Low-Maintenance Turbidimeter for Potable Water Applications

Higher demand for safe drinking water and tighter monitoring of contaminants in potable water are in contrast to the current trend towards reducing maintenance / operating costs and remote controlled plants. Main maintenance tasks on a regular base for turbidimeters are cleaning the optical windows and replacement of the light source as well as readjustment / recalibration with a primary standard. A new approach with a non-contact, LED turbidimeter reduces maintenance efforts significantly and thereby contributes to lowering the cost of ownership.

State of the art turbidimeters for potable water analysis are based on the nephelometric measurement principle as described in the Standard Methods [1] and adapted by ISO (ISO 7027 [2]) or EPA (EPA 180.1 [3]). A ratio turbidimeter measures the ratio between scattered and transmitted light. If just the transmitted light is detected, it is a single beam turbidimeter.

The set up is quite simple but there are some disadvantages, especially in terms of maintenance effort.

Several tasks have to be conducted on a regular base for these types of turbidimeters to ensure its reliability and functionality.

Nephelometry

In a nephelometric set-up, turbidity is determined by the measurement of light, scattered at an angle of 90° to the incident beam.

Readings are from a calibration curve established with a primary standard (i.e. Formazine). Results are expressed in FNU (Formazine Nephelometric Units) or NTU (Nephelometric Turbidity Units).

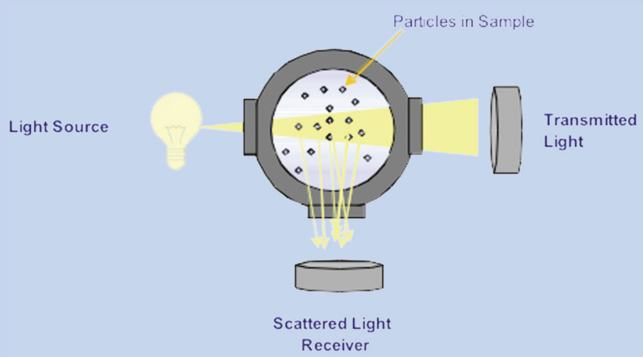

Figure 1: Schematic set-up of a nephelometric turbidimeter

The main maintenance tasks

Cleaning of optical windows

The turbidimeters consist of a flow cell design, where the optical windows are in direct contact with the sample. It is obvious, that cleaning is sometimes necessary, which means maintenance hours, causing operating costs. Cleaning the optical windows often requires a readjustment of the turbidimeter's sensitivity.

Replacement of the light source

A light bulb with a tungsten filament has to be replaced at least once a year which needs a readjustment or recalibration of the turbidimeter. Additionally, a decrease of the lamp intensity leads to wrong measurement values if not monitored correctly

Chamber drain

Settled particles in the measurement chamber have to be removed from time to time to avoid interference based on a carry-over effect.

Measuring principle AMI Turbiwell

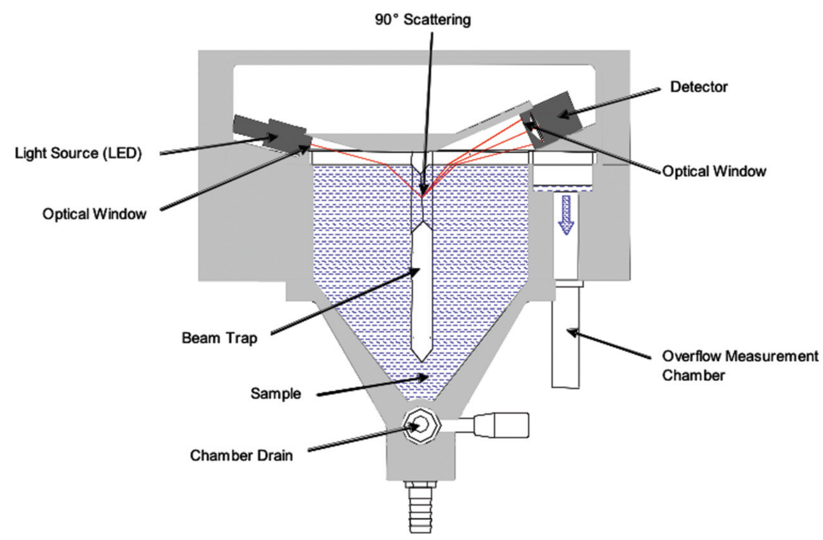

Figure 2: Set-up of the SWAN AMI Turbiwell

The light beam of the LED source falls on the water surface and is refracted.

At an angle of 90°, the detector measures the incoming, scattered light.

The transmitted beam intensity is not measured; therefore, the AMI Turbiwell is a single beam turbidimeter and not a ratio turbidimeter.

The special design of the chamber (barrier and beam trap) prevents measurement errors due to light reflection.

A dark current measurement is completed at least once a day to compensate the influence of temperature variations on the electronics

But how can a single beam turbidimeter compensate for fluctuations in the intensity of the light source?

