Thermometry for future generations

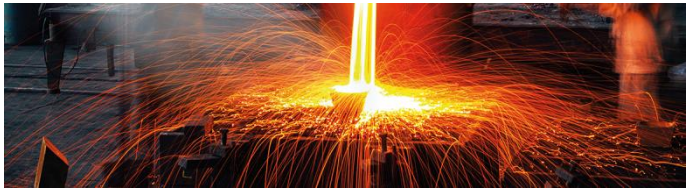
Dr Yuning Duan
CCT president
CIPM member

Bureau International des Poids et Mesures

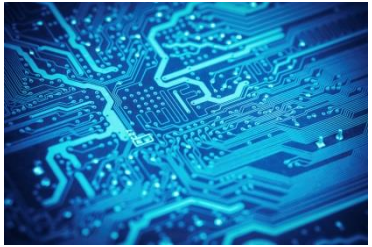
Thermometry measurements in daily life

Sustainable society

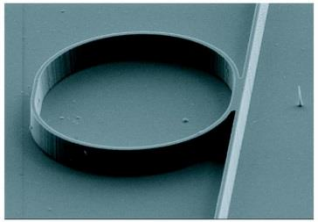
Health, safety and research



Any technology relies on reliable temperature and/or humidity measurements



Manufacturing and fair trade



New techniques and innovation

CCT – some figures

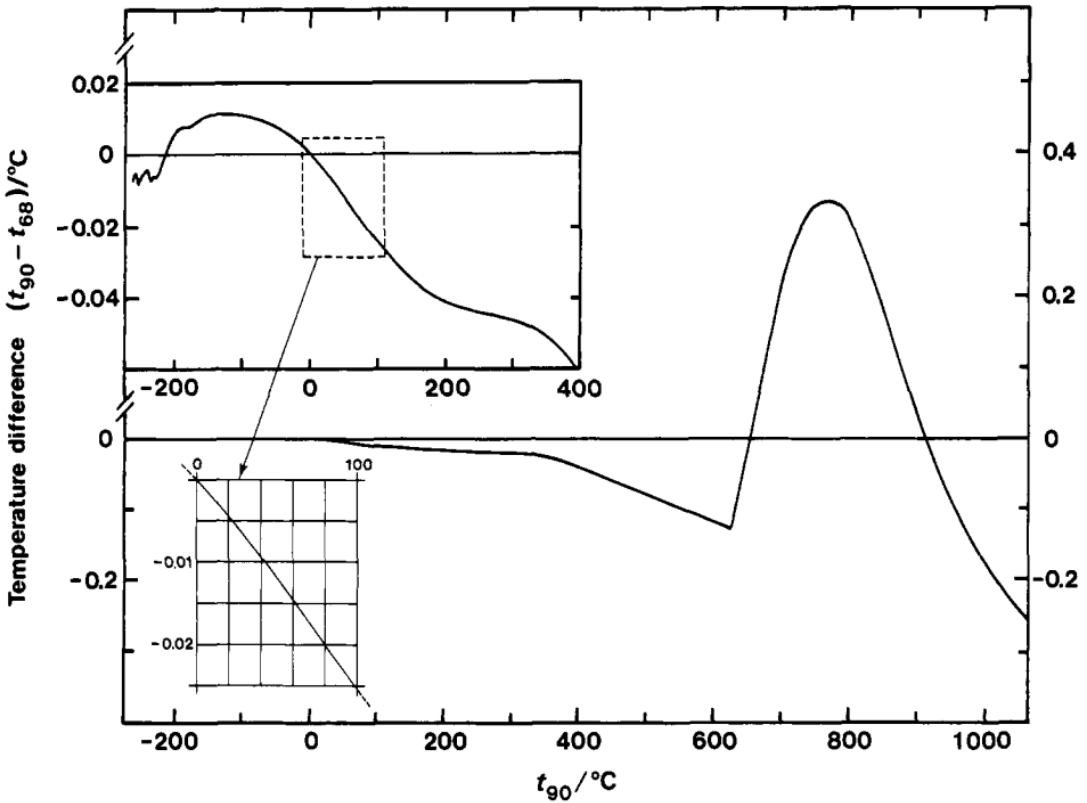
- 24 members and one official observer
- Met in June 2017
- CMI (Czech Republic) new member in 2017
- INM (Colombia), INTiBS (Poland), NIS (Egypt) and SASO-NMCC (Saudi Arabia) participated as observers
- Seven working groups

