CCT/17-36

TC Thermometry
Graham Machin

June 2017

Thermometry

Overview

- Introduction to TC-T
- Annual meetings + technical workshops
- Highlights from TC-T community
  - EMPRESS and New kelvin projects
- Future plans

TC-T overview

- Main field – thermometry (NPL)
- Sub committee on humidity (INRIM, [LMK vice convenor])

- Working groups on
  - Cmc review (NPL)
  - Strategy (CEM)
  - Best practice and guides (SMD)
  - Thermophysical quantities (CNAM-LNE [SMU])

Annual meeting 23-26 Feb 2016

Hosted by MCCAA, Malta – around 70 delegates

Annual meeting: 25-28 April 2017

Hosted by CEM, Madrid – around 70 delegates

- Next meeting: 24-27 April 2018, RISE, Sweden

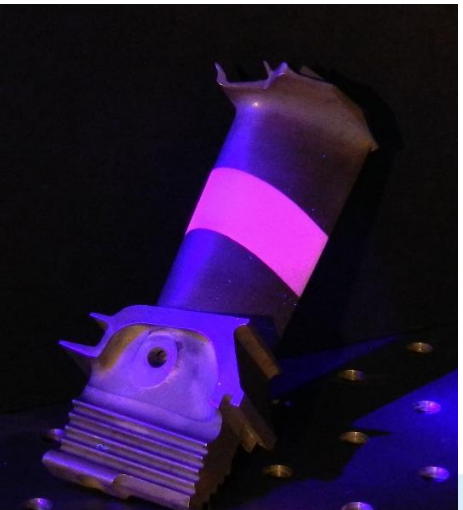
Thermometry

TC-T – plenary meetings

- Sub committee on humidity & all four working groups meet during TCT
- Take opportunity to train new colleagues and discuss contemporary thermal measurement related issues
- Technical workshop on contact surface thermometry (2016)

Technical workshop at TC-T plenary on surface contact thermometry

- Organised by Emese Turzó-András (MKEH, Hungary)
- 11 presentations; 8 different countries
- Disseminating SoA, and current research in difficult measurement area to all the leaders of the Euramet TC-T community
- Workshop on air temperature measurement (organised Stephanie Bell, NPL and Davor Zvizdic, FSB) Apr 2017



TC-T – plenary meeting 2017

- Technical workshop – air temperature measurement
  - Organised by Stephanie Bell (NPL) and Davor Zvizdic (FSB)
  - 5 presentations + active contact person involvement
  - Led to formation of TC-T TG on air temperature measurement

- Engagement workshop
  - TG convenors, CB and STAIR coordinators short presentations
  - Contact person discussions about strengthening engagement with TGs, CB, STAIR

- 2018 technical workshops; on thermal imaging, ice & sea temperature measurement

Highlights from TCT

- EMPRESS
- Implementing the new kelvin 1+2

EURAMET

Partners

Internal:

- NPL (UK) (coordinator)
- BRML (Romania)
- CEM (Spain)
- CMI (Czech Republic)
- DTI (Denmark)
- DTU (Denmark)
- INRIM (Italy)
- JV (Norway)
- PTB (Germany)

External funded:

- Elkem (Norway)
- Gamma Forgiati (Italy)
- MUT Advanced Heating (Germany)
- AFRC (UK)
- Universidad Carlos III de Madrid (Spain)
- University of Cambridge (UK)
- University of Oxford (UK)

Unfunded:

- BAE Systems (UK)
- CCPI Europe (UK)

Formal Collaborators:

- Aubert & Duval (France)
- Bodycote UK
- Bodycote Romania
- Imperial College (UK)

EMPIR thermometry project for industry

- EMPIR Industry focused project – “EMPRESS” (Enhancing process efficiency through improved temperature measurement) – started May 15
  - Strong focus on addressing unsolved thermometry problems in industry – industrial trials planned in all project WPs
    - Low drift temperature sensors with target *in-situ* traceable uncertainty of <3 ºC at 1450 ºC, <5 ºC at > 2000 ºC
    - Non drift temperature sensors (<1 ºC >6 months service), optimised for temperatures around 1350 ºC
    - Traceable surface temperature measurement methods to~500 ºC
    - *in-situ* combustion standard of known temperature
      with x10 lower uncertainty than current approaches
      to validate flame temperatures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NMi
METROSOL
Metrology Solutions
SIEMENS
JM
Johnson Matthey
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NETZSCH
icPECA
University of Strathclyde Glasgow

