National Physical Laboratory

CCT Working Group for Humidity

Report to the CCT 2017

Stephanie Bell

CCT Working Group for Humidity

National Physical Laboratory

Terms of reference:

- to advise the CCT on matters relating to humidity;
- to pursue harmonization relevant to the field of humidity measurements;
- to develop and maintain an effective liaison with the international humidity and moisture community.

Tasks:

- draft a document on uncertainty in humidity;
- operation of ~~the~~ CCT-K6 and CCT-K8;
- strategic planning of ongoing and future key and supplementary comparisons in the field;
- clarification of quantities, units, symbols and realizations relating to humidity measurement.

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Terms of reference:

Within the terms of reference, particular actions of the WG are:

- coordination and collaboration with
  - IAPWS in area of water vapour formulae
  - CCQM in areas of trace moisture in gases and moisture in materials
  - and other links as required
- convening the International Symposium on Humidity and Moisture (ISHM).

CCT Working Group for Humidity

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Membership 18

CETIAT, CENAM, INRIM, INTA, KRISS, MIKES, MSL, NIM, NIST, NMC A-STAR, NMIJ-AIST, NMISA, NPL (Chair), PTB, VSL, UME, VNIIFTRI

and IAPWS

NMI	Named member	Quantities, units, symbols and realizations relating to humidity measurement	Key comparisons			Document on uncertainty in humidity	CCQM liaison - trace moisture in gases, and moisture in materials	International Symposium on Humidity and Moisture (ISHM)
			Strategic planning	CCT-K6 participants	CCT-K8 participants			
KRISS	**Byung Il Choi**	**x**					**x**	(all, as/when required)
NIST	**Chris Meyer**	**x**	**x**	**x**	**x**		**x**	
CETIAT	**Eric Georgin**	**x**					**x**	
NMIJ	**Hisashi Abe**	**x**		**x**	**x**		**x**	
NIM	**Hong Yi**	**x**		**x**			**x**	
MSL	**Jeremy Lovell-Smith**	**x**			**x**	**xx**	**x**	
CENAM	**Leonel Lira-Cortes**					**x**	**x**	
MIKES	**Martti Heinonen**	**xx**	**x**	**x**				
VNIIFTRI ESB	**Mikhail Vinge**	**x**		**x**	**x**		**x**	
IAPWS	**Rainer Feistel**	**x**	**x**					
NMISA	**Regina Mnguni**	**x**				**x**		
NMi	**Rien Bosma**		**x**	**x**		**x**		
CEM-INTA	**Robert Benyon**		**xx**	**x**	**Pilot**	**x**		
UME	**Seda Oğuz Aytekin**	**x**				**x**	**x**	
NPL	**Stephanie Bell**	**x**	**x**	**Pilot**	**x**	**x**	**xx**	
INRiM	**Vito Fernicola**		**?**	**x**	**x**	**x**	**x**	
PTB	**Volker Ebert**	**x**		**x**	**x**	**x**	**x**	
NMC A-STAR	**Wang Li**		**x**	**x**	**x**	**x**		

Key comparisons

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CCT-K6 – completed

Dew point -50 ° C to +20 ° C, 10 participants

Draft B report presented to last CCT

Final report completed 2015,

Available in KCDB and *Metrologia* Technical Supplement

Linkage template in preparation

CCT-K8 – in progress

Dew point, 30 ° C to 95 ° C, 10 participants

Long planning period - measurements started Sep. 16

Drift checks May 2017 (small acceptable drift)

Instruments *en route* to final participants June 2017

Humidity KCs/SCs - progress 2014 to 2017

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Comparison	Quantity	Range	Status	Note
CCT-K6	dew point	-50 °C to +20 °C	Completed 2015	
CCT-K6.1	dew point	-50 °C to +20 °C	Reporting in progress	Bilateral MSL/NPL
CCT-K6.2	dew point	-50 °C to +20 °C	In progress	Bilateral NIST/NMIJ AIST
CCT-K8	dew point	30 °C to 95 °C	In progress	
AFRIMETS.T-S4	relative humidity		Reporting in progress	
APMP.T-K6.2013	dew point	-50 °C to +20 °C	In progress	
APMP.T-K8	dew point	30 °C to 95 °C	In progress	
APMP.T-S13	dew point	-60 °C to -90 °C	In progress	Simultaneous with APMP.T-K6.2013
APMP.T-S14	relative humidity		In progress	
COOMET.T-K6	dew point	-50 °C to +20 °C	In planning	
EURAMET.T-K6.2	dew point	-20 °C to +20 °C	Protocol under review	
EURAMET.T-K8	dew point	30 °C to 95 °C	In progress	
EURAMET.T-K8.1	dew point	30 °C to 95 °C	Protocol under review	
GULFMET.T-S1	relative humidity		Protocol under review	
SIM.T-K6.1	dew point	-25 °C to +20 °C	Completed 2015	Bilateral NIST/NRC
SIM.T-K6.2	dew point	-20 °C to +20 °C	Completed 2014	Bilateral NIST/CENAM
SIM.T-K6.3	dew point	30 °C to +20 °C	Completed 2014	Bilateral NIST/INMETRO
SIM.T-K6.5	dew point	-40 °C to +20 °C	Completed 2016	Bilateral NIST/LACOMET
SIM.T-K6.6	dew point	-10 °C to +20 °C	In progress	Bilateral NIST/INM(Co)
SIM.T-K6.7	dew point	-30 °C to +60 °C	Protocol under review	INACAL/INMETRO/INTI
SIM.T-S9	dew point	-95 °C to -50 °C	In progress	Bilateral NIST/MIRS/UL-FE/LMK

