TASK GROUP ON THE SI (TG-SI) REPORT TO CCT
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Terms of reference: The Terms of Reference follow closely CIPM Recommendation 1 of 2005, (CI-2005), "Preparative steps towards new definitions of the kilogram, the ampere, the kelvin and the mole in terms of fundamental constants". The TG-SI is presently tasked with the following two terms:

- monitor closely the results of new experiments relevant to the possible new definition of the kelvin, and to identify necessary conditions to be met before proceeding with changing the definition;
- solicit input from the wider scientific and technical community on this important matter.

The TG-SI members met at the 4th International Workshop on Progress in Determining the Boltzmann Constant, held from 22 to 24 September 2009 at INRiM.

Regarding input from the wider scientific and technical community VNIIM discussed in the period from May 2008, to May 2009, the problem of redefinition of the kelvin in terms of the Boltzmann constant at the Scientific Council of the Academy of Science of Russia within the complex problem “Thermal Physics and Thermal Energetics”; at the Scientific Council of the Saint-Petersburg Technical University of Fine Mechanics and Optics; at the Scientific Council of the All-Russia D.I. Mendeleyev Institute for Metrology; at the XII Russian Conference on Thermophysical Properties of Substances held in Moscow in October, 2008; at the sessions of the Technical Committee on Metrology “Thermal, Thermophysical and Dilatometric Measurements” attached to the Metrological Department of Rostekhregulirovaniye; at the Commission on Metrology attached to the Scientific Council of the Academy of Science of Russia; and at the meeting of COOMET Technical Committee TC 1.10 “Thermometry and Thermal Physics”. The discussion was summarized in a report authored by A.I. Pokhodun and S.F. Gerasimov, circulated to the members of TG-SI at 14 July 2009. At the meeting of 23 September 2009 the questions raised in the report were comprehensively discussed and resolved satisfactorily.

During the meeting at CCT-24 in 2008, and at the meeting of 23 September 2009 at INRiM the members monitored closely the results of new experiments relevant to the possible new definition of the kelvin. We note that contributions to the 3rd International Workshop on Progress in Determining the Boltzmann Constant, held at 7 April 2008 at LNE-INM, had been published in a special issue of Comptes Rendus Physique de L´Académie des Sciences in November 2009.

The 4th International Workshop on the Determination of the Boltzmann Constant was held at INRiM from 22 Sept. to 23 Sept. 2009. At this workshop the present state of the methods acoustic gas thermometry, dielectric constant gas thermometry, Johnson noise thermometry, and Doppler broadening thermometry was discussed by an international audience. The workshop enabled once more efficient knowledge transfer from and to the collaborating universities of Paris North (LPL), Naples (UniNA2), Milan (PoliMI) and Valladolid (UVa). The presentations will be published in a special issue of the International Journal of Thermophysics and will therefore achieve a broad reception in different scientific communities.

Remarkable progress has been reported for acoustic gas thermometry (AGT) with spherical or quasi-spherical cavity resonators. The determination of preliminary values for the Boltzmann constant with an uncertainty of about 3 ppm by two different institutes, NPL and LNE, should be highlighted [see e.g. L. Pitre, C. Guianvarc'h, F. Sparasci, A. Guillou, D. Truong, Y. Hermier, M. Himbert, C. R. Physique 10 (2009) 835-848]. At INRiM, the present value for the Boltzmann constant is discrepant to the CODATA value by 8 ppm and for 2010 new measurements are planned with an uncertainty aiming at 3 to 4 ppm. The researchers at CEM, Spain could not forecast the uncertainty value achievable with their experiment within 2010. At the National Institute of Metrology (NIM, China) AGT is still under development and a period of 3 to 4 years is required to develop the method to achieve uncertainties at the ppm level.

The progress in dielectric-constant gas thermometry (DCGT) [see also C. Gaiser, B. Fellmuth, Europhys. Lett. 83 (2008) 15001] is in line with the envisaged aims but it may happen that due to delays in the delivery of the pressure measurement system only an uncertainty in the order of 5 ppm can be achieved within 2010.

The other promising method to complement AGT, Doppler-broadening thermometry (DBT) [see C. Daussy, M. Guinet, A. Amy-Klein, K. Djerroud, Y. Hermier, S. Briaudeau, Ch. Bordé, and C. Chardonnet, Phys. Rev. Lett. 98 (2007) 250801; G. Casa, A. Castrillo, G. Galzerano, R. Wehr, A. Merlone, D. Di Serafino, P. Laporta and L. Gianfrani, Phys. Rev. Lett. 100 (2008) 200801] has to resolve discrepancies in different line fitting models which may limit the achievable uncertainty to 10 ppm within 2010. At the experiment of Danish Fundamental Metrology (DFM) even discrepancies of 2% when using different line fitting models have to be resolved. A new Doppler experiment has been started at University of Western Australia (UWA) where in the short term an uncertainty of around 400 ppm with rubidium atoms is envisaged.

Johnson noise thermometry (JNT) [S.P. Benz, J. Qu, H. Rogalla, D.R. White, P. D. Dresselhaus, W.L. Tew, IEEE Trans. on Instr. and Meas., 58:884–890, (2009)] reported 25 ppm uncertainty at the workshop and the foreseen reduction to 6 ppm is extremely challenging. The recently started Johnson noise thermometry experiment at INRiM has a target uncertainty of 20 ppm to be achieved within 2 to 3 years.

The following table gives an updated summary overview of the potential of the currently available relevant primary thermometers, as deduced from the 4th International Workshop on the Determination of the Boltzmann Constant in 2009 at INRiM compared to the 2nd workshop held at PTB in 2006 [B. Fellmuth and J. Fischer (Eds.), Report PTB-Th-3, Braunschweig, ISBN 978-3-86509-684-5 (2007)]. Within the next year, it still exists the possibility of achieving a relative uncertainty of order one part in 10^6 (1 ppm) but only based on measurements applying one method, acoustic gas thermometry, with similar experimental and theoretical techniques, performed at LNE-INM and NPL. All other experiments, especially the other methods need significantly more time to achieve the envisaged uncertainties in order to confirm the results of acoustic gas thermometry.

Table Recent development of the relative uncertainty for determining the Boltzmann constant *k* applying different methods and involved institutes.

Method	2nd WS 2006	4th WS 2009	2010 possibility	institute
AGT	> 20 ppm	3 ppm	1 ppm	CEM, INRiM, LNE-INM/CNAM, NPL, UVa, NIM
DCGT	15 ppm	-	5 ppm	PTB
JNT	-	25 ppm	6 ppm	NIST, INRiM
DBT	200 ppm	44 ppm	10 ppm	DFM, LNE-INM/CNAM, LPL, INRiM, UniNA2, PoliMI, UWA