

Bureau International des Poids et Mesures

Consultative Committee for Thermometry (CCT)

Report of the 23rd meeting
(9–10 June 2005)
to the International Committee for Weights and Measures



Comité international des poids et mesures

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Note:

Following a decision made by the International Committee for Weights and Measures at its 92nd meeting in October 2003, Reports of meetings of Consultative Committees will henceforth be published only on the BIPM website in the form presented here.

Full bilingual printed versions in French and English will no longer appear.

Working documents for the meetings are listed at the end of each Report and those which the Consultative Committee decides are for public use are available also on the website.

T.J.Quinn,
Director BIPM,
November 2003.

**LIST OF MEMBERS OF THE
CONSULTATIVE COMMITTEE FOR THERMOMETRY**
as of 9 June 2005

President

H. Ugur, member of the International Committee for Weights and Measures.

Executive Secretary

M. Stock, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

Conservatoire National des Arts et Métiers, Institut National de Métrologie [LNE-INM], Paris.
 CSIR – National Measurement Laboratory [CSIR-NML], Pretoria.
 D.I. Mendeleev Institute for Metrology [VNIIM], Rostekhnregulirovaniye of Russia, St Petersburg.
 Institute for Physical, Technical and Radiotechnical Measurements [VNIIFTRI], Rostekhnregulirovaniye of Russia, Moscow.
 Istituto di Metrologia G. Colonnetti, Consiglio Nazionale delle Ricerche [IMGC-CNR]*, Turin.
 Korea Research Institute of Standards and Science [KRISS], Daejeon.
 Measurement Standards Laboratory of New Zealand [MSL], Lower Hutt.
 National Institute of Metrology [NIM], Beijing.
 National Institute of Standards and Technology [NIST], Gaithersburg.
 National Measurement Institute of Australia [NMIA], West Lindfield.
 National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.
 National Physical Laboratory [NPL], Teddington.
 National Research Council of Canada [NRC], Ottawa.
 NMI Van Swinden Laboratorium, Nederlands Meetinstituut [NMI VSL], Delft.
 Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.
 Slovak Metrology Institute/Slovenský Metrologický Ústav [SMU], Bratislava.
 Standards, Productivity and Innovation Board [SPRING Singapore], Singapore.
 Ulusal Metroloji Enstitüsü/National Metrology Institute of Turkey [UME], Gebze-Kocaeli.
 The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

* The IMGC and IEN were merged into INRIM (Istituto Nazionale di Ricerca Metrologica) on 1 January 2006.

Observers

Centro Español de Metrología [CEM], Madrid.

Centro Nacional de Metrología [CENAM], Querétaro.

Instituto Nacional de Tecnología Industrial [INTI], Buenos Aires.

Instituto Português da Qualidade [IPQ], Caparica.

1 OPENING OF THE MEETING; APPOINTMENT OF THE RAPPORTEUR; APPROVAL OF THE AGENDA

The twenty-third meeting of the Consultative Committee for Thermometry (CCT) took place at the International Bureau of Weights and Measures (BIPM), Pavillon de Breteuil, Sèvres, on 9 and 10 June 2005.

The following were present: T. Baba (NMIJ/AIST), M. Ballico (NMIA), M. Battuello (IMGC-CNR*), Y. Duan (NIM), S. Duris (SMU), B. Fellmuth (PTB), V. Fericola (IMGC-CNR*), J. Fischer (PTB), Y. Hermier (LNE), P. Huang (NIST), K.H. Kang (KRISS), Y.G. Kim (KRISS), H. Liedberg (CSIR-NML), G. Machin (NPL), M. Matveyev (VNIIM), C.W. Park (KRISS), F. Pavese (IMGC-CNR*), A. Peruzzi (NMi VSL), A. Pokhodun (VNIIM), J. Ranostaj (SMU), D.C. Ripple (NIST), R.L. Rusby (NPL), N. Sokolov (VNIIM), A.G. Steele (NRC), G.F. Strouse (NIST), C. Takahashi (NMIJ/AIST), H. Ugur (President of the CCT), A.J. Wallard (Director of the BIPM), L. Wang (SPRING), D.R. White (MSL), Y. Yamada (NMIJ/AIST), K. Yamazawa (NMIJ/AIST), H. Yoon (NIST), J. Zhang (NIM).

Observers: V. Chimenti (CEM), M.E. Filipe (IPQ), E. Méndez-Lango (CENAM).

Invited guests: P. Bloembergen (retired from NMi VSL, consultant of NMIJ), J. Bojkovski (MIRS), G. Bonnier (retired from LNE-INM, the former BNM-INM), M. Durieux (KOL), N.I. El Sayed (NIS), R. Teixeira (INMETRO).

Also present: P. Espina (Executive Secretary of the JCRB); P. Giacomo (Director Emeritus of the BIPM), T.J. Quinn (Director Emeritus of the BIPM); M. Stock (Executive Secretary of the CCT), C. Thomas (Coordinator of the BIPM KCDB).

Absent: K. Hill (NRC) and S. Ugur from UME sent apologies.

The President opened the meeting. Dr Steele (NRC) was appointed rapporteur.

The agenda was approved with minor revisions to the order of items.

2 DOCUMENTS PRESENTED TO THE 23rd MEETING OF THE CCT

Twenty-nine working documents were presented for consideration at the CCT meeting. The titles and authors are listed in Appendix T 1 to these minutes, and the full text can be found on the BIPM website (<http://www.bipm.org>). Not all documents were considered explicitly during the meeting, in accordance with the decision taken at the 21st CCT meeting: only those items specifically mentioned under the relevant agenda items (namely the working group and key comparison reports, and

* The IMGC and IEN were merged into INRIM (Istituto Nazionale di Ricerca Metrologica) on 1 January 2006.

documents related to the discussions concerning ITS-20XX) were discussed by the Committee at this meeting. There was general agreement on the desirability of addressing topics of scientific interest to the Committee, perhaps during a one-day workshop during the week of the next CCT meeting, as well as at international events such as TempMeko 2007. As one step to achieving this goal, there was presidential agreement that some of the purely administrative tasks of the CCT could be handled via e-mail, in advance of the meeting, leaving more time for discussions of scientific and laboratory reports.

President Ugur sought recommendations on improving the usage of the BIPM website for the CCT working documents, beyond the existing public and private archiving function. Dr Fischer advised that some restrictions on published content are desirable, since no formal review process exists. Prof. Wallard indicated that some of the other Consultative Committees provide an opportunity for laboratories to give brief presentations on their activities, supported by reports on the BIPM website; these reports facilitate the exchange of information and collaboration among national metrology institutes (NMIs), and the documentation provides technical information to support inter-regional confidence in Quality Systems, calibration and measurement capabilities, etc., thus supporting the overall mission of the Consultative Committee. President Ugur requested that such submissions of laboratory reports be made a minimum of two months in advance of the scheduled CCT meeting, and that short presentations summarizing these reports would be included as the agenda and time allow. Other documents should be accompanied by a statement indicating whether they are working documents for the meeting or general scientific contributions. Working documents shall be submitted to the relevant working group chairman, who also determines the suitability for inclusion on the public website.

