TECHNICAL COMPARISON

# Clamp-on Ultrasonic Density Meter vs. PS7000 Ultrasonic Acoustic-Impedance Density Meter

Principles and characteristics for online slurry density measurement — a neutral technical brief

**Typical processes:** non-ferrous metallurgy, FGD in thermal power, coal washing, chemical & metallurgical processing, potash / salt, mine tailings & backfill, and other solid–liquid slurries. | Prepared by PISONICS · June 2026

## 1. Overview

Online measurement of slurry (solid–liquid) density can be performed with several non-nuclear ultrasonic methods. This brief objectively compares two representative technologies: the **clamp-on ultrasonic density meter** (transducers on the pipe exterior, through-transmission) and the **PS7000 ultrasonic acoustic-impedance density meter** (probe window in contact with the slurry, interface reflection). Neither uses an ionizing-radiation source; they differ in sensing geometry and applicable conditions. The sections below compare measuring principle, key characteristics and installation, and give condition-based selection guidance.

**Note:** this brief does not judge either principle as superior. It clarifies how each works and where each applies, to help match the right method to the process.

## 2. Measuring Principles

**Clamp-on (transmission):** paired transducers clamp onto the pipe; ultrasound passes in turn through couplant, pipe wall, liner and slurry, and density is derived from the relationship between sound speed and / or attenuation and density. It is non-invasive and can be installed or relocated without shutting the line down.

**PS7000 (acoustic-impedance reflection):** a single self-transmit / self-receive probe; the sapphire window sits flush with the pipe bore and contacts the slurry. Density is inverted from the window–slurry interface reflection coefficient $R = (Zm - Zw)/(Zm + Zw)$, with acoustic impedance $Z = \rho \cdot c$, using a linear-frequency-modulated (Chirp) wideband signal with pulse compression. The window contacts the slurry, the path is short, and measurement bypasses the pipe wall and liner.

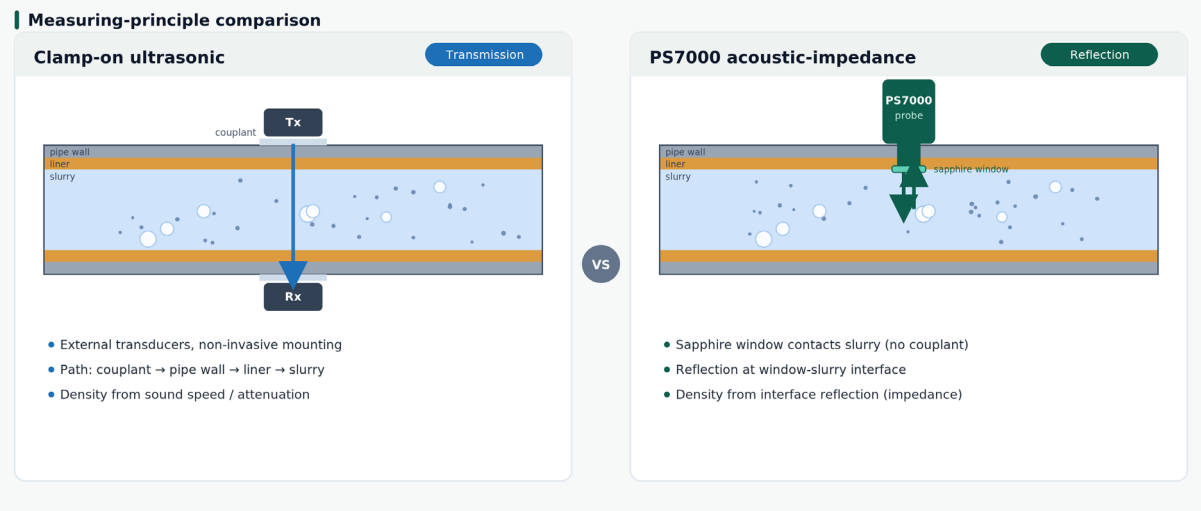


*Fig. 1 Two measuring principles: left, clamp-on transmission (ultrasound passes through pipe wall, liner and slurry; density from sound speed / attenuation); right, PS7000 acoustic-impedance reflection (window contacts slurry; density from interface reflection coefficient).*

