Attracting Tomorrow

NTC Thermistors

Thermal Response Time Measurement

PT TDK ELECTRONICS INDONESIA
A TDK Group Company
Temperature & Pressure Business Group • BT TPS PD
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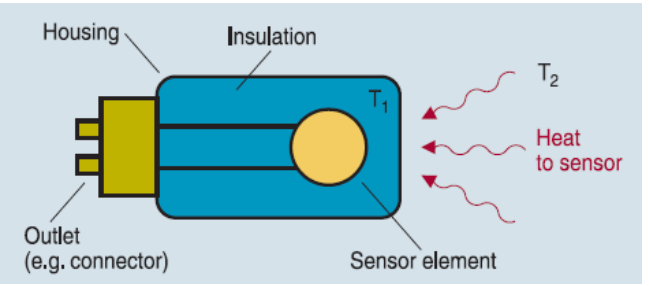
Thermal response time measurement

Thermal response time can be a crucial parameter when selecting a temperature sensor to match an application. Receiving raw data in the right time enable engineers to optimize energy efficiency and improve operating safety and convenience in various applications.

The thermal response time of a temperature sensor is mainly influenced by:

- design (e.g. sensor element, material used to assemble the sensor element in the sensor case, connection technology, housing),
- its mounting configuration (e.g. immersed, surface mounted),
- the environment it will be exposed to (e.g. air flow, inactive air, fluid).

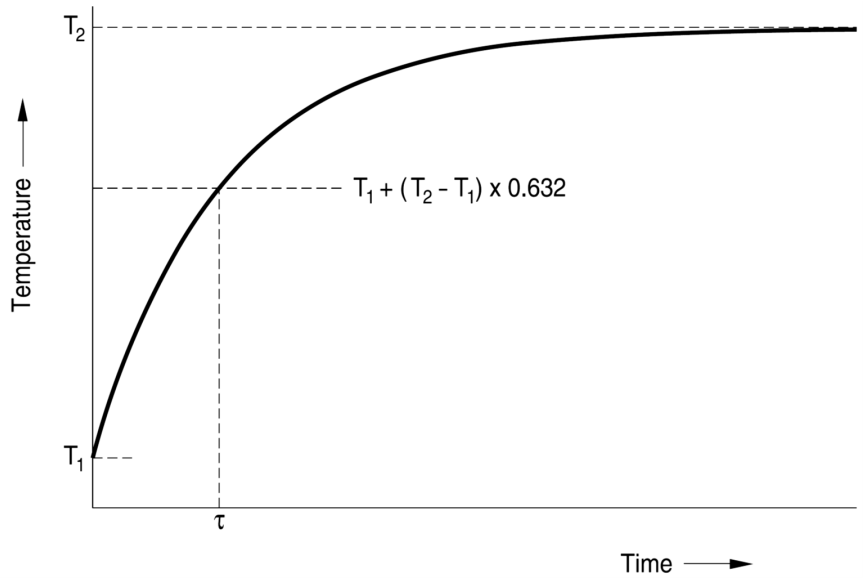


TDK possesses extensive and sophisticated inhouse facilities to test the performance and reliability of temperature sensors. Test stations exist to carry out thermal response time measurement in water/water or air/air.

The item is mounted in a defined position and tests are run under reproducible and user-defined conditions. In this way it is possible to compare the test results of different temperature sensors.

Definition of thermal response time

When a temperature sensor with a temperature T_1 is immersed in a medium (air, fluid) with a temperature T_2, the change in temperature of the sensor as a function of time follows to a first approximation the following equation: $T(t) = T_2 + (T_1 - T_2) \cdot e^{-t/\tau}$



T_1	Temperature of temperature sensor [K]
T_2	Temperature of the medium [K]
e	Euler‘s number (2.718)
t	Time [s]
τ	Thermal response time [s]

τ is the thermal response time (thermal time constant). After the time τ (also denoted $t_{0.63}$) the temperature change of the sensor is 63.2% of the temperature difference $T_1 - T_2$, which follows from:

$$T(\tau) = T_1 + (T_2 - T_1) \cdot (1 - 1/e)$$

Thermal response time methods

The thermal response time measurements are done at TDK:

