

## Key comparisons CCT-K5, CCT-K5.1, APMP.T-K5 and EUROMET.T-K5

MEASURAND : Temperature

NOMINAL TEMPERATURE :  $T_{\text{nom}} = 1000 \text{ }^\circ\text{C}$

### Key comparison CCT-K5

Four Tungsten-strip lamps were used as transfer standards for radiance temperature measurements at specific currents corresponding to each nominal temperature  $T_{\text{nom}}$ . To shorten the measurement time significantly the set of transfer standards was split in two sets of two lamps for simultaneous comparisons in two loops. The pilot of each loop measured both lamp sets in order to establish a linkage mechanism described on page 19 of the CCT-K5 Final Report.

$T_i$ : temperature value measured by laboratory  $i$

$u_i$ : standard uncertainty of  $T_i$

#### Lamp S/N C564

Lab <i>i</i>	$T_i$ / °C	$u_i$ / °C
VSL	1002.078	0.10
NMIA	1001.998	0.02
KRISS	1001.978	0.09
NIM	1002.098	0.12
A*STAR	1001.678	0.15
NMIJ	1002.128	0.12
VNIIM	1002.568	0.16

#### Lamp S/N C681

Lab <i>i</i>	$T_i$ / °C	$u_i$ / °C
VSL	1001.808	0.10
NMIA	1001.778	0.02
KRISS	1001.868	0.09
NIM	1001.968	0.12
A*STAR	1001.208	0.15
NMIJ	1001.868	0.12
VNIIM	1001.988	0.16

#### Lamp S/N C860

Lab <i>i</i>	$T_i$ / °C	$u_i$ / °C
NPL	1000.124	0.14
NIST	1000.464	0.24
CENAM	1000.294	0.22
LNE-INM	999.754	0.14
INRIM	1000.414	0.08
PTB	1000.284	0.16

#### Lamp S/N C864

Lab <i>i</i>	$T_i$ / °C	$u_i$ / °C
NPL	1000.118	0.14
NIST	1000.308	0.24
CENAM	1000.278	0.22
LNE-INM	1000.108	0.14
INRIM	1000.278	0.08
PTB	1000.078	0.16

## Key comparison CCT-K5.1

This is a bilateral comparison between the PTB and the NRC.

$T_{\text{NRC}}$ : temperature value measured at the NRC

$u_{\text{NRC}}$ : standard uncertainty of  $T_{\text{NRC}}$

Lamp C598	$T_{\text{NRC}} = 999.95 \text{ }^\circ\text{C}$	Lamp 644C	$T_{\text{NRC}} = 1000.14 \text{ }^\circ\text{C}$
	$u_{\text{NRC}} = 0.20 \text{ }^\circ\text{C}$		$u_{\text{NRC}} = 0.20 \text{ }^\circ\text{C}$

## Key comparison APMP.T-K5

Laboratory individual measurements of APMP.T-K5 participants are given in Appendix B of the APMP.T-K5 Final Report both in tabulated and in graphical forms. There were taken between 1997 and 2000.

## Key comparison EUROMET.T-K5

This comparison involved eight participants and was carried out from October 1999 to February 2001.

The two transfer standards were Lamp S/N C564 and Lamp S/N C681 already used in CCT-K5.

The individual laboratory measurements and their uncertainties are given in Tables 5 to 11 of the EUROMET.T-K5 Final Report.

## Key comparisons CCT-K5, CCT-K5.1, APMP.T-K5 and EUROMET.T-K5

### Key comparison CCT-K5

MEASURAND : Temperature

NOMINAL TEMPERATURE :  $T_{\text{nom}} = 1000 \text{ }^\circ\text{C}$

The key comparison reference value  $T_R$  for each nominal temperature  $T_{\text{nom}}$  and each lamp  $k$  is calculated on the basis of the median of measured radiance temperatures  $T_i(k, T_{\text{nom}})$ . Its standard uncertainty,  $u(T_R)$ , is obtained as the standard uncertainty of the median.

Lamp	$T_R / ^\circ\text{C}$	$u(T_R) / ^\circ\text{C}$
C564	1002.130	0.117
C681	1001.760	0.038
C860	1000.280	0.151
C864	1000.190	0.191

For each temperature  $T_{\text{nom}}$  the degree of equivalence of laboratory  $i$  with respect to the key comparison reference value is given by a pair of terms:  $D_i$  and its expanded uncertainty  $U_i$  ( $k = 2$ ) both expressed in K. The computation of  $D_i$  and  $U_i$  is explained in the Addendum to the CCT-K5 Final Report.

