

Thermal Dispersion

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



Main topic: Main Page
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Thermal dispersion is a fundamental physical principle used extensively in industrial instrumentation for measuring the flow and level of fluids. Unlike mechanical or optical methods, thermal dispersion relies on the transfer of heat from a sensing element to the surrounding medium. This technology is prized in B2B industrial environments for its lack of moving parts, high reliability, and ability to operate in challenging conditions where other sensors might fail.

In this guide, we explore the underlying physics of thermal dispersion, its application in level and flow sensing, and the practical considerations engineers must address when selecting these instruments for water treatment, chemical processing, and oil and gas applications.

| Understanding the Thermal Dispersion Principle

At its core, the thermal dispersion principle is based on the cooling effect of a moving or static fluid. In a typical sensor configuration, two Resistance Temperature Detectors (RTDs) are placed within a probe. One RTD is the "reference sensor," which measures the ambient temperature of the process medium. The second RTD is the "active sensor," which is internally heated to a temperature higher than the reference sensor.

As the process medium (liquid or gas) comes into contact with the heated sensor, it carries heat away from the probe. This heat transfer occurs through conduction and convection. The rate at which this heat is dissipated depends on the physical properties of the fluid—specifically its thermal conductivity, density, and velocity.

| The Relationship Between Heat Transfer and Measurement

There are two primary methods used to process the signal in thermal dispersion instruments:

1. **Constant Temperature Difference (ΔT):** The electronics vary the power supplied to the heated RTD to maintain a constant temperature difference between the active and reference sensors. The amount of electrical power required to maintain this ΔT is directly proportional to the mass flow rate or the presence of a liquid medium.

2. **Constant Power:** A fixed amount of electrical power is supplied to the heated RTD. The resulting temperature difference (ΔT) between the two sensors is measured. As the cooling effect increases (e.g., when a probe is immersed in liquid or when flow velocity increases), the ΔT decreases.

Because liquids generally have much higher thermal conductivity and heat capacity than gases, the transition from gas to liquid (level detection) or the movement of a fluid (flow detection) creates a distinct and measurable change in the thermal profile of the sensor.

Thermal Dispersion in Level Measurement: Point Level Switches

In level measurement, thermal dispersion technology is most commonly employed in point level switches. These devices are designed to detect the presence or absence of a liquid at a specific height in a tank or vessel.

When the sensor probe is in air or gas, the heat dissipation is relatively low, and the temperature of the heated RTD remains high. However, once the liquid level rises and submerges the probe, the liquid's superior thermal conductivity rapidly draws heat away. This sudden drop in temperature (or increase in required power) triggers the switch to change state (e.g., from "normally open" to "normally closed").

Advantages for Level Detection

No Moving Parts: Unlike float switches, thermal dispersion sensors do not have mechanical components that can jam, corrode, or wear out over time.

Versatility: They can detect the interface between two different liquids (such as oil and water) if the two media have significantly different thermal conductivities.

Heavy Duty Performance: Thermal switches are often constructed from robust materials like 316L stainless steel, Hastelloy, or Monel, making them suitable for high-pressure and high-temperature environments.

For engineers looking to integrate these sensors into broader automation systems, it is essential to Review product options and application support to ensure the chosen instrument matches the specific chemical compatibility of the process.

| Industrial Applications and Use Cases

Thermal dispersion instruments are utilized across various sectors due to their durability and precision.

| 1. Water and Wastewater Treatment

In water treatment plants, thermal dispersion switches are used for pump protection. By detecting a "dry run" condition (the absence of liquid), the switch can automatically shut down a pump before it sustains damage from overheating. They are also used to monitor the flow of chemical additives, ensuring that disinfection or flocculation processes are receiving the correct dosages.

| 2. Chemical and Petrochemical Processing

These industries often deal with viscous liquids or fluids that may coat a sensor. While high-viscosity fluids can pose challenges, thermal dispersion sensors are often preferred over ultrasonic or optical sensors in applications involving foam or turbulence, as the thermal transfer is less affected by surface agitation.

| 3. Oil and Gas

In separator tanks, thermal dispersion technology is used to detect the interface between oil, water, and gas. Because each phase has a distinct thermal conductivity, a single probe can sometimes be calibrated to distinguish between the emulsion layers, providing critical data for the separation process.

