Comparison in humidity (dew-point temperature high range) dew point temperature +30 °C to 95 °C

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Comparison in Humidity

(dew-point temperature high range)

Dew Point Temperature +30 °C to +95 °C

EURAMET.T-K8

(EUROMET Project No. P 717)

Final Report

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List of Symbols

Symbol	Description	Unit
A	coefficient IEC60751	°C^{-1}
a	parameter	
B	coefficient IEC60751	°C^{-2}
b	parameter	
$B(i,j)$	linkage of loop *i* and *j*	°C
$corr_{i,j}$	correlation coefficient between *i* and *j*	-
$cov(a,b)$	ovariance of a and b	-
D_{ij}	bilateral degree of equivalence between laboratory *i* and *j*	°C
$D_{LL1,LL2}^{(L1)}$	bilateral degree of equivalence between laboratory *i* and *j* in loop 1	°C
$F(a,b)$	Function of a and b	-
k	coverage factor	-
l	number of measurements of laboratories with multiple measurements	-
$loop(i)$	loop of *i*th laboratory	-
m	counter	-
n	number of total measurements	-
P	aggregated loop difference	°C
$P_{s,i}$	loop difference single *i*th measurement	°C
R_t	resistance of the PRT at temperature t	Ω
R_0	nominal resistance at 0 ℃	Ω
t_d	dew-point temperature	°C
$t_{d,i}^{(hyg)}$	dew-point temperature measured by transfer-standard, *i*th measurement	°C
$\Delta t_d^{(lab)}$	aggregated lab result of laboratory *lab*	°C
$\Delta t_d^{(lab)\prime}$	aggregated lab result of laboratory *lab,* corrected to a loop with $B(i,j)$	°C
$\Delta t_{d,i}^{(lab)}$	dew-point temperature of laboratory *lab*, *i*th measurement	°C
$\Delta t_{d,L1,i}^{(lab)}$	aggregated lab result of laboratory *lab, i*th measurement in loop 1	°C
$\Delta t_{d,L2,i}^{(lab)}$	aggregated lab result of laboratory *lab, i*th measurement in loop 2	°C
$\Delta t_{d,loop(i)}^{(i)}$	aggregated lab result of laboratory *i,* in the loop of laboratory *i*	°C
$\Delta t_d^{(LRV)}$	loop reference value	°C
$\Delta t_d^{(LRV1)}$	loop reference value, corrected to loop 1	°C
$\Delta t_d^{(LRV2)}$	loop reference value, corrected to loop 2	°C
$t_{d,i}^{(ref)}$	dew-point temperature of reference, *i*th measurement	°C
u	uncertainty (*k*=1)	
u_{BM}	Uncertainty multiplied with modified Birge ratio	
u_{corr}	correlated parts of the uncertainty	
u_{stab}	uncertainty of the stability term	
$u_{stab,loop(i)}$	uncertainty of the stability term of the artefact in the loop of laboratory *i*	
u_{stat}	statistical independent parts of the uncertainty	
U	uncertainty (*k*=2)	
x	number of link laboratories	-
x_i	value	-
X_i	property	-
y	estimate	-

Greek Symbols

Symbol	Description	Unit
α	significance	-
α_i	weight	-
δ_{rep}	correction due to non-ideal reproducibility	-
δ_{stab}	drift correction	°C
μ	mean value	
μ_{arith}	arithmetic mean value	
μ_{WM}	weighted mean value	
μ_{BM}	weighted mean with modified Birge ratio	
ν	variance	K^2
σ_B	Birge ratio	-
σ_{BM}	modified Birge ratio	-
X^2_{obs}	observed chi-squared value (chi-squared consistency test)	

Subscript

Subscript	Description
arith	arithmetic
B	Birge ratio
BM	modified Birge ratio
corr	correlated
d	dew-point
hyg	hygrometer, transfer standard
lab	laboratory
L1	loop 1
L2	loop 2
stab	stability
stat	statistically independent
ref	reference
res	resolution
WM	weighted mean

Abbreviations

Abbreviation	Description
CCT	Consultive Committee for Thermometry
DoE	Degree of Equivalence
ERV	EURAMET Reference Value
EURAMET	European RMO
KCRV	Key Comparison Reference Value
LL	Link Laboratory
LL1	Link Laboratory 1
LL2	Link Laboratory 2
LRV	Loop Reference Value
LRV1	Loop Reference Value for loop 1
LRV2	Loop Reference Value for loop 2
nLL	non Link Laboratory
RMO	Regional Metrological Organisation

1 Introduction

The EURAMET.T-K8, corresponding EUROMET project P717, covers the high dew-point temperatures starting at 30 °C up to 95 °C. It is the follow-up comparison to the EURAMET.T-K6 (P621) [1] and the CCT-K6 [2] which cover the frost point range -50 °C up to +20 °C dew-point. The aim of EURAMET.T-K8 comparison is to establish the degree of equivalence between the realization of local dew-point temperature of humid gas, in the range from +30 °C to +95 °C, among the participating national metrology institutes [3].

The agreement on a comparison in the high dew-point temperature range was reached at the EUROMET TC-Therm Meeting in Wabern, Switzerland, in 2003. Due to several delays caused by the workload and staff problems in the pilot laboratory, PTB, and the availability of transfer standards, provided by MBW, Switzerland, the project start was delayed. The first draft of technical protocol was presented at TC-Therm meeting in March 2007, finally agreed in 2008 and submitted to the chairman of CCT WG 6 and TC-Therm in 2009 and 2013.

The initial measurement started in 2008, the measurement of the initially 15 participants were organized in two loops, with link laboratory INTA, co-pilot BEV/E+E and PTB as coordinator/pilot. Croatia joined the project as participant in 2010, increasing the number of participating laboratories up to 16. The measurements were performed in the time span of 2008 till 2011. In 2009/2010 the former EUROMET project P717 was changed to key-comparison, named EURAMET.T-K8.

After completion of all measurements in 2011 the start of preparation of Draft A was delayed first by high workload at PTB. In June 2013 it was decided to wait with the elaboration until the process of handing over responsibility for humidity in Switzerland from the NMI METAS to MBW as DI would be completed in order to give the new DI a good validation for the start-up [33]. A further delay was caused by the retirement of the former working group head at the pilot laboratory PTB in 2015. New actions were taken by PTB, jointly with co-pilot BEV/E+E and link laboratory INTA, in the end of 2016 with a re-collection of all measured data of the participants. The data evaluation and preparation of Draft A was started by PTB in the mid of 2017, after all participants had finally confirmed their data.

The progress of evaluation of the data and preparation of Draft A was presented and agreed with the participants at the EURAMET TC-T meetings in 2017, 2018, and 2019. The basic scheme of evaluation was presented, discussed, and agreed by the participants at TC-T Meeting, Borås Sweden, in April 2018.

The first version of Draft A was sent to the participants in November 2019. The evaluation of the data was based on the evaluation of EURAEMT.T-K6 [1] and CCT-K6 [2]. Two methods of evaluation were presented. The first one was strictly based on the procedure of EURAMET.T-K6 with a few modifications (e.g. introduction of Birge ratio), the second one only with a different handling of laboratories with multiple measurements. The comments were collected until August 2020. Due to an extensive comment the whole evaluation method was revised. The approach presented in the following was elaborated by Dr. Helmut Mitter, BEV/E+E, based on the before mentioned methods. The basic ideas of the modified method is not only applied for EURAMET.T-K8 but also will be applied for the current key comparison on CCT level, CCT-K8 [27]. The approach aims to represent the state-of-the-art evaluation method for key comparisons in the sub-field of dew-point temperature.

Draft A2 was sent to the participants in June 2022, comments were collected until end of August 2022. For preventing the aim of harmonization of the evaluation of EURAMET.T-K8 and CCT-K8 the method was adapted in concern of using chi-squared test and averaging of multiple measurements. The Draft A3 was finally presented in January 2023 to the participants for comments. This version of the draft was approved by the participants and the final Draft B was prepared in April 2023.

Draft B was sent to the CCT working group key-comparison for review in April 2023. The reviewers' comments were received in December 2023. The amended version (Draft B2) was prepared until May 2024 and sent to the reviewers for approval afterwards.

The main results are listed in chapter 7.2 and chapter 8. The degree of equivalence between the laboratories are listed in Table 8 to Table 14 (page 39 to 42). The difference to the reference value are shown in Figure 9 to Figure 15 (page 52 to 55) as well as in Table 16 and Table 17 (page 56 to 57).

2 Organization

The organization of EURAMET.T-K8 is based on the former humidity comparisons EURAMET.T-K6 [1] and CCT-K6 [2]. The comparison is organized in two loops, more details of the topology of the comparison is presented in chapter 2.2. In each loop a chilled mirror hygrometer manufactured by MBW was used as transfer standard and comparator. A detailed description of the transfer standards and their performance is presented in chapter 4.

2.1 Participants

Table 1 lists all participating laboratories of the comparison, more detail information of the participants is given in Appendix C. The comparison started with 15 participants. FSB-LPM, Croatia, joined the project as participant in 2010, increasing the number of participating laboratories up to 16. There are two groups in Table 1: laboratories working with primary standards (type p) and laboratories working with secondary standards (type s).

Table 1 Participating laboratories of EURMAET.T-K8, type p = primary laboratory, s = secondary laboratory

Lab code	Name of Participant	Abbreviation	Country	Loop	Type
P	Central Office of Meaures	GUM	Poland	2	p
N	National Metrology Institute VTT MIKES (former Centre for Metrology and Accreditation)	VTT (former MIKES)*)	Finland	2	p
E	Centre Technique des Industries Aérauliques et Thermiques	CETIAT	France	1	p
C	FORCE Technology (former DELTA Danish Electronics, Lights & Acoustics)	FORCE (former DELTA) *)	Denmark	1	s
B	BEV/E+E Elektronik	BEV/E+E	Austria	1,2	p
K	Federal Institute of Metrology (former Federal Office of Metrology)	METAS	Switzerland	2	p
I	Hellenic Institute of Metrology	EIM	Greece	1	p
F	Instituto Nacional de Téchnica Aeroespacial	INTA	Spain	1,2	p
L	Instituto Nazionale die Ricerca Metrologica	INRIM	Italy	2	p
D	National Metrology Laboratory	NML/NSAI	Ireland	1	s
O	National Physical Laboratory	NPL	UK	2	p
M	VSL National Metrology Institute (former VSL Dutch Metrology Institute and Nederlands Meetinstituut)	VSL (former NMi-VSL)*)	The Netherlands	2	p
A	Physikalisch-Technische Bundesanstalt	PTB	Germany	1,2	p
G	TUBITAK Ulusal Metroloji Enstitüsü	TUBITAK UME	Turkey	1	p
H	Univeristy of Ljubljana	MIRS/UL-FE/LMK	Slovenia	1	p
J	University of Zagreb	FSB-LPM	Croatia	1	p

*) The name of the institution has changed during the time span of the comparison. In brackets former name and abbreviation as used in the technical protocol, see Appendix F.

2.2 Comparison scheme

The comparison is organized in two loops with link laboratory INTA, co-pilot BEV/E+E and PTB as coordinator/pilot. INTA and BEV/E+E can measure two devices under test at the same time. Therefore, they are predestinated to serve as link laboratory.

Figure 1 shows a schematic flow chart of the comparison.

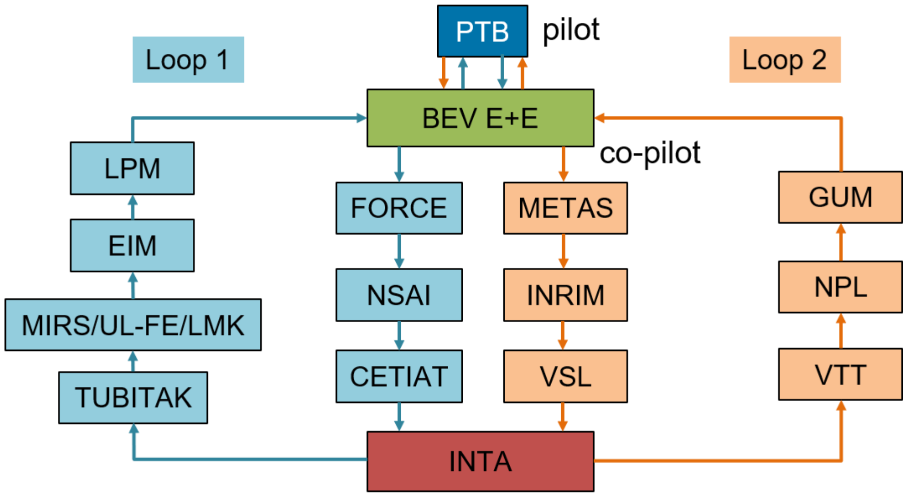

Figure 1 EURAMET.T-K8 comparison scheme

In each loop one transfer standard was sent around the participants, in total two transfer standards were needed. Not all participants measure both transfer standards, only BEV/E+E, PTB and INTA performed measurements with both transfer standards. Thus, an overall reference value was not able to be determined. To compare the results in both loops among each other the measurements of the linking laboratories are used as described in chapter 7 and 8.

2.3 Comparison schedule

Due to several delays the original schedule of the first technical protocol had to be adapted several times including the time schedule for measurements, see technical protocol in Appendix F [3]. Table 2 and Table 3 give the actual time slots of the measurements of the participants.

Table 2 Actual time slots of measurement of participants of loop 1 (S/N 08-0413)

Loop 1 (S/N 08-0413)	**from**	**to**
PTB	08/2008	08/2008
BEV/E+E	09/2008	10/2008
FORCE (former DELTA)	02/2008	03/2009
NSAI	05/2009	06/2009
CETIAT	07/2009	07/2009
INTA	11/2009	11/2009
TUBITAK	02/2010	03/2010
MIRS/UL-FE/LMK	04/2010	05/2010
EIM	06/2010	07/2010
FSB-LPM	12/2010	01/2011
BEV/E+E	02/2011	02/2011
PTB	11/2011	11/2011

Table 3 Actual time slots of measurement of participants of loop 2 (S/N 08-0414)

Loop 2 (S/N 08-0414)	**from**	**to**
PTB	08/2008	08/2008
BEV/E+E	09/2008	10/2008
METAS	02/2009	02/2009
INRiM	05/2009	06/2009
VSL (former NMi-VSL)	07/2009	08/2009
INTA	11/2009	11/2009
VTT (former MIKES)	01/2010	02/2010
NPL	03/2010	03/2010
GUM	04/2010	06/2010
BEV/E+E	02/2011	02/2011
PTB	06/2011	06/2011

The time slots shown in Table 2 and Table 3 represent the time of the actual measurements not including transportation. Most of the participants performed their measurements within 2 or 3 months. The gap between EIM an FSB-LPM in loop 1 is caused by a necessary repair at the owner MBW in Switzerland during the measurements in Croatia. The major gap in loop 2 between GUM and BEV/E+E was caused due to a loss of the ATA carnet in Poland with subsequent transport to Switzerland and issue of a new ATA carnet. [32]

The measurements at BEV/E+E and INTA for the instruments of both loops took place at the same time.

3 Comparison Method

3.1 Transfer standards

As transfers standard two chilled dew-point hygrometer MBW 373 HX (S/N 08-0413 and 08-0414) manufactured by MBW Calibration Ltd, Switzerland, were used. Technical details of the traveling standard are given in Table 4.

Table 4 Details of both travelling standards

Model	MBW 373 HX
Size (in packing case)	75 x 69 x 41 cm
Weight (in packing case)	36 kg
Manufacturer	MBW Calibration Ltd
Owner	MBW Calibration Ltd
Electrical supply	230 V / 50 Hz
Electrical connection	Instrument socket IEC/EN 60320-2-2, Schuko plug Standard CEE 7/VII
Power consumption	300 W
Tube connectors	Swagelok® 6 mm
Accessories	Endoscope, 4-wire cable for resistance measurements (3 m), heated flexible hose with 6 mm Swagelok® connectors, operating manual
Approximate value for insurance and customs declaration	40 000 €

Both transfer standards were shipped in transport cases which were sufficiently robust to ensure safe transportation. The technical protocol includes a packing list and description of handling the transfer standard and transportation guidelines.

3.2 Measurements

The transfer standards were used as comparators, i.e., each laboratory used its own facility to generate a gas stream of humified air which is measured with the transfer standard. The deviation of reading of the second PRT of the mirror and the generated dew-point temperatures is used for the evaluation of the comparison reference value and degree of equivalence.

As shown in the technical protocol [3], the Appendix F in this report, the calibration points were selected in such way, that each participating laboratory was able to measure at its highest possible generated dew-point temperature. The following calibration points were defined: 30 °C, 50 °C, 65 °C, 80 °C, 85 °C, 90 °C and 95 °C. The small interval steps of 5 °C between the top four values is mainly caused by constraints of the CMC review protocol [31] in this range.

The measurement instructions are described in detail in the technical protocol in chapter 4.1 [3]. The generated sample gas was introduced into the inlet of the travelling standard through the supplied heated flexible hose with 6 mm connectors. Heating should be used to avoid condensation in sample lines. For generators which need a precise pressure measurement at the point of condensation the pressure measurement was advised to be done as close to the rear terminal outlet. The remaining pressure drop had to be determined. The reference point for all measurements was declared as the point of condensation on the mirror of the travelling standard. The participants were advised to measure the flow at the outlet with a laboratory own flow meter considering the saturation at nominal dew-point temperatures higher than ambient lab conditions.

Each nominal dew-point temperature was measured four times. The condensate on the mirror should be cleared and re-formed for each value or repetition of dew point temperature by performing a “Manual Mirror Check”.

Impartiality The impartibility (“blindness”) of the comparison was ensured by the pilot conserving the confidentiality of the data throughout the whole process. There was no exchange of data among the participants from the start of instrument evaluation, during the measurement of the participating laboratories and data evaluation by the pilot. The only direct correspondence was between the pilot and each participant e.g., for clarification of data or outlier. The data was first presented the participants in Draft A version 1 in 2019.

There are no conflicts with CCT-K8 where some of the participants also took part in. The measurements of this comparison started in 2016 with adequate gap after EURAMET.T-K8 measurements.

4 Transfer Standards

4.1 Description of transfer standards

The transfer standards are described in chapter 3.1.

4.2 Stability of transfer standards

Figure 2 shows the difference between both transfer standards (SN 08-0413 and 08-0414) measured by the laboratories which measured both transfer standards. The difference is calculated by subtracting the mean value of the four single measurements with the second transfer standard (SN 08-0414) from the mean value of the four single measurements with the first transfer standard (SN 08-0413). The term measurement refers to the value of error, i.e. the instrument reading minus the reference value.

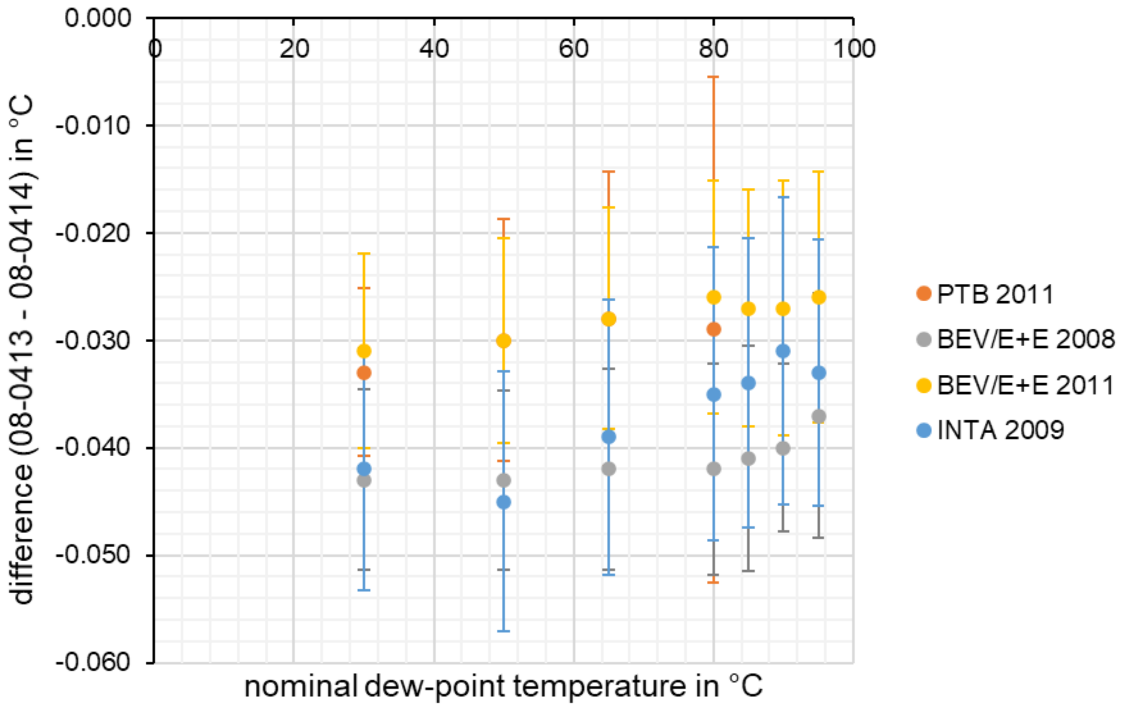

Figure 2 Difference between both transfer standards (SN 08-0413 and 08-0414) of laboratory PTB in 2011, laboratory BEV/E+E in 2008 as well as 2011, and laboratory INTA in 2009

The difference of both transfer standards and therefore the value for the linkage of both loops shows a drift of less than 0.02 K from 2008 to 2011. The values in 2011 measured by the pilot and co-pilot are in excellent agreement. The values in 2008 and 2009 measured by the co-pilot and link laboratory show a slight drift which is conform with the overall tendency from 2008 to 2011. All values are in the magnitude of the uncertainties (k=1) assigned with displayed differences. Additionally, Figure 2 shows that the difference between both transfer standards decreases of the period of the three years due to the drift of each transfer standards. There is also a slight dependence of the nominal dew-point temperature where an increase of less than 0.01 K is observed.

