The accuracy of length measurement limited by unknown temperature

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The Accuracy of Length Measurement Limited by Unknown Temperature

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SUMMARY. A short discussion on the definition of temperature and its consequence for accurate length measurement.

RESUME. La température et ses conséquences pour la métrologie.

ZUSAMMENFASSUNG. Im vorliegenden Beitrag wird der Einfluß der Temperatur auf die Genauigkeit von Längenmessungen kurz erörtert.

ALTHOUGH the subject of this note may be well known, the author would like to enlarge on it, because of its technical importance in metrology.

The knowledge of temperature is essential to precise length measurement. At present, the best accuracy realised on industrial standards may be about 10^{-7}. If it is acceptable that half of this value is caused by inaccuracy of temperature measurement, temperature must be known to 5 mK or better.*

As a rule length measurements are stated to be corrected to 20°C, but often it is not made clear what is meant by 20°C. Temperature is defined in physics by thermodynamic relations, together with the value 273.16 K = 0.01°C for the temperature of the triple point of water. In practice, however, temperature is measured following the routine of the international practical temperature scale (IPTS). Therefore it can be taken for granted that 20°C normally stands for 20°C IPTS.

It is well known that the IPTS in the region of 20°C is defined by interpolation between certain fix points by means of a platinum resistance thermometer, using a quadratic equation.

Recent measurements[1] have shown this scale to differ 8 mK from true (thermodynamic) temperature at 20°C. The latest version of the IPTS (IPTS 1968)[2] takes this difference into account. This means, however, that there exists a difference of 10^{-7} in length measurements performed before and after October 1968.

IPTS cannot be more than an approximation to true (thermodynamic) temperature. The accuracy of the fix points, as stated (Ref.[2], table 7), limits the accuracy of this approximation at 20°C to 2 mK.

It seems advisable to state explicitely that 20°C is meant to be true temperature. IPTS is used, of course, as a practical approximation. In that case the symbol t_{68} is to be used.

The properties of platinum resistance thermometers being well known, it seems advisable to use such thermometers for the more exacting work. Thermometers are available with dimensions down to 2 mm dia. and 50 mm length and maybe smaller. If such a thermometer, having $R_0 = 100\,\Omega$, is supplied with a current of 2.5 mA, a potential difference of 1 mV per K results, which can be measured and registered conveniently.

* Kelvin for a temperature difference of 1 degree Celsius = 1 degree Kelvin; thus 5 mK = 0.005 deg.

REFERENCES

1. PRESTON-THOMAS, H. and KIRBY, C. G. M. *Metrologia* **4**, 30 (1967).
2. *Metrologia* **5**, 36 (1969).