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SPOILT FOR CHOICE

Criteria for selecting the most suitable electrical temperature measuring point — The temperature is one of the most important measured variables of a process medium and is predominantly monitored with electrical thermometers. But as simple as the task sounds, know-how is required when choosing the right sensor. We will give you some helpful tips.

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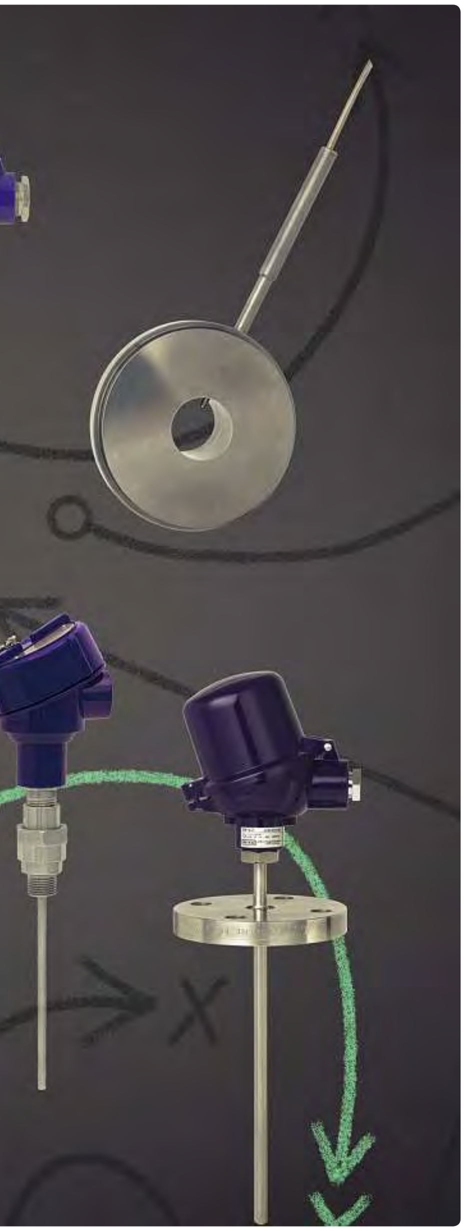
The chemical and physical characteristics of a process medium almost always depend on the temperature. Electrical thermometers are the preferred method for monitoring this effectively. Owing to the complexity and individual nature of the processes, the necessary measuring instruments can only rarely be ordered from a catalogue. When selecting instruments which are op-



timally tailored to the task at hand, particular consideration should be given to the following criteria:

The contact measurement method with resistance thermometers and thermocouples is first choice in industry and this article will therefore focus on these two device types. Resistance thermometers generally work with platinum sensors, for example Pt100 or Pt1000. The metal material is embedded within a ceramic body as a wire or applied to a ceramic substrate as a layer. The temperature is measured by determining the electrical resistance of the platinum sensor. This changes as a function of the temperature according to characteristic curves defined, for instance, in IEC 60751 and corresponds to an absolute temperature value.

Thermocouples consist of two wires made of different metals and welded together. If a temperature difference occurs along these two phases, a thermoelectric voltage is produced between the two legs (Seebeck effect). This can be measured at the ends of the metallic conductors and is in the region of a few µV per 1 °C. The voltage corresponds to a relative temperature value referred to the temperature at the cold junction.

Measuring accuracy and operating temperature

Resistance thermometers 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 preclude use at higher temperatures. According to IEC 60751, classic ceramic sensors span a range from -200 °C to +600 °C.

Although the long-term stability of thermocouples is significantly lower, apart from a few exceptions they are capable of recording temperatures of up to 1700 °C. Some thermocouples — like tungsten-rhenium, gold-platinum or platinum-palladium — are indeed suitable for much higher values.

Since each measurement technology has its own benefits, the choice is inevitably a compromise between accuracy and long-term stability, influenced particularly by the required measuring range.

