Reducing complexity in data center cooling temperature measurements

Endress+Hauser's iTHERM SurfaceLine TM611 non-invasive temperature measurement performs comparably to traditional industrial thermometers with an elegant mechanical innovation

As computing workloads grow increasingly dense, hyperscale data centers are transitioning from air-based to liquid cooling solutions. Driven by advancements in high-performance computing (HPC) and AI workloads, liquid cooling offers excellent thermal efficiency for modern hardware, such as GPUs and high-density CPUs. Air cooling struggles with thermal management in densely packed environments, leading to hotspots and reduced efficiency.

The shift to liquid cooling is being driven by these limitations of air cooling, which may no longer be able to keep up with the thermal demands of cutting-edge technology. Liquid cooling offers superior heat transfer capabilities, addressing these limitations by efficiently dissipating heat from high-performance components. This trend has resulted in a growing demand for solutions ensuring uptime and reliability in these high-performance environments.

This white paper explores the challenges of reducing complexity in data center cooling temperature measurements and how modern instrumentation, like Endress+Hauser's iTHERM SurfaceLine TM611, can enhance related processes.

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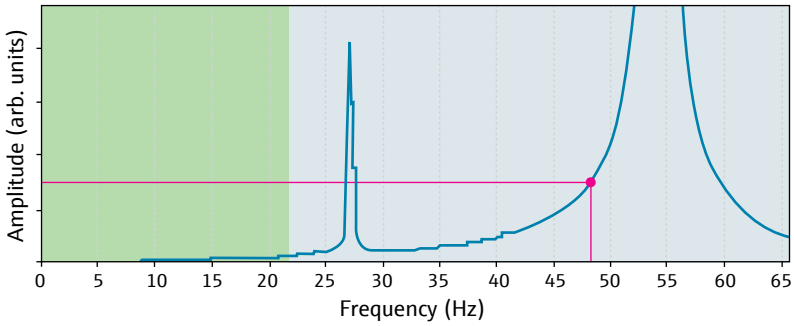


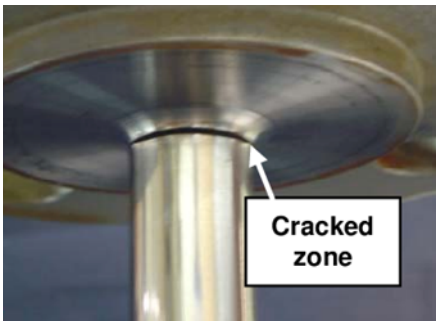


Figure A

Temperature measurements for process control (typical)

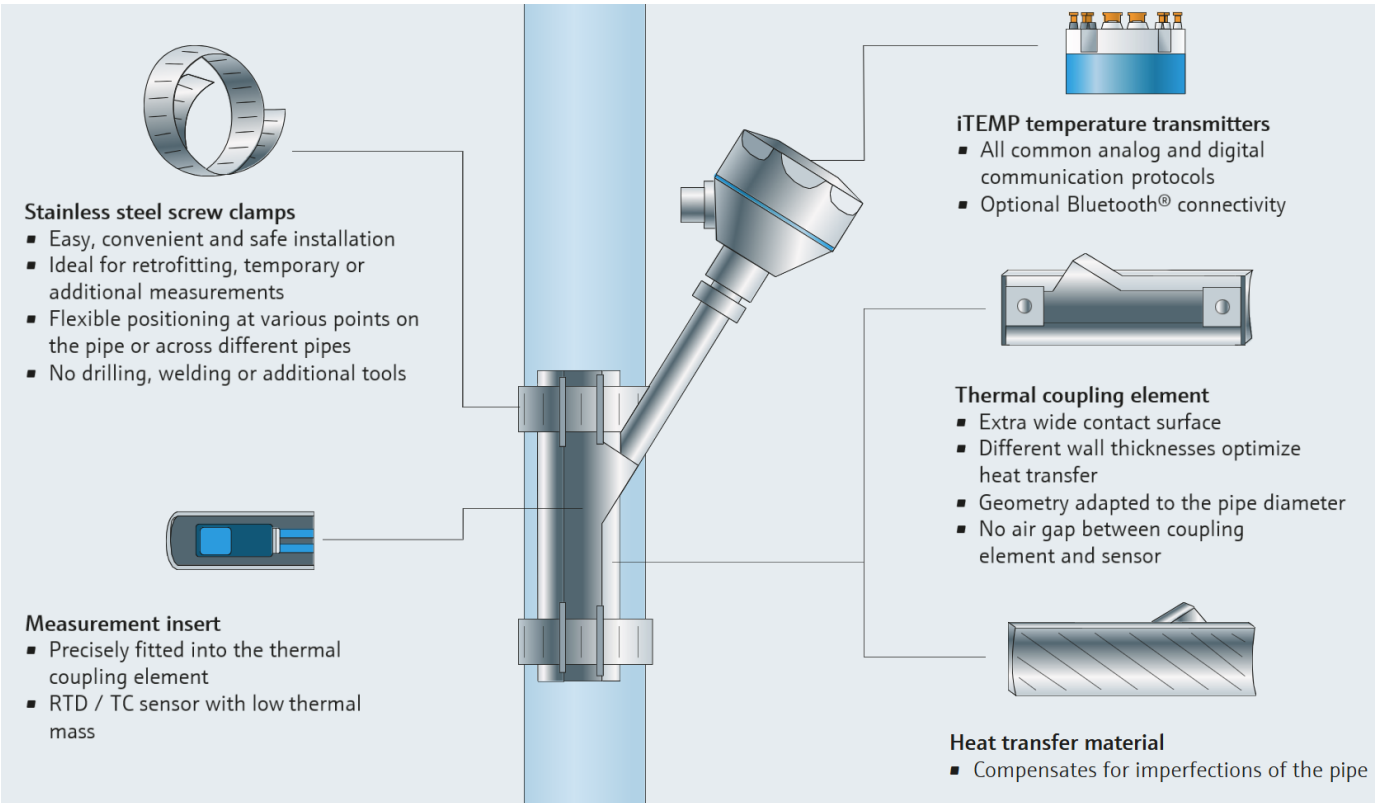
Temperature measurement in cooling loops, and many other industrial processes, has traditionally relied on invasive sensors like thermocouples and RTDs inside thermowells, which penetrate the process pipe or vessel. While effective, these setups may be prone to risks such as leakage, contamination, increased maintenance requirements and flow disturbances that impact system performance. Thermowells also require specific engineering, such as wake frequency calculations, to avoid vibration-induced failures (see Figure A), adding complexity and cost to the engineering and installation process. Wake frequency calculations ensure that thermowells are designed to avoid resonant frequencies that can cause vibration-induced failures, enhancing the reliability of temperature measurements.

