THE PROPAGATION OF MISCONCEPTIONS OF THERMOCOUPLE PRECISION

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In the course of preparing undergraduate lectures in thermodynamics here at the University of Aberdeen I have been drawing extensively on a text which I was sent, free of charge, by the publisher some months ago. The text is dated 2001 and runs to several hundreds of pages. One numerical example therein is concerned with water flow and states that a differential thermocouple indicates a temperature rise of the water of 0.072^{o}F (0.04 K).

In fact it is doubtful whether a thermocouple pair could detect such a minute temperature change in the water. To calibrate even a single thermocouple to within ± 0.05 K is extremely challenging. Many previously unused thermocouples even when fully 'within spec' could not be calibrated to this degree of precision because of the intrinsic inhomogeneity of the wires. Even if the thermocouples in the question had each been calibrated to ± 0.05 K, the error on the pair can be estimated as:

$$\sqrt{(0.05^2 + 0.05^2)} = 0.07 \text{ K}$$

almost twice the precision claimed. This is called, in the terminology of thermocouple thermometry, the mismatch error and can be minimised by using wires from the same reel. There will also be a small error in the e.m.f. measurement device which might double the mismatch uncertainty or worse, as might the presence of metallic electrical connectors in the circuit. On top of this is the much larger error, due to inhomogeneity, about 2K. A differential thermocouple, even if perfectly 'matched', cannot have a smaller tolerance than that on a single thermocouple.

No useful purpose would be served by identifying this otherwise very good text in the columns of this journal. The present author has sometimes encountered in research literature excessive and quite unjustifiable claims of thermocouple precision. The message needs to be got across that thermocouple reading uncertainties in routine applications are always of the order of whole degrees. This is due to inhomogeneity, previously referred to, as well as heat transfer effects and uncertainties arising from other parts of the measuring circuit.