Size of Sensor and vibration resistance

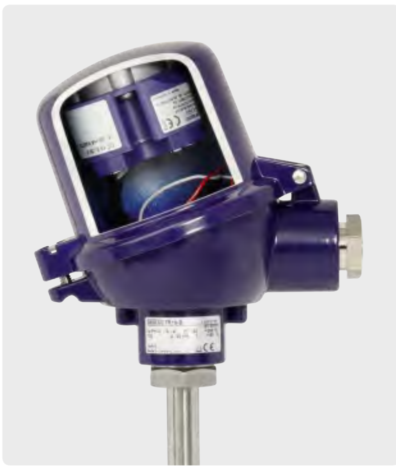
Due to the size and design of their sensors, resistance thermometers have a larger diameter than thermocouples. Wika temperature measuring instruments, for instance, have a minimum size of approximately 2.01 mm and 0.5 mm respectively. Thermocouples are highly insensitive to vibration on account of their simple type of construction. Ordinary resistance thermometers are rated for a 6 g load at the probe tip; this value can be increased to as much as 60 g by incorporating special designs.

Operating and installation conditions

The dimensions of the complete temperature measuring point also play a crucial role in addition to the sensor size, especially in the light of the trend towards modular smart-scale production units. Manufacturers of measurement technology are responding to this development with miniature measuring instruments like Wikas's TR34, in which — despite a diameter of just 19 mm and a maximum height of 68 mm — a transmitter with a 4…20 mA output can also be installed.

If the measuring points are difficult to access, connecting the cable by means of individual stranded wires can be a complicated affair. Classic thermometer types with a connection head have a cable gland at the inlet, which protects the device against foreign bodies or the ingress of dust and water. With Wika miniature thermometers, for example, M12 plug connectors simplify the electrical connection.

Measuring points with an in situ display are recommended for small, autonomous systems or for units where the temperature sensors are not connected to a control room. The display is directly inte-



Electrical thermometer with a typical connection head and transmitter

Sources: Wika

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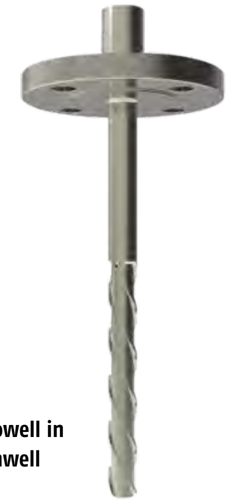
Global product certifications are a condition of global use



Thermowell in Scrutonwell design

grated in the housing of the connection head. If the measured value is hard to read because of the mounting position, a remote display can be used as well.

Invasive temperature measurements are not allowed in some processes, for instance sterile processes where the pipelines are cleaned with a pig. In this case, in-line resistance thermometers enable hygienically designed temperature measuring points which are free from dead spaces. The cylindrical stem, which acts like a thermowell, is fitted into the pipe directly.

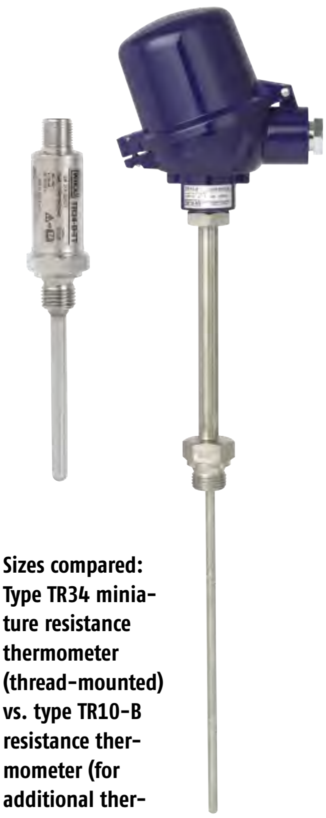
Surface resistance thermometers for welding or for mounting with a clamp can be used to obtain additional measuring points in an existing piping system if retrofits are ruled out. Since the measuring point is located on the outer pipe wall, it can only indicate the actual process temperature approximately compared to in-line measurements. Surface resistance measurements are always a compromise with regard to accuracy and response.

Response time to step change in temperature

Account must also be taken of the thermal response time when selecting a thermometer. How fast does the measuring instrument respond to a step change in temperature on the process side? The 90 % or t90 time which is very often specified for thermometers is the time taken to reach 90 % of the steady-state value following a sudden temperature change.