"Normalisation" of Turbidity Signals

$$NTS = I_{90} / I^{0}$$

NTS:	Normalised turbidity signal
I_{90}:	Scattered light intensity
I^{0}:	Emitting light intensity

The new SWAN AMI Turbiwell

In the design of the new AMI Turbiwell, the focus was on low maintenance:

- Non-contact set-up: The optical windows are not in direct contact with the sample which means there is no fouling and as a consequence, no cleaning is required. The optical windows are heated to prevent condensation.
- Light source: Instead of a "light bulb" with a lifetime of around 8000 operating hours, a light emitting diode (LED) with a lifetime of approximately 100'000 operating hours is used. Therefore, a replacement is not necessary and readjustment or recalibration is redundant. Two different light sources are available which are either ISO 7027 compliant or accepted as an alternative method to EPA 180.1 [4]/[5]
- Chamber drain: An automatic or manual chamber drain avoids a carry-over effect and contributes to reliable measurement value.

Hgh precision Secondary Standard for AMI Turbiwell

Figure 3: Verification Kit

The absence of the transmitted beam intensity measurement and consequently the absence of the ratio for light source fluctuation compensation requires a new/different approach.

Compensation is achieved by normalizing the emitted light intensity. A beam splitter (semi-transparent mirror) within the light source directs a part of the emitted light to a photodiode which registers the emitted beam intensity. Building the ratio of the scattered light intensity to the emitted beam intensity eliminates the fluctuations in the light source.

This "normalisation", the non-contact set-up, the long-life LED light source and the regular chamber drain make a recalibration of the turbidimeter with a primary standard unnecessary.

If a system check is required due to local regulations, a dry verification using a high precision secondary standard can be conducted to validate the instrument's performance.

Figure 4: Monitor AMI Turbiwell

Main application for the new AMI Turbiwell

Raw water monitoring (surface water)

Most of the measurement points are at some distance in the countryside. Due to long travel times to the site, an instrument with as little maintenance as possible is required /called for.

The sample contains harmful substances, pathogenic contaminants and particles of different sizes as mud or sand. Optical windows in direct contact with the sample would be covered with a biofilm or other sample-related precipitations which inevitably lead to turbidimeter performance failure and finally wrong measurement values.

The non-contact optics is the perfect solution to ensure measurement reliability and stability.

A programmable, automatic chamber drain clears the measurement chamber from settled particles.

ISO 7027 [2] vs. EPA 180.1 [3]

ISO 7027 specifies a nephelometer uses a "red" light source with an emitting wavelength of 860nm. There are no limitations regarding application and measurement value.

The EPA regulates the use of a nephelometer, depending on the turbidity value in the sample. Below 40 NTU, a tungsten lamp operated at a color temperature between 2200-3000°K and a detector with a spectral peak response between 400 nm and 600 nm have to be used; white light, because of the sensitivity to smaller particles (sensitivity ~ 1/λ4).

Above 40 NTU, red or white light is accepted.

Water treatment process

Reliability of the instrument - especially that of the instrument's light source and verified measurement values is the main feature in monitoring of the clarification / filter processes. Providing safe drinking water is the main objective and a deviation in turbidity will lead to different procedures.

But how to distinguish if this deviation is caused by a thin biofilm on the optical windows, a decreased lamp intensity or a real incident with the filters?

The answer is to exclude the possibility of deviation in the instrument itself.

Biofilm is not an issue for a non-contact set-up; lamp intensity monitoring and a dark current measurement provide the most accurate and verified measurement value possible.

Conclusion:

The new non-contact turbidimeter, the AMI Turbiwell with automatic or manual chamber drain and lamp intensity monitoring offers a variety of benefits in terms of reducing maintenance work and cost of ownership, and with the enhancement of reliability and stability. Therefore, not only the initial costs of a turbidimeter have to be considered. The economical factor of a low-maintenance but sophisticated instrument must also be taken into account.

[1] Standard Methods.1995.Standard Methods for Examination of Water and Wastewater, 19th edition, America Public Health Association, AWWA, Water Environment Federation. Franson, M.H., A.D. Eaton, L.S. Clesceri and A:E: Greenberg (editors). Port City Press, Baltimore, MD

[2] International Organization for Standards (ISO). 1990. International Standard 7027 – Water Quality – Determination of Turbidity. ISO

[3] Environmental Protection Agency (EPA)

[4] Federal Register / Vol. 74, No. 216 / Rules and Regulations, ALTERNATIVE TESTING METHODS FOR CONTAMINANTS LISTED AT 40 CFR 143.4(b), Tuesday, November 10, 2009

[5] AMI Turbiwell, ''Continuous Measurement of Turbidity Using a SWAN AMI Turbiwell Turbidimeter,'' August 2009. Available at http://www.nemi.gov

AUTHOR DETAILS

Markus Bernasconi
Sales & Support manager
Swan Analytical Instruments

Markus Bernasconi, graduated from the University of Applied Sciences in Burgdorf, Switzerland in 2000 with a bachelor degree in chemistry and in 2002 with a post graduate course in integrated micro systems. He worked at the same location for about 4 years, leading research projects in the field of thin film deposition (PVD, CVD) and wet chemical wafer processing. He then changed to Mettler-Toledo Thornton, working as a project leader in the R&D. Subsequently, he joined Swan Analytical Instruments in 2006 working first as product manager and since the beginning of 2009 as a sales & support manager.