



Why is my sensor assembly not as accurate as I was expecting?

Temperature sensors have defined accuracy. Thermocouples according to BS EN 60584.2:1993 and Resistance Thermometers to BS EN 60751:1996. These tolerances relate to the measured primary sensing element at the point of manufacture.

Parties involved include calibration laboratories, element manufacturers making high volumes of standard primary sensing elements. Finally sensor makers who take the primary elements and fabricate a sensor assembly according to user design requirements

Calibration Laboratories

All calibrations have uncertainty ranges. Individual calibrations at laboratories can cost £200 or more each. With that a high quality lab does multiple readings in highly controlled conditions. They produce results with small uncertainty figures. Different UKAS accredited labs will have different uncertainties and capabilities according to their equipment and procedures. Many other labs are traceable to UKAS, but are not accredited. Laboratories that do not specialise in temperature calibration will be prone to many sources of unexpected error. Accurate calibration usually involves significant sensor immersion. This may not reflect application conditions. Surface temperature sensors are the extreme in terms of a difference between the nominally expected accuracy and actual application performance

Primary Element Makers

Primary element makers want to minimise scrap. They will know how to process materials to maximise items within specification. They will also pass goods near but inside limits from their own labs. An element manufacturer's calibration will be for the element only.

RT elements typically cost from £ 1.00 to £ 10.00, so the quality of element production calibration is significantly different to full UKAS accreditation. The elements are tested at limited points, typically 0 and 100 deg C. This calibration has its own uncertainty. By selection, units with readings close to nominal accuracy are taken as higher tolerance batches. Selected sensors will cover the spectrum of acceptable tolerance.

Thermocouple alloys will be tested during production at limited specific temperatures well within operating extremes. Suppliers have different procedures. Metal wires may only be tested at two points as a thick wire batch. Subsequent drawing to smaller diameters is not always tested before dispatch, however verification of accuracy maintenance should have occurred. Modified wires, such as Mineral Insulated cables will usually be tested in the supplied form, but again at limited temperatures. These test results will come from batch samples. Our experience shows that figures will vary along a wire batch to an extent.

Sensor makers

Subsequent work on an element by a sensor assembly maker will do nothing to increase nominal accuracy. Good design can minimize new errors. Poor design can create huge errors. Sensor makers will typically not calibrate final assemblies before dispatch unless it is a contract requirement.

Resistance Thermometers often have welded leads. A 2 wire unit will have a simple lead resistance addition. 3 wire mostly removes it and 4 wire should totally remove if done correctly. Clearly any leads should be as thick as possible and in suitable conductive materials (Copper if the temperature allows). Pt 1000's have the advantage over Pt 100's because the lead resistance is relatively smaller

Individual sensors in a batch will have small physical differences which can influence final readings. The smaller the sensor the more significant this is



Resistance Thermometer Elements are usually supplied with 10mm leads on them, and in element production they get calibrated by connection usually 2mm from the end. Sensor makers should try to replicate this in the assembly design. In small assemblies these leads will often be cut down to a minimum (thus reducing resistance)

Thin film elements do not have a straight resistance v temperature line because of the ceramic substrate. Considering they are batched by readings at 0 and 100 then errors should be expected at other temperatures

I would always recommend that organizations subcontract all temperature calibrations to specialists. There is much variability on lab quality, temperature ranges and cost.

Conclusion

It is inevitable that some final assemblies will be outside nominal expected accuracy. Quality element makers, sensor makers and calibration labs will be familiar with and work to reduce errors, however everybody is in the real physical world, which is not as we would like.

If assembly accuracy at specific temperatures is important to an application, the only option is to calibrate final assemblies and select on results or compensate for the error. This calibration accuracy is therefore vitally important.