For each temperature  $T_{\text{nom}}$  the pair-wise degree of equivalence between laboratory  $i$  and  $j$  is given by two terms:  $D_{ij}$  and its expanded uncertainty  $U_{ij}$  ( $k = 2$ ). The computation of  $D_{ij}$  and  $U_{ij}$  is also explained in the Addendum of the CCT-K5 Final Report.

### Linking key comparison CCT-K5.1 to CCT-K5

The linkage is made through the common participation of PTB in both key comparisons, and is detailed in the CCT-K5 and CCT-K5.1 Linkage Report.

### Linking key comparison APMP.T-K5 to CCT-K5

The linkage is made through the common participation of NMIJ, NIM, KRISS and NMIA in both key comparisons, and is detailed in the Addendum to the APMP.T-K5 Final Report.

### Linking key comparison EUROMET.T-K5 to CCT-K5

The measurements of the EUROMET.T-K5 participants are directly linked to the key comparison reference value obtained in CCT-K5 as the protocols of the two key comparisons are identical and the transfer standards are the same (see in Chapter VII of the EUROMET.T-K5 Final Report).

Degrees of equivalence relative to the CCT-K5 key comparison reference values are computed for each of the transfer standards. Pair-wise degrees of equivalence inside EUROMET.T-K5 are available in the EUROMET.T-K5 Final Report (Tables 15 to 36).

## Key comparisons CCT-K5, CCT-K5.1, APMP.T-K5 and EUROMET.T-K5

MEASURAND : Temperature

NOMINAL TEMPERATURE :  $T_{\text{nom}} = 1000 \text{ }^\circ\text{C}$

Degrees of equivalence relative to the CCT-K5 key comparison reference value

Lab*i*

	$D_i$	$U_i$
	/ K	
VSL	-0.002	0.221
NPL	-0.114	0.294
NMIA	-0.057	0.116
KRISS	-0.022	0.235
NIM	0.088	0.279
A*STAR	-0.502	0.314
NMIJ	0.053	0.258
VNIIM	0.333	0.345
NIST	0.151	0.487
CENAM	0.051	0.449
LNE-INM	-0.304	0.366
INRIM	0.111	0.179
PTB	-0.054	0.183
<b>NRC</b>	<b>0.081</b>	<b>0.559</b>
<b>A*STAR</b>	<b>0.08</b>	<b>0.59</b>
<b>KIM-LIPI</b>	<b>0.30</b>	<b>1.84</b>
<b>CMS/TRI</b>	<b>-0.17</b>	<b>1.07</b>

Lamp S/N C564

	$D_i$	$U_i$
	/ K	
<b>CEM</b>	<b>-0.01</b>	<b>0.33</b>
<b>IPQ</b>	<b>0.13</b>	<b>0.70</b>
<b>UME</b>	<b>-1.30</b>	<b>0.40</b>
<b>MKEH</b>	<b>-0.73</b>	<b>2.49</b>
<b>SMU</b>	<b>-0.86</b>	<b>0.50</b>
<b>SP</b>	<b>-0.47</b>	<b>0.74</b>
<b>MIKES</b>	<b>-0.64</b>	<b>1.03</b>
<b>VSL</b>	<b>0.15</b>	<b>0.31</b>

Lamp S/N C681

	$D_i$	$U_i$
	/ K	
<b>CEM</b>	<b>0.03</b>	<b>0.23</b>
<b>IPQ</b>	<b>-0.12</b>	<b>0.69</b>
<b>UME</b>	<b>-1.38</b>	<b>0.29</b>
<b>MKEH</b>	<b>-0.65</b>	<b>2.48</b>
<b>SMU</b>	<b>-0.46</b>	<b>0.45</b>
<b>SP</b>	<b>-0.46</b>	<b>0.71</b>
<b>MIKES</b>	<b>-0.51</b>	<b>0.86</b>
<b>VSL</b>	<b>0.00</b>	<b>0.22</b>