3 REPORTS OF THE WORKING GROUPS

3.1 Working Group 1: defining fixed points and interpolating instruments

Dr Ripple presented the report of the chairman for Working Group 1 (CCT/05-25). Their recommendations on how to address uncertainties in fixed-point cells due to impurities were submitted (CCT/05-08). A suggestion to minimize variations in independent realizations of the hydrogen fixed points by specifying that the ITS-90 proviso for using materials of “natural isotopic composition” be interpreted to mean hydrogen with isotopic composition equivalent to the reference material Standard Light Antarctic Precipitation (SLAP) was also presented (CCT/05-06).

The recommendation from the *ad hoc* Task Group on the Triple Point of Water (TPW) related to clarifying the definition of the kelvin by specifying the isotopic composition of water in the SI brochure was presented (CCT/05-07 and [CCT/05-30](#)), motivated by the recent results of [CCT-K7](#). It was noted that the status of the *Supplementary Information* material was not sufficiently clear, insofar as “recommended practice” versus “complete definition” of the fixed points are concerned. Recommendation T 1 ([CCT/05-30](#)) and document CCT/05-07 were approved, including the recommended addendum to the *Supplementary Information*.

The Task Group recommended the creation of a “Technical Annex” to the *Supplementary Information*, to serve as a repository for information necessary for a complete and unambiguous interpretation of the ITS-90. Dr Pavese proposed the creation of a *mise en pratique*, to enable a swift mechanism for the CIPM to adopt and approve CCT-recommended technical changes and clarifications to the ITS-90. Dr Quinn suggested that the *mise en pratique* should be for the definition of the unit of thermodynamic temperature, the kelvin, and could include the aforementioned Technical Annex as a formally approved interpretation document for the ITS-90 and the PLTS-2000; in the future, if the definition of the kelvin were to change, then the *mise en pratique* could be expanded to include the text of the ITS as one recommended practice for realization. There was general agreement on the merits of these suggestions, and Dr Ripple was tasked with producing the corresponding CCT Recommendations and the Technical Annex ([CCT/05-32](#) and -33), discussed under agenda item 12 (see below).

3.2 Working Group 2: secondary fixed points and techniques for approximating the ITS-90

Mr White presented the report of the chairman for Working Group 2 (CCT/05-21) on behalf of Mr Hill, summarizing work done to make the *Techniques for Approximating the ITS-90* (the “Blue Book”) available as a searchable electronic document on the BIPM website, discussions related to thermocouple reference functions, and secondary fixed points (including progress on the metal-carbon eutectics). Dr Rusby noted that the updated “Blue Book” should include both general information on sensors, and specific emphasis on interpolation schemes and reference functions. Mr White noted that analysis of the eutectic fixed points is under way, pointing out that the science is good, with 0.1 °C reproducibility, but cautioning that the calculation of the uncertainty budgets requires further investigation.

3.3 Working Group 3: uncertainties

Mr White presented the report of the chairman for Working Group 3 (CCT/05-15), offering thanks to Dr Bonnier upon his retirement by stating that his enthusiasm and rigor has been an inspiration for a good many of us in the thermometry community. The CCT applauded the contributions of Dr Bonnier. Activities of the working group have concentrated on the production of a *Guide on uncertainty in the SPRT subranges of ITS-90*, the first draft of which is under review; the final document is anticipated within the next year. Dr Hermier raised a number of concerns related to the chemical composition and thermal effects, which are often underestimated in the uncertainty budgets for metal fixed points, and which require additional scientific investigation by the community. Mr White endorsed these comments, and included them among a number of research opportunities relevant to the mandate of the working group and the thermometry community at large. Prof. Wallard reminded the CCT that use can be made of the BIPM website as a repository for working documents, and as a point of departure for web searches of the bibliographic websites maintained by various NMIs.

3.4 Working Group 4: thermodynamic temperature determinations and extension of the ITS-90 to lower temperatures

Dr Rusby presented the report of the chairman for Working Group 4 ([CCT/05-19](#)), noting that the first teleconference held to accommodate absent working group members was a success, and thanking the BIPM for the introduction of this new service. Activities of relevance to Working Group 4 include the presentation of several conference papers, and a special one-day meeting on the determination of the Boltzmann constant (see agenda item 10). A summary of the current state of knowledge and ongoing activities to determine the differences $T - T_{90}$ between thermodynamic temperature and the ITS was presented, and a Recommendation ([CCT/05-31](#)) encouraging NMIs to initiate and continue this important basic research. The Recommendation (T 2) was approved, with a note that this type of encouragement is exactly the kind of support for metrological activities that the thermometry community should expect and enjoy from the CCT, even though the Committee can exert no direct influence on internal funding decisions. The CCT granted approval to publish the *Supplementary Information for the PLTS-2000* in the *Journal of Low Temperature Physics*, to enable broad circulation of this information among those most directly impacted by the provisional extension to the Scale.

3.5 Working Group 5: radiation thermometry

Dr Fischer presented the report of the chairman for Working Group 5 ([CCT/05-10](#)), including a summary of the joint workshop of the CCT and CCPR held at TempMeko 2004, the European research project HIMERT, and other work related to the high temperature carbon eutectics. A draft version of the working document cataloguing the uncertainty associated with a radiation thermometry approximation of the ITS-90 below the silver point is under review, with the final version anticipated prior to the next meeting of the CCT.

3.6 Working Group 6: humidity

Dr Huang presented the report of the chairman for Working Group 6 ([CCT/05-23](#)), including a summary of progress in international key comparisons and the development of a document on uncertainty in the generation of humidity ([CCT/03-20](#)). This latter document is under review, and it is hoped that the final version will be completed within the year.

3.7 Working Group 7: key comparisons

Dr Steele presented the report of the chairman for Working Group 7 ([CCT/05-27](#)), summarizing the technical review and approvals for both CIPM and RMO key comparisons in thermometry and humidity, thanking Dr Thomas for her efforts to maintain Appendix B of the BIPM Key Comparison Database (KCDB) as well as Dr Miles and Mr Petitgand for their assistance in establishing and maintaining the BIPM Discussion Forum. The working group confirmed its commitment to assist pilot laboratories of ongoing key comparisons in whatever way possible to bring their work to a speedy and successful conclusion.

