The CCT K10 radiation thermometry comparison – update on progress

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CCT-K10 - ITS-90 realisations above the silver point

CCT-K10 covered the temperature range from 962 °C to 3000 °C

Transfer artefacts were:

• Two radiation thermometers (an IKE LP3 and a Chino radiation thermometer IR-RST65)
• A transfer copper fixed-point source (for monitoring thermometer drift)
• A set of high temperature fixed-point cells (HTFPs) which were doped Ni-C, doped Co-C, Ru-C and WC-C
CCT-K10 participants and timescales

<table>
<thead>
<tr>
<th>Region</th>
<th>Participants</th>
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<tbody>
<tr>
<td>EURAMET</td>
<td>NPL (Pilot) (UK), LNE-Cnam (FR), PTB (DE), CEM (ES)</td>
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<tr>
<td>SIM</td>
<td>NRC (CA), NIST (US)</td>
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<td>APMP</td>
<td>KRISS (KR), NMIJ (JP), NIM (CN)</td>
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<tr>
<td>COOMET</td>
<td>VNIIM (RU)</td>
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The circulation was a semi-collapsed star with instruments being returned to NPL for re-measurement after looping round each region.

Measurements were started summer 2014 and completed January 2022.

The (Interim*) Draft B report has been approved for publication by CCT WG-KC.

(*The results of VNIIM have been removed from the report and the analysis)
CCT-K10 issues

Previous updates have highlighted some of the issues that were experienced including:

• Breakage of cells, particularly the Ni-C cells which had to be replaced with Co-C cells part way through the circulation (Co-C more robust)
• Delays (participant and customs)
• Drift of the transfer thermometers
Stability of the Chino thermometer

Stability of the Chino transfer thermometer at copper point relative to the start

0.8 °C at copper point ≈ 4.6 °C at 3000 °C
Stability of the LP3

Stability of the LP3 transfer thermometer at the Cu point, relative to start

0.75 °C ≈ 4.4 °C at 3000 °C
The results for the two transfer thermometers were corrected for:

- drift at reference copper point (scaled as ratio of $T_X^2 / T_{Cu}^2$)
- drift in range/gain ratio values
- drift in neutral filter transmission (LP3)

and adjusted (if required) to give the corresponding signal at the actual comparison temperature (e.g., 1100 °C, 1300 °C)
CCT-K10 – e.g., LP3 data before corrections
CCT-K10 – e.g., LP3 data after corrections
CCT-K10 – data analysis (II)

For each of the transfer thermometers the median of the results was used as the reference value for that thermometer.

Median chosen due to the spread of results and number of ‘outliers’ especially for the Chino thermometer.

The difference of each participant’s results from the median, for each thermometer at each temperature was calculated.

Error bars in charts are total $k = 2$ uncertainties (combined lab and comparison uncertainties).
CCT-K10 – the LP3 results

Differences between corrected participant data and the median

Error bars are the total $U (k = 2)$ uncertainties/ °C, which includes the short term stability, the range ratio and neutral filter uncertainties, and the uncertainty in the median.
CCT-K10 – the Chino thermometer results

Differences of laboratory measurements from the median

Error bars are the total \( U (k = 2) \) uncertainties/°C, which includes the short term stability and gain ratio uncertainties and the uncertainty in the median.
The final step was to calculate, for each participant, one difference from a KCRV at each temperature.

Results of both thermometers were used (neither performed better or worse than the other).

The \{participant - KCRV\} difference is the average (simple mean) of the differences of the LP3 and Chino thermometers from, respectively, the LP3 and Chino reference values (medians).

Error bars in charts are total $k = 2$ uncertainties (combined lab and comparison uncertainties).
CCT-K10 – results with the thermometers

Average differences from the KCRV (for LP3 and Chino thermometers)

Error bars are $k = 2$ total uncertainties/ °C

Temperature/ °C

-6.0  900  1100  1300  1500  1700  1900  2100  2300  2500  2700  2900  3100

Difference from KCRV/ °C

-4.0  -2.0  0.0  2.0  4.0  6.0

NMJJ  NIM  KRISS  NRC  NIST  LNE-Cnam  PTB  CEM  Average NPL
CCT-K10 – HTFP results

For each HTFP the weighted mean with cut off was used for the KCRV

The Co-C-X and Ni-C-X cell results were treated separately, and also combined by applying a correction of -3.46 °C to the Ni-C-X cell results.

Error bars in charts are total $k = 2$ uncertainties (combined lab and comparison uncertainties)
CCT-K10 – Co-C and Ni-C results

The comparison of the measurements of the Ni-C and Co-C cells (linked)

Error bars are $U_{\text{total}} \ (k = 2) \ /^\circ{\text{C}}$
CCT-K10 – Ru-C results

The comparison of the measurements of the Ru-C cells

Error bars are $U_{\text{total}} (k = 2)/ ^\circ \text{C}$
CCT-K10 – WC-C results

Comparison of measurements of the WC-C cells

Error bars are $U_{total} (k = 2) / ^\circ C$
Conclusion

The CCT-K10 comparison has been completed and the Interim Draft B report is being prepared for publication.

The results will be used to underpin claimed CMCs of the participants.

The results using the HTFPs have allowed participants’ claimed uncertainties to be probed more thoroughly.

It is hoped that, at some future point, the results from VNIIM can be included again and the final Draft B report published.