Implementing the new kelvin 1 and 2

The two Implementing the new kelvin (InK) projects

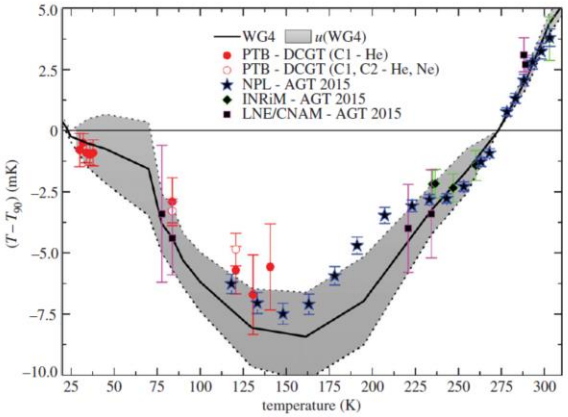
- Together cover the temperature range ~1mK to 3000 K
- Objective
- EMRP: InK-1 Sep 2012 – Oct 2015
- EMPIR: InK-2 Jun 2016 – May 2019

Most major institutes in the world in primary thermometry are contributing to the InK activity

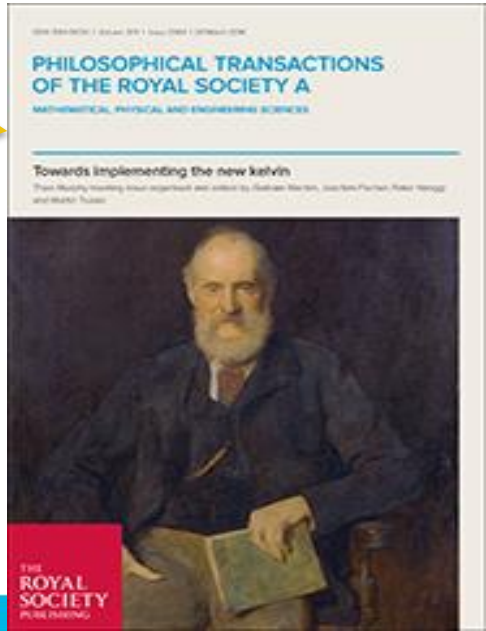
InK-1 Summary of contribution to world thermometry

- Significant contributions to world thermometry
  - First *reliable T* values for high temperature fixed points (to ~2800 K)
  - Definitive recommendations to CCT about possible dissemination mechanisms for high temperatures (>1300 K)
  - Lowest uncertainty values for $T - T_{90}$ ever determined (<303 K)
  - Practical sensors for ULT dissemination and new values for $T - T_{2000}$ from 0.02 K to 1 K
  - Outcomes of InK-1 project published in:

Phil. Trans R. Soc. A. **374:** 20150048 (2016)



Ultra low uncertainty $T - T_{90}$ values measured in InK-1



InK-2: June 2016-May 2019

- Key activities

Primary thermometry (complete primary temperature evaluation from 0.0009 K to ~3000 K for MeP-K-19)

  - T-T_{90}
    - ~300 K – 1358 K: high temperature acoustic thermometry and low temperature primary radiometry
    - ~1 K – 200 K: acoustic thermometry, dielectric constant gas thermometry, refractive index thermometry
  - T-T_{2000}
    - T from 0.02 K to 0.0009 K, completing full T-T_{2000} evaluation
    - Practical primary thermometers for direct T dissemination (<1 K)

Dissemination

- CCT workshop 2019, definitive contributions to *MeP*-K-19
  - Including worlds lowest uncertainty T-T_{90} and T-T_{2000}

Plans for 2017 - 2018

- Begin transition to new chair – Q3 ‘17
- Preparation of new JRPs; e.g. Industrial thermometry (EMPRESS-2)
- Progress towards the redefined kelvin
  - CCT (31 May 2 June 2017), InK 2 LNE-CNAM Dec ‘17
- Proposed 2018 Euramet Summer School for next generation of thermal metrologists
- Revision of TC-T area roadmaps Q4 ‘18 – Q1 ’19