4-Beam Turbidity

Technical White Paper

Measuring turbidity is now accepted worldwide as one of the best ways of measuring changes in water quality. The full definition of turbidity as defined by *Standard Methods for the Examination of Water and Waste Water* is "an expression of optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample." This can be summarized as a measurement of sample clarity.

U.S. Environmental Protection Agency (EPA) Approved Methods

The Hydrolab 4-Beam turbidity sensor (patent #5,140,168 and other patents pending) utilizes the GLI International, Inc. Method 2 for the measurement of turbidity. GLI Method 2 is an EPA approved methodology under the *Safe Drinking Water Act*. By utilizing GLI Method 2, Hydrolab is the only manufacturer to incorporate EPA-approved technology for in-situ turbidity measurements.

How the GLI Method 2 works

The 4-Beam method operates in accordance with U.S. EPA-approved GLI Method 2 and ISO 7027 and provides unparalleled measurement accuracy and stability. The 4-Beam method uses two light sources and two photodetectors spaced at 90^o intervals around the sample chamber. Two measurement phases provide four independent measurements from two light sources.

During Phase 1, photodetector 2 provides a 90^o scattered light active signal (active 2) while photodetector 1 provides a forward scattered light reference signal (reference 1). During Phase 2, the process is reversed.

The Hydrolab 4-Beam turbidity sensor uses a ratiometric algorithm to calculate the turbidity value from the four readings.

The formula is as follows:

$$\text{NTU} = \left(\text{CAL SLOPE} * \left(\sqrt{\frac{\text{ACTIVE 1} * \text{ACTIVE 2}}{\text{REFERENCE 1} * \text{REFERENCE 2}}} - \text{CAL ZERO}\right)\right)$$

Turbidity Linearization Function (above)

For example, if:

LIGHT SOURCE 1 (ON) → ACTIVE 2 – 12,000
REFERENCE 1 – 40,000

LIGHT SOURCE 2 (ON) → ACTIVE 1 – 10,000
REFERENCE 2 – 48,000

NTU = ((80 * SQRT ((10,000 * 12,000) / (40,000 * 48,000)) – 0) = 20 NTU

This methodology, utilizing the linearization function, eliminates all errors due to LED, photo diode drift and considerable fouling. The effects of sediment, scratches, and color are also nullified. Even if all four lenses are partially blocked, it is still possible to obtain accurate turbidity measurements.

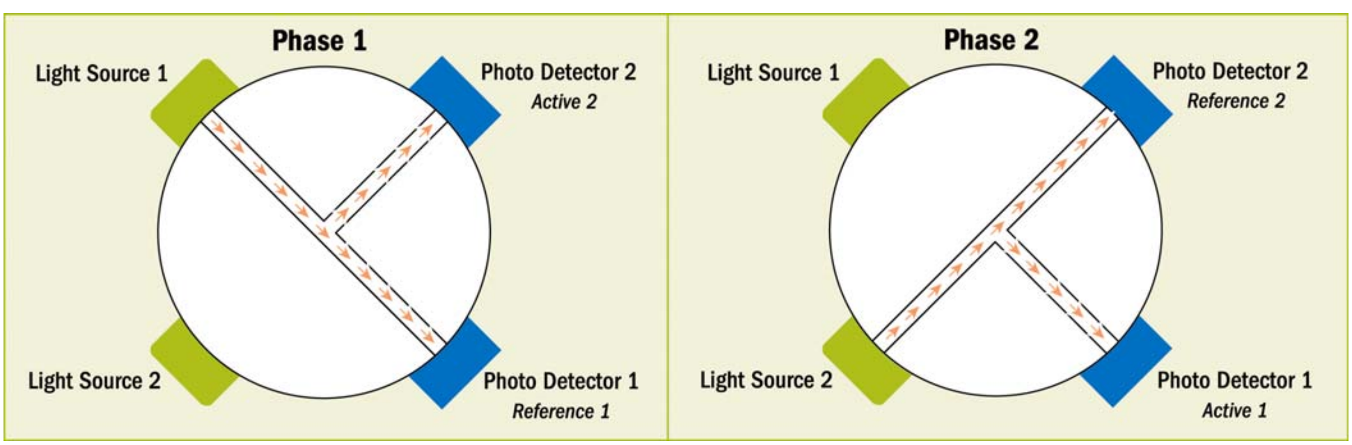
For example, now assume 20% fouling on Light Source 1 (or 20% reduction):