The evaluation of the stability of the transfer standards during the comparison is evaluated based on the measurement of the co-pilot BEV/E+E at the beginning (2008) and end (2011) of both loops. PTB as pilot also measured at the beginning and end of both loops but its measurements only cover the range of 30 °C up to 80 °C dew-point temperature. Therefore, the evaluation of drift is based on the measurements of BEV/E+E.

Different approaches for the evaluation of the stability of the transfer standards are investigated using the arithmetic and weighted mean value of the four single measurements at each nominal dew-point temperature:

- simple difference between the mean values of the measurement (error, i.e. instrument reading minus reference value) of 2011 and 2008,
- linear approximation of dependency of nominal dew-point temperature (as done in EURAMET.T-K6): The mean values of the measurement (error, i.e. instrument reading minus reference value) were fitted in dependency of the dew-point temperature separately for the data in 2008 and 2011. The displayed difference in Figure 3 and Figure 4 is the value of the resulting line equation of 2011 minus the value of the resulting line equation of 2008 at each nominal dew-point temperature for the instrument SN 08-0413 (Figure 3) and respectively SN 08-041 (Figure 4).
- polynomic approximation (degree 2) of dependency of nominal dew-point temperature: The mean values of the measurement (error, i.e. instrument reading minus reference value) were fitted to a polynomial of degree 2 in dependency of the dew-point temperature separately for the data in 2008 and 2011. The displayed difference in Figure 3 and Figure 4 is the value of the resulting polynomic equation of 2011 minus the value of the resulting polynomic equation of 2008 at each nominal dew-point temperature for the instrument SN 08-0413 (Figure 3) and respectively SN 08-041 (Figure 4).

Figure 3 and Figure 4 show the calculated drift between 2008 and 2011 for both transfer standards.

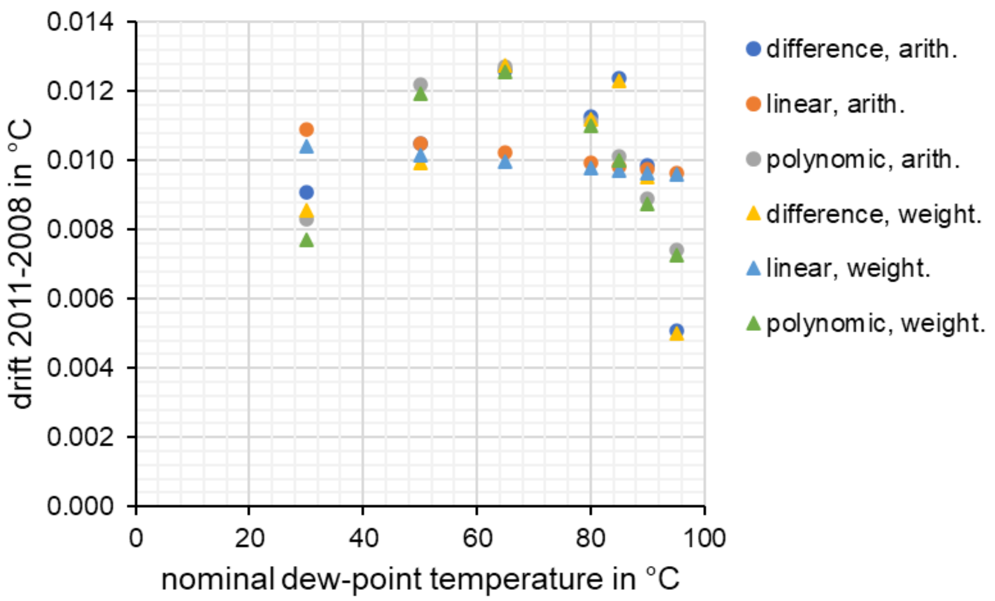

Figure 3 Drift of transfer standard SN 08-0413 (loop 1) based on the measurements of laboratory BEV/E+E, evaluated for the three methods simple difference (difference), linear approximation (linear), and polynomic approximation (polynomic) for the arithmetic (arith.) and weighted (weight.) mean

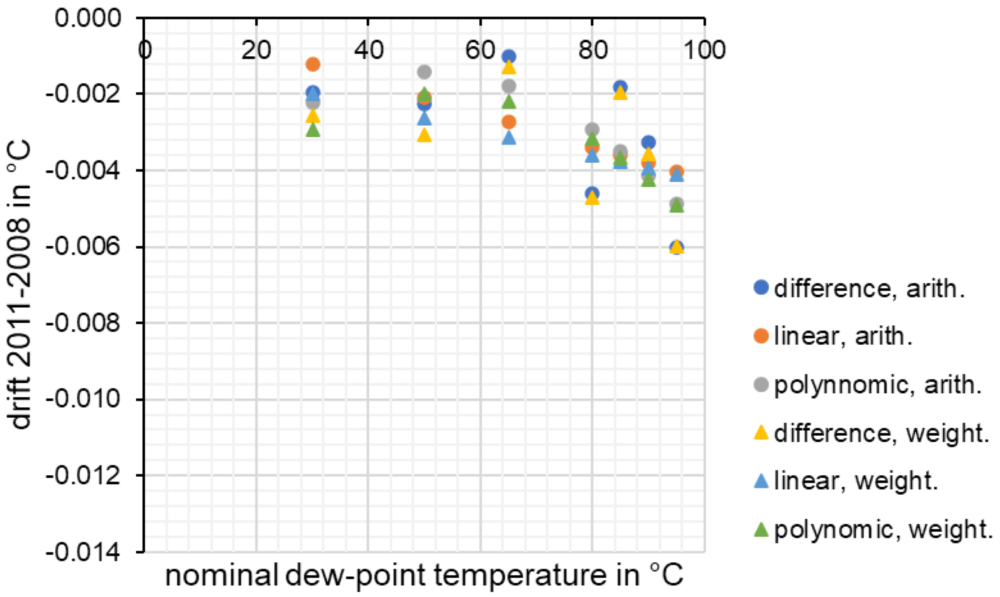

Figure 4 Drift of transfer standard SN 08-0414 (loop 2) based on the measurements of laboratory BEV/E+E, evaluated for the three methods simple difference (difference), linear approximation (linear), and polynomic approximation (polynomic) for the arithmetic (arith.) and weighted (weight.) mean

The differences between the different calculation methods are less than 0.005 K, the differences between the arithmetic and weighted mean are less than 0.001 K. Thus, the approaches are considered as equivalent and appropriate for the evaluation of drift.

The maximum deviation is +0.013 K for the transfer standard of loop 1 (SN 08-0413) and - 0.006 K for the transfer standard of loop 2 (SN 08-0414). The magnitude of the values for the drift are in the range of reproducibility of a typical dew-point hygrometer and additionally in the range of the uncertainty reported by laboratory BEV/E+E. Therefore, no correction due to drift is performed ($\delta_{stab} = 0$), but an uncertainty $u(\delta_{stab})$ is considered. Its value is determined using a rectangular contribution of the maximum deviations and is shown in Table 5.

Table 5: Values for the uncertainty contribution (k=1) due to stability of the transfer standards

Loop	SN		30 °C	50 °C	65 °C	80 °C	85 °C	90 °C	95 °C
1	08-0413	$u(\delta_{stab,L1})$	0.0038 K						
2	08-0414	$u(\delta_{stab,L2})$	0.0017 K						

5 Local Dew/Frost-Point Temperature Scales

A brief description of the facility of each participating laboratory is given in the following. The text and description are provided by each participant.

GUM

Text and figure provided by Rafał Jarosz, Poland

“This system is applied in hygrometer's calibration if the dew-point temperature T_d is near or above the ambient temperature T_a. This circuit is shown schematically in Figure 5.

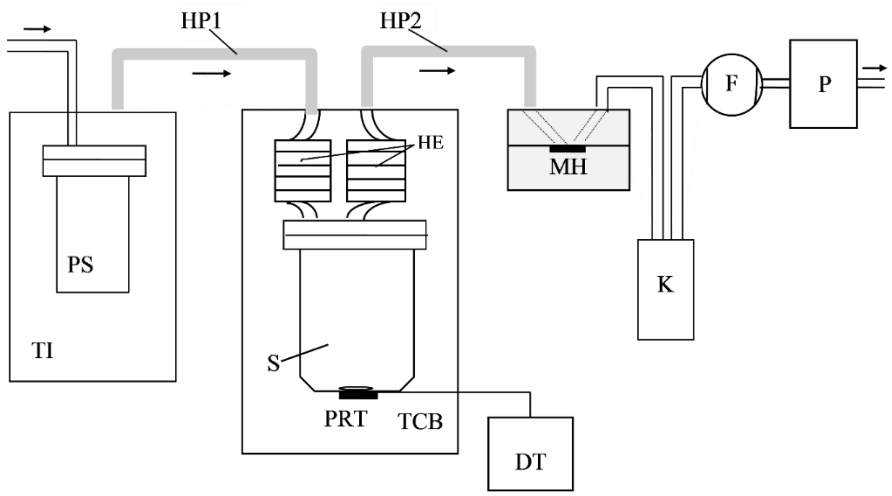

Figure 5 GUM: Schema of dew-point generator's configuration for open circuit: TI – thermostat for pre-saturator, TCB – thermostat – calibration bath, PS – pre-saturator, S – reference saturator, PRT – temperature sensor, DT – digital-thermometer or resistance bridge, HE – external heat exchangers, MH – heated measuring head of the hygrometer under test, HP1 and HP2 – heated pipes, F – flowmeter and P – gas pump (optionally).

Two-step saturation and heating of the part of installation is presented in Figure 5. The pre-saturator is different to the reference saturator and its construction is simpler. The air flows in the measuring circuit is caused or by the overpressure at the inlet (e.g. air pump or gas cylinder). Air flows through pre-saturator PS, heated pipe HP1, reference saturator S and then through heated pipe HP2 and heated measuring head MH.

Generator's principle of operation is in this version as follows:

- In pre-saturator PS the air stream is saturated about in 96÷98% in a temperature T_{ps} a bit higher than the temperature T_r of the reference thermostat.
- In saturator S dew-point temperature of air stream is ‘stabilized’ as T_{rs} if the temperature of pre-saturator is in right range, which is determined as the result of previous tests.
- This reference value T_{rs} is ‘transferred’ to the measuring head of the dewpointmeter under calibration.

Dew/frost point temperature generator has measurement traceability related to the national standard of temperature and resistance standard which are maintained in GUM.

The pressure measurement is traceable to reference standard of pressure gauge of GUM."

VTT (former MIKES)

Text provided by Richard Högström, Finland

“MIKES used the MIKES Dew/Frost-point Generator (MDFG) as the dew-point temperature standard in this comparison [30]. The generator comprises three saturators: LRS2 (-80 °C to +15 °C), LRS1 (-60 °C to +15 °C) and HRS (0 °C to +90 °C). In this comparison, measurements were only performed with HRS.

All three saturators operate on the same principle. Air flowing at a rate of typically less than 2 l/min is saturated with water vapour by a single pass through a precision saturator located in a temperature-controlled liquid bath. A pre-saturator ensures that the dew-point temperature of air entering a main saturator is slightly higher than the main saturator temperature. Thus, condensation takes place in the inlet heat exchanger tube of the main saturator. Saturation with respect to plane water or ice layer is completed by forcing air flow on water or ice surface in a saturation chamber connected to the outlet of the heat exchanger tube. Saturated air flows through an internally electropolished tubing to the hygrometer under calibration. The tubing is heated when needed to prevent any water condensation in it. The generated dew-point temperature is determined from the measured saturator temperature, the saturator pressure and the air pressure in the hygrometer under calibration. Being the primary realisation for dew-point temperature, MDFG provides traceability to the SI through traceable temperature and pressure measurements. The traceability of these measurements is established through calibrations at MIKES within its CMCs published at the BIPM website.“

CETIAT

Text provided by Eric Georgin, France

“Humid Air Generator, used during EURAMET.T-K8, is a 1-Temperature type, working as a closed loop. The flow coming inside the saturator exchange water molecules with the sheet of water contained in the equilibrium chamber of the saturator. Humid air from the saturator is then distributed to the hygrometer in calibration. At last, the humid air goes back to the saturator, thus closing the loop. Humid air generated is in equilibrium with water or ice at a given temperature and pressure, which is closed to ambient pressure. Reference dewpoint is determined by measuring the temperature of the saturator, with a standard platinum thermometer Pt25 type, corrected from pressure drop between saturator and the hygrometer. The reference equipment is traceable to national standards of France.

This calibration facility has also been used in the former comparison EURAMET.T-K6/P621. Since 2010 it is no longer in use nor exists. It has been replaced by new humid air generators with wider capabilities or based on different generation principles.”

FORCE Technology (former DELTA)

Text provided by Andres Bonde Kentved, Denmark

“All measurements in the EURAMET.T-K8 (P717) were carried out using FORCES’s so-called “Wet range calibrationsystem” (FORCE EVFGT-43), which is a custom-made climatic test chamber (875 litres), modified for calibration purposes (for: air temperature, dew point and relative humidity).

In brief, the calibration chamber simply provides a stable combination of temperature and humidity in a defined space (~21 litres), controlled by: standard temperature sensors, a psychrometer and a computer. Temperature and dew-point are measured by separate reference instruments.”

The reference for dew-point temperature is a chilled mirror hygrometer Michell S4000, traceable to VTT MIKES, Finland. Thus, FORCE is marked as secondary laboratory in Table 1.

BEV/E+E

Text provided by Helmut Mitter, Austria

“The BEV / E+E Elektronik humidity reference generator [4] is a continuous flow 2-pressure generator of own design and can be operated as single pressure generator, too. It is used as primary generator in the dew- / frost-point range from -75 °C to 95 °C with a gas flow of 5 L/min at standard conditions maximum and pressures up to 1 MPa. Dry nitrogen from a liquid nitrogen evaporation is guided directly or via a pre-saturator into the three-stage main saturator where the gas is conditioned to the required state of saturation temperature and saturation pressure. Then the gas is guided via a heated expansion valve and heated gas lines to the consumer, e.g. up to three chilled mirror hygrometers operated in parallel. In case of operating in single pressure mode the gas is let without expansion valve directly to the consumer with very low pressure difference between point of saturation and point of use.

The saturator is immersed in a high stability temperature bath with a volume of about 60 L. In general, the saturator is operated in too different modes:

- At saturator temperatures t_1 with $0\,°C\ <\ t_1\ \ \leq 98\,°C$ the generator is operated with pre-saturator in the “condensation mode”; saturation occurs over a water surface.
- At saturator temperatures t_1 with $-60\,°C\ \leq\ t_1\ \ < 0\,°C$ the generator is operated without pre-saturator in the “sublimation mode”. Dry gas is let directly into the saturator and saturation occurs over an ice surface via sublimation.

The pressures at point of saturation and point of use are measured by two Paros 6000-200A pressure transducer traced directly to BEV.

Saturation temperature is measured by two high quality industrial Pt100 and a MKT100 millikelvin thermometer, traced via a SPRT Rosemount 162CE to BEV.

Vapour pressures and enhancement factors used in the calculation of the reference dew-point temperature are given in [7], [8], [9]."

METAS

Text provided by Remo Senn, Switzerland

"The METAS measurements were performed with two different dew point generators.

For the measurements from 30 °C to 65 °C, the Thunder 2500 (METAS No. 6674) two-pressure principle generator was used. The temperature operating point was set 1 K higher for all measurement points. The final dew point at the generator output was adjusted by the pressure control in the saturator. The temperature of the thermostatic fluid circulating around the saturation cell was measured directly by means of an inserted standard platinum resistance thermometer (SPRT).

For the measurements at 80 °C and 85 °C, the CETIAT1 single-pressure closed-loop generator (METAS No. 1823), developed at CETIAT France, was used. The saturation cell, designed to provide the highest possible exchange between the humid air and the condensed phase along a helicoidal path, was completely immersed in a thermostatic bath. This allows for very good temperature stability and homogeneity as well as very well-defined temperatures of the saturation cell over a working range of -85 °C to +85 °C. A diaphragm pump drove the humid air flow through the tubes of the generator and hygrometers, creating slight pressure gradients in the tubes of the system. The pressure differences between the output of the generator and the input of the hygrometers were measured with two absolute pressure gauges. Through a metal tube connected to the top of the cell, the water vapor-saturated air stream exits the saturation cell. Inside the tube, the temperature of the humid air was measured by a precision resistance thermometer.

Full traceability to the SI is provided by the METAS temperature, electricity and pressure laboratories and their registered CMCs."

EIM

Text provided by E. Kokkini, Greece

"The primary dew point generator was designed and constructed at NPL [5]. The saturator is housed in a concentric cylindrical fluid bath, which is used with an external recirculating thermostat. The principle for the bath is well established. It consists of an inner and an outer chamber, separated by a cylindrical wall of a height that allows fluid to circulate between the two spaces. The fluid bath is sealed to minimise the rate of evaporation and the contamination of the fluid. Connections to the saturator feed through the bath lid, and at the bottom of each chamber is an access port for the temperature-controlled fluid to go to and from the circulating cooler. Locating the temperature control and pumping of the fluid away from the bath allows the bath construction to be simplified with all moving parts remote from the bath. A flow-mixing pre-saturator is used to achieve an approximate dew-point temperature in the inlet gas, this is measured by the pre-saturator sensor. This sensor can be calibrated against the monitoring hygrometer in-situ via a bypass valve. The mixed gas is adjusted to have a dew point slightly above the desired dew point so that the temperature gradients in the main saturator are not affected by the evaporation of water and also the coils of the saturator are not emptied.

All parts of the generator pipework that are not inside the bath are housed inside a temperature controlled enclosure fitted to the top of the bath to prevent condensation. The humidified gas is then passed via heated hoses to the monitoring hygrometer and to instruments being calibrated.

At the exit of the saturator, located in the gas stream, is a PRT which is calibrated according to ITS-90, in EIM's Hg triple point, water triple point, Ga melting point and in freeze point cells.

The thermometer bridge ASL 250 used is calibrated by EIM's Low Frequencies Electrical Measurements laboratory."

INTA

Text provided by Robert Benyon, Spain

"The INTA high range humidity generator is based on the main components supplied by BEV/E+E, consisting of a temperature-stabilized pressure unit, a temperature regulation unit, a pre-saturator, a pressure regulation system, a temperature-stabilized expansion unit, and the main saturator (condenser) [6]. The main saturator in placed in a 95 liter temperature-controlled bath.

The saturator temperature is measured with two Rosemount 162CE standard platinum resistance thermometers calibrated at INTA at ITS-90 fixed points from the triple point of water to the freezing point of indium, an ASL F700A AC resistance bridge, with a measurement frequency of 75 Hz, calibrated in-house using a inductive voltage divider calibrated by PTB, and Tinsley Wilkins standard resistors calibrated by the INTA electricity laboratory. Absolute pressure measurements are performed with Ruska 6230 digital pressure gauges and Paroscientific series 6000 pressure transducers, calibrated by the INTA Pressure and Mass Laboratory using Ruska 2465 pressure balances. Auxilliary flow and differential pressure measurements to establish the required conditions in the transfer standards have been made with instruments calibrated by the INTA Flow and Pressure and Mass laboratories, respectively.

All measurements have metrological traceability to the SI via regular calibration of reference standards at *Centro Español de Metrología* (temperature, DC resistance, vacuum), *Physikalisch-Technische Bundesanstalt* (IVD ac voltage ratio), and the *National Physical Laboratory* (AC/DC difference of standard resistors and pressure)."

The vapor pressures and enhancement factors used in the calculation of the reference dew-point temperature are given in [7], [8], [9].

INRiM

Text provided by Denis Smorgon, Italy

“The comparison was made between the two-temperature IMGC-01 generator and the transfer standard model MBW 373 HX.

The IMGC-01 generator operates according to the principle commonly named "two-temperature at constant pressure", and it is a recirculation type generator. The internal pressure is kept constant to better than 0.1% by means of a pressure controller. The pressure controller keeps the pressure constant even when a small flow, typically 0,5 l/min in normal conditions, is drawn from the generator in order to feed an external dew- point hygrometer under calibration. The small flow vented through the external dew- point hygrometers is replaced by the same volume of dry gas coming from the cylinder used as dry gas-source. This connection mode of the hygrometer under calibration is commonly named as parallel, open-circuit mode. The dew-point value is established within an isothermal saturator as sole function of its temperature measured by means of a pair of calibrated PRTs traceable to ITS-90. Neglecting any possible difference between evaporation and condensation temperatures, which for pure water (demineralized water) is well below 0,01 °C with both liquid and solid phases, the dew point is the unique parameter describing the saturation of a gas stream over water and the frost point that for the saturation over ice. The IMGC-01 generator is a closed-loop and gas-tight generator and covers the dew point range from -15 °C to 90 °C. The carrier gas recirculating in it is nitrogen. The generated dew point in the saturator is transmitted to a measuring chamber and a small correction is applied to compensate for the pressure drop, which does not exceed 125 Pa (experimentally determined before starting with the comparison measurements by means of a calibrated differential pressure gauge). The hygrometer under calibration is connected to the measuring chamber by means of a 1.5-m length and 6 mm o.d. heated flexible hose hold at a temperature at least 10 °C higher than dew-point.

The mirror-PRT of the transfer standard was measured by means of a temperature analyzer model F. Corradi RP7000 with a pulsed current of 1 mA (duty-cycle 20%). The resulting self-heating is more than a factor of 10 lower than that produced by a constant current of equal value; a self-heating uncertainty component was added.

The reference frost-point temperature in the INRIM generator is determined as the mean value of the temperature measured by two PRTs (one in air, one in ice) placed at the saturator outlet at the equilibrium condition. The traceability to SI of the generated conditions is guaranteed through the calibration of the two saturator-outlet PRTs by comparison with a PRT calibrated at the fixed points according the ITS-90.