In discussing [CCT-K1](#), Dr Pavese said that all the participants, except two, in one range did not actually “realize” the ITS-90 as required in the title of the key comparison, but used an “approximation” of the ITS-90, by implementing instead a thermodynamic scale, in one case

different from the constant volume gas thermometry (CVGT), in the other cases with a constant volume gas thermometer not used according to the ITS-90 definition of interpolating constant volume gas thermometry (ICVGT). As the ITS-90 is an approximation of the thermodynamic temperatures, conversely the thermodynamic scales with definitions other than the one of the ITS-90 become approximations, not realizations, of the ITS-90. He opposed the approval by Working Group 7 of draft B because, the title of key comparison 1 was not changed according to his request, by adding “and approximations” and the text of the submission to MRA Appendix B of the KCDB did not mention this fact. Dr Fellmuth commented that the situation is clearly described in the report, thermodynamic measurements can simulate T_{90} in this range, and there would be problems for users wanting to see equivalences in the KCDB. Dr Rusby added that in the range where the interpolation instrument is itself a gas thermometer, a gas thermometer scale which is consistent with the ITS-90 fixed points can be considered as a realization of the ITS-90. It would serve no purpose to distinguish between them in the KCDB.

3.8 Working Group 8: calibration and measurement capabilities

Mr Strouse presented the report of the chairman for Working Group 8 (CCT/05-12), including a summary of the status of review processes for calibration and measurement capabilities (CMCs) in thermometry and humidity. With reference to CMCs for the water triple point, and in light of the results of [CCT-K7](#) and the Triple Point of Water (TPW) Task Group Report (CCT/05-07), the working group requested that each NMI with a previously-submitted CMC review the new documents and decide what action, if any, to take regarding their realization. After that, [CCT-K7](#) participants should submit a justified TPW realization correction value (as required) to be added to their key comparison result, along with the new CMC uncertainty value; non-participants should submit a new CMC entry. The Appendix C entry for the TPW CMC will specify the realization correction value in the comment field to ensure complete transparency to the user community. Based on the results of [CCT-K7](#), these newly-submitted values from the participants will be used by the working group to generate a review protocol for the triple point of water CMCs; all NMIs, whether they are participants in [CCT-K7](#) or not, will be reviewed in a manner similar to that used for the other ITS-90 fixed points. The deadline for new triple point of water CMC submissions to the appropriate RMO representative is 2 September 2005.

Prof. Wallard observed that there has been some confusion in the past as to whether the triple point of water falls under the ISO Guide 34, relevant to chemical reference materials, rather than ISO 17025, the standard to which Quality Systems in thermometry are normally held. In spite of the fact that one of the examples in the *International Vocabulary of Basic and General Terms in Metrology* (the VIM) cites the triple point of water as a reference material, Prof. Wallard clarified that there is no Guide 34 requirement for thermometry Quality Systems, and that ISO 17025 is completely acceptable.

President Ugur noted that the number of published CMCs in thermometry is small relative to those in other Consultative Committees. The Executive Secretary of the JCRB, Dr Espina, encouraged the Regional Metrology Organizations to empower their Working Group 8 representatives to act and vote independently while respecting the best interests and policies determined at the various RMO meetings. Dr Ballico explained that a partial explanation rests on the fact that the uncertainty claims and requirements for routine services in thermometry are quite close, often within a factor of 2, of the very best measurement capabilities in the field.

Special acknowledgement of the BIPM Discussion Forum as a vehicle for conducting working group business online was made, and thanks were offered to Dr Miles and Mr Petitgand for their pioneering efforts in making this new service available to the Consultative Committees.

3.9 Working Group 9: thermophysical properties

Dr Baba presented the report of the chairman for Working Group 9 on behalf of Dr Redgrove, who resigned in 2004 ([CCT/05-29](#)). The working group is accumulating a list of requirements and capabilities among the member NMIs, and is planning to conduct pilot studies on the thermal conductivity of insulating materials, on the thermal diffusivity of dense materials up to high temperatures using laser flash techniques, and on the normal spectral emissivity of solids. Dr Steele pointed out that a directory of services for thermophysical properties work conducted at various NMIs would have general use, particularly for those institutes doing no work in this area.

President Ugur noted that there has been some discussion at the CIPM concerning the creation of a Consultative Committee for Materials Research. Prof. Wallard indicated that it has long been a goal to bring materials metrology within the framework of the Metre Convention, but that this is a difficult objective given the fact that most work is done by testing, rather than metrology, organizations, thus exploring the role of the existing Consultative Committees regarding traceability may be among the first actions to emerge. Dr Baba affirmed that such traceability issues are often very difficult problems in materials science, and that the expertise of the CCT in forming appropriate thermal uncertainty budgets has great value to the community.

Dr Pavese reported that a European Commission project has been established to form a Virtual Institute on Thermal Metrology (www.evitherm.org). This institute will become a permanent, legally independent society in July 2005, no longer tied only to the European frame. There was some concern expressed that thermometry and the field of thermophysical properties of materials in general may be suffering from lower visibility in comparison to other metrology areas. Knowledge of this type of project was suggested as one means to raise the profile of our discipline. There was some discussion on possible roles and activities in which the CCT could engage, in order to better assume the role as the Consultative Committee working on all aspects of thermal quantities.

4 REPORTS OF CCT KEY COMPARISONS

4.1 CCT-K1: Realizations of the ITS-90 from 0.65 K to 24.5561 K using rhodium-iron resistance thermometers

Dr Rusby presented the draft B report of key comparison CCT-K1, which received majority approval by Working Group 7. There was general discussion on the difference between what constitutes a direct realization of the ITS-90 in the low temperature region (e.g. by interpolating gas thermometry, with calibration at the helium, hydrogen, and neon points) and an approximation of the scale (e.g. by applying corrections to archival thermodynamic data in order to rationalize the results with the ITS-90). It was noted that, in the special case of $T < 24$ K, this distinction is less helpful

than elsewhere since the interpolating instrument is the same as that used for performing thermodynamic measurements. The question of “approximation” versus “realization” is referred to the working groups of the CCT for further consideration. The CCT voted (IMGC abstained; none opposed) to approve the final draft B report for this key comparison. The pilot laboratory will create and submit the final Appendix B entries to the KCDB with the assistance of Working Group 7.

Dr Pavese, on the behalf of the Italian delegation, declared that, at the moment of CCT voting, IMGC abstained on the ground that, as stated before in respect to Working Group 7 discussion, some of the NMIs participated in [CCT-K1](#) with approximations and not with definitions of the ITS-90: this is explicitly recognized in the text of the draft B shown by the [CCT-K1](#) rapporteur, but the consequences are not taken into account when writing the text of the Appendix B for [CCT-K1](#), and in the title of the report. In his view the fact that, in some cases, the physical instrument is the same for the CVGT and the ICVGT and that the results are numerically consistent with each other is not sufficient, since also the rest of the ITS-90 definition should be applied to become “realizations”.

