CCT/01-16

Report of CCT working group 5 on radiation thermometry

Joachim Fischer (PTB, chairman), Mark Ballico (CSIRO), Mauro Battuello (IMGC), Seung Nam Park (KRISS), Peter Saunders (MSL), Yuan Zundong (NIM), B. Carol Johnson (NIST), Eric van der Ham (NMi), Fumihiro Sakuma (NMIJ), Graham Machin (NPL), Wang Li (PSB), Mikhail Matveyev VNIIM)

Working Group 5 (WG5) of the CCT was formed at the 2000 meeting of the CCT. After discussions (by email) representatives from each participating NMI were nominated (see list of authors above). The president of the CCPR is sending a delegate (Nigel Fox, NPL) to the WG5 meetings, to represent and formally report to the CCPR. The president of the CCT and the chairman of WG5 are in agreement with this concept.

The first activity of the CCT WG5 was discussions about the WG5 Terms of Reference. A draft version of these were circulated and finalised at the first meeting on 18 June 2001 held at PTB in Berlin. The terms are listed below :

Terms of Reference

Guideline:

- Development and improvement of optical methods for temperature measurement in the framework of the ITS
- Maintain good links/interface with the radiometry community
- Liaison between CCT and CCPR

Current problems in radiation thermometry:

- Examining the base-line parameters underlying the radiation thermometry scale realisation (effective wavelength, size-of-source effect, ...) with rigorous standard approach to uncertainty analysis
- Progress and function of metal-carbon eutectics (in collaboration with WG2)
- Broadening the base for a comparison of radiation thermometry scales with transfer thermometers between 1500 °C up to 3000 °C
- Determination of temperatures of HTBBs used for dissemination of radiometric quantities (includes absolute radiometry and aperture determination)

Contact to normative bodies:

- Standardisation issues in the framework of CEN / ISO / ASTM
- Dissemination of good practice derived from the outputs of TRIRAT
- Validation of thermal imagers, fibre-optic thermometers, ...

New developments:

- Radiation Thermometry below 962 °C and traceability in remote sensing
- Radiation thermometry above 3000 °C (new methods : CARS, plasma spectrometry, FT spectroscopy, ...)
- Special applications (rapid thermal processing, thermal imaging...)
- Thermal measurements (emissivity, ...)

It was decided to start the work on the following two items :

i) Examining the base-line parameters underlying the radiation thermometry scale realisation (effective wavelength, size-of-source effect, ...) with rigorous standard approach to uncertainty analysis
ii) Progress and function of metal-carbon eutectics (in collaboration with WG2)

To make progress in these fields a working paper on uncertainty budgets for realisation of scales by radiation thermometry was prepared by M. Battuello and a review paper on the development of metal-carbon eutectic fixed points was prepared by F. Sakuma and Y. Yamada. At the 18 June meeting these two papers were presented and discussed in detail. As for the uncertainty problem is was found necessary to continue the discussion at the second meeting of WG5 on 11 September 2001 at BIPM. This meeting is especially aiming at achieving consensus in the meaning of the uncertainty terms and how they are calculated. The working paper will then be progressed to a final document. With the same perspective an EUROMET workshop on uncertainties in radiation thermometry has been organised by, and will be held at, BNM-INM on 7 September 2001 with the involvement of CCT WG5 and CCT WG3.

Regarding the metal-carbon eutectics the presentation of NMIJ dealt with the uncertainties in temperature determination, problems encountered, areas for future investigations, and impact on future revisions of the ITS. A list of 20 related publications demonstrated the tremendous progress in that field. At present metal-carbon eutectic fixed points are operational in the temperature range from 1153 °C (Fe-C) to 2474 °C (Re-C)[1]. The reproducibility of the melting temperature of the eutectic fixed-point cells has reached a state that is sufficient for very accurate comparisons of local temperature scales. There are deficiencies in the understanding of the influence of impurities on the melting temperatures and there are some practical issues with regards the use of high temperature furnaces. When these problems have been solved, the determination of the thermodynamic temperatures of these eutectics will provide the thermometry and radiometry community's stable, repeatable ultra-high temperature fixed points. To achieve this, work continues at NMIJ, in addition work has begun in Europe through EUROMET project 550 and, later in 2001, in the EU-funded joint research programme HIMERT (co-ordinator Graham Machin, NPL). If the eutectics are used in a re-definition of the future ITS a revision of the value of the radiation constant c_2 is desirable for highest accuracy.

[1] Note that it was reported at TEMPMEKO 2001 by Yamada et al. that it is possible to realise metal carbide-carbon eutectics at even higher temperatures