

Potentiometric Detection

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



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In the diverse landscape of industrial level measurement, selecting the appropriate technology requires a deep understanding of the physical properties of the media and the environmental conditions of the process. Potentiometric detection has emerged as a specialized and highly reliable method for continuous level measurement, particularly in applications where traditional non-contact methods or capacitive sensors struggle. This article provides a comprehensive engineering reference for potentiometric detection, explaining its underlying principles, practical advantages, selection criteria, and installation requirements.

| The Principle of Potentiometric Level Measurement

Potentiometric detection operates on the principle of a voltage divider. Unlike conductive point-level switches that simply detect the presence or absence of a medium at a specific height, potentiometric sensors provide a continuous analog output proportional to the liquid level.

| The Voltage Divider Mechanism

The sensor typically consists of a measuring probe (a metallic rod or tube) and a reference electrode. In many installations involving metallic tanks, the tank wall itself acts as the reference electrode. A low-frequency alternating current (AC) is fed into the probe. Because the liquid medium is conductive, it creates a shunt between the probe and the reference electrode (or tank wall).

As the liquid level rises, the resistance between the probe and the ground changes. However, the potentiometric method does not measure absolute resistance, which can fluctuate with temperature or chemical composition. Instead, it measures the voltage drop along the probe. The electronics calculate the ratio between the voltage at the tip of the probe and the voltage at the point where the probe enters the medium. This ratio is directly proportional to the immersion depth of the probe, regardless of the specific conductivity of the liquid, provided the conductivity remains above a minimum threshold (typically 50 $\mu\text{S}/\text{cm}$).

| Why AC Current is Used

Potentiometric detection utilizes AC current to prevent electrolysis at the probe surface. If direct current (DC) were used, the constant flow of ions in one direction would lead to material buildup or corrosion on the electrodes, quickly degrading the accuracy of the sensor and the integrity of the probe.

| Why Choose Potentiometric Detection?

This technology is favored in specific industrial sectors, such as food and beverage, pharmaceuticals, and chemical processing, due to its unique physical characteristics.

| 1. Immunity to Foam and Bubbles

One of the primary challenges for ultrasonic and radar level meters is surface foam. Foam can absorb ultrasonic waves or cause false reflections for radar. Potentiometric detection, however, is an immersion-based technology. It measures the liquid phase and is virtually unaffected by the presence of foam on the surface, making it ideal for fermentation tanks, bottling machines, and mixing vessels.

| 2. Performance in Viscous and Coating Media

Capacitive sensors often struggle with "build-up" or coating on the probe, which the sensor interprets as a higher liquid level. Potentiometric sensors are designed to ignore the thin film of liquid left on the probe as the level drops. Because the measurement is based on the voltage ratio at the point of immersion, the residual coating does not complete the circuit in the same way the bulk liquid does, ensuring high accuracy even with viscous substances like honey, syrups, or detergents.

| 3. Suitability for Small Vessels

Non-contact sensors like radar have "dead zones" or "blocking distances" near the top of the sensor where measurement is impossible. In small process tanks or pipes (e.g., DN50 or DN80 pipes), these dead zones can represent a significant portion of the total volume. Potentiometric probes can measure almost to the very top of the mounting connection, maximizing the usable volume of small containers.

| 4. High-Speed Response

Potentiometric detection offers extremely fast response times, often in the millisecond range. This makes it the preferred choice for filling machines and high-speed dosing applications where the level changes rapidly and must be monitored in real-time to prevent overfilling.

| Technical Selection and Specification

When specifying a sensor for potentiometric detection, engineers must evaluate several parameters to ensure compatibility with the process. The following table outlines the typical selection criteria for industrial-grade potentiometric level transmitters.

Parameter	Typical Specification	Engineering Note
Minimum Conductivity	> 50 μ S/cm	Not suitable for deionized water or oils.
Probe Length	200 mm to 3,000 mm	Custom lengths are standard for specific tank heights.
Accuracy	$\pm$ 1% of Full Scale	High precision in small-scale applications.
Process Temperature	-40°C to +150°C	Supports CIP/SIP (Clean-in-Place) cycles.
Process Pressure	Up to 40 bar (580 psi)	Suitable for pressurized mixing vessels.
Wetted Materials	316L Stainless Steel, PEEK	Must be chemically compatible with the medium.
Output Signal	4-20 mA, IO-Link	Integration with PLC and automation systems.

| Media Conductivity Requirements

It is critical to confirm that the medium has a minimum conductivity. While the potentiometric principle is independent of changes in conductivity, it requires the medium to be conductive enough to facilitate the voltage shunt. Most aqueous solutions, acids, alkalis, and milk products meet this requirement. However, pure hydrocarbons, oils, and highly purified water (DI water) are non-conductive and cannot be measured using this method.

| Installation and Engineering Best Practices

Correct installation is paramount to the long-term reliability of potentiometric detection systems. Engineers should adhere to the following guidelines during the design and commissioning phases:

| Grounding and Reference Electrodes

For the voltage divider to function, there must be a return path for the current.