# 3. Key Technical Characteristics

## 3.1 Pipe lining

- **Clamp-on:** ultrasound must cross the pipe wall and liner; it suits unlined or thin-lined, acoustically transmissive (e.g., metal) pipes. With thick or strongly absorbing / impedance-mismatched liners (rubber, thick PTFE, ceramic, cement) attenuation rises, so transmissivity should be assessed before installation.
- **PS7000:** the window is inside the pipe in direct contact with the slurry; measurement does not pass through the pipe wall or liner and is therefore unaffected by liner material. A liner can also be specified on the spool for corrosion / abrasion.

**Where each fits:** clean thin-wall metal lines suit both; lined lines favor the contact acoustic-impedance method.

## 3.2 Bubbles and solids

- **Clamp-on:** the transmission path spans the bore and is relatively long; with bubbles or higher solids, scattering and attenuation increase, affecting SNR and reading stability, so a well-mixed, low-gas point is preferred.
- **PS7000:** measurement is a short interface reflection at the window, with Chirp wideband signaling, sub-band consistency discrimination and multi-shot statistics to reduce bubble interference, giving good tolerance to bubbly / high-solids conditions.

**Where each fits:** low-gas, well-mixed conditions suit both; bubbly or high-solids conditions favor short-path contact reflection.

## 3.3 Acoustic coupling

- **Clamp-on:** a couplant is needed between transducer and pipe to conduct ultrasound; its condition changes with time, temperature and vibration, so periodic inspection or re-application is required to keep the signal stable.

- **PS7000:** the window contacts the slurry directly, using the slurry itself as the coupling medium, so no external couplant is needed; the sapphire window is smooth and scaling-resistant.

**Where each fits:** where periodic maintenance is acceptable, clamp-on offers flexible mounting; where long-term, low-intervention operation is wanted, the contact method is more convenient.

## 4. Other Characteristics

- **Accuracy & pipe-wall dependence:** clamp-on accuracy is affected by pipe material, wall thickness, liner and coupling, and calibration is tied to pipe condition; PS7000 is independent of the pipe wall and holds ±1% FS across the range after calibration.
- **Full pipe & flow:** clamp-on transmission usually needs a full pipe and avoidance of top-of-pipe gas; PS7000 has no full-pipe requirement and can measure small flows, with > 1 m/s recommended to prevent settling.
- **Concentration & temperature:** clamp-on range depends on acoustic transmissivity and coupling; PS7000 covers 0–80% mass concentration (0–3000 kg/m³), medium 0–80°C, high-temp to 120°C.
- **Installation & maintenance orientation:** clamp-on is non-invasive, no-shutdown and movable, but needs couplant care; PS7000 needs a one-time flange installation in return for long-term, maintenance-free, high-accuracy measurement. The orientations differ; neither is absolutely superior.

## 5. Comparison Summary

(The table objectively lists characteristics and applicable conditions of both technologies, without value judgement; “model- / condition-dependent” means it depends on the specific configuration or site.)

| Aspect | Clamp-on ultrasonic (transmission) | PS7000 acoustic-impedance (reflection) |
|---|---|---|
| **Measuring principle** | External transducers; ultrasound transmitted through pipe wall / liner / slurry (sound-speed · attenuation) | Single probe, window contacts slurry; interface reflection (acoustic impedance) |
| **Mounting** | Non-invasive clamp-on; installable without shutdown, movable | Flanged measuring spool on a straight run; integral / remote |
| **Pipe lining** | Suited to acoustically transmissive pipes; thick / strongly absorbing liners need assessment | Measurement bypasses the liner; unaffected by liner material; liner optional on spool |
| **Bubbles / high solids** | Longer transmission path; scattering / attenuation increase; choose a well-mixed, low-gas point | Short interface reflection + Chirp wideband processing; tolerant of bubbles / high solids |
| **Acoustic coupling** | Couplant required; periodic check / re-application | Slurry couples directly; no couplant; sapphire window resists scaling |
| **Pipe-wall dependence** | Depends on pipe material, wall thickness, scale, liner | Independent of the pipe wall |
| **Full-pipe** | Usually requires a full pipe; avoid | No full-pipe requirement |