4.2 [CCT-K5](#): Realizations of the ITS-90 between the silver point and 1700 °C using vacuum strip lamps as transfer standards

Dr Peruzzi summarized the status of [CCT-K5](#), describing the results and analysis included in the most recent draft A report, which has been under consideration by the participants since April 2005. Working Group 7 was requested to become directly involved in supporting the computation and presentation of the degrees of equivalence in terms of a single KCRV per temperature, since there is evidence to suggest that it may be inappropriate to average the results from all of the circulating artefacts. It is desirable to bring this key comparison to a successful conclusion within the year.

4.3 [CCT-K6](#): Comparison of humidity standards

Dr Takahashi summarized the status of [CCT-K6](#), including an explanation of the technical failures which have led to a delay in the measurement schedule that is approaching one year in duration. President Ugur encouraged the pilot laboratory and participants to act quickly to address and resolve these issues, and to make every effort to complete the draft B report by the beginning of 2007 so that the Working Group 7 review can be completed prior to the next CCT meeting.

4.4 [CCT-K7](#): Comparison of water triple point cells

Dr Stock summarized the status of [CCT-K7](#), for which the draft B report is under technical review by Working Group 7, and highlighted the importance of the results of this key comparison in initiating the work of the Triple Point of Water Task Force. It is expected that the final approval of the revised report and subsequent publication of the degrees of equivalence in the KCDB will take place shortly, bringing this work to a timely and successful conclusion.

5 STATUS, RESULTS AND LINKING OF RMO COMPARISONS

There was general discussion of these items under agenda item 3.7. The first example of a linked key comparison in thermometry now exists in the KCDB (for [CCT-K2.1](#)), and a general understanding of the linking issues for an RMO key comparison ([EUROMET.T-K3](#)) are being considered in Working Group 7. Dr Thomas pointed out that there are technical limitations in the case of very large tables of bilateral degrees of equivalence. In such a case a formula for the calculation of bilateral degrees of equivalence between participants of linked comparisons may preferably be specified.

Pilots of CCT and RMO key and supplementary comparisons were reminded of and encouraged to use the JCRB form ([JCRB/9-9](#)) for registering and updating the status of their work with the KCDB. This form simplifies the maintenance of the KCDB, and a new version summarizing the recent activities should be submitted each time the key comparison enters a new phase. Copies of the form are available from Dr Espina, the Executive Secretary of the JCRB, or Dr Thomas, Coordinator of the KCDB. As well, this form is archived on the BIPM Forum for Working Groups 7 and 8.

The RMO Technical Committee Chairs in Thermometry were requested to conduct a survey of ongoing regional comparisons in order to produce a summary document for the next CCT meeting and to profit from the resulting inter-regional interaction. Dr Ballico presented the summary of such activities for the APMP region.

6 SITUATION OF CMC ASSESSMENT

This discussion took place under agenda item 3.8, during the report by Mr Strouse on the activities of Working Group 8.

7 REVIEW OF WORKING GROUP TASK DEFINITIONS, ROLES, RESPONSIBILITIES AND OPERATIONAL PROCEDURES

President Ugur thanked the chairmen of the CCT working groups for their efforts on behalf of the thermometry community, and encouraged active participation by the growing number of emeritus members and observers with expertise in a broad range of temperature measurement techniques. A reminder was given that, although the Chairs are named individuals, the formal members of the working groups are the NMIs. The named NMI delegates participating in the activities of the working groups were encouraged to continue and increase the practice of consultation and

information sharing with their local colleagues. Those NMIs unable to meet their commitments to the working groups are asked to consider carefully whether it is more appropriate to withdraw, to maintain and enhance efficiency.

7.1 Working Group 1: defining fixed points and interpolating instruments

Terms of reference:

- to improve techniques for the realization of defining fixed points and for interpolating instruments;
- to study non-uniqueness and the thermophysical properties of fixed points;
- to update the *Supplementary Information for the ITS-90*;
- to maintain the *mise en pratique* for the definition of the kelvin; and
- to assess needs and formulate plans for the next International Temperature Scale.

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, to coordinate a task group (including a representative from Working Groups 3, 4, and 5) formulating an assessment and possible work plan for the next International Temperature Scale and to prepare and maintain the *mise en pratique* for the definition of the kelvin.

Membership:

- D. Ripple (NIST, chairman)
- INRIM (P. Steur)
- KRISS (K.H. Kang)
- LNE (Y. Hermier)
- NMIJ (O. Tamura)
- NPL (D. Head)
- NRC (K. Hill)
- PTB (B. Fellmuth)
- VNIIM (A. Pokhodun)

7.2 Working Group 2: secondary reference points and techniques for approximating the ITS-90

Terms of reference:

- to revise the *Techniques for Approximating the ITS-90*; and
- to revise and update the list of secondary reference points.

Working Group 2 is tasked to continue with the updates to the *Techniques for Approximating the ITS-90*, including advice on secondary fixed-point construction and operation.

Membership:

- K. Hill (NRC, chairman)
- CENAM (E. Méndez-Lango)

- CSIR (H. Liedberg)
- INRIM (A. Merlone)
- KRIS (Y.G. Kim)
- LNE (R. Morice)
- MSL (D.R. White)
- NIM (Y. Duan)
- NMIJ (Y. Yamada)
- PTB (F. Edler)
- Co-opted: P. Bloembergen (NMI VSL, retired); M. Gotoh (Tamagawa University); B. Fellmuth (PTB)

7.3 Working Group 3: uncertainties

Terms of reference:

- to establish and recommend methods for quoting uncertainties in realizing the ITS-90 using contact thermometry; and
- to ensure notational consistency in methods for quoting uncertainties for other areas of interest to the CCT (including optical thermometry and humidity).

Working Group 3 is tasked with continuing the production of a document on uncertainty budgets for contact thermometry, and to act in an oversight role for similar documents produced by other working groups.

Membership:

- D.R. White (MSL, chairman)
- CEM (V. Chimenti)
- CENAM (E. Méndez-Lango)
- INRIM (F. Pavese)
- IPQ (E. Filipe)
- LNE (E. Renaot)
- NMIA (M. Ballico)
- NMIJ (K. Yamazawa)
- NMI VSL (A. Peruzzi)
- NIST (C. Meyer)
- PTB (S. Rudtsch)
- SMU (S. Duris)
- UME (A. Kartal Dogan)
- VNIIM (A. Ivanova)

7.4 Working Group 4: thermodynamic temperature

Terms of reference:

- to review and make recommendations concerning thermodynamic temperature determination and the definition of the kelvin.

Working Group 4 is tasked with continuing the production and dissemination of *Supplementary Information for the PLTS-2000* and with monitoring progress on potential redefinition of the kelvin in terms of the Boltzmann constant.