Metallic Tanks: The tank itself acts as the ground. Ensure the sensor is mounted with a metal-to-metal connection to the tank nozzle.

Non-Metallic Tanks (Plastic/Glass): If the tank is non-conductive, a reference electrode must be used. This can be a second rod probe installed parallel to the measuring probe or a metallic fitting at the bottom of the tank that is wired back to the sensor's ground terminal.

| Mounting Position

The probe should be mounted vertically. If horizontal mounting is required (e.g., in a pipe), the probe must be positioned so that it does not trap air pockets, which would interfere with the liquid contact. In tanks with agitators or stirrers, the probe should be installed away from the vortex and may require a steadying bracket if the probe length exceeds 1,000 mm to prevent mechanical fatigue from vibration.

| Avoiding Obstructions

While potentiometric sensors are less sensitive to internal tank obstructions than radar or ultrasonic sensors, the probe should not touch the tank walls or other internal components (like heating coils). A minimum clearance of 50 mm is generally recommended to avoid short-circuiting the measurement signal.

| Limitations and Constraints

While highly effective in its niche, potentiometric detection is not a universal solution. Understanding its limitations prevents costly misapplications:

1. **Conductivity Threshold:** As mentioned, it is strictly for conductive liquids. It will not work for diesel, vegetable oils, or dry solids.

2. **Contact Measurement:** Unlike radar, this is a contact technology. The probe is submerged in the medium, which may not be desirable for highly corrosive chemicals that attack stainless steel or PEEK, though specialized coatings can mitigate this.

3. **Probe Length Limits:** Because the probe is a physical rod, it is rarely used in very deep silos or tanks (over 3-4 meters) where cable-based radar or hydrostatic transmitters are more practical and easier to install.

| Comparison with Alternative Technologies

To better understand where potentiometric detection fits, it is helpful to compare it against other common level measurement technologies.

Potentiometric vs. Radar: Radar is non-contact and works for non-conductive liquids, but it is more expensive and struggles with heavy foam. Potentiometric is better for small, foamy hygienic tanks.

Potentiometric vs. Hydrostatic: Hydrostatic sensors measure the pressure of the liquid column. They are excellent for large tanks but are sensitive to changes in liquid density. Potentiometric detection is density-independent.

Potentiometric vs. Ultrasonic: Ultrasonic sensors are cost-effective for water but fail in vacuum conditions or where steam and foam are present. Potentiometric sensors are unaffected by the vapor space composition.

| Frequently Asked Questions (FAQs)

Q: Can potentiometric sensors be used in CIP (Clean-In-Place) processes?

A: Yes. Most potentiometric probes are designed with hygienic fittings (like Tri-Clamp) and materials (316L/PEEK) that withstand the high temperatures and caustic chemicals used in CIP and SIP cycles.

Q: Does the sensor need recalibration if the liquid type changes?

A: Generally, no. Because the sensor measures a voltage ratio rather than absolute resistance, it remains accurate even if you switch from milk to fruit juice, provided both meet the minimum conductivity requirement.

Q: What happens if the probe is covered in thick sludge?

A: Potentiometric detection is specifically designed to ignore coatings. As long as the bulk liquid level moves, the sensor will accurately track the point where the probe enters the main body of the liquid, ignoring the residue on the upper part of the rod.

Q: Is it possible to shorten the probe in the field?

A: This depends on the manufacturer. Some probes are factory-sealed and cannot be cut, while others allow for field-trimming followed by a simple recalibration of the electronics to the new length.

| Conclusion

Potentiometric detection represents a robust and precise solution for continuous level monitoring in challenging process environments. By leveraging the voltage divider principle, these sensors provide a level of immunity to foam, coating, and rapid level changes that few other technologies can match. For engineers working in the food, beverage, and pharmaceutical industries, understanding the nuances of this technology is essential for optimizing process control and ensuring product consistency.

For a comprehensive overview of level measurement technologies and to find the right sensor for your specific application, visit the Main Page of our product catalog. Reviewing product options and application support from a professional manufacturer like Welk can ensure that your level measurement solution is both accurate and cost-effective.