

Turbidity Sensor

A practical guide to turbidity sensor, covering the reader intent, the relationship to turbidity sensor, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next step.



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In industrial process control and environmental monitoring, the measurement of liquid clarity is a fundamental parameter for ensuring product quality and regulatory compliance. A turbidity sensor (often referred to as a turbidity sensor) is an optoelectronic device designed to quantify the concentration of suspended solids and particulate matter within a fluid. By measuring the loss of transparency caused by the presence of undissolved substances, these instruments provide real-time data essential for water treatment, chemical processing, and food production.

For engineers and plant managers, selecting the correct analytical instrumentation is as critical as choosing the right level measurement technology. While Welk specializes in high-precision level instruments such as radar and ultrasonic sensors, understanding the analytical side of fluid management—specifically how a turbidity sensor operates—is vital for holistic process automation. This guide explores the principles, selection criteria, and practical installation requirements for these essential industrial tools.

| Measurement Principles of Turbidity

Turbidity is not a direct measurement of a specific pollutant; rather, it is an optical property that describes how light interacts with suspended particles. When light passes through a liquid containing solids, the particles scatter and absorb the light energy. The intensity of this scattered light is proportional to the amount of particulate matter present.

| 1. Nephelometry (90° Scattering)

Nephelometry is the most common method for measuring low to medium turbidity levels. In this configuration, a light source (typically an LED or tungsten lamp) sends a beam through the sample. A detector is positioned at a 90-degree angle relative to the light path. This method is highly sensitive to small particles and is the standard for drinking water applications. The results are usually expressed in Nephelometric Turbidity Units (NTU) or Formazin Nephelometric Units (FNU).

| 2. Light Absorption (Transmittance)

For high-concentration applications, such as wastewater sludge or concentrated chemical slurries, the absorption method is preferred. The detector is placed directly opposite the light source (180 degrees). As the concentration of solids increases, more light is absorbed or blocked, reducing the intensity reaching the detector. This is often used to calculate Total Suspended Solids (TSS).

| 3. Backscattering

In extremely dense fluids where light cannot penetrate deeply, backscattering sensors measure light reflected at angles greater than 90 degrees (often 135 degrees). This is particularly useful in industrial processes where the liquid is nearly opaque.

| Key Evaluation Criteria for Industrial Applications

Selecting a turbidity sensor requires a thorough analysis of the process environment. A sensor designed for a laboratory will rarely survive the rigors of an industrial pipeline or an open aeration tank. Engineers should evaluate the following factors:

| Measurement Range and Accuracy

Turbidity can range from 0.01 NTU in ultrapure water to over 4,000 NTU in raw sewage or industrial effluents. It is essential to match the sensor's calibrated range to the expected process fluctuations. Using a high-range sensor for low-turbidity monitoring will result in poor resolution and inaccurate data.

| Light Source Selection

Infrared (IR) LED (860 nm): Complies with ISO 7027 standards. IR light is less affected by the inherent color of the liquid, making it ideal for wastewater or colored chemical solutions.

White Light (Tungsten): Complies with EPA 180.1 standards. It is more sensitive to very small particles but can be interfered with by the color of the sample.

Material Compatibility

The sensor body and the optical window must withstand the chemical properties of the fluid. Common materials include 316L stainless steel, PVC, or PEEK for the housing, and sapphire or quartz glass for the optical window. Sapphire is often preferred for its scratch resistance, which is critical if the sensor utilizes a mechanical wiper.

Practical Selection Table

The following table provides a comparison of common turbidity sensor configurations used in industrial settings:

Feature	Nephelometric (90°)	Absorption (180°)	Four-Beam (Multi-Angle)
Primary Use	Drinking water, filtered water	Wastewater, sludge, pulp	High-precision industrial process
Range	0 - 400 NTU	100 - 4,000+ NTU	0 - 2,000 NTU
Sensitivity	Very High	Moderate	High
Color Interference	Moderate	High	Low (Compensated)
Typical Accuracy	±2% of reading	±5% of reading	±1% of reading

Installation Considerations

Proper installation is the most significant factor in the long-term reliability of a turbidity sensor. Even the most expensive instrument will provide false readings if installed incorrectly.