Any non-negligible pressure drop between the measurement point and the generation point is measured with a differential pressure meter calibrated at the INRIM primary pressure laboratory which guarantees the traceability of the measurements to the SI.

All the instrumentation for the measurement of the electrical quantities is calibrated at INRIM which guarantees the traceability of the measurements to the SI.”

NML/NSAI

Text based on information provided by Dubhaltach MacLochlainn, Ireland

The setup used for the EURAMET.T-K8 was as follows:

- Dewpoint generator: Thunder Scientific 2500s (S/N 0207366)
- Chilled Mirror: MBW DP30-BCS-K2 (S/N 02-0919)

The chilled mirror was calibrated by INTA on the 10th of April 2008 and the 8th of September 2009, cert numbers: 8063 and 8709. Therefore, NML/NSAI is marked as secondary laboratory in Table 1.

NPL

Text provided by Paul Carroll, UK

„The NPL measurements were carried out against the NPL Standard Humidity Generator (SHG2), in terms of dew-point temperature. The "generated dew point" was determined from measurements made using a PRT immersed at a point in the generator where the gas has reached complete saturation and therefore a measurement of air temperature is equal to that of dew-point temperature. Traceability of measurement was provided by calibration of this thermometer to the International Temperature Scale of 1990 (ITS-90) through NPL Temperature Standards.

Air of a known dew-point temperature, at a pressure of 105.0 kPa, was supplied to the test hygrometer inlet. A 1.2 m length of 4 mm internal diameter PTFE tubing was used to connect the moist air to the transfer standard hygrometer. The moist air was then vented to atmosphere, through a cold trap and then a rotameter with a needle valve assembly for flow control. The air flow rate was set so that the flow through the test hygrometer was nominally 0.5 litres per minute."

VSL National Metrology Institute (former NMI-VSL)

Text provided by Matthijs Panman, The Netherlands

"The High Temperature Saturator (HTS, described in detail here [10]) used in this comparison is a single-pass dew-point generator capable of generating dewpoints ranging from 30 °C to 95 °C under atmospheric pressure. The HTS is suppliedwith compressed air or nitrogen gas which is regulated using a mass-flow controller. All connecting tubes are ¼" electropolished stainless steel tubing using Swagelok® fittings. A chalk-filter was used to presaturate the carrier gas by bubbling it through demineralized water in a chamber preceding the saturator. The saturator comprises a stainless-steel block with a machined, winding channel. Barriers and dams in the channel maximize the interaction between the carrier gas and the water. The pre-saturator and saturator are fully submerged in a Tamson TV7000SP thermostat. The temperature of the saturator, and thus the reference dewpoint temperature, was measured with a calibrated Standard Platinum Resistance Thermometer (SPRT) located within 1 cm from the output tube of the saturator. The temperature gradient across the saturator is measured at three different positions with calibrated PT100's. The output tube is heated at least 10 °C above the saturator temperature with a heating wire to prevent condensation from occurring. The resistance of all four thermometers, as well as that of the mirror PRT of the transfer standard, were measured using an ASL F-700 AC thermometry bridge against a calibrated standard resistor.

All equipment used for the measurement of the dewpoint, and atmospheric pressure, are calibrated against primary or secondary standards which are traceable to internationally accepted measurement standards. The SPRT is calibrated on the freezing point of Indium of the ITS-90 at the primary contact thermometry laboratory of VSL. The Pt100 sensors are calibrated by comparison with an SPRT in liquid thermostats at the secondary contact thermometry laboratory of VSL. The standard resistance is calibrated in comparison to a 100 Ω standard resistor in the primary thermometry laboratory of VSL, which in turn is traceable to the primary resistance standard of VSL. The thermometric bridge is calibrated using a resistancebridge calibrator (Aeonz Resistance Bridge Calibrator RBC100). The pressure meters are calibrated against the primary standards of the pressure laboratory at VSL."

PTB

PTB's humidity generator is a two-pressure generator with a range from -25°C frost point temperature up to +80°C dew point temperature. The generator is supplied by oil and dust free, compressed air up to 15 bar. The pressure is precisely regulated by a pressure regulator. The gas stream passes a heated pre-saturator in which the air is saturated with water with respect to temperature and pressure in the pre-saturator. Afterwards the air is fed to the main saturator which is a specially designed metal block immersed in a thermostatic bath. The temperature in the bath is slightly below the temperature of the pre-saturator. Therefore, water condenses along the horizontally arranged fins of the saturator. At the end of the saturator the gas stream is saturated with respect to the temperature and pressure in the saturator. After the saturator block the gas stream is expanded via a needle valve to atmospheric pressure. The temperature is measured within the bath in direct vicinity of the saturator with two SPRT PT-25, Tinsley. Each of the two relevant pressure values (saturator and point-of-use) is measured by Baratron pressure transmitter, MKS Instrument Inc.. Both, temperature and pressure measurement, is direct traceable to the national standards of Germany. The generated moist air stream is directed to the transfer standard via heated line and 6 mm Swagelok® tubing. The resistance value of the second PRT of the mirror of the transfer standard is read via resistance bridge F17, ASL.

TUBITAK UME

Text provided by Seda Oğuz Aytekin, Turkey

"TUBITAK UME humidity generator system (model ST2500-LT) is based on two-pressure principle manufactured by Thunder Scientific Corporation. For the generator system, compressed air of up to 1207 kPa (175 psia) was passed through filters and regulators resulting in a regulated air of 1034 kPa (150 psia). After the adjustment of flow control valve in order to set an air flow rate of to 2-20 slpm, the gas was directed to a presaturator. In order to saturate the air nearly 100 %, air was passed through immersed tubing into the presaturator. Temperature of the presaturator, which was maintained at a temperature of 15 to 20 °C warmer than the saturation temperature and the air flowed to the “tube in shell” type heat exchanger, referred as saturator. As air having nearly 100 % relative humidity it was circulated through the saturator and cooled down and then condensation was ensured a value of 100 % relative humidity i.e., saturation. Saturation pressure was measured as the air was exiting the saturator. Afterwards, the saturated air was reduced to a lower pressure in a chamber through the thermally isolated and heated expansion valve and then final air pressure and temperature in the test chamber were also measured.

Traceability of the generator system is performed by the annual calibration of four thermometers and two pressure transducers at TUBITAK UME Temperature Laboratory and Pressure Laboratory, respectively.

Current situation: Calibration of pressure transducers cannot be performed since 2015, due to problems in the Thunder Scientific humidity generator which could not be solved yet. The humidity generator is now used only as a generator, and the traceability is provided through dew-point hygrometers.

The dew-point hygrometer and the humidity generator system are connected by the use of heated hose and the stainless steel tubing of 6 mm in outer diameter with Swagelok and Cajon fittings.

Resistance measurements are carried out by using a digital voltmeter (HP, Hewlett Packard, DMM 3456A) whose calibration is performed by TUBITAK UME Voltage Laboratory annually. Software, VBA macro program written in excel, was used for the continuous measurements of resistance values. Measurement frequency was user-defined and set to 1 minute for measurements and to 5 seconds for stability measurements. Dew-point temperature values from hygrometer via serial port were read by the standard protocol.”

MIRS/UL-FE/LMK

Text provided by Domen Hudolkin, Slovenia

“LMK primary dew-point generator consists of the low part (PGR-LMK-01), which is used in the dew-point range from -50 °C to +20 °C, and of the high temperature part in the range from +20 °C to +95 °C – PGR-LMK-02. Both parts work on single-pressure principle. The high range PGR-LMK-02, which was used in the comparison P717 operates in a single-pass mode. Detailed description of the PGR-LMK-01 and PGR-LMK-02, which are very similar in design, can be found in [11], [12]. The basic difference between the two parts is in the size of the saturator and in operation mode, which is full recirculation for the PGR-LMK-01, respectively.

The temperature of the saturator is measured by two SPRTs. They are placed at the opposite sites next to the saturator in the water bath, where saturator is placed. The SPRTs were calibrated in fixed points from 0 °C up to 660 °C in the LMK primary temperature laboratory. The resistance was measured by a DC bridge MI 6010 and reference resistor, traceable to the national standard MIRS/SIQ.

Pressure is measured by the barometer, which is traceable to the national standard MIRS/IMT.”

FSB-LPM

Text provided by Danijel Šestan, Coratia

„FSB-LPM uses two primary dew-point generators in the dew-point temperature range between -70 °C and 65 °C. The low-range generator covers the dew/frost-point temperature range between −70 °C and +5 °C (with expanded uncertainties ranging from 60 mK to 100 mK) at airflow rates between 1.0L · min^{-1} and 2.5L · min^{-1}. The high-range generator used for the EURAMET T-K8 intercomparison operates between 1 °C and 65 °C (with expanded uncertainties ranging from 40 mK to 80 mK) at airflow rates between 2.0 L · min^{-1} and 2.6 L · min^{-1}.

The operation of both generators is based on a single pressure, single-pass generation principle at the pressure level slightly above the atmospheric.

Currently, the oil-free compressor is used for supplying the generators with the air. If required, other gasses supplied from the high-pressure gas cylinders can also be used. Before entering the saturators, the air is dried to the dew-point temperature of approx. -40 °C and filtered by coalescing filter and several particle filters that remove the particles larger than 10 nm.

The saturator temperatures are controlled by ethanol and water baths, in which they are immersed. The saturation temperatures are measured by two standard platinum resistance thermometers, connected to the ratio resistance bridges with a resolution of 1 or 0.1 ppm. The traceability of reference thermometers was provided by Temperature Standards at PTB.

The dew/frost point temperatures at the saturator’s outlets are additionally controlled with two high-precision hygrometers (MBW 373L and MBW 373 LHX). Pressure and flow rate are controlled by a combination of precision pressure regulators (at the inlet of each generator) and flow meters with regulation valves (at generator outlets). Precise digital barometers are used for monitoring the pressure inside saturation chambers and at the sensor of a calibrated dew-point hygrometer. Both barometers are traceable to the Croatian national standards. Custom made LabView software is used for data acquisition.“

6 Measurement Results

The evaluation is based on the evaluation of former key comparison in the field of humidity: EURAMET.T-K6 [1] and CCT-K6 [2]. The presented evaluation for EURAMET.T-K8 is mainly elaborated by Helmut Mitter based on his comment to Draft A version 1 of EURAMET.T-K8 and was collaborative further development in exchange with Dr. Helmut Mitter and the pilot of the CCT-K8 [14].

6.1 Summary of results

Measurement results as reported by the participating laboratories are listed in Appendix A. The detailed uncertainty budgets of each participant are summarized in Appendix B. A single result $\Delta t_{d,i}^{(lab)}$ for each laboratory *lab* is derived for each nominal dew-point temperature as followed.

First the difference between the laboratory reference (generated dew-point temperature) $t_{d,i}^{(ref)}$ and the result obtained by the transfer standard $t_{d,i}^{(hyg)}$ is calculated. The dew-point temperature $t_{d,i}^{(hyg)}$ is the converted value of the measured resistance of the second PRT (R_t) based on the international standard IEC 60751:2008.

$$R_t = R_0(1 + At + Bt^2) \tag{6.1}$$

where

t	=	temperature (ITS-90) in °C
R_t	=	resistance of the PRT at temperature t in Ω
R_0	=	nominal resistance of 100 Ω at $0\ ^\circ\mathrm{C}$
A	=	$3.9083\ \cdot 10^{-3}\ ^\circ\mathrm{C}^{-1}$
B	=	$-5.775\ \cdot 10^{-7}\ ^\circ\mathrm{C}^{-2}$

Solving the quadratic equation in Eq. (6.1), the temperature is calculated with

$$t_d^{(hyg)} = t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R_0 - R_t}{BR_0}}. \tag{6.2}$$

Thus, the difference $\Delta t_{d,i}^{(lab)}$ between the laboratory reference $t_{d,i}^{(ref)}$ and the transfer standard $t_{d,i}^{(hyg)}$ is given by:

$$\Delta t_{d,i}^{(lab)} = t_{d,i}^{(hyg)} - t_{d,i}^{(ref)}. \tag{6.3}$$

To get one single value for each laboratory measuring a transfer standard, an aggregated lab result $\Delta t_d^{(lab)}$ of the *n* single measurements $\Delta t_{d,i}^{(lab)}$ of each laboratory must be calculated. There are two options for the aggregated lab result: arithmetic or weighted mean value.

Arithmetic mean:

$$\mu_{arith}\left(\Delta t_d^{(lab)}\right) = \frac{1}{n}\left(\sum_{i=1}^{n} \Delta t_{d,i}^{(lab)}\right) \tag{6.4}$$

Weighted mean:

$$\Delta t_d^{(lab)} := \mu_{WM}\left(\Delta t_d^{(lab)}\right) = \frac{\sum_{i=1}^{n} \frac{\Delta t_{d,i}^{(lab)}}{u^2\left(\Delta t_{d,i}^{(lab)}\right)}}{\sum_{i=1}^{n} \frac{1}{u^2\left(\Delta t_{d,i}^{(lab)}\right)}} \tag{6.5}$$

The evaluation will be carried out with the weighted mean value. Investigations of the arithmetic mean value and a comparison to former calculations used in the first version of Draft A are given in Appendix E.3. Based on the study, the calculation for achieving an aggregated lab result was performed by using the weighted mean because the weighted mean provides the advantage, compared to the arithmetic mean, to be able to deal with reported lab results showing a larger variation among the four measurements (value and/or uncertainty). Additionally, the weighted mean fits better to the later used test of consistency (Birge ratio and/or Chi^2-Test) applied to the four aggregated lab results.

The uncertainty of the aggregated lab result is calculated from the uncertainties of the *n* single measurements of a lab. The uncertainty of a single lab measurement is calculated from the three reported uncertainty contributions by each laboratory *lab*:

$$u^2\left(\Delta t_{d,i}^{(lab)}\right) = u^2\left(t_{d,i}^{(ref)}\right) + u^2\left(t_{d,i}^{(stab)}\right) + u^2\left(t_{d,i}^{(res)}\right) \tag{6.6}$$

with

- uncertainty contribution due to reference system (generation of humidity) $u^2\left(t_{d,i}^{(ref)}\right)$
- uncertainty contribution due to short-term instability of the hygrometer $u^2\left(t_{d,i}^{(stab)}\right)$
- uncertainty contribution due to the resolution of hygrometer $u^2\left(t_{d,i}^{(res)}\right)$.

In order to treat the laboratories equally following decisions about the given uncertainties of the laboratories were set:

- The contribution due to resolution of the hygrometer was only considered if a laboratory stated a value for this contribution. This value was used. If a laboratory did not report a value in this cell or the reporting from, the value is set to zero.
- Contributions, which are not listed above, were not considered (e.g., TUBITAK stated additional values for covariances of the reference dew-point temperature and the output of the hygrometer).

A strict differentiation between correlated and uncorrelated contributions is necessary to correctly take the contributions into account and to avoid underestimations of the uncertainty. The laboratory uses the same reference system for all *n* measurements. Therefore, the uncertainty contribution due to reference system is correlated for all *n* measurements. The separately reported contributions due to short-term instability and resolution are independent in the statistical sense and for this reason uncorrelated.

$$u^2\left(\Delta t_{d,i}^{(lab)}\right) = u^2\left(t_{d,i}^{(ref)}\right) + u^2\left(t_{d,i}^{(stab)}\right) + u^2\left(t_{d,i}^{(res)}\right) = \left(u_{corr,i}\right)^2 + \left(u_{stat,i}\right)^2 \quad (6.7)$$

with

$$u_{corr,i} := u\left(t_{d,i}^{(ref)}\right)$$

Consequently, the uncertainty of the aggregated lab result $u\left(\Delta t_d^{(lab)}\right)$ must be treated as partly correlated. The uncertainty for the weighted mean with correlation is calculated according to Eq. (12.6) in Appendix E.1:

$$u^2\left(\Delta t_d^{(lab)}\right) = u^2\left(\mu_{WM}\left(\Delta t_d^{lab}\right)\right) = \frac{1}{\left(\sum_{i=1}^{n}\frac{1}{u^2\left(\Delta t_{d,i}^{(lab)}\right)}\right)^2} \cdot \left[\sum_{i=1}^{n}\frac{1}{u^2\left(\Delta t_{d,i}^{(lab)}\right)} + 2\cdot\sum_{\substack{i,j\\ i>j}}\frac{corr_{i,j}}{u\left(\Delta t_{d,i}^{(lab)}\right)\cdot u\left(\Delta t_{d,j}^{(lab)}\right)}\right]. \quad (6.8)$$

It must be emphasized that use of the partially correlation for the aggregated lab results leads to the main improvements between Draft A1 and A2, and the following Drafts.

The correlation factor $corr_{i,j}$ is calculated by the correlated contribution of the laboratory reference value $u_{corr,i} = u\left(t_{d,i}^{(ref)}\right)$ and the combined uncertainty $u\left(\Delta t_{d,i}^{(lab)}\right)$:

$$corr_{i,j} = \frac{u_{corr,i}\cdot u_{corr,j}}{u\left(\Delta t_{d,i}^{(lab)}\right)\cdot u\left(\Delta t_{d,j}^{(lab)}\right)} \leq 1\ . \quad (6.9)$$

The average values for the correlation coefficient $corr_{i,j}$ for the lab results are shown in Table 33 in Appendix E.4. The values give an indication of the extent of correlation within aggerated lab result. The values range between 0.68 and 1.00, 65% of the results are larger than 0.95.

A procedure is needed to deal with potential inconsistent data among the reported measurement data. Due to the fact, that only a small number (four) of results should be checked and the four measurements of each laboratory at each nominal dew-point temperature are not independent, the applicability of the chi-squared test and the reliability of its explanatory power is small.

Instead of the chi-squared test, the so-called Birge ratio, which is well-known in metrology [13], can be applied:

$$\sigma_B = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\frac{\left(\Delta t_{d,i}^{(lab)} - \mu_{WM}\left(\Delta t_{d}^{(lab)}\right)\right)^2}{u^2\left(\Delta t_{d,i}^{(lab)}\right)}}\,. \tag{6.10}$$

Besides the classical Birge ratio in Eq. (6.10) a modified Birge ratio is introduced in [13] which is especially applicable for small numbers of *n*.

$$\sigma_{BM} = \left(\frac{n-1}{n-3}\right)^{1/2}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\frac{\left(\Delta t_{d,i}^{(lab)} - \mu_{WM}\left(\Delta t_{d}^{(lab)}\right)\right)^2}{u^2\left(\Delta t_{d,i}^{(lab)}\right)}}. \tag{6.11}$$

Applying the modified Birge ratio, the standard uncertainty of the weighted mean value is multiplied by the modified Birge ratio.

$$u\left(\mu_{BM}\left(\Delta t_{d}^{(lab)}\right)\right) = \sigma_{BM} \cdot u\left(\mu_{WM}\left(\Delta t_{d}^{(lab)}\right)\right). \tag{6.12}$$

The ratio is only applied when its value is larger than 1. In the other cases the value of the ratio is set to 1, i.e., the case of overestimated uncertainties is neither treated nor corrected. The mean value as calculated in Eq. (6.5) is not affected by the Birge ratio.

Laboratory F supplied after the first published version of Draft A corrected values for its uncertainty values at nominal dew-point temperature of 95 °C which are considered in the further calculation [21]. All other data is unchanged compared to the first version of Draft A.

Figure 6 and Figure 7 depict the results obtained for the weighted mean with the partially correlated measurement uncertainty and the modified Birge ratio.

