White Paper

Instruments for Electrical Temperature Measurement:

How to Choose the Right One

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WIKA



TR10

The majority of measuring points in a process are used for monitoring temperature. Nowadays, these measuring points tend to be equipped with electrical temperature measurement instruments such as resistance thermometers and thermocouples. But with all the choices and options in the marketplace, which instrument is best suited for which measuring task?

There is no one-size-fits-all answer to this question. Almost every measuring point has unique criteria that must be taken into consideration. The following are some deciding factors:

1. Measuring accuracy and operating temperature

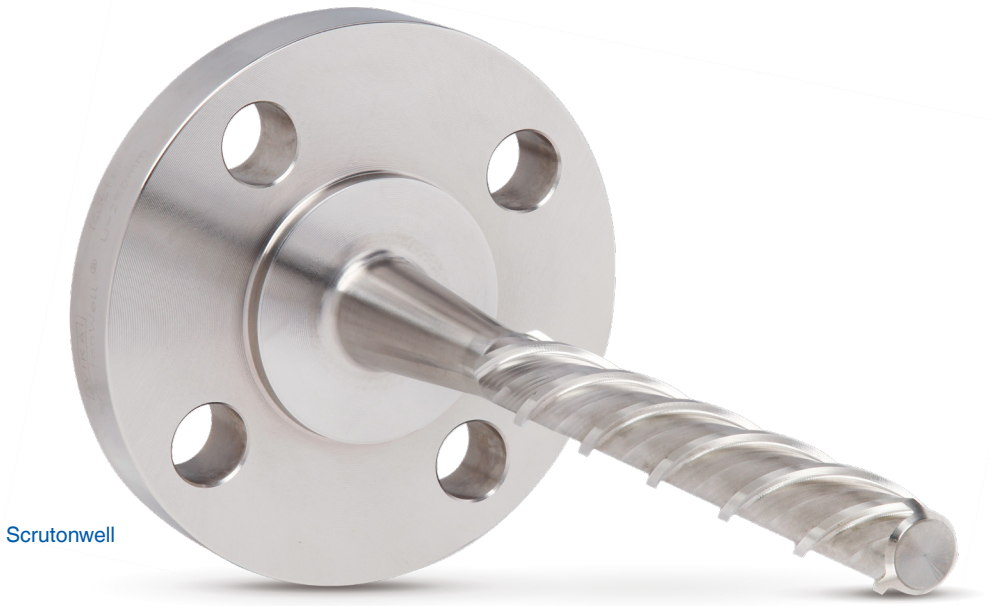
Resistance thermometers, also known as resistance temperature detectors (RTDs), provide high accuracy and excellent long-term stability. The tolerance value for class AA sensors is 0.10°C + 0.0017 | t |. However, the permissible measuring ranges for resistance sensors, according to IEC 60751, generally preclude use at temperatures higher than 600°C (1,112°F).

Although the long-term stability of thermocouples (TCs) is significantly lower than that of RTDs, apart from a few exceptions, TCs are capable of recording temperatures of up to 1,700°C (3,092°F).

2. Size and vibration resistance

Due to the size and design of their sensors, resistance thermometers have a larger diameter than thermocouples. WIKA instruments, for instance, have a minimum size of approximately 2.0 mm (0.08") for RTDs and 0.5 mm (0.02") for TCs.

Due to their simple construction, thermocouples are essentially unaffected by high vibrations. Standard resistance thermometers can withstand a 6 g load at the probe tip, or as much as 60 g if special designs are incorporated.



Scrutonwell

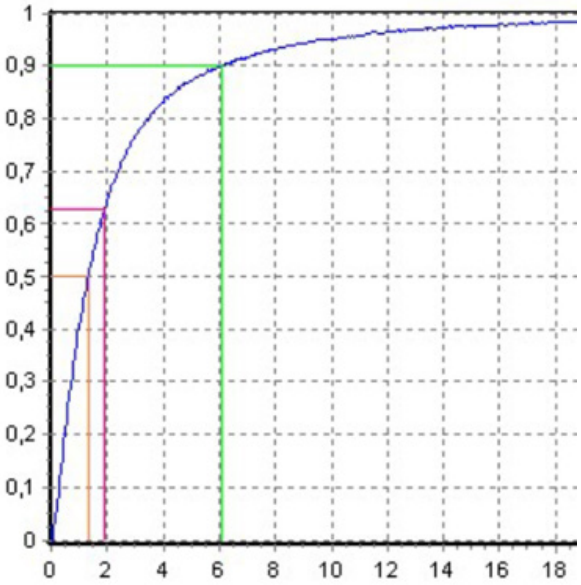
3. Response time

The thermal response time indicates how fast an ETM instrument responds to a step change in temperature on the process side. The common benchmark of 90% time, or t90, is the time it takes for a thermometer to reach 90% of the steady-state value following a sudden temperature change.