Technical Selection Criteria for Engineers

Selecting the right thermal dispersion instrument requires a deep understanding of the process environment. Engineers should evaluate the following parameters before procurement:

Criteria	Description	Impact on Performance
Media Type	Liquid, gas, or slurry.	Determines the required sensitivity and probe material.
Thermal Conductivity	The fluid's ability to conduct heat.	Higher conductivity leads to faster response times.
Operating Pressure	Measured in Bar or PSI.	Sensors must be rated for the maximum vessel pressure (e.g., 40 Bar / 580 PSI).
Temperature Range	Measured in Celsius or Fahrenheit.	High-temperature versions are required for steam or hot oil (up to 200°C / 392°F).
Viscosity	The fluid's resistance to flow.	Extremely thick fluids may cause a "clinging" effect, delaying the reset of the switch.
Wetted Materials	316L SS, PTFE, Hastelloy.	Must be chemically compatible with the process medium to prevent corrosion.

Comparison with Other Technologies

While Welk specializes in a wide range of measurement technologies, it is helpful to compare thermal dispersion to other common methods:

Radar Level Meters: Best for continuous level measurement and non-contact applications. Thermal dispersion is better for point level switching in tight spaces.

Ultrasonic Sensors: Ideal for open-channel flow and non-contact level. However, they can struggle with foam and heavy vapors, where thermal dispersion remains stable.

Hydrostatic Transmitters: Excellent for continuous level based on pressure, but they cannot detect flow or interface as effectively as thermal sensors.

| Installation Guidelines and Best Practices

To ensure accurate measurement and long-term reliability, proper installation of thermal dispersion probes is critical.

1. **Probe Orientation:** For level switching, the probe should be installed horizontally or vertically depending on the tank geometry. In horizontal installations, ensure the two RTD elements are aligned so that the liquid hits them simultaneously to avoid false readings.
2. **Flow Direction:** If used as a flow switch, the probe usually has a directional arrow. It must be oriented so that the fluid flows across the sensing elements properly.
3. **Avoid Obstructions:** Ensure the probe is not located too close to tank walls, agitators, or inlet pipes where turbulence or splashing might cause erratic switching.
4. **Insertion Depth:** The active portion of the probe must be fully immersed in the medium to trigger a state change. In pipe flow applications, the probe should typically be inserted to the center of the pipe where the velocity profile is most stable.
5. **Straight Run Requirements:** For flow measurement, a straight run of pipe (typically 10 diameters upstream and 5 diameters downstream) is recommended to minimize turbulence.

| Limitations and Potential Risks

While highly reliable, thermal dispersion technology is not a universal solution. Engineers must be aware of its limitations:

Coating and Scaling: If the process medium is prone to leaving heavy deposits or scaling (such as calcium buildup or thick crude oil), a layer of insulation can form over the probe. This reduces the heat transfer efficiency and can lead to sluggish response times or failure to detect the medium. Regular cleaning or the use of specialized coatings may be necessary.

Response Time: Thermal dispersion is inherently slower than electronic methods like radar. Because it relies on physical heat transfer, there is a delay (often 1 to 3 seconds) while the sensor reaches thermal equilibrium.

Specific Heat Changes: If the composition of the fluid changes significantly (e.g., switching from water to an alcohol-based solvent), the sensor may require recalibration, as the thermal properties of the new fluid will differ.

| Frequently Asked Questions (FAQ)

Q: Can thermal dispersion sensors be used in hazardous areas?

A: Yes. Most industrial thermal switches are available with explosion-proof (Ex d) or intrinsically safe (Ex i) ratings, making them suitable for use in volatile environments like oil refineries.

Q: How do I handle air bubbles in the liquid?

A: Significant aeration can change the effective thermal conductivity of the liquid. In applications with high aeration, it is best to install the sensor in a stilling well or a location where the fluid is more stable.

Q: Do these sensors require frequent calibration?

A: Generally, no. Since there are no moving parts to wear out, the factory calibration remains stable for years unless the process medium changes or the probe becomes severely coated.

Q: What is the maximum temperature these sensors can handle?

A: Standard probes typically handle up to 120°C (248°F), but specialized high-temperature models can operate at 200°C (392°F) or higher with remote electronics to protect the circuitry from heat.

| Conclusion

Thermal dispersion remains a cornerstone of industrial process control, offering a unique combination of durability and sensitivity. By understanding the principles of heat transfer and carefully evaluating the physical properties of the process media, engineers can implement level and flow solutions that require minimal maintenance and provide years of reliable service. For those seeking comprehensive measurement solutions across radar, ultrasonic, and thermal technologies, visiting the Main Page of a professional manufacturer like Welk is the best way to ensure your project receives the technical support and high-quality instrumentation it requires.