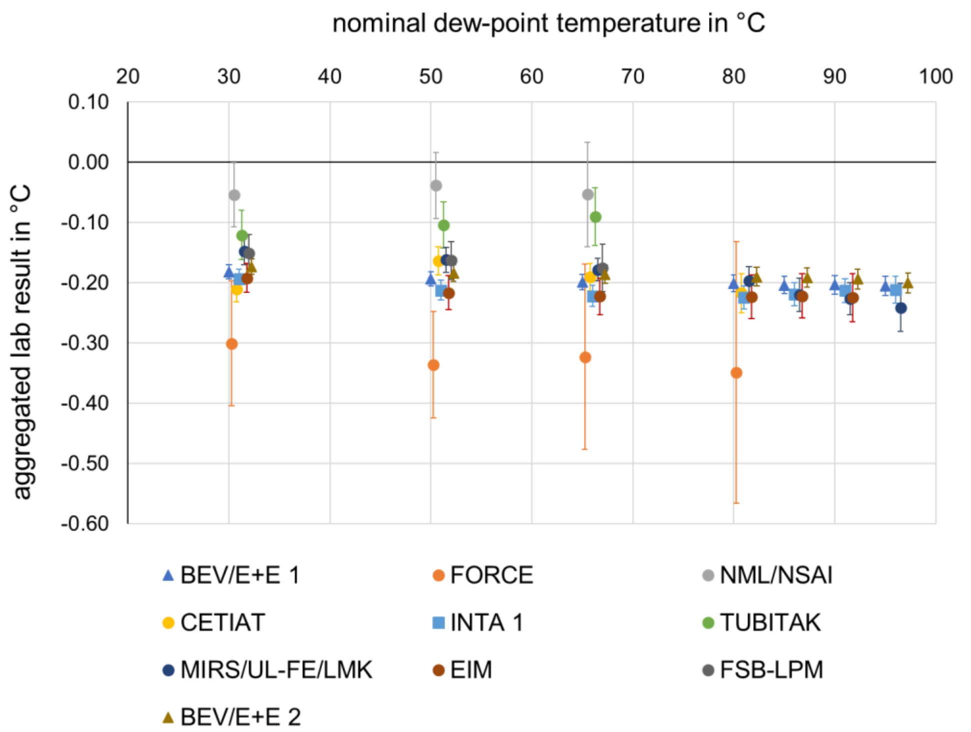

Figure 6 Aggregated lab results for loop 1, obtained for the weighted mean with the partially correlated measurement uncertainty and the modified Birge ratio, uncertainty k = 1, values shown slightly scattered (offset 0.25 K)

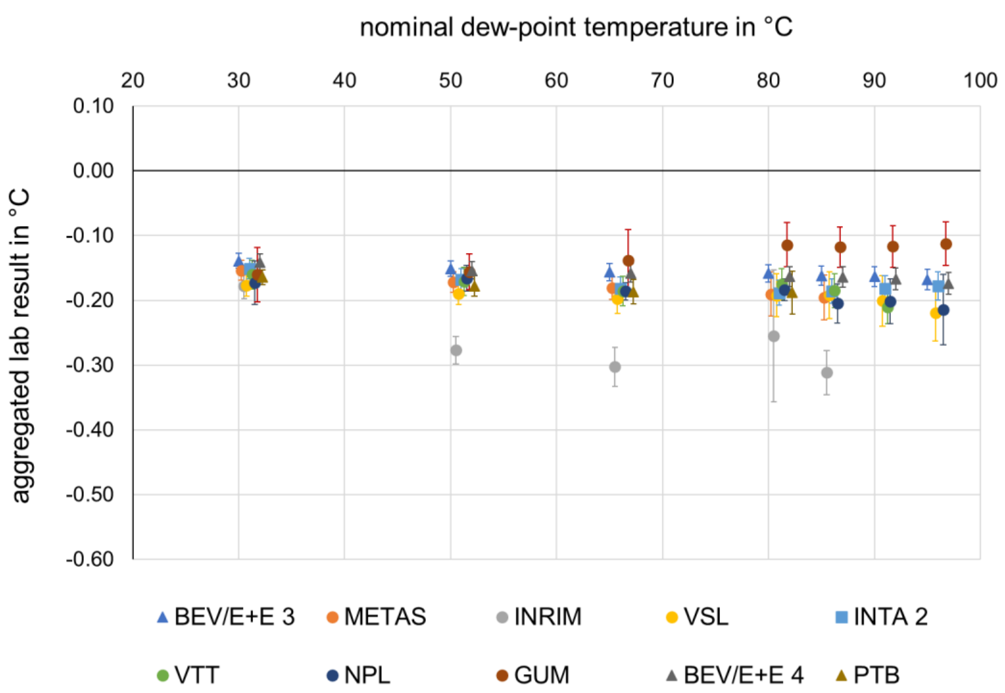

Figure 7 Aggregated lab results for loop 2, obtained for the weighted mean with the partially correlated measurement uncertainty and the modified Birge ratio, uncertainty k = 1, values shown slightly scattered (offset 0.25 K)

The results show good agreement for most of the laboratories. In loop 1, FORCE and NML/NSAI (secondary laboratories), and in smaller extension also TUBITAK, show in the range of 30 °C up to 65 °C respectively 80 °C dew-point temperature larger deviations and uncertainty values compared to the other laboratories. The agreement in the higher dew-point temperature range of 80 °C up to 95 °C is very good.

In loop 2, an excellent agreement at 30 °C is obtained. Larger deviations are observed for INRIM, and in smaller extension for GUM, in the range from 50 °C up to 85 °C.

A further study of this observation and its consequences for the calculation of the ERV will be discussed in the following chapters.

The difference of arithmetic mean (see Appendix E.3) and weighted mean is less than 0.008 K for all measurements. In loop 1, the difference is smaller than 0.002 K for all measurements in loop 1. In loop 2, the difference for all measurements in loop 2 except the measurement of INRIM at 80 °C dew-point temperature is smaller than 0.001 K. Therefore, the difference between both methods is small and it is justified to choose the weighted mean as mean value for the further calculation.

The consideration of correlation in form of partially correlated measurement uncertainty contributions describes the real behavior very well and leads to senseful values for the uncertainty (see Appendix E.3).

Table 6 lists the values of modified Birge ratio when the value exceeds the value of one.

Table 6 Values for the modified Birge ratio for laboratories: given values are considered in the calculation of the aggregated lab result; "< 1" Birge ratio smaller than one, set to one in calculation; "-" no lab results at this nominal dew-point temperature reported.

laboratory	30 °C	50 °C	65 °C	80 °C	85 °C	90 °C	95 °C
BEV/E+E 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
FORCE	1.17	< 1	1.71	2.40	-	-	-
NML/NSAI	< 1	< 1	< 1	-	-	-	-
CETIAT	1.31	1.47	< 1	< 1	-	-	-
INTA 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TUBITAK	< 1	< 1	< 1	-	-	-	-
MIRS/UL-FE/LMK	1.49	< 1	< 1	< 1	< 1	< 1	1.20
EIM	< 1	< 1	< 1	< 1	< 1	< 1	-
FSB-LPM	< 1	< 1	< 1	-	-	-	-
BEV/E+E 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1
BEV/E+E 3	< 1	< 1	< 1	< 1	< 1	< 1	< 1
METAS	< 1	< 1	< 1	< 1	< 1	-	-
INRIM	< 1	< 1	1.12	3.72	< 1	-	-
VSL	< 1	< 1	< 1	< 1	< 1	< 1	< 1
INTA 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1
VTT	1.01	< 1	< 1	1.06	1.08	< 1	-
NPL	3.00	1.75	1.21	< 1	< 1	< 1	< 1
GUM	1.42	< 1	1.52	1.12	< 1	< 1	< 1
BEV/E+E 4	< 1	< 1	< 1	< 1	< 1	< 1	< 1
PTB	< 1	< 1	< 1	< 1	-	-	-

Note: VSL only reported three measurements at 95 °C. Therefore, the modified Birge ratio is not applicable. Instead, the Birge ratio is calculated which gives a value smaller than one. Therefore, the measurement of VSL will be considered in the further calculation.

Table 6 lists 18 cases where the modified Brige ratio is larger than one, i.e., the four reported measurements of a laboratory are inconsistent. In these cases, the uncertainty will be multiplied by the factor listed in the table in order to get consistent aggregated lab results.

7 Bilateral Equivalence

The bilateral equivalence (DoE) is calculated using a modified method compared to the first version of Draft A and is based on the method for the link also applied for the ERV later on in chapter 8 [19].

7.1 Analysis method

The bilateral equivalence D_{ij} of laboratory *i* and *j* can be calculated as

$$D_{ij=}\,\Delta t_d^{(i)} - \Delta t_d^{(j)} + \delta_{stab} = \Delta t_{d,loop(i)}^{(i)} + B(i,j) - \Delta t_{d,loop(j)}^{(j)} + \delta_{stab} \tag{7.1}$$

The subscript *loop(i)* and *loop(j)* marks the loop of laboratory *i* and *j*, respectively. The stability term δ_{stab} is zero, see chapter 4.2, but a contribution due to stability of the transfer standards will be considered in the uncertainty.

The discrete function $B(i,j)$ is used to represent the possible linkage between the two loops:

$$B(i,j) = \begin{cases} \dfrac{\sum_{m=1}^{x} \dfrac{P(i,j,m)}{u^2[P(i,j,m)]}}{\sum_{m=1}^{x} \dfrac{1}{u^2[P(i,j,m)]}} & \text{for } loop(i) \neq loop(j) \\ 0 & \text{for } loop(i) = \ loop(j) \end{cases}, \quad (7.2)^{1}$$

where *P(i,j,m)* describes the possible routs of linking and *x* is the number of link laboratories. It is the weighted mean of all possible routs of linking.

In general, the possible paths for the linkage are calculated by the difference of measurements of loop 2 and loop 1, e.g., for link laboratory INTA

$$P(1,2,INTA) = \ \Delta t_{d,L2}^{(INTA)} - \Delta t_{d,L1}^{(INTA)}. \tag{7.3}$$

First of all, the discrete function $B(i,j)$ is discussed. The linkage of both loops is calculated based on the measurements of laboratory BEV/E+E and INTA, which performed measurements with the chilled mirror hygrometer of loop 1 and loop 2. The main difference compared to the former EURAMET.T-K6 is the fact, that both laboratories were able to measure both artefacts at the same time in parallel. In EURAMET.T-K8, it is now possible to calculate a loop difference for each single measurements including the corresponding uncertainty. The advantage is that possible correlations of the measurements can be considered directly and separately. They have not to be summarized or estimated by an unknown correlation coefficient as in EURAMET.T-K6. The uncertainty for the linkage is

[1] In contrast to EURAMET.T-K6 no correction function *δ* in the function $B(i,j)$ is used. After consulting the author of EURMAET.T-K6, the correction function has no statistical motivation [22]. Instead, the consistency of the measurements, which are used for the linking, is tested.

minimized because it is reduced to the effects of the hygrometers, see also the discussion of uncertainty of $B(i,j)$ below.

The same gas flows through the chilled mirror hygrometers of loop 1 and loop 2 at the same time in the link laboratories. The devices have the same reference value $t_{d,i}^{(ref)}$ for a single measurement at a certain nominal dew-point temperature, but naturally they do not display the same value, i.e., that there are two results $t_{d,L1,i}^{(hyg)}$ and $t_{d,L2,i}^{(hyg)}$, respectively.

$$\text{loop 1: } \Delta t_{d,L1,i}^{(lab)} = t_{d,L1,i}^{(hyg)} - t_{d,i}^{(ref)}. \tag{7.4}$$
$$\text{loop 2: } \Delta t_{d,L2,i}^{(lab)} = t_{d,L2,i}^{(hyg)} - t_{d,i}^{(ref)} \tag{7.5}$$

A difference $P_{s,i}$ of both loops is calculated for each single measurement of each link laboratory:

$$P_{s,i} = \Delta t_{d,L2,i}^{(lab)} - \Delta t_{d,L1,i}^{(lab)}. \tag{7.6}$$

The index *i* represents the *i*th measurement of the four single measurements of a laboratory at each nominal dew-point temperature.

The uncertainty calculation for $\Delta t_{d,L1,i}^{(lab)}$ and $\Delta t_{d,L2,i}^{(lab)}$ is analogous to the calculation of uncertainty of aggregated lab results. There are correlated terms as well as statistical independent terms, e.g., for loop 1:

$$\begin{aligned} u^2\left(t_{d,L1,i}^{(lab)}\right) &= u^2\left(t_{d,L1,i}^{(ref)}\right) + u^2\left(t_{d,L1,i}^{(stab)}\right) + u^2\left(t_{d,L1,i}^{(res)}\right) \\ &= (u_{corr,L1,i})^2 + (u_{stat,L1,i})^2 . \end{aligned} \tag{7.7}$$

The correlated uncertainty of the reference for loop 1 and loop 2 is the same, because both chilled mirror hygrometers see the same reference value during the whole single measurement *i* at a certain nominal dew-point temperature:

$$u_{corr,i} = u_{corr,L1,i} = u_{corr,L2,i} . \tag{7.8}$$

The uncertainty for $P_{s,i}$ is given as follows:

$$u^2\left(P_{s,i}\right) = u^2\left(t_{d,L1,i}^{(lab)}\right) + u^2\left(t_{d,L2,i}^{(lab)}\right) - 2 \cdot u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right) \cdot corr_{L1,L2} . \tag{7.9}$$

The main advantage is that compared to the method of EURAMET.T-K6 and the first version of Draft A single measurements are considered. Thus, the correlation coefficient $corr_{L1,L2}$ can be calculated because the correlated and uncorrelated terms are well known:

$$corr_{L1,L2} = \frac{u_{corr,L1,i} \cdot u_{corr,L2,i}}{u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right)} = \frac{u_{corr,i} \cdot u_{corr,i}}{u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right)} = \frac{\left(u_{corr,i}\right)^2}{u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right)} . \tag{7.10}$$

Finally, the uncertainty for $P_{s,i}$ with the correlation coefficient is calculated.

$$\begin{aligned} u^2\left(P_{s,i}\right) &= u^2\left(t_{d,L1,i}^{(lab)}\right) + u^2\left(t_{d,L2,i}^{(lab)}\right) - 2 \cdot u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right) \cdot \frac{\left(u_{corr,i}\right)^2}{u\left(t_{d,L1,i}^{(lab)}\right) \cdot u\left(t_{d,L2,i}^{(lab)}\right)} \\ &= u^2\left(t_{d,L1,i}^{(lab)}\right) + u^2\left(t_{d,L2,i}^{(lab)}\right) - 2 \cdot \left(u_{corr,i}\right)^2 \end{aligned} \tag{7.11}$$

For EURAMET.T-K8, there are two sets of four measurements of laboratory BEV/E+E (BEV/E+E 1 / BEV/E+E 3 and BEV/E+E 2 / BEV/E+E 4) and one set of four measurements of laboratory INTA (INTA 1 / INTA 2), i.e., in total three link possibilities.

Each set of link laboratory provides four loop differences $P_{s,i}$ which are statistical independent. These differences $P_{s,i}$ are calculated by Eq. (7.6) and the corresponding uncertainty $u\left(P_{s,i}\right)$ by Eq. (7.11). A modified Birge ratio is calculated and applied to the value of the uncertainty when the value of the Birge ratio exceeds one. The values for the modified Birge ratio are given in Appendix E.5.

Analogous to the aggregated lab results a weighted mean for the four single loop differences $P_{s,i}$ for each of the three link laboratory sets at each nominal dew-point temperature is calculated by Eq. (7.12). The result are three aggregated loop differences $P\ (L1, L2, m)$. A modified Birge ratio for the uncertainty is applied when the value of it exceeds one, see. Eq. (7.13). The values for the modified Birge ratio are given in Appendix E.5.

$$P(L1, L2, m) = \frac{\sum_{i=1}^{n} \frac{P_{s,i}}{u^2\left(P_{s,i}\right)}}{\sum_{i=1}^{n} \frac{1}{u^2\left(P_{s,i}\right)}} \tag{7.12}$$

$$u[P(L1, L2, m)] = \frac{1}{\sum_{i=1}^{n} \frac{1}{u^2\left(P_{s,i}\right)}}$$
$$u_{BM}[P(L1, L2, m)] = \sigma_{BM} \cdot u[P(L1, L2, m)] \tag{7.13}$$

with link laboratory *m* with $i \in [1, n]$ and *n* = 4.

The three aggregated loop differences $P\ (L1, L2, m)$ are used to calculate one value for $B(L1, L2)$ at each nominal dew-point temperature. A weighted mean value without correlation is applied, as shown in Eq. (7.14). Since only three terms, the Birge ratio instead of the modified Birge ratio must be used for the uncertainty of $B(L1, L2)$, see Eq. (7.15). The values for the modified Brige ratio are given in Appendix E.5.

$$B(L1, L2) = \frac{\sum_{m=1}^{x} \frac{P(L1, L2, m)}{u_{BM}{}^2[P(L1, L2, m)]}}{\sum_{m=1}^{x} \frac{1}{u_{BM}{}^2(P(L1, L2, m))}} \tag{7.14}$$

$$u[B(L1, L2)] = \frac{1}{\sum_{m=1}^{x} \frac{1}{u_{BM}{}^2(P(L1, L2, m))}}$$
$$u_B[B(L1, L2)] = \sigma_B \cdot u[B(L1, L2)] \tag{7.15}$$

The uncertainty of the bilateral equivalence is given based on Eq. (7.1):

For $loop(i) \neq loop\ (j)$:

$$u^2(D_{ij}) = u^2\left(\Delta t_{d,loop(i)}^{(i)}\right) + u^2[B(i,j)] + u^2\left(\Delta t_{d,loop(i)}^{(j)}\right) + u_{stab}^{\,2}(i,j) \tag{7.16}$$

For $loop(i) = loop\ (j)$:

$$u^2(D_{ij}) = u^2\left(\Delta t_{d,loop(i)}^{(i)}\right) + u^2[B(i,j)] + u^2\left(\Delta t_{d,loop(i)}^{(j)}\right) + u_{stab,loop(i)}^{\,2} \tag{7.17}$$

The uncertainty due to the drift of the transfer standards in the case of different loops ($loop(i) \neq loop\ (j)$) are calculated by values of the single loops, see Table 5.

$$u_{stab}^{\,2}(i,j) = u_{stab,loop(i)}^{\,2} + u_{stab,loop(j)}^{\,2}$$

In the case of the same loop ($loop(i) = loop\ (j)$) the value for the specific loop is used, see Table 5. The calculated values and uncertainties of $B(i,j)$ are shown in Table 7.

Table 7 Calculated value and uncertainty (k=1) of $B(i,j)$ for loop 1 and 2 for combinations with loop(i) ≠ loop(j) for each nominal dew-point temperatures

	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
$B(i,j)$ in °C	0.0337	0.0389	0.0350	0.0394	0.0315	0.0305	0.0334
$u(B(i,j))$ in °C	0.0031	0.0048	0.0042	0.0040	0.0045	0.0039	0.0043

7.2 Results of the analysis

The bilateral degrees of equivalence (DoE) for each nominal dew-point temperature are listed in Table 8 to Table 14. The identification of laboratory *i* is presented in the first column, the identification of laboratory *j* is listed horizontally in the first row.

There is more than one possibility for link laboratories to calculate the DoE with other laboratories and, of course, between the link laboratories itself. In order to present only one result for each participant an averaging procedure in these cases is needed.
In the averaging process direct paths within a loop are preferred. Generally, there are two different types of laboratories: “non link laboratories” (nLL) and “link laboratories” (LL)
The following combinations occur [29]:

- nLL to nLL: For nLL in the same loop the direct path is used. For nLL within different loops the indirect path must be used using loop difference $B(i,j)$. The DoEs are calculated using Eq. (7.1). The uncertainty is given by Eq. (7.17) (same loop) and (7.16) (different loops).
- nLL to LL: Each nLL has a direct path to all LL within the same loop because both LLs have a measurement in both loops. There is no need to use the indirect path via the loop difference. The indirect paths are not considered here. The DoEs are calculated using Eq. (7.1). The uncertainty is given by Eq. (7.17).

- LL to LL: There is a direct path between the LL in each loop. Both possible results (loop 1 and loop2) are equivalent. Both results are averaged using Eq. (7.18). The uncertainty is given by Eq (7.19).

As discussed earlier, the transfer standards were measured simultaneously in a symmetric system at the link laboratories LL (here laboratory BE/E+E and INTA). The consequence of this setting is that the DoE $D_{LL1,LL2}^{(L1)}$ of the LL1 and LL2 in loop 1 and the DoE $D_{LL1,LL2}^{(L2)}$ of the LL1 and LL2 in loop 2 are fully correlated. The DoE $D_{LL1,LL2}$ for the LLs are calculated as arithmetic mean of both loop DoEs $D_{LL1,LL2}^{(L1)}$ and $D_{LL1,LL2}^{(L2)}$ [29].

$$D_{LL1,LL2} = \frac{1}{2} \cdot \left(D_{LL1,LL2}^{(L1)} + D_{LL1,LL2}^{(L2)} \right) \quad (7.18)$$

The corresponding uncertainty of this aggregated DoE $D_{LL1,LL2}$ for the LLs is calculated based on the fully correlation of the uncertainties of the loop DoEs $D_{LL1,LL2}^{(L1)}$ and $D_{LL1,LL2}^{(L2)}$.

$$u^2(D_{LL1,LL2}) = \frac{1}{2} \cdot \left(u^2\left(D_{LL1,LL2}^{(L1)} \right) + u^2\left(D_{LL1,LL2}^{(L2)} \right) \right) \quad (7.19)$$

The uncertainties of DoE are calculated according to Eq. (7.16), (7.17) and (7.19) respectively. The finally listed values of the expanded uncertainty are gained by $U(D_{ij}) = 2\,u(D_{ij})$.