Moreover, any disturbance in the flow, caused by the thermowells, can increase energy consumption as pumps must work harder to overcome additional pressure drops created by these invasive sensors.

Criticality of pump performance and pipe cleanliness

In liquid-cooled data centers, the reliability of pump performance is critical. Any disruption in the coolant flow can lead to rapid temperature spikes, risking hardware damage. Therefore, ensuring smooth, uninterrupted coolant flow is essential.

Additionally, in these systems, the cleanliness of the cooling loop is paramount. Poor water quality, including contaminants or debris, can damage components and reduce cooling efficiency. Harmful contaminants include particulate matter, biological growth and chemical impurities, which can cause blockages, corrosion and reduced cooling efficiency. Regular filtration, chemical treatment and UV sterilization are standard to maintain water purity, preventing fouling and



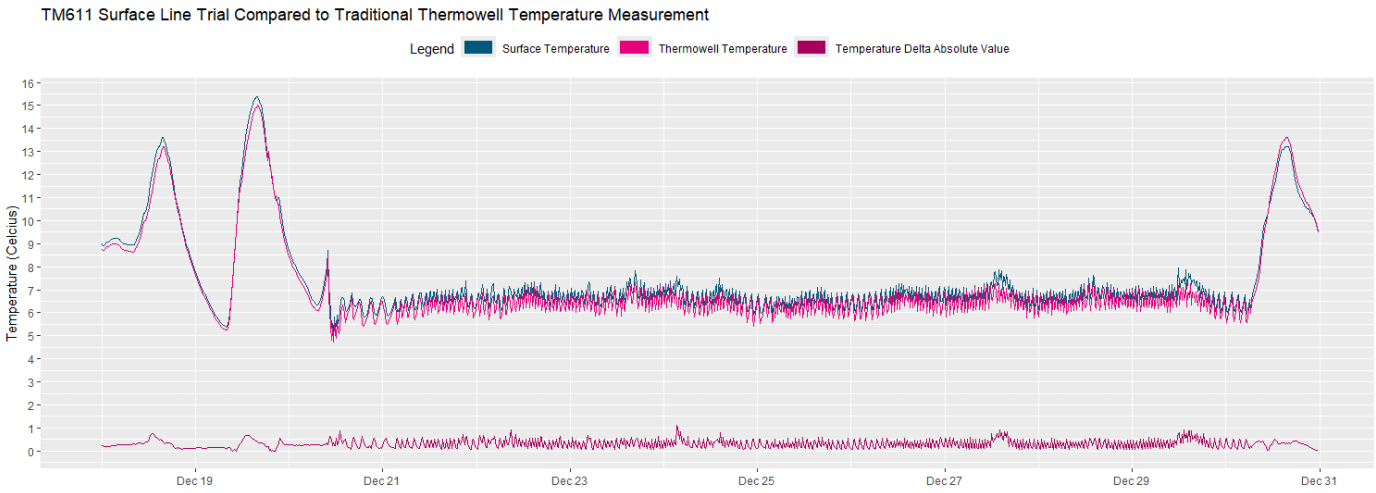


Figure B: While the device was uninsulated through Dec. 19, the subsequent data shows the iTHERM SurfaceLine TM611's faster response times and improved accuracy compared to other non-invasive approaches.

corrosion, possibly leading to system failures. The frequency of these treatments depends on the specific system and water quality, but regular intervals (e.g., monthly or quarterly) are recommended to prevent contamination and maintain efficiency. These measures ensure pumps operate efficiently, without unnecessary strain and prevent performance degradation or downtime.