| 1. Avoiding Air Bubbles

Air bubbles scatter light exactly like solid particles, leading to false high-turbidity readings. Sensors should be installed in locations where the pressure is sufficient to keep gases in solution, or a "de-bubbler" (air trap) should be used. In gravity-fed pipes, ensure the pipe is always full by installing the sensor in a U-section or a riser.

| 2. Flow Velocity and Orientation

To prevent sediment from settling on the optical window, a minimum flow velocity of 0.5 m/s (1.6 ft/s) is generally recommended. The sensor should be oriented such that the optical face is parallel to the flow direction, allowing the moving fluid to provide a natural "self-cleaning" effect.

| 3. Ambient Light Interference

For sensors installed in open channels or basins, ambient sunlight can interfere with the optical detectors. Using a submerged sensor with an integrated light shield or installing the unit in a dark, enclosed flow cell is necessary to maintain accuracy.

| 4. Pressure and Temperature Limits

Standard industrial sensors are typically rated for pressures up to 10 bar (145 psi) and temperatures up to 50°C (122°F). High-temperature processes, such as those found in food pasteurization, require specialized high-temperature variants capable of withstanding CIP (Clean-In-Place) cycles reaching 130°C (266°F).

| Limitations and Common Risks

While modern sensors are robust, they face several inherent challenges in industrial environments:

Biofouling and Scaling: In water treatment, algae or mineral scale (calcium carbonate) can accumulate on the lens. Automatic cleaning systems, such as mechanical wipers or ultrasonic transducers, are highly recommended for unattended installations.

Particle Size Variation: Turbidity sensors assume a consistent particle size distribution. If the process changes such that particles become significantly larger or smaller (even if the total mass remains the same), the NTU reading may shift.

Stray Light: Reflections from the internal walls of a small-diameter pipe can reach the detector. Using matte-black finished flow cells or ensuring a minimum distance from the sensor face to the opposite wall helps mitigate this.

| Integrating Quality and Level Measurement

In many B2B applications, turbidity measurement is part of a larger automation strategy that includes level control. For example, in a sedimentation tank, a turbidity sensor monitors the clarity of the effluent at the top, while a hydrostatic level transmitter or a radar level meter monitors the overall tank volume. In more advanced setups, ultrasonic sludge blanket detectors are used to find the interface between clear water and settled solids.

Welk provides the foundational level measurement technology required to manage these industrial vessels. For comprehensive instrumentation needs beyond water quality, including advanced radar and ultrasonic solutions, engineers can visit the [Main Page of Welk's product catalog](#) to review product options and application support.

| Frequently Asked Questions (FAQ)

Q: What is the difference between NTU and FNU?

A: Both units measure turbidity using the same scale, but the terminology indicates the light source used. NTU (Nephelometric Turbidity Units) refers to a white light source (EPA 180.1), while FNU (Formazin Nephelometric Units) refers to an infrared light source (ISO 7027).

Q: How often should a turbidity sensor be calibrated?

A: In stable environments, quarterly calibration is often sufficient. However, in high-fouling applications or critical regulatory points, monthly verification against a secondary standard (like Formazin or stabilized primary beads) is recommended.

Q: Can a turbidity sensor measure dissolved chemicals?

A: No. Turbidity sensors only detect suspended, undissolved solids. Dissolved substances like salt or sugar do not scatter light and therefore do not contribute to turbidity, although they may affect the refractive index of the fluid.

Q: Is it possible to correlate turbidity to mg/L of suspended solids?

A: Yes, but only for a specific process. By taking laboratory samples of the liquid and comparing the dry-weight TSS (mg/L) to the sensor's NTU reading, a correlation curve can be established. This curve must be updated if the nature of the solids changes.

| Conclusion

The implementation of a turbidity sensor is a vital step for any industrial operation requiring precise liquid analysis. By understanding the optical principles of scattering and absorption, and by carefully considering installation factors like bubble mitigation and material compatibility, engineers can ensure long-term data integrity. When combined with reliable level measurement systems, these analytical tools provide the transparency needed for efficient, automated, and compliant industrial processing.