LIGHT SOURCE 1 (ON) → ACTIVE 2 – 12,000
REFERENCE 1 – 40,000

LIGHT SOURCE 2 (ON) → ACTIVE 1 – 10,000
REFERENCE 2 – 48,000

NTU = ((80 * SQRT ((10,000 * 12,000) / (40,000 * 48,000)) – 0) = 20 NTU

PRINCIPAL OF 4-BEAM TURBIDITY OPERATION



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The turbidity sensor pivots, allowing access to other sensors for routine maintenance.

The four optical windows, located at 90° intervals, provide accurate readings by calculating and compensating for fouling.

SUMMARY OF BENEFITS OF THE HYDROLAB 4-BEAM TURBIDITY SENSOR

COMPLIANT WITH U.S. EPA-APPROVED GLI METHOD 2

COMPLIANT WITH ISO 7027

PATENTED WITH ADDITIONAL PATENTS PENDING

EXTREMELY ACCURATE

PATENTED QUICK CAL CUBE™

AMBIENT LIGHT REJECTION

SCRATCH-RESISTANT QUARTZ LENSES

LARGE RANGE

NON-DECAYING INFRARED LIGHT SOURCE

Obtaining accurate data

Traditionally, there have been four key sources of error affecting turbidity measurements. Hydrolab's 4-Beam turbidity sensor is designed to eliminate these sources providing the most accurate turbidity data.

Good turbidity data starts with proper calibration of the sensor. Unfortunately, Formazin solution can be a significant source of error. Formazin's instability, variability from batch to batch, and propensity to degrade can cause variations in data. In addition, Formazin must be mixed and stirred properly or further errors can be introduced. Hydrolab's 4-Beam turbidity sensor is available with an optional Quick-Cal Cube™ set, allowing for easy verification of calibration.

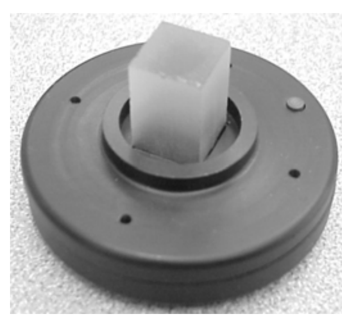
Dirt, debris, air bubbles, and scratches in the optical lenses can also provide source of error. Hydrolab's 4-Beam turbidity sensor is made of hard quartz glass, which is difficult to scratch. The sensor is also designed to prevent air bubbles from sticking to the lenses. Hydrolab's unique ratiometric algorithm compensates for the effects of partial beam blockage on the lenses.

Ambient light can also provide a significant source of error. Hydrolab engineers have programmed the sensor to eliminate the effects of ambient light. As a result, the sensor can be used in shallow streams.

Hydrolab's 4-Beam turbidity sensor uses an infrared LED light source. This light source is very robust, especially when compared with tungsten lamps.

Quick-Cal Cube™

The Quick-Cal Cube™ provides quick and easy calibration verification. Two Quick-Cal Cubes™ are available from Hydrolab, in mid and high turbidity ranges. The Quick-Cal Cube™ can simply be inserted into the middle of the sensor. Note: For EPA reporting purposes, sensors must be calibrated with a primary standard, but the Quick-Cal Cube™ can still be used to determine if the sensor is within specification.



4 – BEAM TURBIDITY SPECIFICATIONS

Range	Accuracy	Resolution
0 to 1000 NTU	$\pm$ 5% of reading $\pm$ 1 NTU	0.1 NTU < 100 NTU 1 NTU $\geq$ 100 NTU