Table 8 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 30 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-0.246	0.233	-0.089	0.211	-0.107	0.209	-0.180	0.223	-0.153	0.212	-0.108	0.213	-0.150	0.216	-0.128	0.209	-0.113	0.209	-0.089	0.211	-0.090	0.210	-0.106	0.212	-0.094	0.218	-0.106	0.224	-0.102	0.209
NSAI	0.246	0.233	-	-	0.157	0.114	0.139	0.111	0.066	0.135	0.094	0.115	0.138	0.117	0.097	0.123	0.119	0.110	0.133	0.111	0.157	0.114	0.156	0.112	0.140	0.116	0.152	0.126	0.140	0.136	0.144	0.109
CETIAT	0.089	0.211	-0.157	0.114	-	-	-0.018	0.053	-0.090	0.093	-0.063	0.061	-0.019	0.064	-0.060	0.074	-0.038	0.049	-0.023	0.053	0.000	0.058	-0.001	0.055	-0.017	0.062	-0.004	0.080	-0.017	0.094	-0.013	0.049
INTA	0.107	0.209	-0.139	0.111	0.018	0.053	-	-	-0.073	0.088	-0.046	0.054	-0.001	0.057	-0.043	0.069	-0.015	0.041	0.003	0.044	0.026	0.050	0.025	0.047	0.009	0.054	0.022	0.074	0.009	0.090	0.013	0.039
TUBITAK	0.180	0.223	-0.066	0.135	0.090	0.093	0.073	0.088	-	-	0.027	0.094	0.072	0.095	0.030	0.103	0.052	0.087	0.067	0.088	0.091	0.092	0.090	0.090	0.074	0.094	0.086	0.107	0.073	0.118	0.078	0.086
MIRS/ UL-FE/ LMK	0.153	0.212	-0.094	0.115	0.063	0.061	0.046	0.054	-0.027	0.094	-	-	0.044	0.065	0.003	0.076	0.025	0.052	0.040	0.055	0.064	0.060	0.062	0.057	0.046	0.063	0.059	0.081	0.046	0.096	0.050	0.051
EIM	0.108	0.213	-0.138	0.117	0.019	0.064	0.001	0.057	-0.072	0.095	-0.044	0.065	-	-	-0.041	0.078	-0.019	0.055	-0.005	0.058	0.019	0.062	0.018	0.060	0.002	0.066	0.014	0.083	0.002	0.097	0.006	0.054
FSB-LPM	0.150	0.216	-0.097	0.123	0.060	0.074	0.043	0.069	-0.030	0.103	-0.003	0.076	0.041	0.078	-	-	0.022	0.066	0.037	0.069	0.061	0.073	0.060	0.071	0.044	0.076	0.056	0.091	0.043	0.104	0.047	0.066
BEV/E+E	0.128	0.209	-0.119	0.110	0.038	0.049	0.015	0.041	-0.052	0.087	-0.025	0.052	0.019	0.055	-0.022	0.066	-	-	0.012	0.040	0.036	0.047	0.035	0.043	0.019	0.051	0.031	0.072	0.019	0.088	0.023	0.035
METAS	0.113	0.209	-0.133	0.111	0.023	0.053	-0.003	0.044	-0.067	0.088	-0.040	0.055	0.005	0.058	-0.037	0.069	-0.012	0.040	-	-	0.024	0.050	0.023	0.046	0.007	0.054	0.019	0.074	0.006	0.090	0.011	0.039
INRIM	0.089	0.211	-0.157	0.114	0.000	0.058	-0.026	0.050	-0.091	0.092	-0.064	0.060	-0.019	0.062	-0.061	0.073	-0.036	0.047	-0.024	0.050	-	-	-0.001	0.052	-0.017	0.059	-0.005	0.078	-0.017	0.093	-0.013	0.046
VSL	0.090	0.210	-0.156	0.112	0.001	0.055	-0.025	0.047	-0.090	0.090	-0.062	0.057	-0.018	0.060	-0.060	0.071	-0.035	0.043	-0.023	0.046	0.001	0.052	-	-	-0.016	0.056	-0.004	0.075	-0.016	0.091	-0.012	0.042
VTT	0.106	0.212	-0.140	0.116	0.017	0.062	-0.009	0.054	-0.074	0.094	-0.046	0.063	-0.002	0.066	-0.044	0.076	-0.019	0.051	-0.007	0.054	0.017	0.059	0.016	0.056	-	-	0.012	0.080	0.000	0.095	0.004	0.050
NPL	0.094	0.218	-0.152	0.126	0.004	0.080	-0.022	0.074	-0.086	0.107	-0.059	0.081	-0.014	0.083	-0.056	0.091	-0.031	0.072	-0.019	0.074	0.005	0.078	0.004	0.075	-0.012	0.080	-	-	-0.013	0.108	-0.008	0.071
GUM	0.106	0.224	-0.140	0.136	0.017	0.094	-0.009	0.090	-0.073	0.118	-0.046	0.096	-0.002	0.097	-0.043	0.104	-0.019	0.088	-0.006	0.090	0.017	0.093	0.016	0.091	0.000	0.095	0.013	0.108	-	-	0.004	0.087
PTB	0.102	0.209	-0.144	0.109	0.013	0.049	-0.013	0.039	-0.078	0.086	-0.050	0.051	-0.006	0.054	-0.047	0.066	-0.023	0.035	-0.011	0.039	0.013	0.046	0.012	0.042	-0.004	0.050	0.008	0.071	-0.004	0.087	-	-

Table 9 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 50 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-0.298	0.209	-0.173	0.183	-0.124	0.180	-0.232	0.193	-0.174	0.182	-0.120	0.186	-0.173	0.188	-0.152	0.179	-0.126	0.180	-0.020	0.182	-0.108	0.181	-0.126	0.182	-0.131	0.181	-0.141	0.185	-0.120	0.180
NSAI	0.298	0.209	-	-	0.125	0.120	0.174	0.116	0.066	0.135	0.123	0.118	0.178	0.124	0.124	0.128	0.145	0.114	0.172	0.116	0.277	0.119	0.190	0.117	0.171	0.120	0.167	0.118	0.156	0.124	0.178	0.116
CETIAT	0.173	0.183	-0.125	0.120	-	-	0.049	0.058	-0.059	0.090	-0.001	0.063	0.053	0.074	0.000	0.079	0.021	0.055	0.048	0.058	0.153	0.065	0.065	0.060	0.047	0.066	0.042	0.063	0.032	0.073	0.053	0.058
INTA	0.124	0.180	-0.174	0.116	-0.049	0.058	-	-	-0.108	0.084	-0.050	0.054	0.004	0.066	-0.049	0.072	-0.021	0.044	0.004	0.046	0.109	0.055	0.022	0.049	0.004	0.056	-0.001	0.052	-0.011	0.064	0.010	0.046
TUBITAK	0.232	0.193	-0.066	0.135	0.059	0.090	0.108	0.084	-	-	0.057	0.088	0.112	0.096	0.059	0.100	0.079	0.082	0.106	0.084	0.211	0.089	0.124	0.085	0.106	0.089	0.101	0.087	0.091	0.095	0.112	0.084
MIRS/ UL-FE/ LMK	0.174	0.182	-0.123	0.118	0.001	0.063	0.050	0.054	-0.057	0.088	-	-	0.055	0.070	0.001	0.076	0.022	0.050	0.049	0.053	0.154	0.061	0.066	0.056	0.048	0.062	0.043	0.059	0.033	0.070	0.055	0.053
EIM	0.120	0.186	-0.178	0.124	-0.053	0.074	-0.004	0.066	-0.112	0.096	-0.055	0.070	-	-	-0.054	0.085	-0.033	0.063	-0.006	0.066	0.099	0.072	0.012	0.067	-0.007	0.073	-0.011	0.070	-0.021	0.080	0.000	0.066
FSB-LPM	0.173	0.188	-0.124	0.128	0.000	0.079	0.049	0.072	-0.059	0.100	-0.001	0.076	0.054	0.085	-	-	0.021	0.069	0.048	0.072	0.153	0.078	0.065	0.074	0.047	0.078	0.042	0.076	0.032	0.085	0.053	0.072
BEV/E+E	0.152	0.179	-0.145	0.114	-0.021	0.055	0.021	0.044	-0.079	0.082	-0.022	0.050	0.033	0.063	-0.021	0.069	-	-	0.018	0.041	0.123	0.051	0.035	0.044	0.017	0.052	0.012	0.048	0.002	0.061	0.023	0.042
METAS	0.126	0.180	-0.172	0.116	-0.048	0.058	-0.004	0.046	-0.106	0.084	-0.049	0.053	0.006	0.066	-0.048	0.072	-0.018	0.041	-	-	0.105	0.053	0.017	0.047	-0.001	0.054	-0.005	0.051	-0.016	0.063	0.006	0.044
INRIM	0.020	0.182	-0.277	0.119	-0.153	0.065	-0.109	0.055	-0.211	0.089	-0.154	0.061	-0.099	0.072	-0.153	0.078	-0.123	0.051	-0.105	0.053	-	-	-0.088	0.055	-0.106	0.061	-0.111	0.059	-0.121	0.070	-0.100	0.053
VSL	0.108	0.181	-0.190	0.117	-0.065	0.060	-0.022	0.049	-0.124	0.085	-0.066	0.056	-0.012	0.067	-0.065	0.074	-0.035	0.044	-0.017	0.047	0.088	0.055	-	-	-0.018	0.056	-0.023	0.053	-0.033	0.065	-0.012	0.047
VTT	0.126	0.182	-0.171	0.120	-0.047	0.066	-0.004	0.056	-0.106	0.089	-0.048	0.062	0.007	0.073	-0.047	0.078	-0.017	0.052	0.001	0.054	0.106	0.061	0.018	0.056	-	-	-0.005	0.059	-0.015	0.070	0.006	0.054
NPL	0.131	0.181	-0.167	0.118	-0.042	0.063	0.001	0.052	-0.101	0.087	-0.043	0.059	0.011	0.070	-0.042	0.076	-0.012	0.048	0.005	0.051	0.111	0.059	0.023	0.053	0.005	0.059	-	-	-0.010	0.068	0.011	0.051
GUM	0.141	0.185	-0.156	0.124	-0.032	0.073	0.011	0.064	-0.091	0.095	-0.033	0.070	0.021	0.080	-0.032	0.085	-0.002	0.061	0.016	0.063	0.121	0.070	0.033	0.065	0.015	0.070	0.010	0.068	-	-	0.021	0.063
PTB	0.120	0.180	-0.178	0.116	-0.053	0.058	-0.010	0.046	-0.112	0.084	-0.055	0.053	0.000	0.066	-0.053	0.072	-0.023	0.042	-0.006	0.044	0.100	0.053	0.012	0.047	-0.006	0.054	-0.011	0.051	-0.021	0.063	-	-

Table 10 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 65 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-0.269	0.354	-0.132	0.312	-0.101	0.311	-0.233	0.323	-0.145	0.311	-0.100	0.314	-0.147	0.318	-0.137	0.310	-0.107	0.310	0.015	0.314	-0.090	0.312	-0.102	0.312	-0.102	0.310	-0.149	0.323	-0.101	0.311
NSAI	0.269	0.354	-	-	0.137	0.180	0.168	0.178	0.037	0.199	0.125	0.178	0.169	0.185	0.122	0.192	0.133	0.177	0.163	0.178	0.284	0.185	0.179	0.181	0.167	0.181	0.168	0.177	0.120	0.199	0.168	0.179
CETIAT	0.132	0.312	-0.137	0.180	-	-	0.031	0.059	-0.101	0.106	-0.013	0.059	0.032	0.077	-0.015	0.092	-0.004	0.055	0.026	0.059	0.147	0.076	0.042	0.066	0.030	0.066	0.030	0.054	-0.017	0.107	0.031	0.061
INTA	0.101	0.311	-0.168	0.178	-0.031	0.059	-	-	-0.132	0.102	-0.044	0.052	0.001	0.072	-0.046	0.087	-0.030	0.047	-0.001	0.050	0.121	0.070	0.015	0.058	0.003	0.059	0.004	0.045	-0.044	0.103	0.004	0.053
TUBITAK	0.233	0.323	-0.037	0.199	0.101	0.106	0.132	0.102	-	-	0.088	0.103	0.133	0.114	0.086	0.124	0.096	0.100	0.126	0.102	0.248	0.113	0.143	0.107	0.131	0.107	0.131	0.100	0.083	0.136	0.132	0.104
MIRS/ UL-FE/ LMK	0.145	0.311	-0.125	0.178	0.013	0.059	0.044	0.052	-0.088	0.103	-	-	0.045	0.072	-0.003	0.088	0.008	0.047	0.038	0.052	0.160	0.071	0.055	0.060	0.042	0.060	0.043	0.047	-0.005	0.103	0.044	0.055
EIM	0.100	0.314	-0.169	0.185	-0.032	0.077	-0.001	0.072	-0.133	0.114	-0.045	0.072	-	-	-0.047	0.101	-0.037	0.068	-0.007	0.071	0.115	0.087	0.010	0.077	-0.002	0.078	-0.002	0.068	-0.049	0.114	-0.001	0.073
FSB-LPM	0.147	0.318	-0.122	0.192	0.015	0.092	0.046	0.087	-0.086	0.124	0.003	0.088	0.047	0.101	-	-	0.011	0.085	0.041	0.087	0.162	0.100	0.057	0.092	0.045	0.092	0.045	0.085	-0.002	0.125	0.046	0.089
BEV/E+E	0.137	0.310	-0.133	0.177	0.004	0.055	0.030	0.047	-0.096	0.100	-0.008	0.047	0.037	0.068	-0.011	0.085	-	-	0.023	0.045	0.145	0.067	0.040	0.054	0.028	0.055	0.028	0.040	-0.020	0.100	0.029	0.048
METAS	0.107	0.310	-0.163	0.178	-0.026	0.059	0.001	0.050	-0.126	0.102	-0.038	0.052	0.007	0.071	-0.041	0.087	-0.023	0.045	-	-	0.122	0.069	0.017	0.057	0.004	0.058	0.005	0.044	-0.043	0.102	0.006	0.052
INRIM	-0.015	0.314	-0.284	0.185	-0.147	0.076	-0.121	0.070	-0.248	0.113	-0.160	0.071	-0.115	0.087	-0.162	0.100	-0.145	0.067	-0.122	0.069	-	-	-0.105	0.075	-0.117	0.076	-0.117	0.066	-0.164	0.113	-0.116	0.071
VSL	0.090	0.312	-0.179	0.181	-0.042	0.066	-0.015	0.058	-0.143	0.107	-0.055	0.060	-0.010	0.077	-0.057	0.092	-0.040	0.054	-0.017	0.057	0.105	0.075	-	-	-0.012	0.065	-0.012	0.053	-0.059	0.106	-0.011	0.060
VTT	0.102	0.312	-0.167	0.181	-0.030	0.066	-0.003	0.059	-0.131	0.107	-0.042	0.060	0.002	0.078	-0.045	0.092	-0.028	0.055	-0.004	0.058	0.117	0.076	0.012	0.065	-	-	0.000	0.053	-0.047	0.106	0.001	0.060
NPL	0.102	0.310	-0.168	0.177	-0.030	0.054	-0.004	0.045	-0.131	0.100	-0.043	0.047	0.002	0.068	-0.045	0.085	-0.028	0.040	-0.005	0.044	0.117	0.066	0.012	0.053	0.000	0.053	-	-	-0.048	0.100	0.001	0.047
GUM	0.149	0.323	-0.120	0.199	0.017	0.107	0.044	0.103	-0.083	0.136	0.005	0.103	0.049	0.114	0.002	0.125	0.020	0.100	0.043	0.102	0.164	0.113	0.059	0.106	0.047	0.106	0.048	0.100	-	-	0.048	0.103
PTB	0.101	0.311	-0.168	0.179	-0.031	0.061	-0.004	0.053	-0.132	0.104	-0.044	0.055	0.001	0.073	-0.046	0.089	-0.029	0.048	-0.006	0.052	0.116	0.071	0.011	0.060	-0.001	0.060	-0.001	0.047	-0.048	0.103	-	-

Table 11 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 80 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-	-	-0.132	0.439	-0.125	0.436	-	-	-0.152	0.437	-0.126	0.440	-	-	-0.159	0.435	-0.119	0.439	-0.054	0.479	-0.117	0.439	-0.134	0.437	-0.125	0.435	-0.195	0.439	-0.121	0.439
NSAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CETIAT	0.132	0.439	-	-	-	-	0.007	0.075	-	-	-0.020	0.081	0.006	0.097	-	-	-0.027	0.072	0.013	0.094	0.078	0.214	0.015	0.094	-0.003	0.082	0.007	0.074	-0.063	0.095	0.010	0.093
INTA	0.125	0.436	-	-	-0.007	0.075	-	-	-	-	-0.027	0.062	-0.001	0.082	-	-	-0.030	0.049	0.002	0.078	0.067	0.207	0.004	0.077	-0.013	0.062	-0.004	0.051	-0.074	0.078	0.000	0.076
TUBITAK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIRS/ UL-FE/ LMK	0.152	0.437	-	-	0.020	0.081	0.027	0.062	-	-	-	-	0.026	0.087	-	-	-0.007	0.057	0.033	0.084	0.098	0.210	0.035	0.083	0.018	0.069	0.027	0.060	-0.043	0.084	0.031	0.082
EIM	0.126	0.440	-	-	-0.006	0.097	0.001	0.082	-	-	-0.026	0.087	-	-	-	-	-0.033	0.079	0.007	0.100	0.072	0.216	0.009	0.099	-0.008	0.088	0.001	0.080	-0.069	0.100	0.004	0.098
FSB-LPM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEV/E+E	0.159	0.435	-	-	0.027	0.072	0.030	0.049	-	-	0.007	0.057	0.033	0.079	-	-	-	-	0.027	0.074	0.092	0.206	0.029	0.074	0.012	0.058	0.021	0.046	-0.049	0.075	0.025	0.073
METAS	0.119	0.439	-	-	-0.013	0.094	-0.002	0.078	-	-	-0.033	0.084	-0.007	0.100	-	-	-0.027	0.074	-	-	0.065	0.215	0.002	0.095	-0.015	0.084	-0.006	0.076	-0.076	0.096	-0.002	0.095
INRIM	0.054	0.479	-	-	-0.078	0.214	-0.067	0.207	-	-	-0.098	0.210	-0.072	0.216	-	-	-0.092	0.206	-0.065	0.215	-	-	-0.063	0.214	-0.080	0.209	-0.071	0.206	-0.141	0.215	-0.067	0.214
VSL	0.117	0.439	-	-	-0.015	0.094	-0.004	0.077	-	-	-0.035	0.083	-0.009	0.099	-	-	-0.029	0.074	-0.002	0.095	0.063	0.214	-	-	-0.017	0.083	-0.008	0.075	-0.078	0.096	-0.004	0.094
VTT	0.134	0.437	-	-	0.003	0.082	0.013	0.062	-	-	-0.018	0.069	0.008	0.088	-	-	-0.012	0.058	0.015	0.084	0.080	0.209	0.017	0.083	-	-	0.009	0.059	-0.061	0.084	0.013	0.082
NPL	0.125	0.435	-	-	-0.007	0.074	0.004	0.051	-	-	-0.027	0.060	-0.001	0.080	-	-	-0.021	0.046	0.006	0.076	0.071	0.206	0.008	0.075	-0.009	0.059	-	-	-0.070	0.076	0.004	0.074
GUM	0.195	0.439	-	-	0.063	0.095	0.074	0.078	-	-	0.043	0.084	0.069	0.100	-	-	0.049	0.075	0.076	0.096	0.141	0.215	0.078	0.096	0.061	0.084	0.070	0.076	-	-	0.074	0.095
PTB	0.121	0.439	-	-	-0.010	0.093	0.000	0.076	-	-	-0.031	0.082	-0.004	0.098	-	-	-0.025	0.073	0.002	0.095	0.067	0.214	0.004	0.094	-0.013	0.082	-0.004	0.074	-0.074	0.095	-	-

Table 12 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 85 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INTA	-	-	-	-	-	-	-	-	-	-	0.001	0.067	0.003	0.083	-	-	-0.024	0.049	0.010	0.078	0.126	0.078	0.007	0.081	0.000	0.064	0.019	0.072	-0.068	0.073	-	-
TUBITAK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIRS/ UL-FE/ LMK	-	-	-	-	-	-	-0.001	0.067	-	-	-	-	0.001	0.092	-	-	-0.029	0.063	0.007	0.089	0.123	0.088	0.003	0.091	-0.003	0.076	0.016	0.083	-0.071	0.084	-	-
EIM	-	-	-	-	-	-	-0.003	0.083	-	-	-0.001	0.092	-	-	-	-	-0.030	0.080	0.006	0.101	0.122	0.101	0.002	0.103	-0.005	0.091	0.015	0.096	-0.072	0.097	-	-
FSB-LPM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEV/E+E	-	-	-	-	-	-	0.024	0.049	-	-	0.029	0.063	0.030	0.080	-	-	-	-	0.031	0.075	0.147	0.075	0.028	0.078	0.021	0.060	0.041	0.068	-0.046	0.069	-	-
METAS	-	-	-	-	-	-	-0.010	0.078	-	-	-0.007	0.089	-0.006	0.101	-	-	-0.031	0.075	-	-	0.116	0.097	-0.004	0.099	-0.011	0.086	0.009	0.092	-0.078	0.092	-	-
INRIM	-	-	-	-	-	-	-0.126	0.078	-	-	-0.123	0.088	-0.122	0.101	-	-	-0.147	0.075	-0.116	0.097	-	-	-0.120	0.099	-0.127	0.085	-0.107	0.091	-0.194	0.092	-	-
VSL	-	-	-	-	-	-	-0.007	0.081	-	-	-0.003	0.091	-0.002	0.103	-	-	-0.028	0.078	0.004	0.099	0.120	0.099	-	-	-0.007	0.088	0.013	0.094	-0.074	0.095	-	-
VTT	-	-	-	-	-	-	0.000	0.064	-	-	0.003	0.076	0.005	0.091	-	-	-0.021	0.060	0.011	0.086	0.127	0.085	0.007	0.088	-	-	0.020	0.080	-0.067	0.081	-	-
NPL	-	-	-	-	-	-	-0.019	0.072	-	-	-0.016	0.083	-0.015	0.096	-	-	-0.041	0.068	-0.009	0.092	0.107	0.091	-0.013	0.094	-0.020	0.080	-	-	-0.087	0.087	-	-
GUM	-	-	-	-	-	-	0.068	0.073	-	-	0.071	0.084	0.072	0.097	-	-	0.046	0.069	0.078	0.092	0.194	0.092	0.074	0.095	0.067	0.081	0.087	0.087	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 13 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 90 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INTA	-	-	-	-	-	-	-	-	-	-	0.013	0.067	0.012	0.090	-	-	-0.017	0.052	-	-	-	-	0.019	0.088	0.028	0.066	0.020	0.080	-0.065	0.076	-	-
TUBITAK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIRS/ UL-FE/ LMK	-	-	-	-	-	-	-0.013	0.067	-	-	-	-	-0.001	0.096	-	-	-0.032	0.063	-	-	-	-	0.005	0.095	0.015	0.075	0.006	0.088	-0.079	0.085	-	-
EIM	-	-	-	-	-	-	-0.012	0.090	-	-	0.001	0.096	-	-	-	-	-0.031	0.087	-	-	-	-	0.007	0.112	0.016	0.096	0.007	0.107	-0.077	0.103	-	-
FSB-LPM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEV/E+E	-	-	-	-	-	-	0.017	0.052	-	-	0.032	0.063	0.031	0.087	-	-	-	-	-	-	-	-	0.034	0.085	0.043	0.062	0.035	0.077	-0.050	0.073	-	-
METAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VSL	-	-	-	-	-	-	-0.019	0.088	-	-	-0.005	0.095	-0.007	0.112	-	-	-0.034	0.085	-	-	-	-	-	-	0.009	0.094	0.000	0.105	-0.084	0.102	-	-
VTT	-	-	-	-	-	-	-0.028	0.066	-	-	-0.015	0.075	-0.016	0.096	-	-	-0.043	0.062	-	-	-	-	-0.009	0.094	-	-	-0.009	0.087	-0.093	0.083	-	-
NPL	-	-	-	-	-	-	-0.020	0.080	-	-	-0.006	0.088	-0.007	0.107	-	-	-0.035	0.077	-	-	-	-	0.000	0.105	0.009	0.087	-	-	-0.085	0.095	-	-
GUM	-	-	-	-	-	-	0.065	0.076	-	-	0.079	0.085	0.077	0.103	-	-	0.050	0.073	-	-	-	-	0.084	0.102	0.093	0.083	0.085	0.095	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 14 Degree of Equivalence DoE between the participating laboratories of EURAMET.T-K8 at nominal dew-point temperature 95 °C

	FORCE		NML/NSAI		CETIAT		INTA		TUBITAK		MIRS/UL-FE/LMK		EIM		FSB-LPM		BEV/E+E		METAS		INRIM		VSL		VTT		NPL		GUM		PTB	
	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)	Dij	Uij (k=2)
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
FORCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INTA	-	-	-	-	-	-	-	-	-	-	0.030	0.092	-	-	-	-	-0.008	0.055	-	-	-	-	0.041	0.098	-	-	0.037	0.117	-0.066	0.080	-	-
TUBITAK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIRS/ UL-FE/ LMK	-	-	-	-	-	-	-0.030	0.092	-	-	-	-	-	-	-	-	-0.041	0.087	-	-	-	-	0.011	0.119	-	-	0.007	0.135	-0.095	0.105	-	-
EIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FSB-LPM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEV/E+E	-	-	-	-	-	-	0.008	0.055	-	-	0.041	0.087	-	-	-	-	-	-	-	-	-	-	0.045	0.094	-	-	0.041	0.114	-0.061	0.075	-	-
METAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VSL	-	-	-	-	-	-	-0.041	0.098	-	-	-0.011	0.119	-	-	-	-	-0.045	0.094	-	-	-	-	-	-	-	-	-0.004	0.140	-0.107	0.110	-	-
VTT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NPL	-	-	-	-	-	-	-0.037	0.117	-	-	-0.007	0.135	-	-	-	-	-0.041	0.114	-	-	-	-	0.004	0.140	-	-	-	-	-0.102	0.128	-	-
GUM	-	-	-	-	-	-	0.066	0.080	-	-	0.095	0.105	-	-	-	-	0.061	0.075	-	-	-	-	0.107	0.110	-	-	0.102	0.128	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

8 EURAMET Comparison Reference Value

The calculation of the EURAMET reference value (ERV) is based on the procedure proposed in M. Cox [15], [16] and the procedure derived in the evaluation of the EURAMET.T-K6 [1]. The ERV is no key comparison value (KCRV) in the sense of a CC key comparison. The ERV is calculated since the KCRVs of the corresponding CCT-K8 are not available at moment of finalizing the Draft B of EURAMET.T-K8 [25].