The response time is influenced by a number of factors. In addition to the process medium and the flow velocity, a key function is performed by the thermowell, which protects measuring instruments from the process environment, such as abrasive flow conditions. Its high thermal mass causes the response time to increase significantly. This can be optimised, however, provided certain requirements are met: at low flow velocities, for example, thermowells with a tapered (Form 3 as per DIN 43772) or exposed tip are worth considering, assuming they are sufficiently stable for the process. The use of so-called face-sensitive sensors, or of sensors integrated in the wall of the thermowell and only separated from the process by a wafer-thin diaphragm, is another option.

Improving the thermal response time in processes with a high flow velocity is rather more complex. One possibility here might be to reduce the insertion depth and hence also the forces acting on the thermowell. However, this could mean that the probe tip is no longer immersed far enough into the process, so that qualified temperature measurements are out of the question. If the immersion depth is fixed, the diameter of the stem can be increased in order to make the thermowell more stable — and unfortunately lengthen



Sizes compared: Type TR34 miniature resistance thermometer (thread-mounted) vs. type TR10-B resistance thermometer (for additional thermowell)

the response time. Thermowells with a helical stem like Wika's Scrutonwell design represent a compromise between high strength and short response times. The spiral reduces the tendency to vibrate and with it the likelihood of thermowell failure.

Effects of Environmental Conditions

Like the internal process, ambient conditions can often impact significantly on the thermometer and the quality of its measurements. The measured value can be influenced, for example, by intense external heat or by uncompensated cable resistances. Electromagnetic fields, too, can interfere with the signal and falsify the temperature measurement.

Even greater caution is advised if the thermometer is to be used in extreme conditions. Users must make sure that the design and materials are suitable. The device must have the appropriate approvals for specific applications, for example in hazardous areas or sterile processes.

Thermometers soon come up against their limits in extreme ambient conditions. Due to the electronic and non-metallic components which are installed there, the maximum operating temperature is typically +85 °C or +105 °C; at the opposite end of the scale, -40 °C is the norm. Wika has also developed and certified instrument designs where the limit is -60 °C for "Arctic" applications, for example.

Thermometers must be equally immune to environmental influences in the form of solid particles or water. According to IEC 60529, the maximum degree of protection is expressed by the IP class. The first digit indicates the level of protection against solid particles and dust. Thermometers with a connection head conform to IP65 or IP68, depending on the version.

Signal Processing, Communication, Calibration

For several decades the measurement signal was transmitted to the control room for further processing via a cable. With this form of transmission, however, the accuracy of the measurement can be impaired by external influences (see above). In the meantime, a transmitter in the thermometer's connection head generally converts the analogue measurement signal locally into a standardised industrial signal that is not susceptible to failure.

The thermometer's functionality can also be expanded by means of digital electronics. The measuring instrument can thus be fully configured using the software in the control room. The most widespread technologies here are 4…20 mA output signals together with the Hart protocol and various fieldbuses.

A thermometer's measuring accuracy must be verified regularly to ensure the required process quality. The instrument must be dismounted for calibration. Provided there is a thermowell at the measuring points, the process remains closed after the sensor has been removed.

Calibration can nevertheless be a problem in continuous processes because no measured values are available for the duration of the inspection. Measuring points with in situ calibration provide a solution in such cases. Parallel to the permanently installed sensor, the thermometer which is necessary for this purpose contains a channel for inserting the calibrated reference. By comparing the two sensor signals, it is possible to gain an idea of the measuring point accuracy without interrupting the process. The higher capital costs are offset by the lower costs of operation and the longer service intervals.

Certifications and barriers to market entry

Any approvals which may be required later at the place of use must be considered when the measuring instrument is selected. Global players need products that are suited for global use and certified accordingly. Not every manufacturer can cover this bandwidth, especially when it comes to explosion protection certifications.

PROCESS-Tip

- You can visit Wika at **Hannover Fair** (April 23-27, 2018): Hall 11, Stand C56