DataTrace Technical Note

DataTrace Response to Change

The speed at which a sensor responds to a change in temperature can be critical to monitoring a process accurately. Every temperature sensor requires a certain time for the temperature reported to react to, and equilibrate with, a change in ambient temperature. Two terms are frequently used to describe this analysis: Thermal Time Constant and Response Time. They are frequently used interchangeably to describe this analysis; however, they are not the same.

The following is the technical description according to MIL-T-23648A:

Thermal Time Constant: The Thermal Time Constant is the time required for a temperature sensor to change 63.2% of the total difference between its initial temperature and final body temperature when subjected to a step function change in temperature.

As defined above, the thermal time constant, t_{th}, is the time that a sensor takes to react to a rapid change in the ambient temperature and to reach 63.2% of the actual temperature change. Typically, in order to determine this value, a sensor is moved rapidly from one temperature environment to another. The time taken to reach the second value, or Thermal Time Constant, is then measured.

In many applications, the Thermal Time Constant is not the most important measure of response. More important for many users of temperature sensors is Response Time.

Response Time, or t_{90}, is the time required for a temperature sensor to achieve 90% of the actual temperature change.

Typically, t_{90} is slightly more than two times the t_{th} value for the same sensor configuration in the same environment.

The actual reaction time depends on the size of the sensor, the media in which the temperature is being measured, and on how good the thermal contact is between the sensor and the target. Small sensors in fluid react quickest and large sensors in air react slowest. Sensors react 10 to 50 times faster in a well-stirred fluid than in still air.

Both the Thermal Time Constant and the Response Time are usually more important in a rapidly changing process environment than in a more stable storage environment. However, they are important concepts to be aware of as measurement needs are considered.

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PROBE	SENSOR	PROBE TIP DIAMETER	WELL-STIRRED FLUID 63%	WELL-STIRRED FLUID 90%	AIR 63%
Rigid Bullet Tip 	Thermistor	0.188" (4.78mm)	8 sec.	21 sec.	36 sec.
Stainless Steel Taper Tip (EXT) 	RTD	0.125" (3.18mm)	<8 sec.	17 sec.	26 sec.
Bendable Flex Rounded Tip	RTD	0.079" (2.00mm)	<3 sec.	<6 sec.	24 sec.
Rigid Taper Tip Stainless Steel Flex Taper Tip Silicone Flex Taper Tip 	Thermistor	0.125" (3.18mm)	2 sec.	5 sec.	27 sec.
Stainless Steel Flex Needle Tip Silicone Flex Needle Tip 	Thermistor	0.058" (0.15mm)	<2 sec.	<5 sec.	11 sec.

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