

## Monitoring Temperature During Heat Processing, Werner Jensen, Ellab A/S

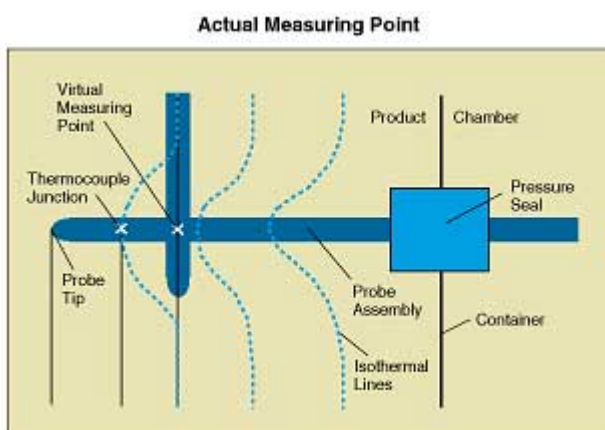
*With proper probe design and careful choice of materials, the influence of temperature gradients upon measuring accuracy can be reduced.*

When using temperature probes to measure the "cold spot" temperature during heat processing of canned products, the general laws governed by fundamental physics sometimes are ignored. As these rules are valid for any probe type and cannot be overruled, understanding the mechanisms that may have an adverse effect upon measuring accuracy is essential.

Temperature gradients larger than 100oC/cm are not uncommon in canned products during the dynamic stages of food preservation processes. To exactly determine the product's temperature within the gradient layers, a probe must be able to measure the temperature within a single point at any given moment. As to be expected, such an ideal probe exists only in theory. With proper probe design and choice of materials, the influence of wide temperature gradients upon the measuring accuracy can be reduced -- but never completely eliminated.

A probe always indicates the temperature of its sensing element. This may or may not correspond with the actual -- or expected -- product temperature at the probe tip. For resistance-type probes such as a 100 ohm platinum RTD, the temperature reading is the average value for the area covered by the sensing element. When used in a static field, the location of the measuring point generally is stated as the geometric center of the element. But, if the probe is used within a gradient layer of fast-changing temperatures, the actual position of the measuring point is hardly predictable.

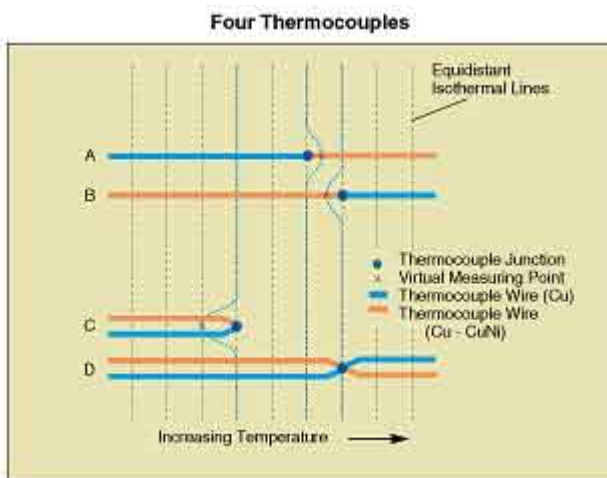
For thermocouple- and thermistor-type probes, the measuring point often is considered "point-shaped" and situated at the very tip of the probe. This assumption is not quite accurate: The actual position is a few millimeters from the probe tip (figure 1). The actual location is governed by the physical dimensions of the assembly, which provides electrical insulation and mechanical protection for the sensing elements.



*Figure 1. The actual measuring point of most thermocouple- and thermistor-type probes is located a few millimeters from the probe tip.*

## Sensor Performance Varies

The behavior of some thermocouple configurations within an area of equidistant isothermal lines is shown in figure 2. It can be seen that even under static conditions, the indicated value at the readout is the temperature at a "virtual" measuring point, which can be displaced from the position of the thermocouple junction. For example, two thermocouples (labeled A and B) are shown in figure 2. The reversed positions of the virtual measuring points for the identical thermocouples (A and B) are caused by the different thermal properties of the probe materials. For an asymmetrical thermocouple (labeled C), at the equivalent conditions, the virtual measuring point is most distant from the thermocouple junction. For obvious reasons, this is the only practical configuration. Only for the symmetrical thermocouple (D), having the junction placed some distance from the end of the extended wires, the junction senses the temperature value corresponding to its physical position. Unfortunately, this does only apply for the probe when used in a static temperature field.



*Figure 2. As the thermal properties of different probe materials vary, the position of the virtual measuring point of the thermocouple varies.*

The displacement of the virtual measuring point is a function of the thermocouple wire's dimensions. The thermocouple wire diameter can be reduced to a size where this influence generally may be ignored, but the use of such probes is confined to the laboratory environment, as it is a difficult and time-consuming process to install such probes in a precise and stable position and, at the same time, provide a positive pressure seal. For such laboratory use, fast-responding miniature probes produced from 0.12 to 0.15 mm dia. thermocouple wires readily are available.

For standard probes suitable for routine measurements, the virtual measuring point may differ from the actual position of the sensing element, depending upon the existing temperature gradients, the container dimensions and the product's thermal properties. But, for cold spot measurements in products where heat transfer mainly is due to convection, the effect is usually negligible. For products in which the heat transfer is solely by conduction, the effect may be appreciable during any phase where large temperature gradients are spanned by the probe.

Because the deviation is proportional to the temperature gradients existing within the product, any deviation from the actual temperature at the measuring points is most evident during the dynamic first and last stages of a process. By contrast, the deviation approaches zero near to and during static holding phases.

By measuring a small batch of containers using a few probes inserted at different depths, the proper location for any subsequent cold spot measurements may easily be established. To obtain the position by calculation only is hardly possible, as the effects of container geometry and filling grade, and the thermal properties of the product in combination with the probe and pressure sealing gland, can only be approximated.

### **Minimize Gradient Effects**

To ensure adequate temperature sensing accuracy, select a probe with the smallest possible diameter consistent with practical use. Eventually, use a sharp-tipped naked probe without an external steel tube in connection with a piercing-type pressure sealing gland. Estimate the position of the virtual measuring point for the entire assembly with respect to the actual thermocouple junction, which is placed approximately 3 mm from the cylindrical edge of the naked probe tip. Use this distance for centering the probe at the "cold spot" position. Select the type, material and positioning of the pressure-sealing gland with respect to the product and container size. For very small containers, thermoplastic seals are recommended. And, for measuring temperature within steep temperature gradients, insert the probe in parallel to the expected isothermal lines within the product if at all possible.