Membership:

- J. Fischer (PTB, chairman)
- INRIM (P. Steur)
- KRISS (I. Yang)
- LNE (L. Pitre)
- MSL (D.R. White)
- NIST (M. Moldover)
- NMIJ (O. Tamura)
- NPL (M. de Podesta)
- NRC (K. Hill)
- Available for assistance: M. Durieux (University of Leiden).

Dr Hudson was recognized and thanked for his extended contributions to the working group and to the CCT over a long and illustrious career.

Dr Rusby was thanked for the excellence of his long service as chairman, and commended for being fair, considerate, and skilled at achieving technical consensus particularly during the formulation of the PLTS-2000.

7.5 Working Group 5: radiation thermometry

Terms of reference:

- to study, develop and advise the CCT on issues related to optical methods for temperature measurement, including the reporting of uncertainty budgets;
- to maintain good links/interface with the radiometry community; and
- to provide formal liaison between the CCT and CCPR.

Working Group 5 is tasked with producing a document on uncertainty in radiation thermometry at temperatures below the Ag freezing point, with the coordination of thermodynamic measurement results at higher temperatures, and with continuing the examination and coordination of activities related to the metal-carbon eutectics.

Membership:

- G. Machin (NPL, chairman)
- INRIM (M. Battuello)
- KRISS (C.W. Park)
- LNE (M. Sadli)

- MSL (P. Saunders)
- NIM (Yuan Zundong)
- NIST (H. Yoon)
- NMC/SPRING (Wang Li)
- NMIA (M. Ballico)
- NMIJ (J. Ishii)
- NMi VSL (E.W.M. van der Ham)
- PTB (J. Hollandt)
- SMU (P. Nemeček)
- UME (S. Ugur)
- VNIIM (M. Matveyev)
- CCPR liaison: N. Fox (NPL)
- Co-opted: Y. Yamada (NMIJ); P. Bloembergen (NMi VSL, retired)

7.6 Working Group 6: humidity

Terms of reference:

- to advise the CCT on matters relating to humidity;
- to produce a working document on principal uncertainty components in humidity measurements for input to Working Group 3; and
- to harmonize the terms and definitions related to humidity measurements.

Working Group 6 is tasked with continuing production of the document on uncertainty in humidity, with the operation of [CCT-K6](#), and with providing strategic planning information on future key and supplementary comparisons in the field.

Membership:

- P. Huang (NIST, chairman)
- CENAM (E. Martines)
- INRIM (V. Fericola)
- KRISS (Hyun-Soo Nham)
- LNE-CETIAT (B. Blanquart)
- MSL (J. Lovell-Smith)
- NMIJ (H. Kitano)
- NMi VSL (R. Bosma)
- NPL (S. Bell)
- NRCCRM (Y. Hong)
- PTB (N. Boese)
- SPRING (Wang Li)
- UME (S. Ugur)

- VNIIM (M. Mamontov)

7.7 Working Group 7: key comparisons

Terms of reference:

- to examine all relevant documents for each key comparison, starting with the protocol and ending with the draft B report;
- to advise the pilot laboratory in preparing the text of the entry to Appendix B of the MRA as required, and to prepare a recommendation on these subjects for approval by the CCT;
- to prepare guidance documents on identifying significant deviations for use by the pilot laboratories; and
- to advise the pilot laboratory in preparing a comparison status document, and to prepare a recommendation for this summary for the CCT.

Working Group 7 is tasked with continuing the oversight of ongoing key comparisons, and with the production of guidance documents on comparison deviations. Including pilot laboratories of ongoing and completed CCT key comparisons in the membership of this working group captures and preserves the experience and lessons-learned during previous comparison exercises.

Membership:

- A. Steele (NRC, Pilot [CCT-K2](#), chairman)
- Pilot [CCT-K1](#) (NPL, R. Rusby)
- Pilot [CCT-K3](#) (NIST, G. Strouse)
- Pilot [CCT-K4](#) (PTB, E. Tegeler)
- Pilot [CCT-K5](#) (NMI VSL, E. van der Ham)
- Pilot [CCT-K6](#) (NPL, S. Bell)
- Pilot [CCT-K7](#) (BIPM, M. Stock)
- Chairman CCT-WG3 (R. White)
- Manager KCDB (C. Thomas, non-voting)
- NMIA (M. Ballico)
- INRIM (F. Pavese)
- KRISS (K.H. Kang)

7.8 Working Group 8: calibration and measurement capabilities

The remit of Working Group 8 was expanded substantially to include broad responsibilities related to Appendix C entries. One member is drawn from each of the RMOs to ensure consistency between the technical expertise offered by the CCT and the administrative and technical roles of the RMOs; additional technical experts will be co-opted on a short term basis to provide assistance on issues related to the particular field under discussion and review. The terms of reference are substantially those recommended by the JCRB in the document JCRB-10/6(3).

Terms of reference:

- to establish and maintain lists of service categories and, where necessary, rules for the preparation of CMC entries;
- to agree on detailed technical review criteria;
- to coordinate and, where possible, conduct inter-regional reviews of CMCs submitted by RMOs for posting in Appendix C of the MRA;
- to provide guidance on the range of CMCs supported by particular key comparisons;
- to examine the sufficiency of existing comparisons for supporting CMC submissions and to recommend new comparisons where deemed necessary; and
- to coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons.

Working Group 8 is tasked to continue with the creation of CMC review protocols and the review of fast-track CMC submissions for inclusion in Appendix C, along with the identification of new comparisons needed to support CMC submissions.

Membership:

- G. Strouse (SIM, chairman, NIST)
- APMP (M. Ballico, NMIA)
- COOMET (A. Pokohodun, VNIIM)
- EUROMET (J. Bojkovski, University of Ljubljana, Slovenia)
- SADC MET (H. Liedberg, CSIR)

7.9 Working Group 9: thermophysical properties

Terms of reference:

- to advise the CCT on matters related to thermophysical properties, and to assess the need in this field for a key comparison.

Working Group 9 is tasked with continuing the production of a document on uncertainty, and with identifying and undertaking suitable pilot studies to establish the state of measurement and maturity of the field.

Membership:

- T. Baba (NMIJ, chairman)
- INRIM (F. Girard)
- IPQ (N. de Castro)
- KRISS (Sang Hyun Lee)
- LNE (J.-R. Filtz)
- NIM (Jintao Zhang)
- NIST (L. Hanssen)
- NPL (C. Stacey)
- PTB (S. Sarge)
- VNIIM (N.A. Sokolov)

8 PUBLICATION OF CCT ONLINE DOCUMENTS

Prof. Wallard noted that most Consultative Committees examine the submitted working documents individually, and conduct a brief review to determine whether they are suitable for general release, or are best left as confidential items available only to the members of the Consultative Committees. Authors were reminded that future submissions are to be coordinated through the relevant working group chairmen, who are now assigned the responsibility to determine whether a document is suitable for inclusion on the public website, with the intention being to limit the number of redundant publications.

