Wide range PT100 resistors for temperatures from -200 to +750°C compared to thermocouples Type K

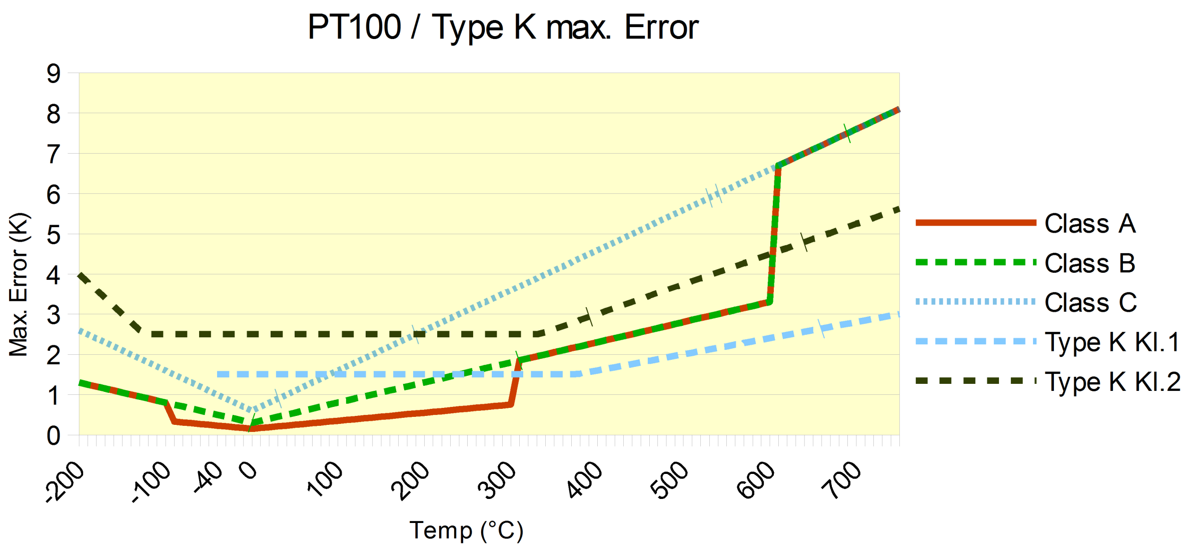
The most common way for temperature measurement in vacuum systems is the use of thermocouples or PT100 resistors. Here a short summary is given for the pros and contras for these two ways.

Thermocouples use the Seebeck effect: If you join two materials, a voltage is created. This voltage can be measured and, by looking it up in a table, the temperature is defined. (it's a little more complex in reality, you need a fixed known reference point etc, but this is all included in the actual displays and controllers). So the thermocouple creates the signal / voltage, which is measured.

A resistor works in a different way. Here the resistivity changes with temperature, so to measure it, you need an external power supply to do this. All electrical conductors change the resistivity with temperature. For precise measurements Platinum resistors are used. The reason is, that Platinum can be manufactured with very poor impurities and the material is inert to a lot of gasses and chemicals. (Other sensors are NTC / PTC resistors. The tolerances on these items are significantly bigger).

So the PT resistor has a very high stability against long term changes.

The new 243-PT100-C1 resistor combines high stability, high accuracy and small size with an expanded usable temperature range up to 750°C.



Maximal allowed error for PT resistors class A/B/C and Thermocouple K class 1 and 2.

As the class A is defined only from -100 to +300°C and B from -200 to +600°C, the allowed error has steps at these values to the next lower class.

Thermocouples Type K have no defined error below -40°C according DIN / ISO standards. For Class 2 a typical specification from a manufacturer is given.

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	PT100 Type 343-PT100-C1	Thermocouple K
Temp. Range	-200 … 750°C	-200 ...1500°C
Size	1.6x5mm	~1mm tip
Connection	standard cables, 2, 3 or 4 wires	special cables, 2 wires
long term stability	< 0.04% after 1000h at max temp	medium (oxidization, ..)
Hysteresis effects	none	up to 10K error possible
Absolute error -100 ...300°C	below 1K	1.5K / 2.5K (Klass 1 / 2)
Absolute error -200 … -100°C	0,3 +(0,005x |T|) (max. 1.3K)	Not specified in DIN / ISO below -40°C, typ. 4K at -200°C
Error of display typ.	<0,5K	<0.5K +/-1K for Zero compensation
Typ. signal	mV	µV
Reaction time	slower	faster
Mounting	more complicated	easy
Number of possible errors	lower	higher (extension grade material, connection errors, induced current ...)

As usual, each method had advantages and disadvantages. A thermocouple is very simple (just two wires) and so installation and mounting is easy. The connection to a display is sometimes complex. Each junction must be done with the right material. If extension grade cables are used, the connections must be at the same temperature. Otherwise an error of some Kelivn is possible.

For accurate measurements, a PT resistor has much higher stability and lower errors over a wide range.
No hysteresis effects appear, no “Zero” is required.
Allectra recommends to use 3- or 4-wire connection to compensate the cable resistivity.
The limit for PT100 are high temperatures. Above 750°C it cannot be used. Here the Thermocouples type R and S are the most accurate alternatives.

Fixing a PT100 is more complex than fixing a thermocouple. For god thermal contact, Allectra offers Liquid Metal (317-TCL-1 / 317-TCP-20x20 / 317-TCP-38x38) as well as a clamp.

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