Strategic planning of future KCs/SCs

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- WG-Hu is considering when to repeat CCT-K6
- APMP.T-K6.2013 already started
- Several members of WG-Hu are in WG-KC
- EURAMET TC-T is preparing strategy on supplementary comparisons – will interact
- Considering
  - How to reduce effort of KCs
  - Frequency, speed of completion
  - Linkage of comparisons staggered in time

Other tasks

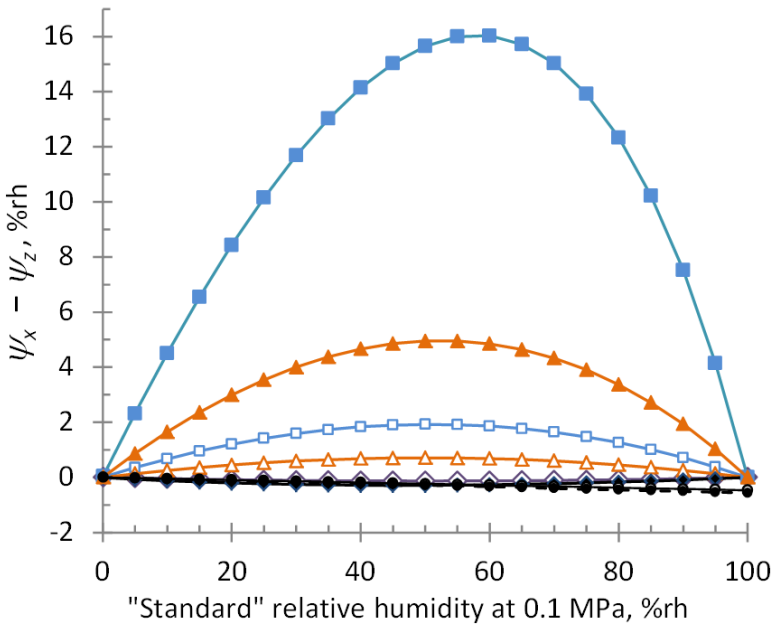
Clarification of quantities, units, symbols and realizations relating to humidity measurement

- Problems with relative humidity definitions
- Alternative definition, relative fugacity, under consideration
- *Metrologia* papers
  - 2015 review papers on RH + …
  - 2017 paper on RH definition based on fugacity (water activity)
- Terms and definitions document addressing the above – in progress
- Separate document on humidity realisations started
- Ultimate aims …

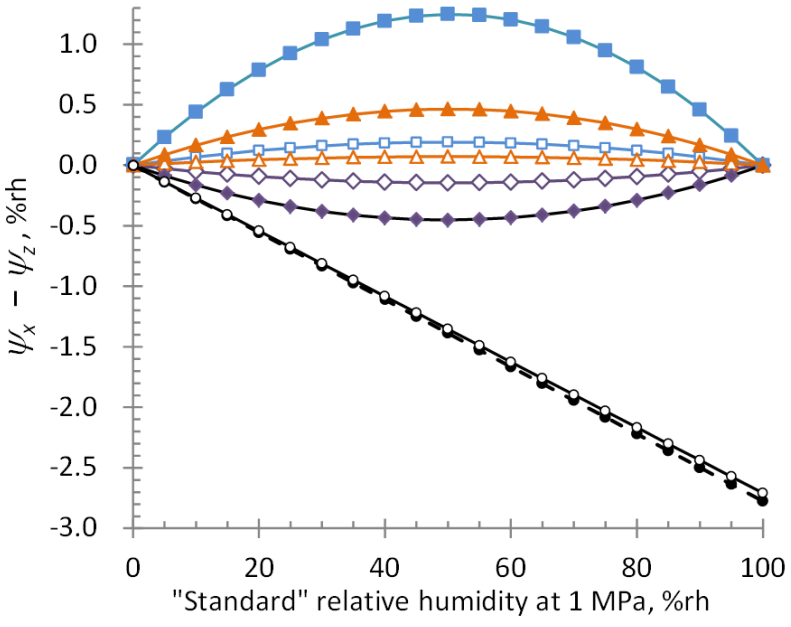
Draft document on uncertainty in humidity realisations

- In progress, slow action due to the above work

Ambiguity of existing RH definitions



(a)



(b)

Figure 4: Differences between the standard definition ψ_x and four non-standard definitions at 40 °C (hollow symbols) and 80 °C (filled symbols) for pressures p = 0.1 MPa, panel (a), and p = 1 MPa, panel (b). Three non-standard definitions are of the form ψ_z, where the humidity quantity z is the the mixing ratio, r (squares), the specific humidity q (triangles), and the fugacity f_V (diamonds). The fourth non-standard definition is ψ_{IUPAC} (circles).

From: Lovell-Smith et al. (2016)

Relative humidity, unit symbol, and the SI brochure

Relative humidity is the most measured quantity to have no mention in the SI brochure

SI brochure revision

- New section on dimensionless units in preparation - CCU
  - (Discussion of angle and related units)

RH is dimensionless in principle, but unit symbol %rh very widely used in practice

- Essential to avoid ambiguity (absolute fractions in %)
- Especially for wider users

Two points:

- How can the SI recognise the *de facto* special unit symbol for RH, %rh ?
- Can relative humidity at least be mentioned in the SI Brochure?

Other actions

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Coordination and collaboration

- IAPWS in area of water vapour formulae
- CCQM in areas of trace moisture in gases and moisture in materials
  - ➢ CCQM-K116 water vapour in N_2 at 10 μmol/mol

International Symposium on Humidity and Moisture (ISHM)

- In discussion - next event yet to be agreed.

IAPWS-BIPM Humidity Workshop at the 17th ICPWS in Prague 2018:

www.icpws2018.com