Several factors influence the response time. Aside from the process medium and the flow velocity, the most important factor is the thermowell. The high thermal mass of this protection tube appreciably prolongs the time it takes for the medium's heat to transfer to the temperature sensor. However, users have options to reduce this response time.

In the event of low-flow velocities, consider using thermowells with a tapered, stepped, or exposed tip. Another option is the so-called face-sensitive sensors; these are integrated in the thermowell wall and are separated from the process by only a wafer-thin diaphragm.

Improving the response time in high-flow processes is rather more complex. One possibility is to reduce the insertion depth and, hence, also the forces acting on the thermowell. However, if this means that the probe tip is no longer immersed far enough into the process, then qualified electrical temperature measurements are out of the question. Users can achieve greater stability by increasing the stem's diameter. The downside to that, of course, is a longer response time.



Detail of a response time diagram with three thresholds: t50 (yellow), t63 (green), and t90 (green). t0.63 (red) and t0.5 (yellow).

Thermowells with a helical stem like WIKA's ScrutonWell® design represent a compromise between greater strength and shorter response times. The strakes on the longer stem serve to break up the vortexes that create vibration, thereby reducing the likelihood of thermowell failure in high-velocity media.



4. Ambient conditions

Like the internal process, ambient conditions often significantly impact the thermometer and the quality of its electrical temperature measurements. Intense external heat, uncompensated cable resistances, and electromagnetic fields are all factors that interfere with the signal, influencing or falsifying the measured value.

If the instrument is to be exposed to extreme cold or heat, users must be even more careful to ensure, among other things, that the design and materials are suitable for those conditions. Additionally, specific applications – e.g., hazardous areas or sterile processes – require appropriate approvals.

Thermometers soon come up against their limits in extreme ambient conditions. Due to their electronic and nonmetallic components, the operating temperature range is typically from –40°C to +85°C or +105°C (–40°F to +185°F or +221°F). Electrical temperature measurement devices must also be resistant to other environmental conditions, such as water or solid particles.



TR10
with TW10

5. Output signal

Although measurement signals, in principle, can be transmitted via a cable to the control room for further processing, external influences (see #4) impair the accuracy of electrical temperature measurements. Alternatively, a transmitter in the thermometer's connection head generally converts the analogue measurement signal locally into a standardized industrial signal that is less susceptible to failure.

Digital electronics can also expand a thermometer's functionality and allow full configuration remotely from the control room. The most relevant and widespread technologies are 4…20 mA output signals together with the HART® protocol and various fieldbuses.

Design of a temperature measuring point and position of the signal processing electronics (transmitter).

6. Installation conditions

Users must consider the physical dimensions of the complete temperature measuring point. The trend toward modular smart-scale production units creates a need for compact ETM instruments. The TR34 miniature resistance thermometer, for example, has a diameter of just 19 mm (0.78") and a maximum height of 68 mm (2.7"), yet it can accommodate a transmitter with a 4…20 mA output.

If the measuring points are difficult to access, connecting the cable by means of individual stranded wires is likely to be a complicated affair. Thermometers with a connection head have a cable gland at the inlet, which protects the device against particles, dust, and water. Process adapters like the M12 plug simplify the electrical connection.

Measuring points with an in situ display in the housing of the connection head are recommended for small, autonomous systems or for units where the temperature sensors are not connected to a control room. If the mounting position results in poor readability, a remote display can be attached as well.

Surface resistance thermometers can be used to obtain additional measuring points in an existing piping system, if retrofits are ruled out. However, they indicate only an approximate process temperature compared to in-line measurements.

7. Approvals

Lastly, end users must consider the country in which the measuring instrument will be located and what approvals may be required. While some regions have lax certification standards, others are very strict about specific approvals.

As a global company, WIKA is your ideal partner for making sure your resistance thermometers and thermocouples are certified for use around the world. We also offer expert advice on a comprehensive portfolio of products for electrical temperature measurement, including transmitters, switches, thermowells, programming units, and other accessories. Contact us for more information on ETM solutions that are customized for your particular applications.



Adam DeLancey started his career with WIKA in 2004 after finishing his studies in Engineering Design and Drafting. After being Product Manager at WIKA Canada for several years, he transferred to the ETM division covering the Americas region, supporting manufacturing and sales with engineered Electrical Temperature Measurement solutions. He focuses on special applications for temperature measurement, including tubeskin and multipoint products.

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