Two methods were studied in the first version of Draft A:

- Method A: EURAMET.T-K6 evaluation with slight adaptions
- Method B: Modification for different methods for laboratories with multiple measurements

In Draft A2 a modified method based on method A, but with adjusted calculations for the linkage of the loops and the term $B(i,j)$ was presented. This method, called here C, was elaborated by Helmut Mitter [19] and will also be applied for the CCT-K8 [27]. The main difference is the correct consideration of correlation in the calculation of the aggregated lab result. Additionally, the consideration of drift term in the calculation of the function $B(i,j)$ was modified. In Draft A3 the method C is complemented with the consideration of the correlation among the link laboratories and a procedure to aggregate multiple results of the link laboratories [29].

<u>Method C (complemented)</u>

As in in the scheme of the EURMAET.T-K6 not all participants measured both transfer standard. Since only the pilot, co-pilot and the link laboratory measured both transfer standards, no overall ERV is calculated. Instead, the differences between the result of the laboratory and the reference value for its comparison loop are evaluated. The link between the measurements with different transfer standards, respectively different loops, is done via the function $B(i,j)$ as shown in Eq. (8.1). The detailed derivation of the function $B(i,j)$ is given in chapter 7.1. There are two equal ways of correction possible: one to loop 1 (LRV1) and one to loop 2 (LRV2), where LRV is short for loop reference value. The LRV1 and LRV2 are not real reference values but describe a mean offset of the artefacts compared to the laboratory references. The LRVs are characteristics of the transfer standards, not of the laboratory references. Thus, it is clearer to call them “loop reference values” (LRV, LRV1 for loop 1 an LRV2 for loop 2, respectively) which will be done in the further text. ERV will only be used when the final result is meant.

The lab difference to LRV for laboratory *lab* is calculated as follows:

$$\Delta t_d^{(lab)} - \Delta t_d^{(LRV)} = \Delta t_d^{(lab)} - \frac{\sum_{i=1}^{n} \frac{\Delta t_d^{(i)\prime}}{u^2\left(\Delta t_d^{(i)\prime}\right)}}{\sum_{i=1}^{n} u^{-2}\left(\Delta t_d^{(i)\prime}\right)} + \delta_{stab,loop(lab)}$$
$$= \Delta t_d^{(lab)} - \frac{\sum_{i=1}^{n} \frac{\Delta t_d^{(i)} + B(loop(lab),i)}{u^2\left(\Delta t_d^{(i)}\right) + u^2[B(loop(lab),i)]}}{\sum_{i=1}^{n}\left[u^2\left(\Delta t_d^{(i)}\right) + u^2[B(loop(lab),i)]\right]^{-1}} + \delta_{stab,loop(lab)} \quad (8.1)$$

The LRV $\Delta t_d^{(LRV)}$ is calculated as weighted mean of the loop corrected value of the aggregated lab results $\Delta t_d^{(i)\prime}$ of all *n* laboratories, which contributes to the ERV, following Eq. (8.1).The equations is valid for loop 1 with $\Delta t_d^{(LRV1)}$ and the corresponding usage of the use of $B(i,j)$, respectively for loop 2 with $\Delta t_d^{(LRV2)}$.

In the case of EURAMET.T-K8 all laboratories are possible candidates to contribute to the ERV, except the secondary laboratories FORCE and NML/NSAI. For laboratory BEV/E+E only one measurement for each loop is considered, i.e., the measurements BEV/E+E 2 and BEV/E+E 4 (at the end of each loop). The pilot PTB is treated as normal participant, i.e., only one result (measurement PTB 4 at the end of loop 2) is included in the calculation.

The uncertainty of the difference of the lab to the loop reference value consists of four contributions as shown in Eq. (8.6) and Eq. (8.7), [29]:

1. Measurement uncertainty of the aggregated lab result:
   The contribution $u\left(\Delta t_d^{(lab)}\right)$ is calculated by Eq. (6.8).

2. Uncertainty contribution of the weighted mean of the loop corrected lab results (i.e., LRV1 or LRV2):
   The contribution is calculated as the normal variance $\nu\left(\Delta t_d^{(LRV)}\right)$ of the weighted mean value, see Eq. (8.2).

$$\nu\left(\Delta t_d^{(LRV)}\right) = u^2\left(\Delta t_d^{(LRV)}\right)$$
$$= \left[\sum_{i=1}^{n}\left[u^2\left(\Delta t_d^{(i)\prime}\right)\right]^{-1}\right]^{-1} = \left[\sum_{i=1}^{n}\left[u^2\left(\Delta t_d^{(i)}\right) + u^2[B(loop(lab),i)]\right]^{-1}\right]^{-1} \quad (8.2)$$

3. Covariance term due to the correlation between the link laboratories:
   The measurements of the link laboratory in both loops were performed at the same time and simultaneously. The pair of measurements of the link laboratories in both loops are correlated. This influence is considered via a covariance term $cov\left(\Delta t_d^{(LRV)}\right)$.

$$cov\left(\Delta t_d^{(LRV)}\right) = 2\cdot\left[\nu\left(\Delta t_d^{(LRV)}\right)\right]^2\cdot\sum_{i,j}\frac{corr_{i,j}}{u\left(\Delta t_d^{(i)\prime}\right)\cdot u\left(\Delta t_d^{(j)\prime}\right)} \qquad (8.3)$$

The correlation factor $corr_{i,j}$ in Eq. (8.3) is analogous to Eq. (6.9) given as the relation of the product of the correlated parts to the product of the uncertainty of the combined uncertainty as shown in Eq. (8.4).

$$corr_{i,j} = \frac{u_{corr,i}\cdot u_{corr,j}}{u\left(\Delta t_d^{(i)\prime}\right)\cdot u\left(\Delta t_d^{(j)\prime}\right)} = \frac{u\left(\Delta t_d^{(i)}\right)\cdot u\left(\Delta t_d^{(j)}\right)}{u\left(\Delta t_d^{(i)\prime}\right)\cdot u\left(\Delta t_d^{(j)\prime}\right)} \qquad (8.4)$$

The correlation coefficient for non-link laboratories is zero. Thus, there are only terms for pairs of link laboratories, and no contributions for the non-link laboratories. The sum in Eq.(8.5) is therefore only over the link laboratories.
Inserting Eq. (8.4) in Eq. (8.3) leads to the expression for the covariance of $\Delta t_d^{(LRV)}$ for the link-laboratroies:

$$cov\left(\Delta t_d^{(LRV)}\right) = 2\cdot\left[\nu\left(\Delta t_d^{(LRV)}\right)\right]^2\cdot\sum_{\substack{k\\ link-labs}}\frac{u\left(\Delta t_d^{(k,L1)}\right)\cdot u\left(\Delta t_d^{(k,L2)}\right)}{u^2\left(\Delta t_d^{(k,L1)\prime}\right)\cdot u^2\left(\Delta t_d^{(k,L2)\prime}\right)} \qquad (8.5)$$

The correlation is calculated by the lab uncertainties $u\left(\Delta t_d^{(k,L1)}\right)$ of loop 1 and $u\left(\Delta t_d^{(k,L2)}\right)$ of loop 2 of the *k*th link laboratory in relation to the loop corrected variances $u^2\left(\Delta t_d^{(k,L1)\prime}\right)$ of loop 1 and $u^2\left(\Delta t_d^{(k,L2)\prime}\right)$ of loop 2 of the *k*th link laboratory.

4. Contribution due to the stability of the transfer standards:
   In contrast to EURAMET.T-K6 and the first version of Draft A of EURAMET.T-K8 the stability of the artefacts is considered not in the linkage function $B(i,j)$, but as separated term in the calculation of the uncertainty of the lab difference to LRV, see Eq. (8.6) and (8.7). The uncertainty due to stability is the minimum of uncertainty, which will be observed also in the extreme case when the uncertainty of the laboratory equals the uncertainty of LRV.

   As described in chapter 4.2, no drift correction is performed ($\delta_{stab,L1} = \delta_{stab,L1} = 0$ in Eq. (8.1)), but a contribution to the uncertainty $u(\delta_{stab})$ will be considered. Thus, both equations for the uncertainty of the lab difference to LRV include a term for the stability of the artefacts, i.e., the drift of the artifacts is considered in the uncertainty of the lab differences to the LRV. Depending on the loop *loop(lab)* of the laboratory *lab* the corresponding value is chosen, see Table 5.
   For laboratories of loop 1: $u_{stab,loop(lab)} = u(\delta_{stab,L1}) = 0.0038\ \mathrm{K}$
   For laboratories of loop 2: $u_{stab,loop(lab)} = u(\delta_{stab,L2}) = 0.0017\ \mathrm{K}$

For the uncertainty of lab difference to the LRV, it must be distinguished between laboratories which contributes to the LRV and laboratories which do not contribute to the

LRV. The uncertainty of the lab difference to the LRV is for laboratories which contribute to the LRV correlated. This leads to the following two cases:

Laboratory contributes to LRV:

$$u^2\left(\Delta t_d^{(lab)} - \Delta t_d^{(LRV)}\right) = u^2\left(\Delta t_d^{(lab)}\right) - \nu\left(\Delta t_d^{(LRV)}\right) + cov\left(\Delta t_d^{(LRV)}\right) + u_{stab,loop(lab)}^2 \qquad (8.6)$$

Laboratory does not contribute to LRV:

$$u^2\left(\Delta t_d^{(lab)} - \Delta t_d^{(LRV)}\right) = u^2\left(\Delta t_d^{(lab)}\right) + \nu\left(\Delta t_d^{(LRV)}\right) + cov\left(\Delta t_d^{(LRV)}\right) + u_{stab,loop(lab)}^2 \qquad (8.7)$$

The difference between both equations is the sign of the second term considering the status of correlation. Laboratories which contribute to the LRV have correlation between their lab result and the LRV. This correlation leads to the “-“ in Eq. (8.6). Laboratories which do not contribute to the LRV, like the secondary laboratories C and D, are not correlated with the LRV. This is expressed by the “+” in Eq. (8.7). Further explanation of the derivation of Eq. (8.6) is given in Appendix E.2.

Finally, there are two LRVs calculated for each nominal dew-point temperature. One LRV is related to loop 1 (the difference is normalized with the $B(L1, L2)$ to loop 1) and one ERV which is related to loop 2 (the difference is normalized with $B(L1, L2)$ to loop 2). In the final results the lab difference to the ERV is calculated for laboratories of loop 1 with the LRV of loop 1 and for laboratories of loop 2 with the LRV of loop 2. Thus, only one difference to ERV will be given for each laboratory at each nominal dew-point temperature at which the laboratory performed measurements.

For laboratories of loop 1: $\Delta t_d^{(lab)} - \Delta t_d^{(ERV)} = \Delta t_d^{(lab)} - \Delta t_d^{(LRV1)}$

For laboratories of loop 2: $\Delta t_d^{(lab)} - \Delta t_d^{(ERV)} = \Delta t_d^{(lab)} - \Delta t_d^{(LRV2)}$

The link laboratories BEV/E+E and INTA have measurements in loop1 and in loop 2, i.e., a valid result for both artefacts. It is necessary to aggregate the multiple measurements of the link laboratories to show only one results for each laboratory in the final results. The lab difference to the ERV is the arithmetic mean of the result in loop 1 and the result in loop 2, see Eq. (8.8).

$$\Delta t_d^{(lab)} - \Delta t_d^{(ERV)} = \frac{1}{2} \cdot \left[\left(\Delta t_{d,L1}^{(lab)} - \Delta t_d^{(LRV1)}\right) + \left(\Delta t_{d,L2}^{(lab)} - \Delta t_d^{(LRV2)}\right)\right] \qquad (8.8)$$

Both results of a link laboratory are correlated which must be considered in the calculation of the measurement uncertainty, see Eq. (8.9).

$$u^2\left(\Delta t_d^{(lab)}-\Delta t_d^{(ERV)}\right) = \frac{1}{4}\cdot\left[u^2\left(\Delta t_{d,L1}^{(lab)}-\Delta t_d^{(LRV1)}\right)+u^2\left(\Delta t_{d,L1}^{(lab)}-\Delta t_d^{(LRV1)}\right)+2\cdot corr_{L1,L2}\cdot u\left(\Delta t_{d,L1}^{(lab)}-\Delta t_d^{(LRV1)}\right)\cdot u\left(\Delta t_{d,L1}^{(lab)}-\Delta t_d^{(LRV2)}\right)\right] \tag{8.9}$$

The uncertainty $u\left(\Delta t_{d,L1}^{(lab)}-\Delta t_d^{(LRV1)}\right)$ and $u\left(\Delta t_{d,L2}^{(lab)}-\Delta t_d^{(LRV2)}\right)$ are given by Eq. (8.6) and (8.7). They consist of a correlated and an uncorrelated part as Eq. (8.10) shows for example for loop 1:

$$\begin{aligned} u^2\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right) &= u^2\left(\Delta t_d^{(lab)}\right)-\nu\left(\Delta t_d^{(LRV1)}\right)+cov\left(\Delta t_d^{(LRV1)}\right)+u_{stab,L1}^2 \\ &= u_{corr,lab,L1}^2\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right)+u_{stab,L1}^2 \end{aligned} \tag{8.10}$$

with

$$u_{corr}^2\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right) := u^2\left(\Delta t_d^{(lab)}\right)-\nu\left(\Delta t_d^{(LRV1)}\right)+cov\left(\Delta t_d^{(LRV1)}\right)$$

The correlation coefficient in Eq. (8.9) is then given by Eq. (8.11):

$$corr_{L1,L2} = \frac{u_{corr,lab,L1}\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right)\cdot u_{corr,lab,L2}\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV2)}\right)}{u\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right)\cdot u\left(\Delta t_d^{(lab)}-\Delta t_d^{(LRV1)}\right)} \tag{8.11}$$

The final results are checked by using a discrepancy criterion. The criterion is defined as in the evaluation of CCT-K6 [1] and the technical protocol of CCT-K8 [14]. Consequently, a differentiation between laboratories, which contributes to the ERV (Eq. (8.12)) and laboratories which do not contribute to the ERV (Eq. (8.13)), is necessary analogous to the uncertainty of the lab difference to the ERV. The structure of both equations is similar to Eq. (8.6) and Eq. (8.7) for the calculation of the difference of the lab results to the corresponding LRV.

Laboratory contributes to ERV:

$$\left|\Delta t_d^{(lab)}-\Delta t_d^{(ERV)}\right| > 2\cdot\sqrt{u^2\left(\Delta t_d^{(lab)}\right)-\nu\left(\Delta t_d^{(LRV)}\right)+cov\left(\Delta t_d^{(LRV)}\right)+u_{stab,loop(lab)}^2} \tag{8.12}$$

Laboratory does not contribute to ERV:

$$\left|\Delta t_d^{(lab)}-\Delta t_d^{(ERV)}\right| > 2\cdot\sqrt{u^2\left(\Delta t_d^{(lab)}\right)+\nu\left(\Delta t_d^{(LRV)}\right)+cov\left(\Delta t_d^{(LRV)}\right)+u_{stab,loop(lab)}^2} \tag{8.13}$$

Both equations include beside the contributions of the aggregated lab results and the ERV also a term for the stability of the artefacts analogous to the uncertainty of the lab differences to the ERV. Results, which do not pass the criterion, are shown in Table 15. The values of the discrepancy criterion are depicted in Figure 8.

The results are additionally tested by a chi-squared test for each loop. Here only the laboratories are considered which contribute to the ERV. The chi-squared test is performed for the results corrected to loop 1 and loop 2 separately.

The observed chi-squared value is calculated

$$X_{obs}^2 = \sum_{i=1}^{n} \frac{\left(\Delta t_{d,}^{(i)\prime} - \Delta t_d^{(LRV)}\right)^2}{u^2\left(\Delta t_{d,}^{(i)\prime}\right)} . \quad (8.14)$$

The data is consistent at significance of α = 0.95, if

$$X_{obs}^2 \leq X_{n-1,1-\alpha}^2 \quad (8.15)$$

with n number of results which contribute to the evaluated subset. The chi-squared test is applied to subset of all results in order to avoid checking correlated results. If all subsets fulfill the chi-squared test with the same LRV, then the set union also fulfills the chi-squared test in respect to the tested LRV.

Here following subsets are tested for each of the two LRV (LRV1 and LRV2):

- Subset 1 considers only the values of loop 1 for the link laboratories.
- Subset 2 considers only the values of loop 2 for the link laboratories.
- Subset 3 considers the values of both loops for the link laboratories.

All three tests must be fulfilled to pass the chi-squared test.

Table 15 Outliers based on the Eq. (8.12) and (8.13) and result or consistency test for both loops, brackets indicate special cases, see text for further explanation

	30°C	**50°C**	**65°C**	**80°C**	**85°C**	**90°C**	**95°C**
loop 1	NML/NSAI	NML/NSAI, TUBITAK	TUBITAK	-	-	-	-
loop 2	-	INRIM	INRIM	(INRIM)	INRIM	-	-
consistency test	passed	failed (with INRIM) passed (without INRIM)	passed	passed	passed	passed	passed

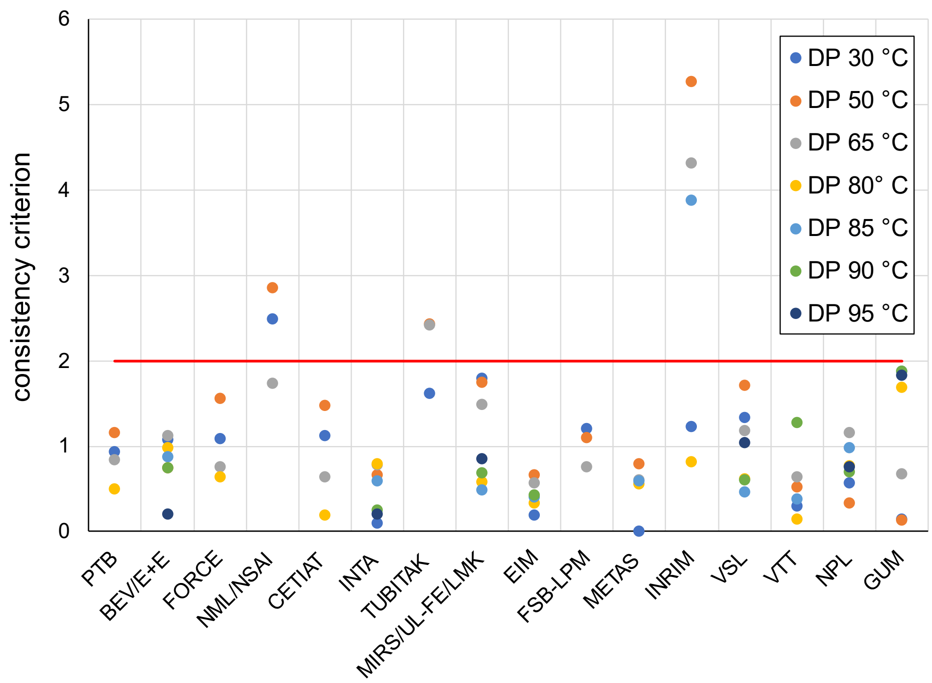

Figure 8 Results of discrepancy criterion according to Eq.(8.12) and (8.13)

Besides the detected outliers the results show excellent agreement, especially at nominal dew-point temperature of 30 °C and at the higher nominal dew-point temperatures 80 °C up to 95 °C. Compared to the first version of Draft A the number of outliers is substantially reduced.