Global forum for progressing the state-of-the art

Key role: establish and maintain a temperture scale

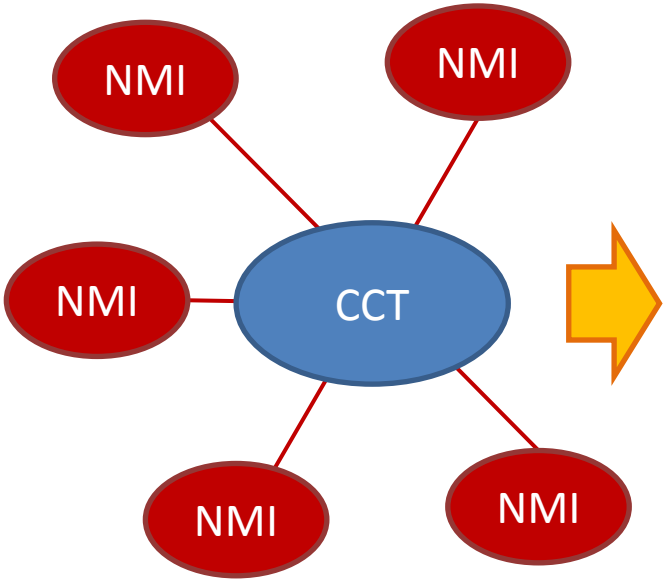
ITS-90

Issues going from extremely low to high temperatures, humidity, thermophysical quantities, environment…