9 DISCUSSIONS ON ITS-20XX

The discussion of this topic took place as part of agenda item 7, where the terms of reference of Working Group 1 were expanded to include the role of coordinating the efforts of the CCT in preparation for a revision of the ITS.

10 SCIENTIFIC TOPICS

Dr Quinn presented some thoughts on the implications for practical thermometry of a possible redefinition of the kelvin in terms of the Boltzmann constant (CCT/05-26), noting that the time has come to consider seriously such proposals in light of the expressed wish of the Consultative Committee for Units to bring forward a coherent package of possible redefinitions of the fundamental units for mass, current, and temperature to the CGPM at their 2011 meeting. There was some discussion of the proposal, and the details of the formulation for the *mise en pratique* for the realization of the kelvin were refined in light of such potential future redefinitions.

Dr Fischer presented a summary of the one-day workshop on methods for new determinations of the Boltzmann constant, held at PTB in January 2005. Dr Rusby, who attended the workshop, noted that the event was thought-provoking, and supports the activity. There was some discussion of specific research work, including gas thermometry and the optical equivalence to dielectric thermometry, the dimensional aspects of acoustic and microwave measurements, the state of Johnson noise thermometry, and the achievable limits of the associated measurement uncertainties.

11 OTHER BUSINESS

There was some discussion of the creation of rules and procedures for the operation of the CCT, and it was decided to make better use of electronic communication prior to the next meeting to address as many of the administrative questions (e.g. chairmen and composition of the working groups) as practicable. There was general agreement that the return to scientific discussion was very welcome, and that every effort should be made to continue and expand this practice in the future, possibly including the creation of a CCT workshop to be held in conjunction with the next meeting. The CCT will continue to take advantage of conferences and other occasions when the community comes together, specifically including the TempMeko conference series, to hold working group meetings and to sponsor technical seminars and workshops.

Prof. Wallard noted that the JCRB documents are collected in a single booklet, soon to be made available on the BIPM website, many of which serve as useful guidelines and interpretation documents for the Mutual Recognition Arrangement.

Dr Ballico proposed that each NMI be invited to submit a brief summary report on their activities and areas of research as a CCT working document, supplemented by a one or two minute presentation, time permitting.

President Ugur reminded the member institutes that there is a maximum delegation of four at the Consultative Committee meetings, and, since space is always at a premium in the main meeting room, requested that everyone be respectful of these limits.

12 REPORT TO THE CIPM AND RECOMMENDATIONS

The report of the President to the CGPM and CIPM will be prepared shortly, to allow time for translation and formatting at the BIPM. The three approved CCT Recommendations to be brought forward are as follows: Recommendation T 1 (2005) on the clarification of the definition of the kelvin, unit of thermodynamic temperature ([CCT/05-30](#)); Recommendation T 2 (2005) on new determinations of thermodynamic temperature and the Boltzmann constant ([CCT/05-31](#)); and Recommendation T 3 (2005) on the creation of a *mise en pratique* of the definition of the kelvin ([CCT/05-32](#)).

13 NEXT MEETING

The CCT recommends that the CIPM schedule the next meeting for Spring 2008, since there will be an occasion to meet and conduct other business during the week of TempMeko 2007. There was general agreement that having a minimum of two CCT meetings prior to the 2011 meeting of the CGPM (e.g. in 2008 and 2009) would maximize the opportunity for formal interactions regarding progress on a Scale revision and on the Boltzmann constant.

A.G. Steele, Rapporteur

Revised January 2006

**RECOMMANDATIONS DU
COMITÉ CONSULTATIF DE THERMOMÉTRIE
PRÉSENTÉES AU
COMITÉ INTERNATIONAL DES POIDS ET MESURES**

RECOMMANDATION T 1 (2005) :

Clarification de la définition du kelvin, unité de température thermodynamique

Le Comité consultatif de thermométrie,

considérant

- que le kelvin, l'unité de température thermodynamique, est défini par la fraction $1/273,16$ de la température thermodynamique du point triple de l'eau,
- que la température du point triple de l'eau dépend des abondances relatives des isotopes de l'hydrogène et de l'oxygène présents dans l'échantillon d'eau utilisé,
- que cet effet est maintenant l'une des sources majeures d'écarts observés entre les différentes réalisations du point triple de l'eau,

recommande

- que la définition du kelvin se réfère à une eau de composition isotopique spécifiée,
- que cette composition isotopique de l'eau soit la suivante :

0,000 155 76 mole de ^2H par mole de ^1H ,
0,000 379 9 mole de ^{17}O par mole de ^{16}O , et
0,002 005 2 mole de ^{18}O par mole de ^{16}O ,

cette composition étant celle du matériau de référence de l'Agence internationale de l'énergie atomique « Vienna Standard Mean Ocean Water (VSMOW) », recommandée par l'Union internationale de chimie pure et appliquée dans « Atomic Weights of the Elements: Review 2000 » ,

- que cette composition soit définie dans une note attachée à la définition du kelvin dans la brochure sur le SI de la manière suivante :

« Cette définition se réfère à l'eau de composition isotopique définie par les rapports de quantité de matière* suivants : 0,000 155 76 mole de ^2H par mole de ^1H , 0,000 379 9 mole de ^{17}O par mole de ^{16}O et 0,002 005 2 mole de ^{18}O par mole de ^{16}O ».

* Le nom de la grandeur a été inséré après la 23^e session du CCT, sur les conseils du Comité consultatif des unités lors de sa 17^e session en juin 2005.

RECOMMANDATION T 2 (2005) :**Nouvelles déterminations de la température thermodynamique et de la constante de Boltzmann**

Le Comité consultatif de thermométrie,

considérant

- que la température thermodynamique, T , est la grandeur physique de base à laquelle toutes les mesures de température devraient en dernière instance se référer,
- que l'Échelle internationale de température de 1990, l'EIT-90, et l'Echelle provisoire pour les basses températures de 2000, EPBT-2000, fournissent des représentations pratiques de T ,
- que les déterminations de la température thermodynamique T sont essentielles pour étayer l'EIT-90 et fournir les valeurs des écarts entre T et les indications de l'échelle EIT-90,
- que l'on a besoin de connaître les valeurs de T pour les températures de congélation du zinc, de l'aluminium, de l'argent, de l'or et du cuivre, et pour les températures de transition des eutectiques et d'autres matériaux à de plus hautes températures, afin de réduire les incertitudes en thermométrie et en radiométrie,
- que l'exactitude de l'EIT-90 par rapport à T n'a pas été entièrement vérifiée dans le domaine situé en dessous de 273,16 K,
- que l'EPBT-2000 pourrait présenter un écart relatif par rapport à T de plusieurs centièmes aux plus basses températures,
- que les nouvelles déterminations de la constante de Boltzmann, k , sont nécessaires à la préparation d'une éventuelle nouvelle définition du kelvin,

recommande que les laboratoires nationaux mettent en œuvre et poursuivent des expériences afin de déterminer des valeurs de la température thermodynamique et de la constante de Boltzmann.