Laboratory NML/NSAI as secondary laboratory does not contribute to the ERV. It shows outliers based on the criterion at 30 °C and 50 °C, i.e., at two at its three measurements. The values of the criterion are approx. 2.5 respectively 2.9 (discrepancy limit of 2). The results do not influence the chi-squared test, because the test is only calculated with laboratories which contribute the ERV. Since the measurements in 2009, NML/NSAI has carried out a lot of improvements to its capabilities (see Appendix C Table 32). NML/NSAI is working on a primary dew-point generator ranging from -45 °C up to 90 °C which will replace the secondary set up in the future.

Laboratory TUBITAK is a primary laboratory and has outliers based on the criterion at 50 °C and 65 °C, i.e., at two of its three measurements. The values of the criterion are approx. 2.4 in both cases (discrepancy limit of 2). The measurements are included in the calculation of the ERV because the chi-squared test is still passed with these two results.

More problematic is the case of the primary laboratory INRIM at nominal dew-point temperatures above 30 °C. At 50 °C nominal dew-point temperature the laboratory must be removed from the contributing laboratories to the ERV otherwise the chi-squared test fails. The laboratory shows values for the discrepancy criterion ranging from approx. 4 up to 5.5 with an exception at 30 °C and 80 °C nominal dew-point temperature. The modified Birge ratio is quite large with 3.72 (see Table 6) at 80 °C nominal dew-point temperature which leads to a huge increasement of the uncertainty for the aggregated lab result at this nominal dew-point temperature (see Figure 7). Thus, the differences between the reported single results of around 0.2 K is covered by the enlarged uncertainty. The overall picture let assume that there were problems with the reference system during the comparison at nominal dew-point temperatures above 30 °C. Therefore, it is decided to reject these results of INRIM for the calculation of ERV. Only at 30 °C nominal dew-point temperature the value is considered in the calculation of the ERV.

The CMCs of INRIM are based and well demonstrated in a comparison with 8 participants from all-over Europe covering a dew-point temperature range from -70 °C and +80 °C [23]. INRIM reported that the reference system was under revision at the time of the EURAMET.T-K8 and that a limitation within the higher range were observed previously and during this comparison [24]. Additionally, a wrong calibration parameter of the reference thermometer caused a systematic deviation in the temperature bridge measurement indication which increases with the nominal dew-point temperature. This was detected in the re-checking of the data during the preparation of the second version of Draft A [24]. After major revision of the generator the reference system shows excellent results in the CCT-K8 [27] demonstrating the successful revision of the reference system.

Generally, it must be emphasized at this point that the measurements describe the status around 10 years ago for all laboratories. Thus, a lot of reference systems have been improved or could have been replaced by new set ups in the meantime. The conclusions drawn here might give only a limited indication of the actual status of the reference systems at the laboratories now, depending on the changes made at the various laboratories. A survey among all participants about the changes applied to their equipment was done in 2023[2]. The results and details are shown in Table 32 in Appendix C: seven participants still use their equipment in an unchanged configuration since the comparison. Seven other participants have performed only slightly changes. Only two participants stated that a new equipment was used. Based on these results it can be concluded that for most of the participants the results of the comparison are still useful.

Figure 9 to Figure 15 summarize the results of the difference to ERV $\Delta t_d^{(lab)} - \Delta t_d^{(ERV)}$ for both loops. The detailed results are listed in Table 16 and Table 17. The final listed values of the expanded uncertainty are gained by $U\left(\Delta t_d^{(lab)} - \Delta t_d^{(ERV)}\right) = 2\,u\left(\Delta t_d^{(lab)} - \Delta t_d^{(ERV)}\right)$.

[2] The survey was refined for some participants during the review process of draft B.

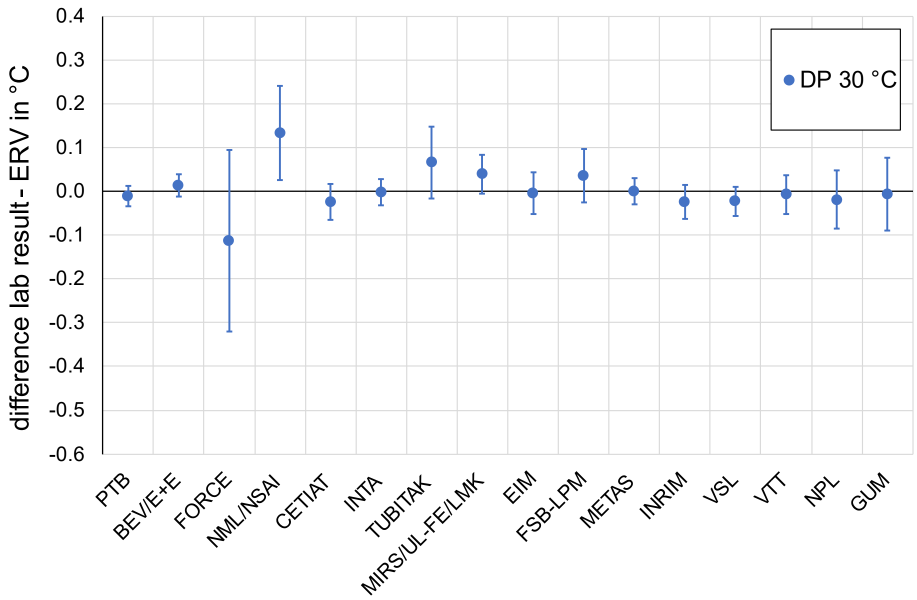

Figure 9 Lab difference to ERV for the nominal dew-point temperature 30 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

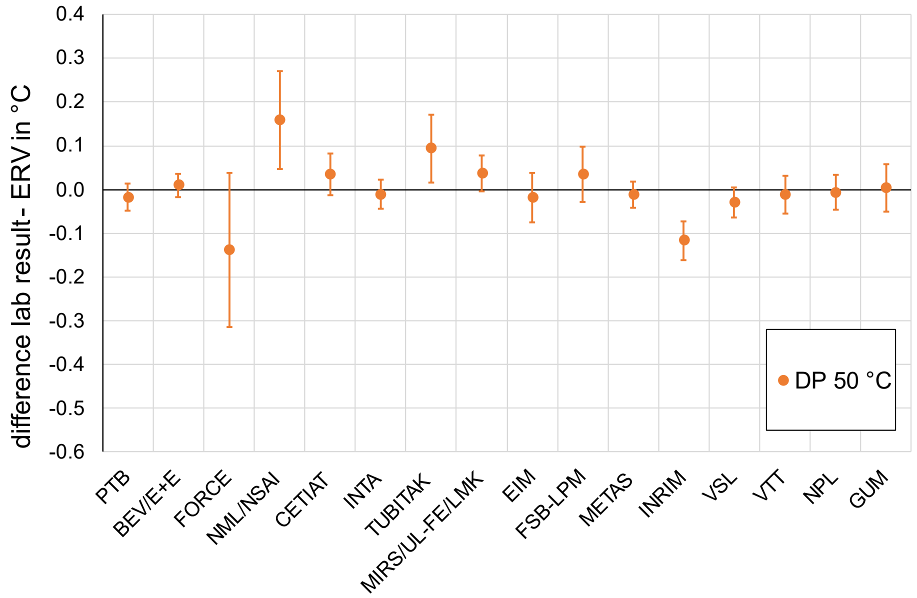

Figure 10 Lab difference to ERV for the nominal dew-point temperature 50 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

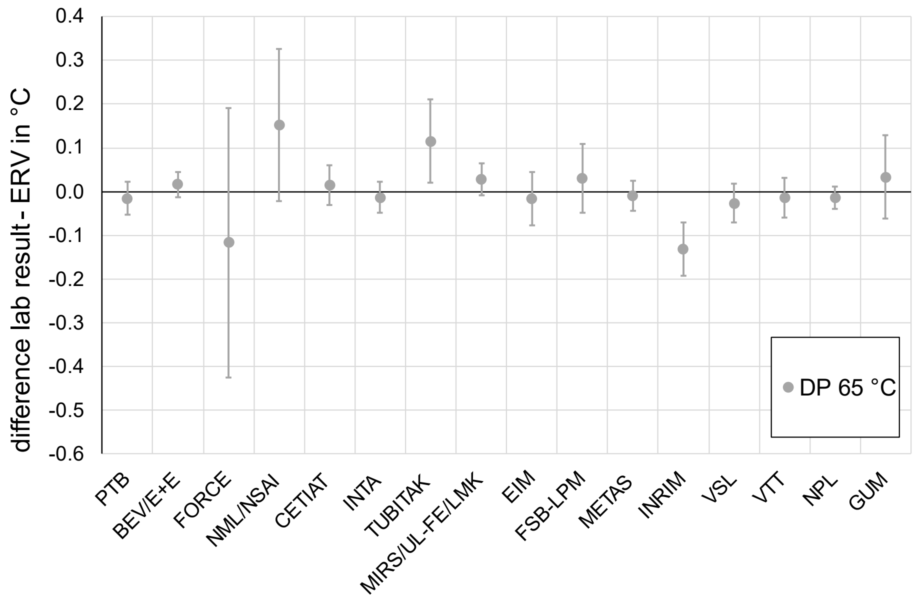

Figure 11 Lab difference to ERV for the nominal dew-point temperature 65 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

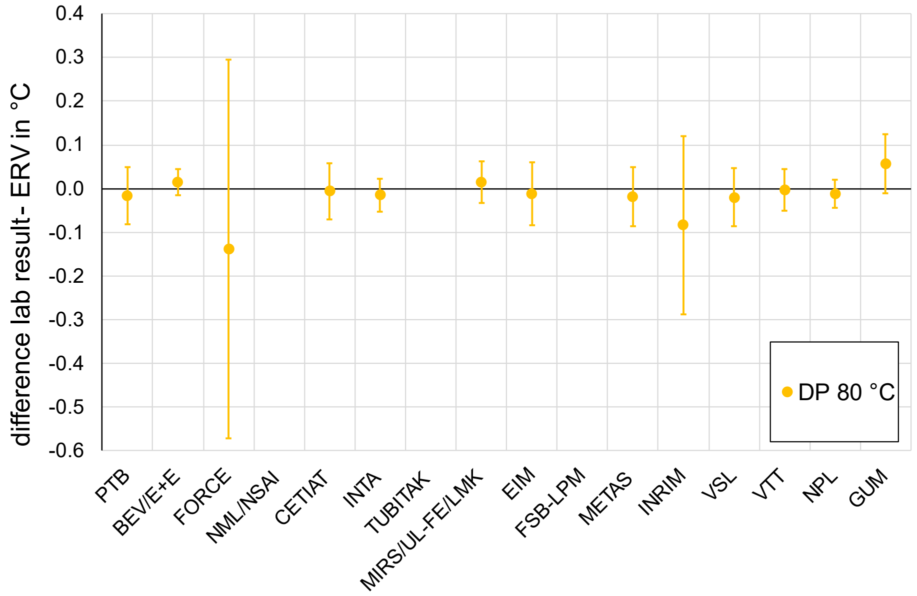

Figure 12 Lab difference to ERV for the nominal dew-point temperature 80 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

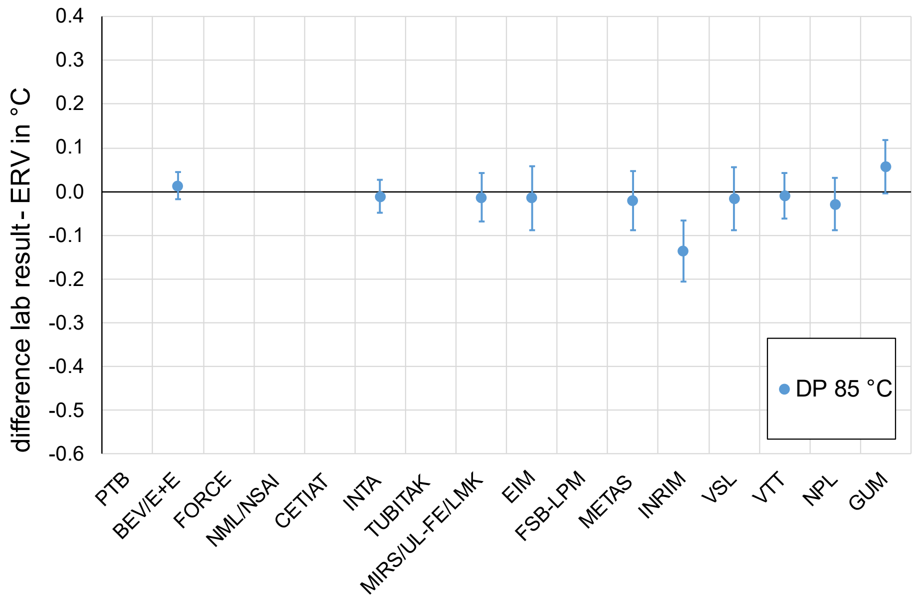

Figure 13 Lab difference to ERV for the nominal dew-point temperature 85 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

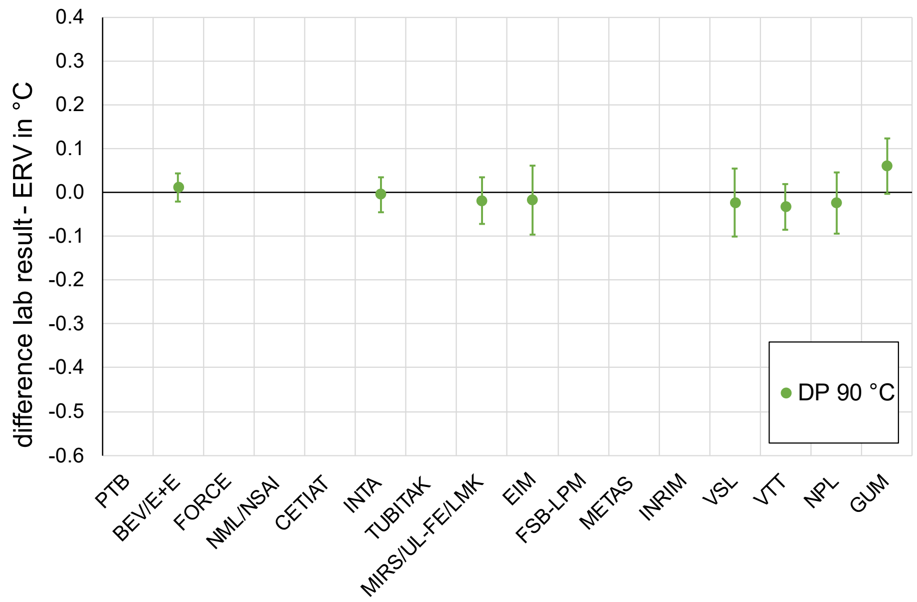

Figure 14 Lab difference to ERV for the nominal dew-point temperature 90 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

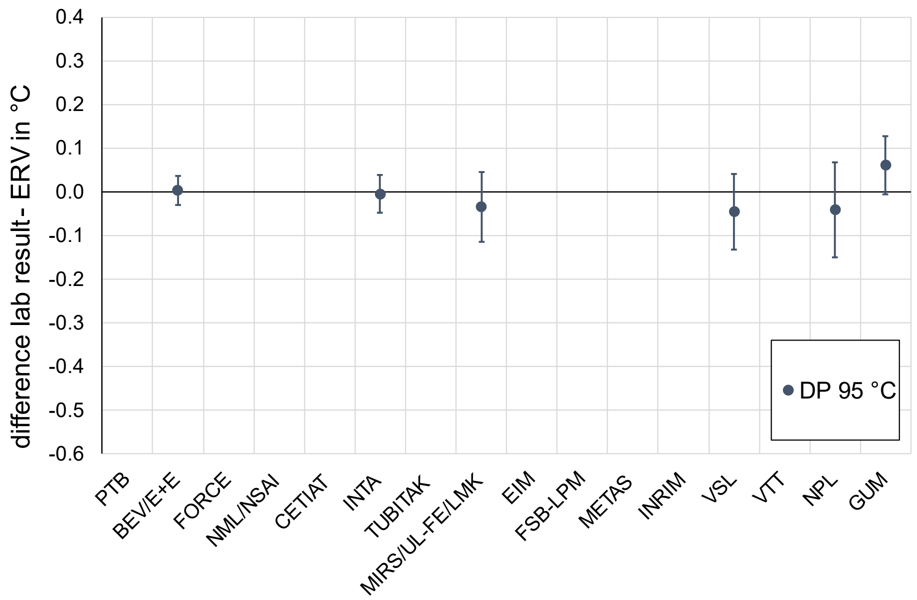

Figure 15 Lab difference to ERV for the nominal dew-point temperature 90 °C according to Eq. (8.1) and (8.8) with uncertainty (k = 2) according to Eq. (8.6), (8.7), and (8.9).

Table 16 Results for the ERV and the lab differences to the ERV including the expanded uncertainty with k = 2 for nominal dew-point temperature 30 °C, 50 °C, 65 °C, and 80 °C. The greyed values mark the results of secondary laboratories. These results are not considered for the calculation of the ERV at those nominal dew-point temperatures.

	DP 30 °C		DP 50 °C		DP 65 °C		DP 80 °C	
	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ *k* = 2	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ *k* = 2	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ *k* = 2	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ *k* = 2
	in °C	in °C	in °C	in °C	in °C	in °C	in °C	in °C
LRV1	**-0.187**	**0.013**	**-0.198**	**0.014**	**-0.205**	**0.014**	**-0.211**	**0.017**
LRV2	**-0.154**	**0.011**	**-0.160**	**0.012**	**-0.171**	**0.013**	**-0.171**	**0.016**
PTB	-0.010	0.022	-0.018	0.031	-0.016	0.038	-0.016	0.065
BEV/E+E	0.014	0.025	0.010	0.027	0.016	0.029	0.015	0.030
FORCE	-0.113	0.207	-0.138	0.177	-0.118	0.309	-0.138	0.434
NML/NSAI	0.133	0.107	0.159	0.111	0.152	0.175	-	-
CETIAT	-0.023	0.042	0.035	0.047	0.015	0.046	-0.006	0.064
INTA	-0.002	0.031	-0.011	0.033	-0.014	0.036	-0.015	0.038
TUBITAK	0.067	0.082	0.093	0.077	0.115	0.095	-	-
MIRS/UL-FE/LMK	0.040	0.044	0.036	0.041	0.027	0.037	0.014	0.048
EIM	-0.005	0.048	-0.019	0.056	-0.017	0.061	-0.012	0.072
FSB-LPM	0.037	0.061	0.035	0.064	0.030	0.079	-	-
METAS	0.000	0.030	-0.012	0.031	-0.010	0.034	-0.019	0.067
INRIM	-0.024	0.039	-0.117	0.044	-0.132	0.061	-0.084	0.204
VSL	-0.023	0.034	-0.030	0.034	-0.027	0.045	-0.021	0.066
VTT	-0.007	0.044	-0.011	0.043	-0.015	0.045	-0.003	0.048
NPL	-0.019	0.067	-0.007	0.039	-0.015	0.026	-0.013	0.033
GUM	-0.006	0.084	0.004	0.054	0.033	0.096	0.057	0.068

Table 17 Results for the ERV and the lab differences to the ERV including the expanded uncertainty with k = 2 for nominal dew-point temperature 85 °C, 90 °C, and 95 °C. The greyed values mark the results of secondary laboratories. These results are not considered for the calculation of the ERV at those nominal dew-point temperatures.

	DP 85 °C		DP 90 °C		DP 95 °C	
	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ $k = 2$	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ $k = 2$	$\Delta t_d^{lab} - t_d^{ERV}$	$U(\Delta t_d^{lab} - t_d^{ERV})$ $k = 2$
	in °C	in °C	in °C	in °C	in °C	in °C
LRV1	**-0.207**	**0.019**	**-0.208**	**0.021**	**-0.207**	**0.024**
LRV2	**-0.175**	**0.018**	**-0.177**	**0.020**	**-0.173**	**0.023**
PTB	-	-	-	-	-	-
BEV/E+E	0.013	0.030	0.012	0.033	0.003	0.033
FORCE	-	-	-	-	-	-
NML/NSAI	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-
INTA	-0.011	0.037	-0.005	0.039	-0.004	0.044
TUBITAK	-	-	-	-	-	-
MIRS/UL-FE/LMK	-0.013	0.055	-0.018	0.053	-0.034	0.080
EIM	-0.015	0.073	-0.017	0.080	-	-
FSB-LPM	-	-	-	-	-	-
METAS	-0.020	0.068	-	-	-	-
INRIM	-0.136	0.070	-	-	-	-
VSL	-0.017	0.071	-0.024	0.078	-0.046	0.087
VTT	-0.010	0.051	-0.033	0.051	-	-
NPL	-0.030	0.060	-0.024	0.069	-0.041	0.109
GUM	0.058	0.061	0.060	0.064	0.061	0.067

A comparison of the calculation with and without considering the stability of the artifacts in the uncertainty shows that the influence is maximum in the magnitude of 0.001 K. The influence on the discrepancy criterion is not larger than 0.056 and therefore in a magnitude which does not influence the decision whether the laboratory has an outliner or not. There is naturally no influence of the results of the laboratory. Nevertheless, since both artefacts show drifts with opposite signs, the effect of the possible drift has its maximum in this case compared to the case of synchronal drifting artefact. Thus, it is here justified and even senseful that the stability of the artifacts is considered in the uncertainty.