**Black:** participants in CCT-K5

**Green:** participant in CCT-K5.1

**Blue:** participants in APMP.T-K5

**Orange:** participants in EUROMET.T-K5 (measurements with Lamp S/N C564)

**Grey:** participants in EUROMET.T-K5 (measurements with Lamp S/N C681)

# Key comparisons CCT-K5 and CCT-K5.1

MEASURAND : Temperature

NOMINAL TEMPERATURE :  $T_{nom} = 1000 \text{ }^\circ\text{C}$

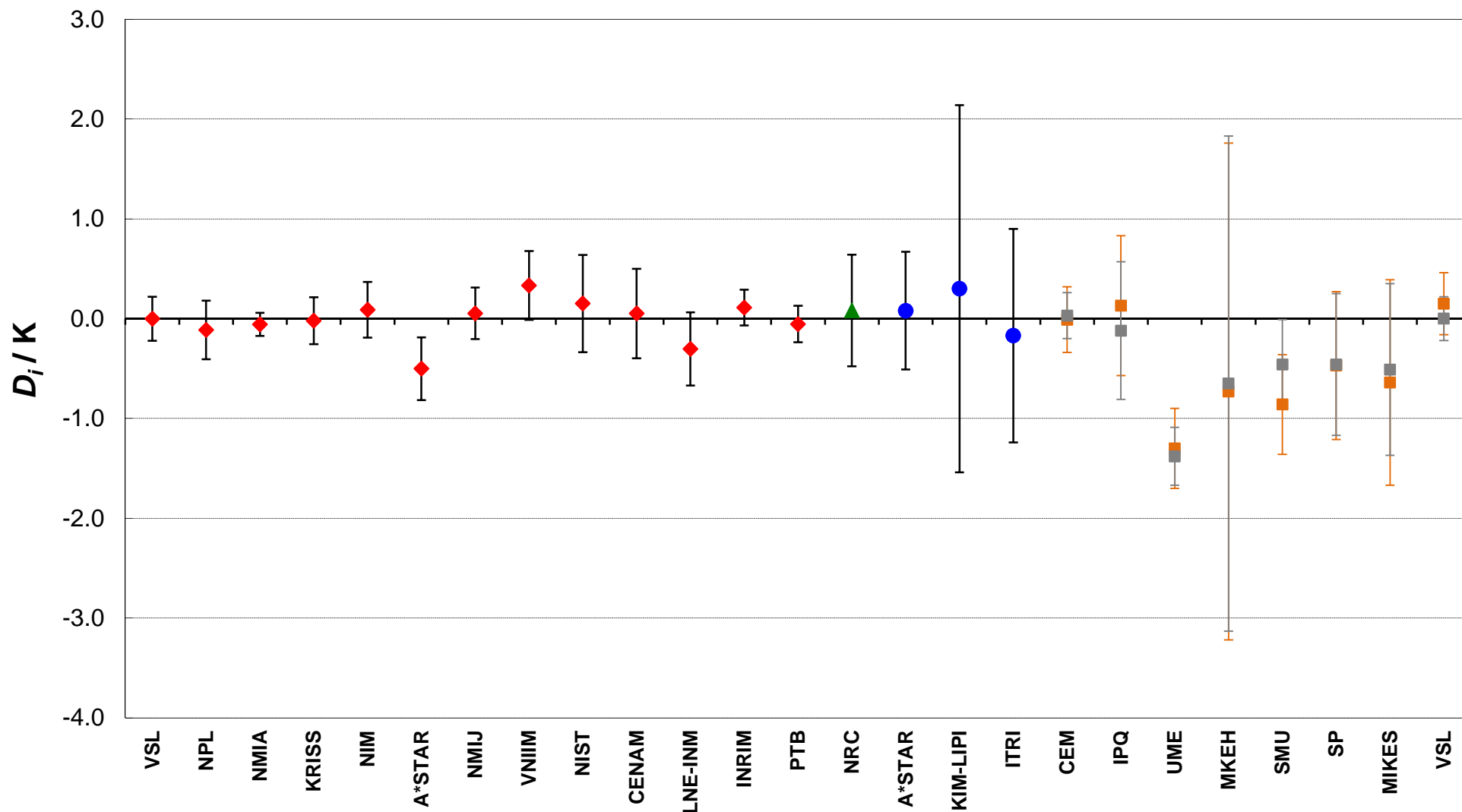
Matrix of equivalence

Pair-wise degrees of equivalence involving APMP.T-K5 participants are not computed.