Innovation in non-invasive measurement (iTHERM SurfaceLine TM611)

Endress+Hauser's iTHERM SurfaceLine TM611 non-invasive temperature sensor offers a unique solution that bypasses the need for thermowells or any penetration into the process pipe. The iTHERM SurfaceLine TM611 is ideal for environments where cleanliness is paramount, such as cooling loops in data centers, as well as applications with high flow velocities, high process pressures and corrosive media.

iTHERM SurfaceLine TM611 insulated in a cooling loop application

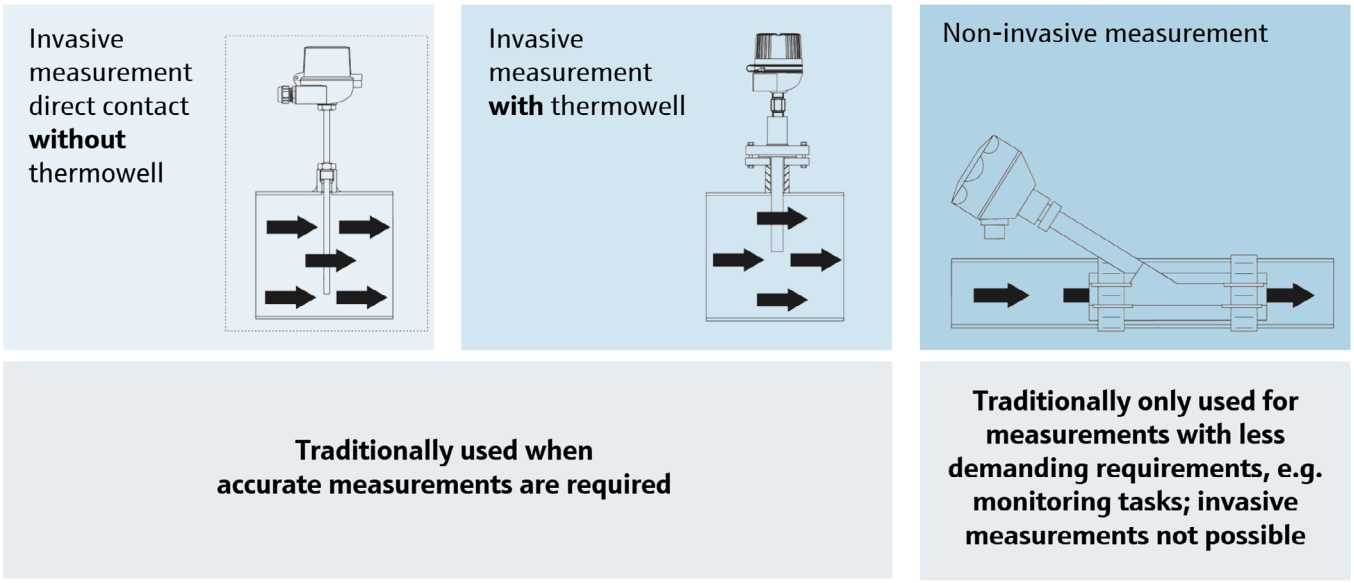
The iTHERM SurfaceLine TM611 utilizes a mechanical clamp-on interface that minimizes the impact of ambient temperature fluctuations, delivering superior accuracy without relying on electronic compensation algorithms. The mechanical clamp-on interface minimizes ambient temperature fluctuations by providing optimal thermal conductivity to the sensor, ensuring accurate measurements without relying on electronic compensation This results in **faster response times** and **improved accuracy** compared to other non-invasive approaches and offers similar performance to an insertion style, industrial thermometer (see Figure B).

By avoiding process penetration, the iTHERM SurfaceLine TM611 reduces the risk of contamination, making it particularly suitable for environments where cleanliness is crucial, such as cooling loops in data centers.

Furthermore, the iTHERM SurfaceLine TM611 enhances system efficiency by minimizing flow disturbances. Since it doesn't disrupt the flow with thermowells, pumps can operate more efficiently, reducing energy consumption. This also reduces the pressure drop across the system, leading to lower operational costs and greater reliability. In liquid cooling systems, especially those using recycled or treated water, the risk of contamination is always a concern. The non-invasive nature of the iTHERM SurfaceLine TM611 minimizes this risk, helping preserve the cooling loop's integrity. Additionally, the absence of direct contact with the fluid lowers the need for frequent maintenance, making it a low-maintenance solution that contributes to long-term system stability.

Holistically, the iTHERM SurfaceLine TM611 aligns perfectly with the evolving demands of hyperscale data centers, where

uptime and system efficiency are critical. The device's non-invasive design ensures consistent temperature monitoring while contributing to better cooling system performance, more significant energy savings and reduced risk of contamination. It's an ideal solution for environments where safety, cleanliness and operational efficiency are of the utmost importance.



Different approaches to temperature measurements; iTHERM SurfaceLine TM611 on right

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