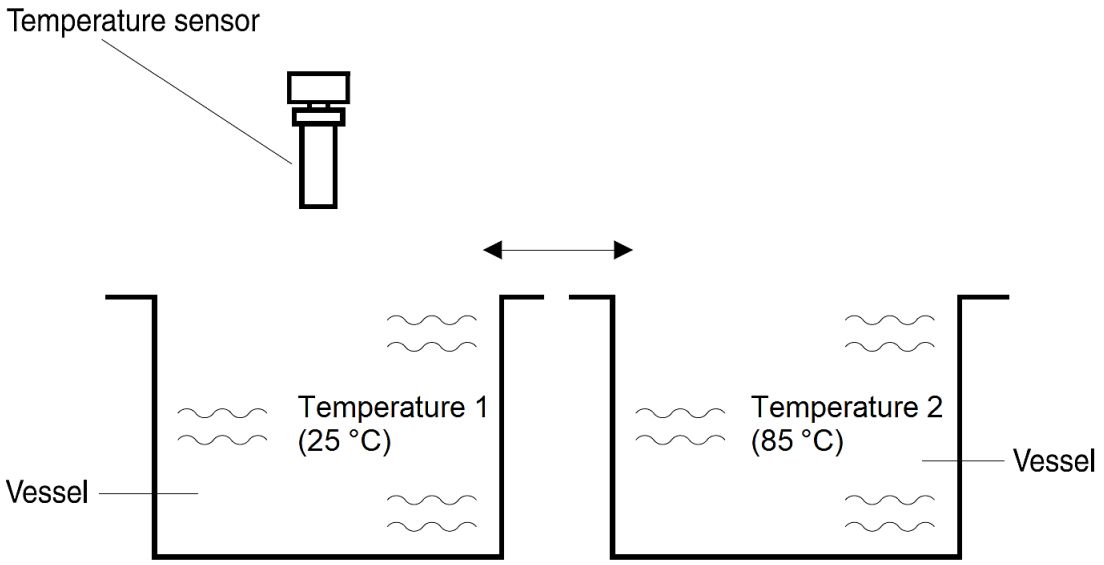
- in fluid,
- in air,
- on metal plate.

Test setup and procedure of each response time measurement methods are described in the following.

Thermal response time in fluid

- The thermal response time in fluid is determinded by a modified two bath method according to EN 60539.

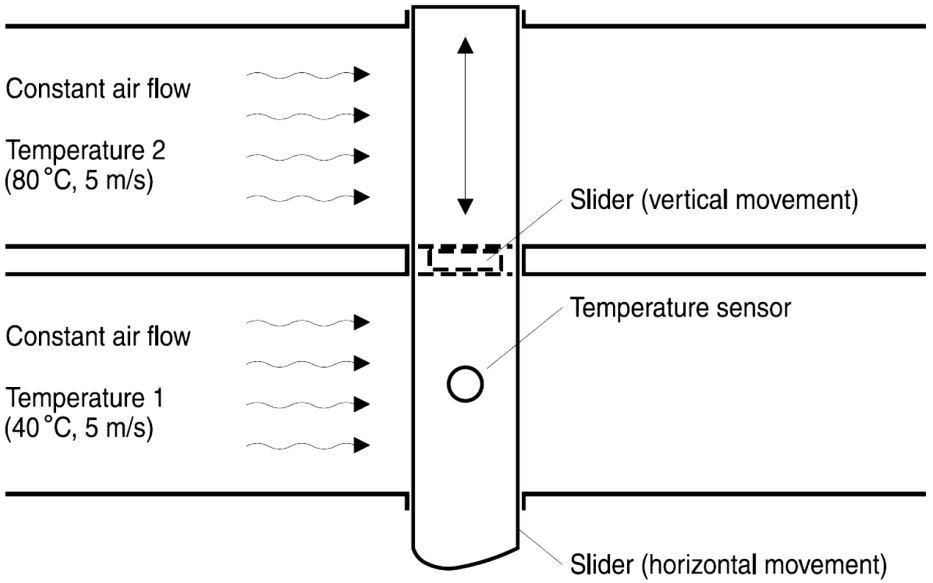
- Test setup
  - Medium: deionized water
  - Bath 1, temperature T_1: 25 °C
  - Bath 2, temperature T_2: 85 °C