Lab <sub>i</sub>	$D_i$ / $U_i$		VSL		NPL		NMIA		KRISS		NIM		A*STAR		NMIJ		VNIIM	
	$D_i$	$U_i$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
VSL	-0.002	0.221			0.113	0.386	0.055	0.206	0.020	0.281	-0.090	0.320	0.500	0.375	-0.055	0.312	-0.335	0.408
NPL	-0.114	0.294	-0.113	0.386			-0.058	0.334	-0.093	0.382	-0.203	0.413	0.388	0.446	-0.168	0.408	-0.448	0.463
NMIA	-0.057	0.116	-0.055	0.206	0.058	0.334			-0.035	0.192	-0.145	0.247	0.445	0.328	-0.110	0.244	-0.390	0.369
KRISS	-0.022	0.235	-0.020	0.281	0.093	0.382	0.035	0.192			-0.110	0.300	0.480	0.394	-0.075	0.309	-0.355	0.436
NIM	0.088	0.279	0.090	0.320	0.203	0.413	0.145	0.247	0.110	0.300			0.590	0.420	0.035	0.345	-0.245	0.459
A*STAR	-0.502	0.314	-0.500	0.375	-0.388	0.446	-0.445	0.328	-0.480	0.394	-0.590	0.420			-0.555	0.398	-0.835	0.442
NMIJ	0.053	0.258	0.055	0.312	0.168	0.408	0.110	0.244	0.075	0.309	-0.035	0.345	0.555	0.398			-0.280	0.431
VNIIM	0.333	0.345	0.335	0.408	0.448	0.463	0.390	0.369	0.355	0.436	0.245	0.459	0.835	0.442	0.280	0.431		
NIST	0.151	0.487	0.153	0.548	0.265	0.561	0.208	0.513	0.173	0.546	0.063	0.568	0.653	0.592	0.098	0.564	-0.183	0.605
CENAM	0.051	0.449	0.053	0.514	0.165	0.522	0.108	0.476	0.073	0.511	-0.038	0.534	0.553	0.560	-0.003	0.530	-0.283	0.574
LNE-INM	-0.304	0.366	-0.303	0.406	-0.190	0.435	-0.248	0.357	-0.283	0.402	-0.393	0.431	0.198	0.463	-0.358	0.427	-0.638	0.479
INRIM	0.111	0.179	0.113	0.310	0.225	0.328	0.168	0.241	0.133	0.305	0.023	0.342	0.613	0.381	0.058	0.337	-0.223	0.401
PTB	-0.054	0.183	-0.053	0.416	0.060	0.437	0.003	0.369	-0.033	0.413	-0.143	0.442	0.448	0.473	-0.108	0.437	-0.388	0.489
NRC	0.081	0.559	0.083	0.601	0.195	0.631	0.138	0.570	0.103	0.606	-0.007	0.624	0.583	0.641	0.028	0.615	-0.252	0.657

Lab <sub>i</sub>	$D_i$ / $U_i$		NIST		CENAM		LNE-INM		INRIM		PTB		NRC	
	$D_i$	$U_i$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
VSL	-0.002	0.221	-0.153	0.548	-0.053	0.514	0.303	0.406	-0.113	0.310	0.053	0.416	-0.083	0.601
NPL	-0.114	0.294	-0.265	0.561	-0.165	0.522	0.190	0.435	-0.225	0.328	-0.060	0.437	-0.195	0.631
NMIA	-0.057	0.116	-0.208	0.513	-0.108	0.476	0.248	0.357	-0.168	0.241	-0.003	0.369	-0.138	0.570
KRISS	-0.022	0.235	-0.173	0.546	-0.073	0.511	0.283	0.402	-0.133	0.305	0.033	0.413	-0.103	0.606
NIM	0.088	0.279	-0.063	0.568	0.038	0.534	0.393	0.431	-0.023	0.342	0.143	0.442	0.007	0.624
A*STAR	-0.502	0.314	-0.653	0.592	-0.553	0.560	-0.198	0.463	-0.613	0.381	-0.448	0.473	-0.583	0.641
NMIJ	0.053	0.258	-0.098	0.564	0.003	0.530	0.358	0.427	-0.058	0.337	0.108	0.437	-0.028	0.615
VNIIM	0.333	0.345	0.183	0.605	0.283	0.574	0.638	0.479	0.223	0.401	0.388	0.489	0.252	0.657
NIST	0.151	0.487			0.100	0.655	0.455	0.612	0.040	0.506	0.205	0.578	0.070	0.741
CENAM	0.051	0.449	-0.100	0.655			0.355	0.554	-0.060	0.472	0.105	0.552	-0.030	0.716
LNE-INM	-0.304	0.366	-0.455	0.612	-0.355	0.554			-0.415	0.405	-0.250	0.509	-0.385	0.668
INRIM	0.111	0.179	-0.040	0.506	0.060	0.472	0.415	0.405			0.165	0.360	0.030	0.587
PTB	-0.054	0.183	-0.205	0.578	-0.105	0.552	0.250	0.509	-0.165	0.360			-0.135	0.588
NRC	0.081	0.559	-0.070	0.741	0.030	0.716	0.385	0.668	-0.030	0.587	0.135	0.588		

CCT-K5, CCT-K5.1, APMP.T-K5 and EUROMET.T-K5 Nominal temperature,  $T_{\text{nom}} = 1000\text{ °C}$   
 Degrees of equivalence,  $D_i$ , and expanded uncertainties ( $k = 2$ )  $U_i$ , expressed in K



Red diamonds: participants in CCT-K5  
 Green triangle: participant in CCT-K5.1  
 Blue circles: participants in APMP.T-K5

Orange squares: participants in EUROMET.T-K5 (measurements with Lamp S/N C564)  
 Grey squares: participants in EUROMET.T-K5 (measurements with Lamp S/N C681)