Global forum : redefinition of the kelvin

Redefinition of the kelvin



Boltzmann Constant

k

Global forum : redefinition of the kelvin

Acoustic Gas Thermometry

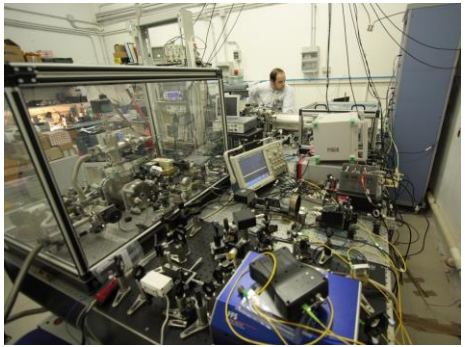
Speed of sound → *kT*

Dielectric Constant Gas Thermometry

$$p = kT\,\varepsilon_0\,(\varepsilon_r - 1)/\alpha_0$$

Johnson Noise Thermometry

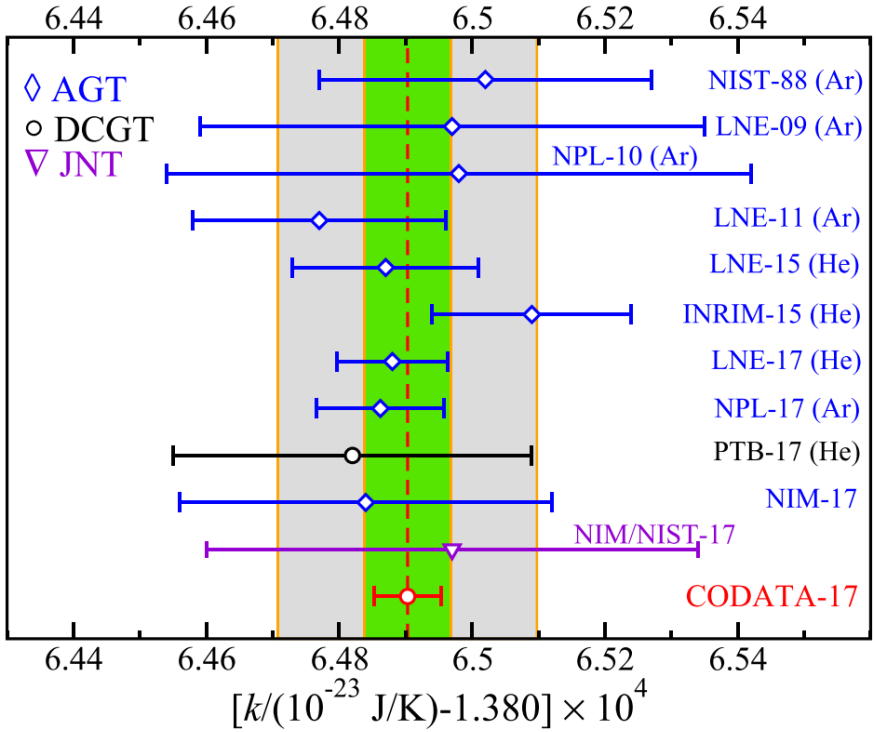
Electric noise → *kT*



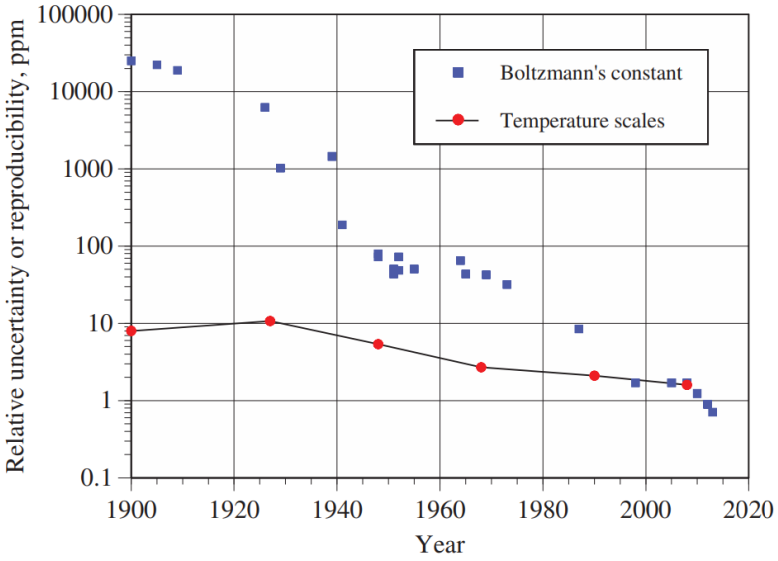
Doppler Broadening Thermometry

Spectral width → *kT*

Global forum : redefinition of the kelvin



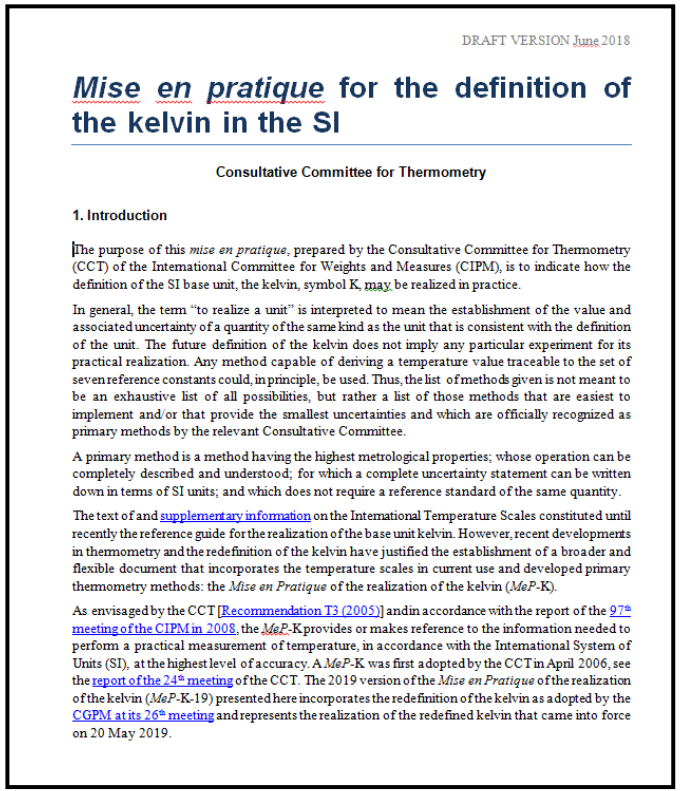
« the right time to redefine… »



