Report presented to the CCT by Working Group 1: April 2014

1. Membership

Working Group 1 members are: Bernd Fellmuth (chairman, PTB), Kee Sool Gam (KRISS), Ken Hill (NRC), Murat Kalemci (UME), Edgar Mendez-Lango (CENAM), Graham Machin (NPL), Andrea Peruzzi (VSL), Anatoly Pokhodun (VNIIM), Fernando Sparasci (LNE-CNAM), Peter Steur (INRIM), Gregory Strouse (NIST), Osamu Tamura (NMIJ/AIST), Jintao Zhang (NIM)

Co-opted specialists are providing assistance: Pieter Bloembergen (VSL), Mikhail Matveyev (VNIIM), Jonathan Pearce (NPL), Weston Tew (NIST), Howard Yoon (NIST)

Changes of the membership after the last CCT meeting: Wukchul Joung (KRISS), Jonathan Pearce (NPL), Jianping Sun (NIM), Jun Tamba (NMIJ/AIST)

Members of the Task Group for the *mise en pratique* for the definition of the kelvin (TG-MeP-K) are: Bernd Fellmuth (chairman, PTB), Joachim Fischer (chairman WG4, PTB), Graham Machin (chairman WG5, NPL), Susanne Picard (executive secretary of CCT, BIPM), Terry Quinn, Peter Steur (INRIM), Osamu Tamura (NMIJ/AIST), Rod White (chairman WG3, MSL), Howard Yoon (NIST)

2. Terms of Reference

The terms of reference of Working Group 1 *Defining fixed points and interpolating equations of the ITS-90 and the dissemination of the kelvin* (WG1), as expressed in the Report of the 24th Meeting of the CCT (2008), are to improve and document the techniques for using defining fixed points and interpolating instruments of the ITS-90 and to supervise the dissemination of the SI unit of temperature through the *mise en pratique* for the definition of the kelvin.

Working Group 1 is tasked to continue with the updates to the *Supplementary Information for the ITS-90*, collaborating with Working Group 3 and Working Group 5 in the incorporation of material on uncertainties.

Working Group 1 also coordinates a task group (including a representative from Working Groups 2, 3, 4 and 5, and the BIPM) that:

- monitors developments supporting a future International Temperature Scale;
- prepares and maintains the *mise en pratique* for the definition of the kelvin;
- monitors research conducted to support the *mise en pratique* and future temperature scales; and
- coordinates the presentation of CCT material on the dissemination of the kelvin by the BIPM.

3. Activities Since the Last CCT Meeting

3.1 Meetings

Since the last CCT meeting, Working Group 1 has met ones in Funchal, Madeira, Portugal, on 18 October 2013, after TEMPMEKO 2013, the 12th *Symposium on Temperature and Thermal Measurements in Industry and Science*.

One meeting of WG1 is planned at BIPM in preparation of the next meeting of the CCT this year on 20 May.

3.2 Updating the Supplementary Information for the ITS-90

The concept for the publication of the *Supplementary Information for the ITS-90* (SInf) on the BIPM website approved by the CCT at its last meeting in 2012 has been realized. The following revised parts of the SInf have been already posted on the website:

- *Foreword and Contents* including links to all parts of the SInf,
- Chapter 1 *Introduction*,
- Section 2.2 *Triple Point of Water*,
- Section 2.5 *Metal Fixed Points for Radiation Thermometry*,
- Chapter 4 *Interpolating Constant-Volume Gas Thermometry*, and
- Chapter 6 *Radiation Thermometry*.

Drafts have been prepared for

- Section 2.1 *Influence of Impurities*, and
- Chapters 5 *Platinum Resistance Thermometry*.

Agreed outlines exit now for the last parts to be revised:

- Section 2.3 *Cryogenic Fixed Points*,
- Section 2.4 *Metal Fixed Points for Contact Thermometry*, and
- Chapter 3 *Vapour pressure scales and pressure measurements*.

The task allocations and the schedule have been updated with the aim to complete the revision of the SInf until the end of 2014. Final formatting and harmonization is planned for the beginning of 2015.

For the application of the methodology recommended in Section 2.1 *Influence of Impurities*, data are needed on the behaviour of impurities in the different fixed-point substances. Starting in 2014, CCT-WG1 will take actively part in putting together an appendix with the necessary data on the behaviour of impurities. The determination of equilibrium distribution coefficients and slopes of the liquidus lines requires evaluating the binary phase diagrams of many relevant impurity-host systems. CCT-WG1 will stimulate, review and evaluate necessary new dedicated experimental (doping experiments) and theoretical investigations (thermodynamic calculations). Two further appendices containing information on the precipitation of impurity oxides and on common impurities found in each of the fixed-point substances need still input.

3.3 Mise en Pratique for the Definition of the Kelvin

As a basis for defining the base unit kelvin by fixing the value of the Boltzmann constant, see the report of the 26th meeting of the CCT, Sections 3.1.1 and 3.4.1, a second version of the *mise en pratique* of the definition of the kelvin, called here provisionally MeP-K-14, has been prepared by the task group for the MeP-K (TG-MeP-K) and approved by the CCT in May 2013 via e-mail voting. The preparation of MeP-K-14 was done along the lines of the TEMPMEKO 2010 paper of this group (Ripple *et al.*: The Roles of the *Mise en Pratique* for the Definition of the Kelvin, Int. J. Thermophys. **31** (2010), pp. 1795-1808) and documents CCT/08-17, CCT/10-26, CCT/12-17, and CCT/12-19, as well as considering the actual documents posted on the BIPM website (report of the 97th meeting of the CIPM, draft of the new SI brochure etc.). The MeP-K-14 has been posted on the BIPM website with restricted access because it cannot come into force before the new definition of the kelvin. Together with its four appendices, the MeP-K-14 was submitted by the CCT to the CCU for discussion at its 21st meeting in June 2013.

The following details concerning the preparation of the MeP-K-14 should be emphasised:

- The MeP-K has been reworded considering the new definition of the kelvin and rearranged with five sections including scope and introduction according to working document CCT/10-26.
- The explicit-constant definition of the kelvin is briefly explained.
- A nomenclature (taxonomy of methods for the realisation of the kelvin) is included (Section 3). Section 3 is based on document CCT/12-19 approved at the 26th meeting of the CCT, but it does not contain the category approximations to thermodynamic temperature because the current second version of the MeP-K does not describe such methods.
- The criteria for the inclusion of primary-thermometry methods in the MeP-K listed in CCT/12-17, also approved at the 26th meeting of the CCT, and not contained in Section 3, are included in the introduction of Section 4.
- Section 4.1 and Section 4.2 are abstracts describing briefly two primary thermometry methods, for the first time within the MeP-K, namely *acoustic gas thermometry* and *radiometric thermometry*. Details, including uncertainty estimates or references to them, are given in appendices. For the content of these three appendices, the respective authors are responsible.

The Technical Annex of the MeP-K for the ITS-90 has been extended and posted on the BIPM website. The extension concerns the following details:

- Addition of uncertainty estimates for the correction equations.
- Inclusion of new data for the triple point of water.
- Section on the triple point of neon. This section is based on a revision of working document CCT/12-21, which has been submitted to Metrologia.

Until the new definition of the base unit kelvin, the TG-MeP-K will monitor research conducted to support the MeP-K, especially the development of primary-thermometry methods to be included, e.g. *dielectric-constant gas thermometry* and *noise thermometry*.

Bernd Fellmuth, April 2014