Basics of Precision Temperature Measuring with Pt100-Probes

Probe Precision

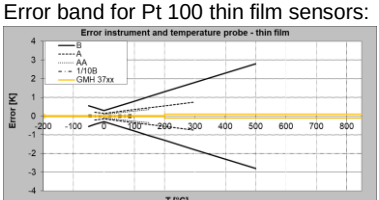
Instruments like GMH 3750 are very precise. To be able to use this high precision, the connected temperature probe has to be as precise as possible, too. The following precision classes are available as a standard at reasonable prices (Platinum resistor thermometers according to EN60751):

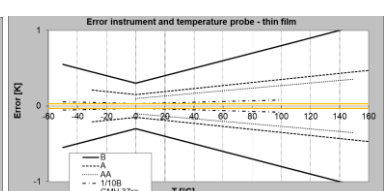
Tolerance class	Norm	max. deviation in Kelvin
B	IEC 751 / EN 60751	± (0,30 + 0,00500 • |temperature|)
A	IEC 751 / EN 60751	± (0,15 + 0,00200 • |temperature|)
AA (= 1/3 B)	IEC 751 / EN 60751	± (0,10 + 0,00167 • |temperature|)
1/10 B (= 1/10 B)	none	± (0,03 + 0,00050 • |temperature|)

The range of validity depends on the design of the sensor. Wire wound sensors allow wider temperature ranges than economic thin film sensors (further restrictions may result from product-specific properties, such as cables or connection technology)

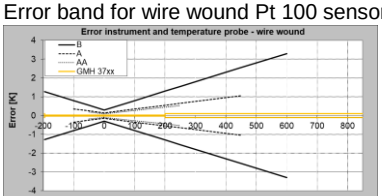
Tolerance class	wire wound	thin film
B	-196 to +600 °C	-50 to +500 °C
A	-100 to +450 °C	-30 to +300 °C
AA (= 1/3 B)	-50 to +250 °C	0 to +150 °C
1/10 B (= 1/10 B)		-50 to 100 °C

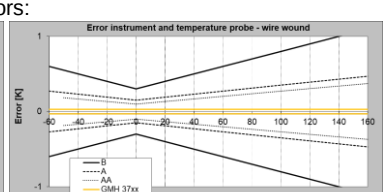
Error band for Pt 100 thin film sensors:





Error band for wire wound Pt 100 sensors:





System accuracy (device / probe)

For applications demanding higher precision than given by these classes we suggest to adjust the device to the used probe or to get a calibration certificate for the device combined with the probe.

Attention:

- If an adjusted or calibrated probe is replaced, also the adjustment or calibration certificate has to be renewed to maintain the referring overall precision!
- Be careful when buying third party temperature probes: Besides the standard EN 60751 there are some other obsolete or unusual standards on the market. If such a probe has to be connected, the user sensor curve can be used to adjust the instrument!

Connection method

- **2-wire connection**
  Easiest but worst possibility to connect a probe is the 2-wire connection. Contact resistance and additional resistance of access lines cause an incorrect (higher) temperature value. Remedy: Adjustment of the probe at 0 °C

- **3-wire connection**
  The 3-Wire connection is the most frequently used measuring method for temperature in industry. The connection is made via 3-pole access line. Due to two separate measurement circuits contact resistance and resistance of access lines can almost be compensated. Even temperature-dependent access lines will be considered. A special adjustment is not required.

- **4-wire connection**
  When using resistance thermometers like the Pt100 a quite large measuring error can be caused by inadequate cables and connections. Using 4-wire measuring avoids these kinds of errors mainly caused by un-wanted resistances. Due to two separate measurement circuits, contact resistance and resistance of access lines can be fully compensated. Even temperature-dependent access lines will be considered. It is suggested to use suitable probes and extensions only.

Heat loss caused by probe construction

Especially when measuring temperatures, which deviate very much from the ambient temperature, measuring errors often occur, if the heat loss caused by the probe is not considered. When measuring fluids therefore the probe should be emerged sufficiently deep

Immersion depth = 10x sensor diameter + active sensor length

and be stirred continuously. When measuring gases the probe should also emerge as deep as possible in the gas to be measured (e.g. when measuring in channel/pipes) and the gas should flow around the probe at sufficient flow.

Measuring surface temperature

If temperature of the surface of an object has to be measured, one should pay attention especially when measuring hot (or very cold) surfaces, that the ambient air cools (or heats) the surface. Additionally the object will be cooled (or heated) by the probe or the probe can have a better heat flow to the ambient temperature as to the objects surface.
Therefore, specially designed surface probes should be used. The measuring precision depends mainly on the construction of the probe and of the physics of the surface itself. If selecting a probe try to choose one with low mass and heat flow from sensor to handle. Thermally conductive paste can increase the precision in some cases.

Allowable temperature Range Of Probes

Pt100 Sensors are defined over a wide temperature range. Depending on probe materials and sort of sensor (e.g. hybrid sensors, wire wound resistors...) the allowable temperature ranges have to be considered. Exceeding the ranges at least causes a wrong measuring; it may even damage the probe permanently!
Often it also has to be considered, that the temperature range is just valid for the probe tube, (plastic-) handles cannot stand the same high temperatures. Therefore, the tube length should be selected long enough, that temperature keeps low at the handle.

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It should also be noted that the permissible temperatures often only apply to the sensor tube, but the (plastic) handle does not necessarily withstand these temperatures. For this reason, when measuring high temperatures, the sensor tube length must be sufficiently long so that the handle is not damaged.

Self-heating

The measuring current of the instrument is just 0.3mA. Because of this comparably low current practically now self-heating effect has to be considered, even at air with low movement the self-heating is <= 0.01°C.

Cooling by evaporation

When measuring air temperature the probe has to be dry. Otherwise, the cooling due to the evaporation causes too low measuring.

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