- Test procedure:
  - First, the resistance values of all measured NTC samples are determined at three different temperatures in a temperature-controlled bath.
  - The resistance values and related temperatures values are entered into the measurement software to set the RT characteristics of the measured samples.
  - Up to 5 NTC samples are mounted on a dedicated test fixture.
  - The samples are placed in vessel 1 and stabilized at temperature T_1.
  - Then, the samples are quickly moved from vessel 1 to vessel 2 (with temperature T_2).
  - A digital multimeter records continuously the resistance during the thermal transfer of the NTC samples and the elapsed time.
  - The software analyzes the data and calculates the thermal response time.
  - By default, the response time will be calculated at 50%, 63% or 90% of the whole temperature change.

Thermal response time in air

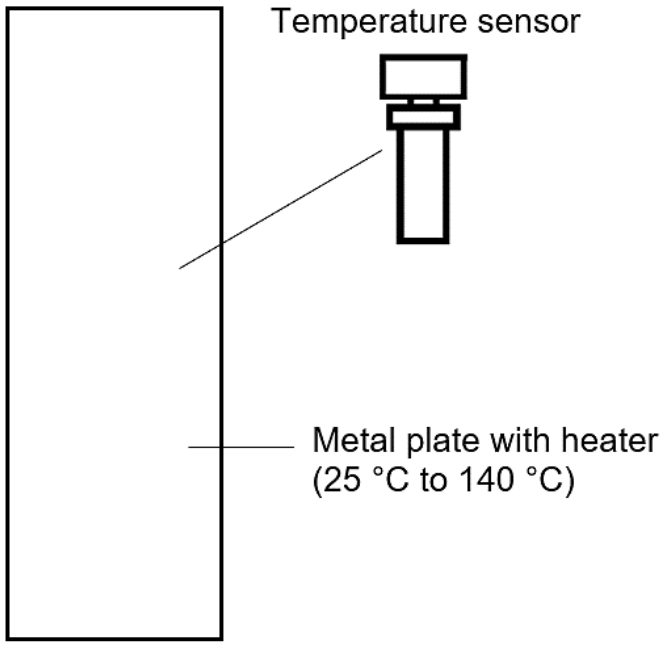
- The thermal response time in air is determined by a double air channel method whose temperatures can be set separately.
- Test setup
  - Medium: air
  - Chamber1, temperature T_1: 40 °C
  - Chamber2, temperature T_2: 80 °C
  - Air speed at each temperature: 5 m/s



- Test procedure:
  - First, the resistance values of all measured NTC samples are determined at three different temperatures in a temperature-controlled bath.
  - The resistance values and related temperatures values are entered into the measurement software to set the RT characteristics of the measured samples.
  - Up to 5 NTC samples are mounted on a dedicated test fixture.
  - The samples are placed in chamber 1 and stabilized at temperature T_1.
  - Then, the samples are quickly moved from chamber 1 to chamber 2 (with temperature T_2).
  - A digital multimeter records continuously the resistance during the thermal transfer of the NTC samples and the elapsed time.
  - The software analyzes the data and calculates the thermal response time.
  - By default, the response time will be calculated at 50%, 63% or 90% of the whole temperature change.

Thermal response time on metal plate

- The thermal response time on metal plate is determined by a metal plate with a heater that is powered to get expected surface temperature.T
- Test setup
  - Medium: metal plate
  - Metal plate temperature T_1: 25 °C
  - Metal plate temperature T_2: 140 °C



- Test procedure:
  - First, the resistance values of the measured NTC sample is determined at three different temperatures in a temperature-controlled bath.
  - The resistance values and related temperatures values are entered into the measurement software to set the RT characteristics of the measured samples.
  - The NTC sample is fixed on the metal plate.
  - At the beginning, the metal plate temperature is set to temperature T_1 and the sample is stabilized at that temperature.
  - Then, the heater is powered until the metal plate reaches temperature T_2.
  - A digital multimeter records continuously the resistance during the thermal transfer of the NTC sample and the elapsed time.
  - The software analyzes the data and calculates the thermal response time.
  - By default, the response time will be calculated at 50%, 63% or 90% of the whole temperature change.

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