k = 1.380 649 10^{-23} J/K

Courtesy: *Metrologia*

Facilitating dialogue between NMIs and stakeholders



DRAFT VERSION June 2018

Mise en pratique **for the definition of the kelvin in the SI**

Consultative Committee for Thermometry

1. Introduction

The purpose of this *mise en pratique*, prepared by the Consultative Committee for Thermometry (CCT) of the International Committee for Weights and Measures (CIPM), is to indicate how the definition of the SI base unit, the kelvin, symbol K, may be realized in practice.

In general, the term "to realize a unit" is interpreted to mean the establishment of the value and associated uncertainty of a quantity of the same kind as the unit that is consistent with the definition of the unit. The future definition of the kelvin does not imply any particular experiment for its practical realization. Any method capable of deriving a temperature value traceable to the set of seven reference constants could, in principle, be used. Thus, the list of methods given is not meant to be an exhaustive list of all possibilities, but rather a list of those methods that are easiest to implement and/or that provide the smallest uncertainties and which are officially recognized as primary methods by the relevant Consultative Committee.

A primary method is a method having the highest metrological properties; whose operation can be completely described and understood; for which a complete uncertainty statement can be written down in terms of SI units; and which does not require a reference standard of the same quantity.

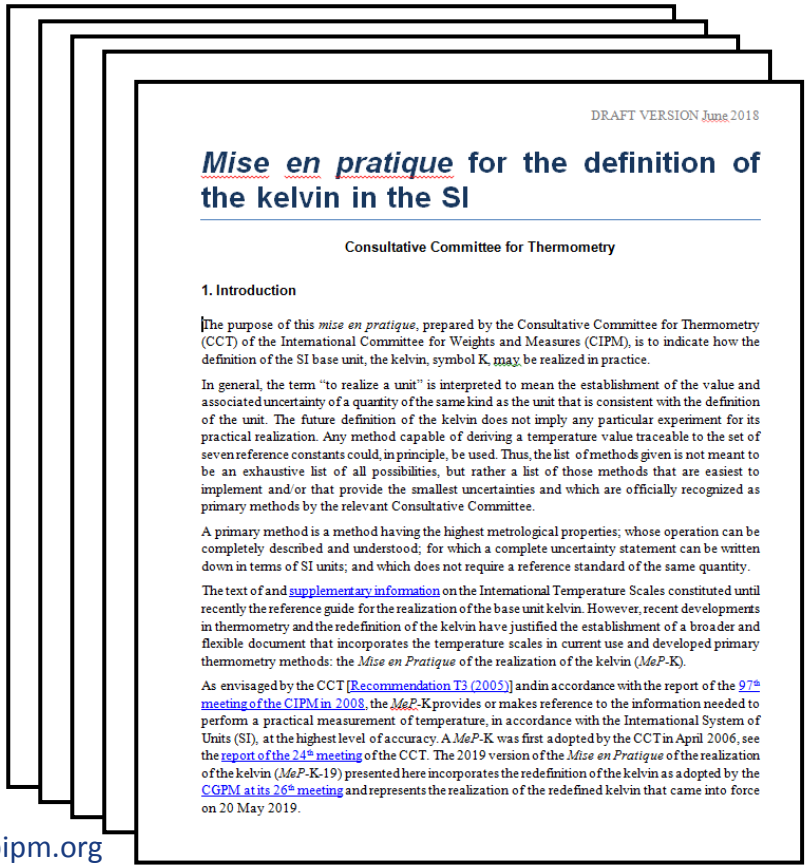
The text of and supplementary information on the International Temperature Scales constituted until recently the reference guide for the realization of the base unit kelvin. However, recent developments in thermometry and the redefinition of the kelvin have justified the establishment of a broader and flexible document that incorporates the temperature scales in current use and developed primary thermometry methods: the *Mise en Pratique* of the realization of the kelvin (*MeP*-K).