| Aspect | Clamp-on ultrasonic (transmission) | PS7000 acoustic-impedance (reflection) |
|---|---|---|
| **requirement** | top-of-pipe gas | |
| **Accuracy** | Affected by path factors; tied to pipe condition | ±1% FS (0–3000 kg/m³) |
| **Medium temperature** | Depends on couplant & hardware | 0–80°C (high-temp to 120°C) |
| **Maintenance** | Monitor couplant; periodic recalibration | ≥ 5 years maintenance-free; non-volatile data |
| **Output / comms** | Model-dependent | 4-20 mA ×2 + RS485 Modbus-RTU (optional 4G) |
| **Ex / certification** | Model-dependent | Optional Ex d IIC T6 Gb; CE |

# 6. Installation & Use

## 6.1 Clamp-on (transmission)

Clean the pipe exterior, fix the paired transducers on a straight run at the specified spacing / angle, apply acoustic couplant to exclude air gaps, set pipe diameter, wall thickness and material, then calibrate. It is non-invasive and can be installed or moved without shutdown; in service, couplant condition and reading calibration should be checked periodically.

## 6.2 PS7000 (acoustic-impedance) — installation requirements & method

PS7000 uses a flanged measuring spool on a straight run, with integral or remote mounting. Key points:

| | |
|---|---|
| **Mounting** | Flanged spool on a straight run; integral (easy reading) / remote (tight space or non-full pipe, signal ≤ 500 m); wall-mount enclosure available |
| **Straight run** | Away from pumps, valves and elbows; horizontal: 10D upstream / 5D downstream (min 5D / 3D); no full-pipe requirement |
| **Orientation & flow** | Prefer vertical, upward flow, > 1 m/s (higher for denser slurry); avoid low or stagnant flow |
| **Horizontal mounting** | Probe at the bottom and immersed; ensure a representative, unstratified, uniform slurry at the point |
| **Environment** | No strong vibration, stable ambient temperature, service clearance; ambient -30–60°C, medium 0–80°C (120°C high-temp) |
| **Wiring** | DC 24V (or 220V via module); 4-20 mA ×2 (load ≤ 500Ω); RS485 A/B/G ≤ 500 m; probe signal to MEA, temperature to PT1000 (red +, white −) |
| **Calibration** | Gravimetric sampling, Y = aX + b; water = 1000 kg/m³; first 12–24 h, then every 6–12 months |

### Installation steps (outline)

- **1) Safety:** power off, depressurize the line, close the sampling valve.
- **2) Install the spool:** flange it into a straight run, preferably vertical with upward flow; away from pumps and fittings; meet 10D upstream / 5D downstream (min 5D / 3D).
- **3) Choose the mounting:** integral directly on the spool; for remote, put the probe at the bottom and immersed on a horizontal pipe, with the enclosure wall-mounted.
- **4) Wiring:** DC 24V (or 220V via module); 4-20 mA ×2 and RS485 as needed; probe signal to MEA, temperature to PT1000 (red +, white −).
- **5) Setup & calibration:** set address, baud rate, output type and range via the remote; obtain true density by gravimetric sampling to compute a, b (Y = aX + b).

# 7. Selection Guidance

The two technologies are complementary. Choose by pipe condition, medium properties,

accuracy and O&M needs; a field trial is advisable where appropriate.

- **Favor clamp-on (transmission) when:** the pipe cannot be cut or shut down, measurement is temporary or mobile, the medium is clean and the pipe full without a (thick) liner, or mounting flexibility is a priority.
- **Favor PS7000 (reflection) when:** the pipe is lined, the medium is bubbly / high-solids, long-term stable maintenance-free high-accuracy continuous measurement is required, or DCS integration / a hazardous-area rating is needed.

**Summary:** clamp-on excels at non-invasive, flexible mounting; the contact acoustic-impedance method excels at being independent of the pipe wall / liner and at long-term stability. Matching to the process lets each play to its strengths.