

Mise en pratique for the definition of the kelvin

Adopted by the CCT in 2011

Scope

This document provides the information needed to perform a practical measurement of temperature in accord with the [International System of Units \(SI\)](#).

Introduction

The unit of the fundamental physical quantity known as thermodynamic temperature, symbol T , is the kelvin, symbol K, defined as the fraction $1/273.16$ of the thermodynamic temperature of the triple point of water [13th CGPM, [Resolutions 3 and 4](#)]. The International Committee for Weights and Measures (CIPM) [[Recommendation 2, CI-2005](#)] recently clarified the definition of the triple point of water by specifying the isotopic composition of the water to be that of Vienna Standard Mean Ocean Water (V-SMOW). Triple-point-of-water cells provide a convenient realization of this definition. For temperatures other than the triple point of water, direct measurements of thermodynamic temperature require a primary thermometer based on a well-understood physical system whose temperature may be derived from measurements of other quantities. In practice, primary thermometry is difficult and time consuming and not a practical means of disseminating the kelvin. As an alternative, the [International Temperature Scale](#) provides an internationally accepted recipe for realizing temperature in a practical way. Beginning in 1927, the CIPM, acting under the authority of the General Conference on Weights and Measures (CGPM) and, since 1937, on the advice of its Consultative Committee for Thermometry (CCT), has adopted a series of International Temperature Scales. Subsequent to the 1927 scale, new scales have been adopted in 1948, 1968, and 1990, with occasional minor revisions in intervening years. The present scale, the International Temperature Scale of 1990 (ITS-90) [[Recommendation 5, CI-1989](#)], was extended downward in temperature in 2000, when the CIPM adopted a supplemental scale, the Provisional Low Temperature Scale from 0.9 mK to 1 K (PLTS-2000) [[Recommendation 1, CI-2000](#)]. The ITS-90 and the PLTS-2000 define temperatures T_{90} and T_{2000} that are good approximations to thermodynamic temperature.

The ITS-90 is the most recent descendant of the original International Temperature Scale of 1927 and replaced the International Practical Temperature Scale of 1968 (IPTS-68) and its extension, the 1976 Provisional 0.5 K to 30 K Temperature Scale. The ITS-90 covers the temperature range from 0.65 K to the highest temperatures that can be determined practically by radiometric means. Supplementary information is available for both the [ITS-90](#) and [approximations to the ITS-90](#).

Considerable research has been conducted on establishing a temperature scale extending to temperatures lower than 0.65 K; the PLTS-2000 is the resulting outcome, defining temperature from 1 K down to 0.9 mK. The PLTS-2000 is explicitly a provisional scale, recognizing that the data sets comprising the basis of the scale were somewhat inconsistent below 10 mK. In the temperature range 0.65 K to 1 K, temperature may be defined on either the ITS-90 or the PLTS-2000. Either scale is acceptable; the choice of scale typically is dictated by convenience or the attainable uncertainty of realization. In those rare cases where use of either scale is convenient, T_{2000} is a better approximation of thermodynamic temperature than T_{90} in the region of overlap. [Supplementary information for the realization of the PLTS-2000](#) is also available.

Historically, the best guide for the realization of the kelvin has been the text and corresponding supplemental information for the International Temperature Scales. Recent developments in thermometry have motivated the creation of a broader, more flexible document that incorporates the temperature scales in current use: the *mise en pratique* for the definition of the kelvin. As envisioned by the CCT [[Recommendation T 3 \(2005\)](#)], the *mise en pratique* will serve as a reference for:

- the text of the ITS-90 and PLTS-2000;
- a Technical Annex of material deemed essential to realization of the ITS-90 or PLTS-2000, but not included in the scale definitions themselves;
- descriptions of primary thermometers for direct measurement of thermodynamic temperature; and
- assessments of the uncertainty of the ITS-90, PLTS-2000, and measurements made by primary thermometry.

In its present form, the *mise en pratique* presented here consists of the text of the ITS-90 (Section 1), the Technical Annex for the ITS-90 (Section 2), the text of the PLTS-2000 (Section 3), and estimates of the differences between thermodynamic temperatures and the ITS-90, $T-T_{90}$, together with their uncertainties (Section 4). The documentation of ITS-90 biases in Section 4 will support thermodynamically highly accurate measurements. The user can now easily convert measurements obtained in terms of T_{90} to T and vice versa. It is anticipated that future versions of the *mise en pratique* will also address the differences $T-T_{2000}$ together with their uncertainties as well as the uncertainty associated with direct, primary determinations of T .

Section 1. [Text of the ITS-90](#)

Section 2. [Technical Annex for the ITS-90](#)

Section 3. [Text of the PLTS-2000](#)

Section 4. [Estimates of the differences \$T-T_{90}\$](#)