RECOMMANDATION T 3 (2005) :

Création d'une mise en pratique de la définition du kelvin

Le Comité consultatif de thermométrie,

considérant

- que l'Échelle internationale de température de 1990 (EIT-90) et l'Échelle provisoire pour les basses températures de 2000 (EPBT-2000) sont des échelles de température pratiques reconnues au niveau international, qui définissent les températures T_{90} et T_{2000} , lesquelles sont de bonnes approximations de la température thermodynamique, T ,
- que l'incertitude sur la réalisation de certains points fixes thermométriques est limitée par des ambiguïtés dans la définition de la composition isotopique des matériaux dont on utilise les points fixes,
- que des définitions claires des compositions isotopiques de référence aideront à établir de façon cohérente les aptitudes en matière de mesures et d'étalonnage au niveau international,
- que des mesures récentes de température thermodynamique ont affiné les meilleures estimations des écarts $T - T_{90}$ et des incertitudes associées,
- que la création d'une mise en pratique officielle de la définition du kelvin simplifierait considérablement et éclaircirait les déclarations et recommandations du Comité consultatif de thermométrie concernant la réalisation de la définition du kelvin et la mise en œuvre d'échelles pratiques de température,

recommande

- la création d'une « mise en pratique de la définition du kelvin », contenant en temps utile des recommandations au sujet de la détermination directe de la température thermodynamique, le texte de l'EIT-90, le texte de l'EPBT-2000, une annexe technique donnant la documentation considérée comme essentielle pour la détermination non ambiguë de l'EIT-90 et de l'EPBT-2000, et une section au sujet des écarts $T - T_{90}$ et $T - T_{2000}$ et des incertitudes associées,
- l'approbation par le Comité international des poids et mesures du texte intitulé « Annexe technique pour la mise en pratique de la définition du kelvin », adopté par le Comité consultatif de thermométrie lors de sa 23^e session, comme première ébauche de l'annexe technique.

**RECOMMENDATIONS OF THE
CONSULTATIVE COMMITTEE FOR THERMOMETRY
SUBMITTED TO THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND
MEASURES**

RECOMMENDATION T 1 (2005):

Clarification of the definition of the kelvin, unit of thermodynamic temperature

The Consultative Committee for Thermometry,

considering

- that the kelvin, unit of thermodynamic temperature, is defined as the fraction $1/273.16$ of the thermodynamic temperature of the triple point of water,
- that the temperature of the triple point depends on the relative amount of isotopes of hydrogen and oxygen present in the sample of water used,
- that this effect is now one of the major sources of the observed variability between different realizations of the water triple point,

recommends

- that the definition of the kelvin refer to water of a specified isotopic composition,
- that this composition be:

$0.000\ 155\ 76$ mole of ^2H per mole of ^1H ,

$0.000\ 379\ 9$ mole of ^{17}O per mole of ^{16}O , and

$0.002\ 005\ 2$ mole of ^{18}O per mole of ^{16}O ,

which is the composition of the International Atomic Energy Agency reference material Vienna Standard Mean Ocean Water (VSMOW), as recommended by IUPAC in “Atomic Weights of the Elements: Review 2000”.

- that this composition be stated in a note attached to the definition of the kelvin in the SI brochure as follows:

“This definition refers to water having the isotopic composition defined by the following amount-of-substance ratios*: $0.000\ 155\ 76$ mole of ^2H per mole of ^1H , $0.000\ 379\ 9$ mole of ^{17}O per mole of ^{16}O and $0.002\ 005\ 2$ mole of ^{18}O per mole of ^{16}O ”.

* The quantity name was inserted subsequently to the 23rd meeting of the CCT, on the advice of the CCU (17th meeting).

RECOMMENDATION T 2 (2005):

New determinations of thermodynamic temperature and the Boltzmann constant

The Consultative Committee for Thermometry,

considering

- that thermodynamic temperature, T , is the basic physical quantity to which all measurements of temperature should ultimately be referred,
- that the International Temperature Scale of 1990, ITS-90, and the Provisional Low-Temperature Scale of 2000, PLTS-2000, provide practical representations of T ,
- that determinations of thermodynamic temperature T are fundamental in supporting the ITS-90 and providing values of $(T - T_{90})$,
- that values of T are needed for the freezing temperatures of zinc, aluminium, silver, gold and copper, and transition temperatures in eutectic and other materials at higher temperatures, to reduce uncertainties in thermometry and radiometry,
- that the accuracy of the ITS-90 with respect to T has not been fully tested in the range below 273.16 K,
- that the PLTS-2000 may deviate from T by several percent at the lowest temperatures,
- that new determinations of the Boltzmann constant, k , are needed in preparation for an eventual re-definition of the kelvin,

recommends that national laboratories initiate and continue experiments to determine values of thermodynamic temperature and the Boltzmann constant.

RECOMMENDATION T 3 (2005):**Creation of a *mise en pratique* of the definition of the kelvin**

The Consultative Committee for Thermometry,

considering

- that the International Temperature Scale of 1990 (ITS-90) and the Provisional Low-Temperature Scale of 2000 (PLTS-2000) are internationally accepted practical temperature scales defining temperatures T_{90} and T_{2000} that are good approximations to thermodynamic temperature, T ,
- that the uncertainty of realization of certain thermometric fixed points is limited by ambiguities in the defined isotopic composition of the materials for these fixed-points,
- that clear definitions of isotopic reference compositions will assist in the establishment of internationally compatible Calibration and Measurement Capabilities,
- that recent thermodynamic temperature measurements have refined the best estimates of the differences $T - T_{90}$ together with their uncertainties,
- that the creation of a formal *mise en pratique* of the definition of the kelvin would considerably simplify and clarify statements and recommendations of the CCT concerning the realization of the definition of the kelvin and the implementation of practical temperature scales,

recommends

- the creation of a *mise en pratique* of the definition of the kelvin containing, in due course, recommendations concerning the direct determination of thermodynamic temperature, the text of the ITS-90, the text of the PLTS-2000, a Technical Annex of material deemed essential for the unambiguous realization of both the ITS-90 and the PLTS-2000, and a section discussing the differences $T - T_{90}$ and $T - T_{2000}$ together with their uncertainties,
- approval by the CIPM of the text entitled “Technical annex for the *mise en pratique* of the definition of the kelvin”, adopted by the CCT at its 23rd meeting, as initial entry to the Technical Annex.

