer electronics. The sample cell can be made from any metal that is compatible with the process stream chemistry, and it also has the capability to be heated up to 150 °C (302 °F) to help ensure the sample remains in the desired phase. The cell also allows for the sample pressure to be as high as 500 psig. Many common stream components, such as water, do not absorb in the UV region. This means that there is less chance of interference from the stream matrix, and it also makes the UV LED a good instrument to measure hot and wet samples. These features help make it a very versatile analyzer that can be used in various chlorine applications.

The use of the ABB UV LED Process Photometer offers both rugged and dependable on-line chlorine measurements. The improvements that the new LED technology bring to the photometer produces an analyzer with a higher precision and less maintenance than a standard filter photometer. This correlates to a lower cost of ownership, as well as less analyzer downtime.

Other components, such as hydrogen sulfide, sulfur dioxide, aromatics, and color measurements can be made with the same UV LED mechanics. This novel approach to online process photometers adds substantial value to the analytical measurement industry.

Notes

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