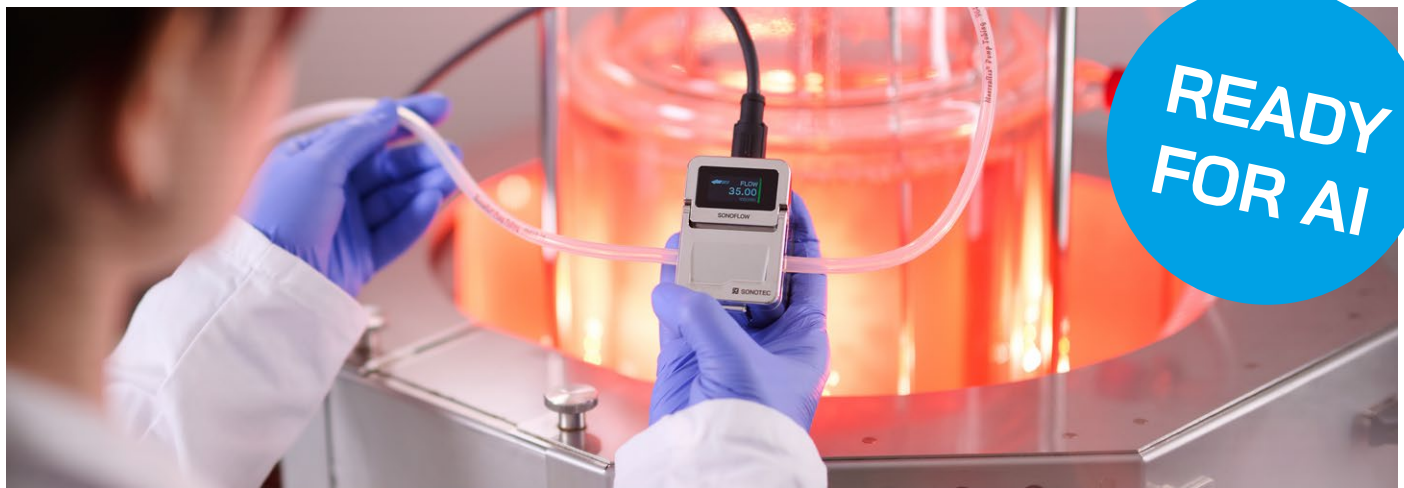




## Technical Note

# Sensor Performance Data for AI Bioprocess Modeling

Developing biopharmaceuticals is a highly complex and demanding process with limited room for errors and constant pressure on resources. With traditional lab tools, it is challenging to achieve significant improvements regarding efficiency and time-to-market. To address this challenge, the high accuracy **SONOFLOW CO.55 V3.0 clamp-on flow meter** provides valuable signal and performance data that can be used in AI-driven bioprocess models.



“Artificial intelligence is transforming bioprocessing. Using advanced sensor performance data in AI bioprocess modeling contributes to improving process efficiency and stability.” Nico Polley, SONOTEC GmbH

### Data for Enhanced Process Stability

By delivering advanced sensor performance data, the ultrasonic flow meter series supports process analytical technology (PAT) initiatives and strengthens quality by design (QbD) strategies. This data enables continuous monitoring of flow as a critical process parameter (CPP), leading to a deeper understanding of the processes and ensuring consistent critical quality attributes (CQAs) across all batches.

Thus, SONOFLOW CO.55 V3.0 provides valuable sensor data for machine learning and advanced data analytics. Patterns in signal quality and acoustic properties help to detect and identify process deviations. This extra insight helps improve process stability, increase consistency in GMP production, and accelerate the development of data-driven bioprocesses.

### Selection of Application Examples

- **Media and buffer preparation**  
Monitoring of flow data and changes of the acoustic properties of the medium for consistent formulation.
- **Cell culture and fermentation**  
Early detection of process deviations due to fluctuations in speed of sound or signal intensity.
- **Downstream processing**  
Verification of liquid transfers and filtration steps to ensure reproducible yield and purity.
- **Single-use systems**  
Reliable, non-invasive flow monitoring to support PAT-driven process intensification.
- **Calibration and validation framework**  
Integration into automated control loops for CPP verification and CQA assurance.

# Sensor Data as Indicator for Process Deviations

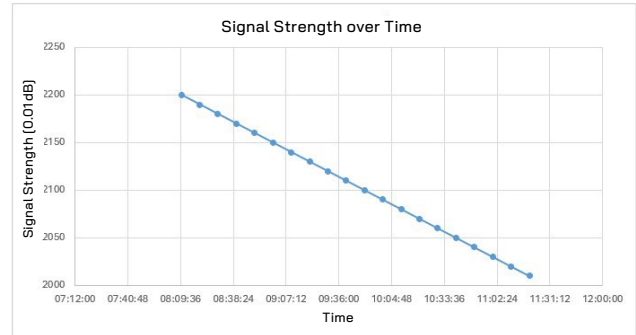
Beyond flow measurement, ultrasonic clamp-on sensors provide additional signal data that reflect changes in the physical properties of the process medium. The following examples illustrate how these parameters can reveal process deviations or changes in the medium composition.

## Signal Strength and Quality

Changes in signal attenuation influence the signal strength detected by the sensor. These variations may occur due to changes in the acoustic properties of the medium or the tubing. Possible causes include:

- Deposits in or on the tubing
- Reduced sound transmission through the medium
- Changes in ambient conditions
- Pressure changes

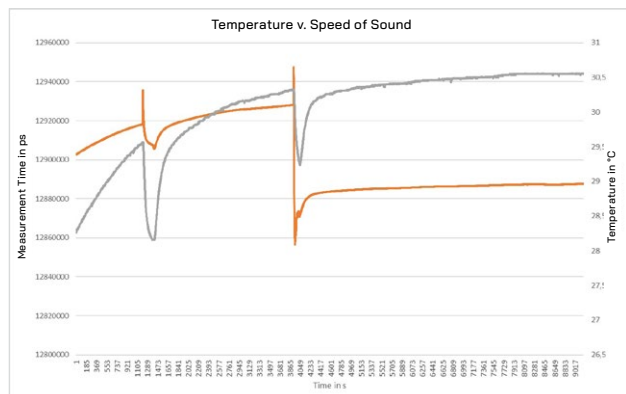
The ultrasonic signal itself remains constant. Variations along the acoustic measurement path influence the measured signal strength. Monitoring signal attenuation over time can reveal gradual changes that might otherwise remain unnoticed.



The test series above illustrates how an increasing number of particles or microbubbles in the medium reduces the signal strength. While the diagram shows a linear decrease, real process deviations may occur more gradually over time.

## Speed of Sound | Measurement Time

In addition to flow, SONOFLOW CO.55 V3.0 clamp-on flow meters also provide information about the speed of sound in the process medium. This parameter depends on physical properties such as material density, temperature, and pressure.



Changes in these properties influence the measurement time of the ultrasonic signal. Variations in the measurement time can indicate changes in medium properties or process conditions. The plot on the left shows two example measurements:

- **Gray curve:**  
Temperature measured at the inlet of the sensor. When slightly colder medium is added, the temperature drops.
- **Orange curve:**  
Measurement time within the measurement channel. The test medium is water; adding small amounts of isopropanol significantly changes the measurement time because the speed of sound differs between the liquids.

## Additional Data for Advanced Process Analytics

These additional ultrasonic signal parameters provide valuable insight beyond pure flow measurement. Combined with advanced data analytics or machine learning models, they can support earlier detection of process deviations and contribute to more stable and data-driven bioprocessing.

## Sales & Support

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