APPENDIX T 1.**Working documents submitted to the CCT at its 23rd meeting**

Open working documents of the CCT can be obtained from the BIPM in their original version, or can be accessed on the BIPM website (<http://www.bipm.org/cc/AllowedDocuments.jsp?cc=CCT>).

Document
CCT/

- [05-01](#) BNM-INM (France), NPL (United Kingdom). — CCT Workshop on Uncertainty in Temperature Fixed Points, G. Bonnier, R. Rusby, 1 p.
- [05-02](#) PTB (Germany). — Workshop on Methods for New Determinations of the Boltzmann Constant, B. Fellmuth, J. Fischer, C. Gaiser, W. Buck, 5 pp.
- 05-03 rev. IMGC (Italy). — On the definition of “pressure” in the ITS-90 definition of the interpolating CVGT, P.P.M. Steur, F. Pavese, 20 pp. (restricted access)
- [05-04 rev.](#) PTB (Germany). — Cryoscopic Constant, Heat and Enthalpy of Fusion of Metals and Water, S. Rudtsch, 3 pp.
- [05-05](#) KRISS (Rep. of Korea). — Spectrally Selected Linearity Measurement of a Radiation Thermometer Using High-brightness Light Emitting Diodes, Chul Woung Park *et al.*, 4 pp.
- 05-06 rev. CCT Working Group 1. — Isotopic Effects in the Hydrogen Fixed Points: Report to the CCT, P.P.M. Steur *et al.*, 8 pp. (restricted access)
- 05-07 rev. *Ad hoc* Task Group on the Triple Point of Water. — Summary of Facts Relating to Isotopic Effects and the Triple Point of Water: Report of the *ad hoc* Task Group on the Triple Point of Water, D.C. Ripple *et al.*, 7 pp. (restricted access)
- 05-07a *Ad hoc* Task Group on the Triple Point of Water. — Draft Recommendation T 1 (2005) to the CIPM on the clarification of the definition of the kelvin, 1 p. (restricted access)
- 05-08 CCT Working Group 1. — Methodologies for the estimation of uncertainties and the correction of fixed-point temperatures attributable to the influence of chemical impurities, B. Fellmuth *et al.*, 15 pp. (restricted access)
- 05-09 MSL (New Zealand). — Two issues relating to the harmonisation of uncertainty analyses, D.R. White, 3 pp. (restricted access)
- [05-10](#) CCT Working Group 5. — Working Group 5 Report to CCT: June 2005, J. Fischer *et al.*, 5 pp.
- [05-11](#) NMIJ/AIST (Japan). — Hydrostatic Pressure Correction Coefficient of the Triple Point Cell of Water, H. Sakurai, 6 pp.
- 05-12 CCT Working Group 8. — Report of WG8 to the 23rd meeting of the CCT held in June 2005, G. Strouse *et al.*, 3 pp. (restricted access)

Document
CCT/

- [05-13](#) SPRING (Singapore). — Comparison of humidity measurements using a dew point meter as a transfer standard, APMP-IC-1-97, draft B, Wang Li, 54 pp.
- [05-14](#) NMIJ/AIST (Japan). — Double anomalous peak in the heat capacity just below the triple point of $e\text{-H}_2$ with FeO(OH), T. Nakano, O. Tamura, H. Sakurai, 4 pp.
- 05-15 rev. CCT Working Group 3. — Working Group 3 Report to CCT: June 2005, D.R. White *et al.*, 4 pp. (restricted access)
- [05-16](#) NMi VSL, Centre for Isotope Research of the University of Groningen, Kelvin-lab (The Netherlands). — Research Activities on Water Triple Point Cells in the Netherlands, A. Peruzzi *et al.*, 5 pp.
- 05-17 IMGC (Italy). — Proposed method for tackling in the ITS-90 definition the issue of isotopic composition prescribed for relevant substances used in the scale definition, F. Pavese, 2 pp. (restricted access)
- [05-18](#) NPL (United Kingdom), NMIJ/AIST (Japan). — Implementation of M-C eutectics into mainstream metrology, G. Machin, Y. Yamada, P. Bloembergen, 3 pp.
- [05-19 rev.](#) CCT Working Group 4. — Working Group 4 Report to CCT, R.L. Rusby *et al.*, 12 pp.
- 05-20 KRISS (Rep. of Korea), VNIIM (Russian Fed.). — Investigation on the stability of 0.6 ohm HTPRTs at KRISS, K.S. Gam, N.P. Moiseeva, 6 pp. (restricted access)
- 05-21 CCT Working Group 2. — Working Group 2 Report to the CCT, May 2005, K. Hill *et al.*, 2 pp. (restricted access)
- [05-22](#) NMIJ/AIST (Japan). — Effect of thermal treatment on realization of the cryogenic fixed points of the ITS-90 (corrected version), T. Nakano, O. Tamura, H. Sakurai, 4 pp.
- 05-23 CCT Working Group 6. — Report to the CCT by Working Group 6 on Humidity Measurements, P. Huang *et al.*, 2 pp. (restricted access)
- 05-24 IMGC (Italy). — Accurate determination of the mercury vapour pressure relation between 5 kPa and 200 kPa as reference function for the temperature amplifier, A. Merlone, P.P.M. Steur, P. Marcarino, 4 pp. (restricted access)
- 05-25 CCT Working Group 1. — Report Presented to the CCT By Working Group 1: May 2005, D. Ripple *et al.*, 3 pp. (restricted access)
- 05-26 Temperature scales and units and implications for practical thermometry of a possible redefinition of the kelvin in terms of the Boltzmann constant, T.J. Quinn, 7 pp. (restricted access)
- [05-27](#) CCT Working Group 7. — 2005 Report of CCT Working Group 7: Key Comparisons, A. Steele, 3 pp.
- [05-28](#) NMIJ/AIST (Japan). — The Relation between Deuterium Content and Melting Range of the Triple Point of $e\text{-Hydrogen}$, H. Sakurai, O. Tamura, 2 pp.
- [05-29](#) CCT Working Group 9. — Working Group 9 Report to CCT, June 2005, T. Baba, 2 pp.

Document
CCT/

- [05-30](#) CCT. — Recommendation T 1 (2005) : Clarification of the definition of the kelvin, unit of thermodynamic temperature, 1 p.
- [05-31](#) CCT. — Recommendation T 2 (2005) : New determinations of thermodynamic temperature and the Boltzmann constant, 1 p.
- [05-32](#) CCT. — Recommendation T 3 (2005) : Creation of a *mise en pratique* of the definition of the kelvin, 1 p.
- 05-33 CCT. — Technical annex for the *mise en pratique* of the definition of the kelvin, 3 pp. (restricted access)