As envisaged by the CCT [Recommendation T3 (2005)] and in accordance with the report of the 97th meeting of the CIPM in 2008, the *MeP*-K provides or makes reference to the information needed to perform a practical measurement of temperature, in accordance with the International System of Units (SI), at the highest level of accuracy. A *MeP*-K was first adopted by the CCT in April 2006, see the report of the 24th meeting of the CCT. The 2019 version of the *Mise en Pratique* of the realization of the kelvin (*MeP*-K-19) presented here incorporates the redefinition of the kelvin as adopted by the CGPM at its 26th meeting and represents the realization of the redefined kelvin that came into force on 20 May 2019.

Mise en Pratique, electronic document

- Drafted by a team from the CCT
- Includes a number of annexes describing different techniques
- New techniques may be added successively

Facilitating dialogue between NMIs and stakeholders



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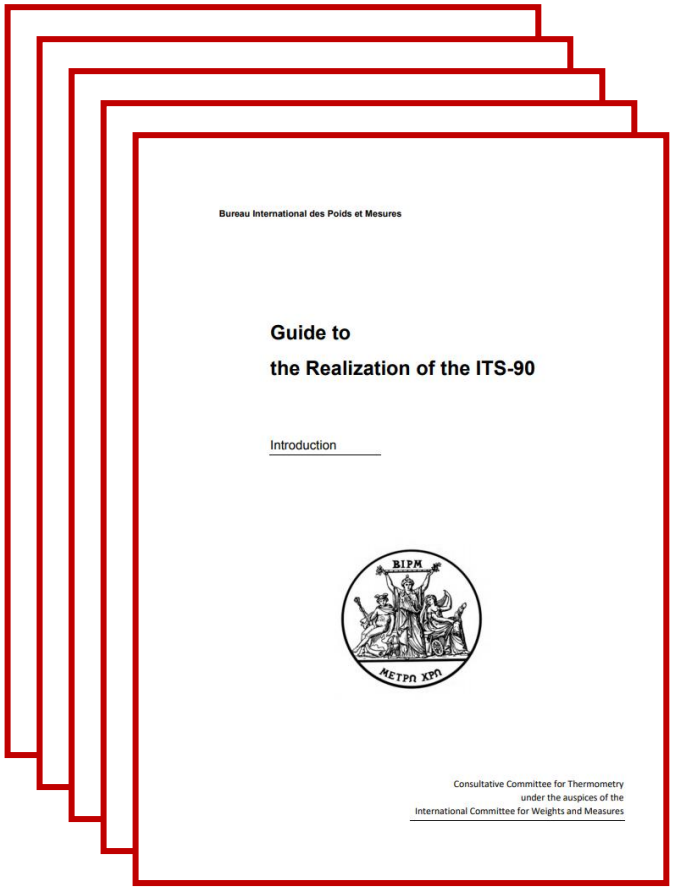

Bureau International des Poids et Mesures

Guide to the Realization of the ITS-90

Introduction

BIPM

ΜΕΤΡΩ ΧΡΩ

Consultative Committee for Thermometry
under the auspices of the
International Committee for Weights and Measures

Facilitating dialogue between NMIs and stakeholders

Working and task groups on

- Contact thermometry
- Radiation thermometry
- Humidity
- Thermophysical quantities
- Environment
- Secondary thermometry
- Emerging technologies

Global comparability of measurements

Influence of isotopic composition of water revealed via the CCT-K7 comparison

CIPM MRA: a framework for world-wide acceptance of measurement results

- 64 countries with CMCs in temperature and humidity
- Efficient review process
- Strategic set of key comparisons

Forward looking

- Possibility for a new temperature scale extended to a wider range, based on measurements using the primary standards that were used for the determination of the Boltzmann constant
- New technologies providing small size and self-calibrated devices will change the themometry landscape and enable progress, notably in bio- and nano science

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