9 Linkage to CCT-K8

According to the EURAMET Guideline No. 4 [25] and the CIPM MRA-11 [26] the linkage between the key comparison on BIPM level and the key comparison on RMO level must be performed by the pilot of the RMO comparison when key comparison reference value (KCRV) of a CC comparison is available.

Recently the first version of the Draft A of the CCT-K8 [27] was distributed to the participants and it is expected that the Draft B of the CCT-K8 will be published within the process of Draft B and final report of EURAMET.T-K8. Therefore, here a procedure according to CIPM MRA-11 will be presented.

9.1 Link between two RMOs

The link between a participating laboratory in EURAMET.T-K8 and another RMO K8 comparison is achieved by using a chain of bilateral degrees of equivalence. Laboratory X participated in EURAMET.T-K8. This laboratory should be linked to a laboratory Z which measured in another RMO K8 comparison. Both laboratories did not take part in the CCT-K8. The link will now be established using the results of two more laboratories who took both part in the CCT-K8 and additionally in the ERUAMET.T-K8 (laboratory Y1) and respectively in the other RMO comparison (laboratory Y2).

The link is written down as a chain of bilateral equivalences [20]:

$$D_{X,Z} = D_{X,Y1}^{EURAMET} + D_{Y1,Y2}^{CCT} + D_{Y2,Z}^{RMO} \tag{9.1}$$

The uncertainty is calculated based on the given values for the bilateral DoE in the respectively comparison. Additionally, correlations must be considered. The value of the correlation coefficients depends on the grade of the dependence of the results of laboratory Y1 and Y2 in the two comparisons they took part in. The grade of dependence is given by the extent of the changes made to the equipment between both measurements.

The uncertainty for the DoE of Eq. (9.1) is then given by [20]:

$$u^2(D_{X,Z}) = u^2(D_{X,Y1}^{EURAMET}) + u^2(D_{Y1,Y2}^{CCT}) + u^2(D_{Y2,Z}^{RMO}) - 2 \cdot corr \cdot u(Y1^{EURAMET}) \cdot u(Y1^{CCT}) - 2 \cdot corr \cdot u(Y2^{CCT}) \cdot u(Y2^{RMO}) \tag{9.2}$$

The correlation coefficient *corr* ranges from 0 up to 1. The correlation coefficient equalling 0 means that there is no correlation between the laboratory the term vanishes (major changes to the reference system of the laboratory). The correlation coefficient equalling 1 means that the results of the measurements in both comparisons are fully correlated (same reference system). The uncertainties in the two covariance terms are the uncertainties of the results of the laboratories in the respectively comparison (aggregated lab results, not the deviation to the reference value).

It has to be noted that the calculation of $D_{X,Z}$ and the uncertainty $u(D_{X,Z})$ neither include the references values of the RMO comparisons nor the KCRV of the CCT-K8.

9.2 Link EURAMET.T-K8 to CCT-K8

There is another kind of linkage which will be described in the following. The focus here is on the link of laboratories to the KCRV which participated in the EURAMET.T-K8 but not in the CCT-K8. A procedure will be described to assign these laboratories a deviation to the KCRV of the CCT-K8, as claimed in CIPM-MRA-11 [26]. The aim of the linkage is to establish a direct link for the RMO comparisons to the KRCV of the CCT-K8.

The link for a laboratory X, which participated in EURAMET.T-K8 but not in CCT-K8, will be performed by using the result of a link laboratory, e.g., Y, in CCT-K8 and the bilateral DoE of the laboratory X and Y of the EURAMET.T-K8. The artificial lab difference of laboratory X to the KCRV $\Delta t_d^{X,CCT*} - \Delta t_d^{KCRV}$ is calculated as follows, e.g., like in EURAMET-P1382 [28]:

$$R_X^{CCT*} = \Delta t_d^{X,CCT*} - \Delta t_d^{KCRV} = \Delta t_d^{Y,CCT} - \Delta t_d^{KCRV} + D_{XY}^{EURAMET} \,. \tag{9.3}$$

Rearranging the equation above explains the link:

$$\begin{aligned} \Delta t_d^{X,CCT*} - \Delta t_d^{KCRV} &= \Delta t_d^{Y,CCT} - \Delta t_d^{KCRV} + D_{XY}^{EURAMET} \\ &= \Delta t_d^{Y,CCT} - \Delta t_d^{KCRV} + \Delta t_d^{X,EURAMET} - \Delta t_d^{Y,EURAMET} \\ &= \Delta t_d^{X,EURAMET} + \left(\Delta t_d^{Y,CCT} - \Delta t_d^{Y,EURAMET} \right) - \Delta t_d^{KCRV} \,. \end{aligned} \tag{9.4}$$

The term $\left(\Delta t_d^{Y,CCT} - \Delta t_d^{Y,EURAMET} \right)$ can be interpreted as a kind of correction term for the result $\Delta t_d^{X,EURAMET}$ of laboratory X in the ERUAMET.T-K8 to obtain the artificial result $\Delta t_d^{X,CCT*}$ of laboratory X in the CCT-K8.

Within in the scheme of both comparisons EURAMET.T-K8 and CCT-K8, there are in total five potential link laboratories, i.e., laboratories which performed measurements in EURAMET.T-K8 and CCT-K8, which are:

- BEV/E+E
- INRIM
- INTA
- NPL
- PTB

In principle it is possible to use one up to all five possible link laboratories for the calculation of the linkage. Following criterions can be formulated for a suitable link laboratory [20]:

- The laboratory measured at the same nominal dew-point temperatures in both comparisons.
- The laboratory must have a valid result in both comparisons.

- The realization of the laboratory must be primary (to avoid correlations with other laboratories).

The laboratory can serve as link laboratory only for a subset of nominal dew-point temperatures. The link is calculated for each nominal dew-point temperature separately.

INRIM does not fulfil the second criterion, all other of the five possible link laboratories fulfil the criterions.

The corresponding uncertainty for the terms of Eq. (9.3) and (9.4) are well known as results of the analysis of both comparisons, but these terms must be analyzed in respect to possible correlations. Correlations occur between terms of KCRV, DoE and laboratory result when the same or similar reference systems are used. The value for the correlation coefficient ranges between 0 and 1 depending on the changes between the reference systems used in EURAMET.T-K8 and CCT-K8, see chapter 9.1.

A further study of the linkage procedure is possible when the final results of CCT-K8 and EURAMET.T-K8 are available.

10 Conclusion

The report presents the results of the first key comparison on RMO level for the dew-point temperature in the range of 30 °C up to 95 °C. The measurements of the 16 participating laboratories were performed in 2008 to 2011. The overall results display a very good agreement of the participating laboratories. Only three laboratories with outliers were detected where two of them could be kept in the analysis and only one laboratory has to be rejected for dew-point temperatures above 30 °C. Stability of the two travelling standards was sufficient stable within the three years of measurement, and the instruments showed a very good performance.

The values of the differences to the ERV (EURAMET reference value) are in the range from 0.000 K up to 0.115 K (only primary laboratories, without INRIM) and for the corresponding expanded uncertainty in the range of 0.022 K up to 0.108 K for the complete range of the nominal dew-point temperature realizations from 30 °C up to 95 °C.

In contrast to the very good results of the measurements the time for the reporting was exceptional long. One reason is that the analysis was not started directly after the end of the measurements. Beside unexpected complication by applying the former analysis of EURAMET.T-K6 and CCT-K6 to the EURAMET.T-K8 the delay was caused mainly by staff changes and absences of key staff at the pilot laboratory. The harmonization of analysis method between CCT-K8 and EURAMET.T-K8 caused only minor delays but enhances the value of both comparisons.

A proposal for a potential procedure to establish a link to the KRCV of the corresponding CCT-K8 [27] as well to other RMO comparisons is given.

Generally, it must be emphasized that the measurements describe the status around 10 years ago for all laboratories. Therefore, the conclusions drawn here might give only a limited indication of the actual status of the reference systems at the laboratories now, depending on the changes made at the various laboratories. A survey among the participants in 2023 indicates that most of the equipment is still unchanged, see Table 32 in Appendix C. When proper maintenance is performed on the unchanged or slightly changed setups, the results of the comparison will most likely be still applicable".

In the framework of the development of the analysis method a wide range of possible ways for achieving an aggregated laboratory result were studied. This includes different mean calculations (arithmetic and weighted), considering correlations (no, fully, complete), and simple approaches (approximations neglecting the calculation of the mean value or approximation terms for the repeatability). Based on the study for the given data set it could be stated that the difference between arithmetic and weighted mean are negligible, whereas neglecting the influence of correlation without using an approximation for the repeatability leads to unrealistic small uncertainties and therefore to wrong results with a huge number of outliers (see Draft A version 1). Approximations considering purely the contributions of the reference and stability of the four single measurements of the transfer standard is not robust since the uncertainties are underestimated in some cases more than 50% compared to the statistical correct calculation as uncertainty of a partially correlated weighted mean.

Based on the study, the calculation for achieving an aggregated lab result was performed by using the weighted mean because the weighted mean provides the advantage compared to the arithmetic mean also to be able to deal with reported lab results showing a larger variation among the four measurements (value and/or uncertainty). Additionally, the weighted mean fits better to the later used test of consistency applied to the four aggregated lab results.

For the analysis only consistent data sets could be used. Thus, an instrument is needed to check the four single measurements at each nominal dew-point temperature for consistency. A method which is applicable to four measurements which are strongly dependent due to used same equipment is the Birge ratio [13]. Applied to the data sets of EURAMET.T-K8 it shows to be more restrictive than the Chi² test and a helpful tool to get consistent data.

Based on the experiences of the preparation of the Draft A and B for EURAMET.T-K8, the author wants to summarize following main points for speeding up future key comparisons on RMO level:

The main risk of delays is the staff situation at the piloting laboratory. When only one person is in charge at the pilot, the risk of delays due to staff changes, retirements, or unexpected absences (e.g., long term illness or parental leaves) of the key personnel leads to huge delays in every step of the comparison. For future comparison the piloting laboratory should have to elaborate a risk assessment including at least one compulsory co-piloting NMI.

Another point is the efficiency of the comparison. The EURAMET.T-K8 comparison was planned to comprise of two loops to include as many institutions as possible. This led to huge complexity of analysis of the comparison yet and will also lead to challenges in the linkage to future comparisons. Therefore, the scheme of future comparisons should be as simple as possible (i.e., as less loops and transfer standards as possible) with as less nominal dew-point temperature as possible depending on the requirements of the CMC protocol. The requirements of the CMC protocol should be checked according to this point.

One more crucial point is the preparation of the comparison. This includes a sound stability investigation of the transfer standards (see advantages in measurement time and quality of the results of EURAMET.T-K8 and CCT-K8), the availability of a suitable data processing procedure, and detailed technical protocol.

The technical protocol should include besides detailed description of the measurement procedure and preparation of the transfer standard also a clear description which data (measurements, uncertainty contributions, especially for the transfer standard, influence conditions, equipment description and traceability…) must be reported to the pilot. Time-consuming requests of the pilot after the measurement period will be avoided and delays prevented.

A common sense about the data processing procedure among the humidity community (including the CMC WG KC) is needed and should be discussed and agreed before the measurements of the key comparison start (e.g., tested with previous results of other comparisons). The data processing procedure including useful preliminary checks of the participants' reported data sets should be fixed and agreed within the technical protocol. Good practise examples published as template for each field of measurand and region seems also to be helpful. Since the procedure is agreed before the measurements, the approval process of the Draft A/B and Final Report will be speeded up. Only in the case of unexpected problems amendments and discussions are needed. Thus, measurement and final report will be closer together. With already available tools for the analysis, NMIs will be encouraged to take the role as pilot since the effort for analysis is minimized. Hopefully, the effort and time invested in the analysis of EURAMET.T-K8, and of course the former EURAMET.T-K6 and CCT-K6 as well as the current CCT-K8, pays off in the future by much more efficient key comparisons in the future.

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Appendix A Results and uncertainty budget of all participants

Table 18 Results and uncertainty budget loop1, 30 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP in °C	resistance output in ohm	output in °C	difference in °C	reference	short term DUT	resolution DUT	combined
BEV/E+E 1	29.9738	111.5921	29.7913	**-0.1825**	0.0124	0.0013	-	**0.0125**
	29.9712	111.5912	29.7889	**-0.1822**	0.0124	0.0022	-	**0.0126**
	29.9823	111.5931	29.7939	**-0.1884**	0.0120	0.0015	-	**0.0121**
	29.9935	111.6029	29.8193	**-0.1742**	0.0105	0.0019	-	**0.0106**
FORCE	29.8420	111.5060	29.5680	**-0.2740**	0.0881	0.0026	-	**0.0882**
	29.8805	111.5365	29.6479	**-0.2326**	0.0881	0.0036	-	**0.0882**
	30.2139	111.6296	29.8883	**-0.3256**	0.0881	0.0056	-	**0.0883**
	30.1926	111.6041	29.8222	**-0.3704**	0.0881	0.0139	-	**0.0892**
NML/NSAI	30.0856	111.6853	30.0320	**-0.0536**	0.0525	0.0174	-	**0.0553**
	30.0914	111.6874	30.0373	**-0.0541**	0.0525	0.0159	-	**0.0549**
	30.0803	111.6841	30.0290	**-0.0513**	0.0525	0.0144	-	**0.0544**
	30.0882	111.6850	30.0312	**-0.0570**	0.0525	0.0167	-	**0.0551**
CETIAT	29.7289	111.4816	29.5062	**-0.2227**	0.0157	0.0047	-	**0.0164**
	29.7293	111.4932	29.5360	**-0.1933**	0.0157	0.0048	-	**0.0164**
	29.7285	111.4847	29.5142	**-0.2143**	0.0157	0.0035	-	**0.0161**
	29.7276	111.4850	29.5149	**-0.2127**	0.0157	0.0039	-	**0.0162**
INTA 1	29.9922	111.5956	29.8004	**-0.1919**	0.0155	0.0046	-	**0.0161**
	29.9913	111.5952	29.7993	**-0.1920**	0.0155	0.0020	-	**0.0156**
	29.9927	111.5950	29.7989	**-0.1938**	0.0155	0.0021	-	**0.0156**
	29.9942	111.5951	29.7990	**-0.1952**	0.0155	0.0037	-	**0.0159**
TUBITAK	30.3958	111.7801	30.2767	**-0.1191**	0.0411	0.0048	0.0029	**0.0415**
	30.4022	111.7813	30.2798	**-0.1224**	0.0411	0.0067	0.0029	**0.0417**
	30.4272	111.7922	30.3079	**-0.1193**	0.0411	0.0048	0.0029	**0.0415**
	30.4135	111.7863	30.2927	**-0.1208**	0.0411	0.0042	0.0029	**0.0414**
MIRS/UL-FE/LMK	30.0150	111.6234	29.8721	**-0.1429**	0.0144	0.0064	-	**0.0158**
	30.0120	111.6184	29.8592	**-0.1528**	0.0144	0.0041	-	**0.0150**
	30.0230	111.6319	29.8942	**-0.1288**	0.0144	0.0095	-	**0.0173**
	30.0160	111.6166	29.8545	**-0.1615**	0.0144	0.0046	-	**0.0151**
EIM	30.0648	111.6284	29.8851	**-0.1797**	0.0237	0.0049	0.0007	**0.0242**
	30.0925	111.6314	29.8927	**-0.1999**	0.0237	0.0025	0.0007	**0.0239**
	30.1555	111.6565	29.9577	**-0.1979**	0.0237	0.0033	0.0007	**0.0240**
	30.1094	111.6416	29.9192	**-0.1902**	0.0237	0.0030	0.0007	**0.0239**
FSB-LPM	29.9770	111.6045	29.8230	**-0.1540**	0.0304	0.0023	-	**0.0305**
	29.9860	111.6106	29.8390	**-0.1470**	0.0304	0.0016	-	**0.0304**
	29.9670	111.6011	29.8140	**-0.1530**	0.0304	0.0026	-	**0.0305**
	29.9460	111.5948	29.7980	**-0.1480**	0.0305	0.0016	-	**0.0306**
BEV/E+E 2	29.9680	111.5909	29.7882	**-0.1798**	0.0129	0.0007	-	**0.0129**
	29.9648	111.5933	29.7944	**-0.1704**	0.0124	0.0010	-	**0.0124**
	29.9667	111.5939	29.7959	**-0.1708**	0.0129	0.0009	-	**0.0129**
	29.9671	111.5943	29.7971	**-0.1700**	0.0131	0.0009	-	**0.0131**

Table 19 Result and uncertainty budget loop 2, 30 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 3	29.9738	111.6077	29.8317	**-0.1421**	0.0124	0.0010	-	**0.0125**
	29.9712	111.6077	29.8317	**-0.1395**	0.0124	0.0013	-	**0.0125**
	29.9823	111.6101	29.8377	**-0.1445**	0.0120	0.0023	-	**0.0122**
	29.9935	111.6196	29.8623	**-0.1312**	0.0105	0.0016	-	**0.0106**
METAS	29.9928	111.6120	29.8429	**-0.1500**	0.0147	0.0099	-	**0.0177**
	29.9935	111.6106	29.8392	**-0.1543**	0.0147	0.0077	-	**0.0166**
	29.9925	111.6102	29.8381	**-0.1543**	0.0147	0.0082	-	**0.0168**
	29.9932	111.6099	29.8373	**-0.1559**	0.0147	0.0092	-	**0.0173**
INRIM	30.0673	111.6313	29.8924	**-0.1749**	0.0195	0.0023	0.0001	**0.0196**
	30.0683	111.6300	29.8893	**-0.1790**	0.0195	0.0028	0.0001	**0.0197**
	30.0673	111.6297	29.8885	**-0.1788**	0.0195	0.0031	0.0001	**0.0197**
	30.0683	111.6307	29.8910	**-0.1773**	0.0195	0.0028	0.0001	**0.0197**
VSL	29.9844	111.5990	29.8090	**-0.1754**	0.0164	0.0130	0.0065	**0.0219**
	30.0399	111.6162	29.8536	**-0.1864**	0.0164	0.0074	0.0065	**0.0191**
	30.0368	111.6202	29.8640	**-0.1728**	0.0164	0.0082	0.0065	**0.0194**
	30.0090	111.6101	29.8378	**-0.1711**	0.0164	0.0066	0.0065	**0.0188**
INTA 2	29.9922	111.6118	29.8421	**-0.1501**	0.0155	0.0043	-	**0.0161**
	29.9913	111.6109	29.8399	**-0.1514**	0.0155	0.0031	-	**0.0158**
	29.9927	111.6116	29.8416	**-0.1510**	0.0155	0.0032	-	**0.0158**
	29.9942	111.6119	29.8425	**-0.1517**	0.0155	0.0034	-	**0.0158**
VTT	30.0950	111.6470	29.9331	**-0.1619**	0.0220	0.0001	-	**0.0220**
	30.0975	111.6533	29.9493	**-0.1482**	0.0220	0.0001	-	**0.0220**
	30.1064	111.6546	29.9528	**-0.1536**	0.0220	0.0001	-	**0.0220**
	30.0923	111.6399	29.9147	**-0.1776**	0.0220	0.0001	-	**0.0220**
NPL	29.9766	111.5897	29.7851	**-0.1915**	0.0110	0.0011	0.0029	**0.0114**
	29.8657	111.5598	29.7079	**-0.1578**	0.0110	0.0034	0.0029	**0.0119**
	29.8503	111.5559	29.6979	**-0.1524**	0.0110	0.0025	0.0029	**0.0117**
	30.1353	111.6527	29.9477	**-0.1876**	0.0110	0.0023	0.0029	**0.0116**
GUM	29.9640	111.5876	29.7798	**-0.1843**	0.0296	0.0007	-	**0.0296**
	30.0182	111.6231	29.8714	**-0.1468**	0.0296	0.0007	-	**0.0296**
	30.0169	111.6280	29.8841	**-0.1328**	0.0296	0.0009	-	**0.0296**
	29.9455	111.5835	29.7691	**-0.1764**	0.0296	0.0006	-	**0.0296**
BEV/E+E 4	29.9680	111.6027	29.8187	**-0.1493**	0.0129	0.0009	-	**0.0130**
	29.9648	111.6056	29.8262	**-0.1387**	0.0124	0.0010	-	**0.0124**
	29.9667	111.6061	29.8275	**-0.1391**	0.0129	0.0008	-	**0.0129**
	29.9671	111.6067	29.8291	**-0.1379**	0.0131	0.0010	-	**0.0131**
PTB	29.9967	111.6081	29.8327	**-0.1640**	0.0101	0.0001	-	**0.0101**
	29.9964	111.6078	29.8319	**-0.1645**	0.0101	0.0002	-	**0.0101**
	29.9988	111.6085	29.8338	**-0.1650**	0.0151	0.0002	-	**0.0151**
	30.0036	111.6110	29.8400	**-0.1636**	0.0151	0.0001	-	**0.0151**

Table 20 Results and uncertainty budget loop 1, 50 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	combined
	in °C	in ohm	in °C	in °C		DUT	DUT	
BEV/E+E 1	49.9776	119.3130	49.7815	**-0.1961**	0.0133	0.0012	-	**0.0133**
	49.9755	119.3120	49.7789	**-0.1967**	0.0133	0.0011	-	**0.0133**
	49.9998	119.3227	49.8067	**-0.1931**	0.0109	0.0011	-	**0.0110**
	49.9868	119.3187	49.7964	**-0.1904**	0.0105	0.0009	-	**0.0105**
FORCE	50.0857	119.2919	49.7268	**-0.3589**	0.0881	0.0085	-	**0.0886**
	50.1194	119.3352	49.8392	**-0.2801**	0.0881	0.0040	-	**0.0882**
	50.1167	119.3041	49.7583	**-0.3584**	0.0881	0.0133	-	**0.0891**
	50.1543	119.3226	49.8066	**-0.3477**	0.0881	0.0155	-	**0.0895**
NML/NSAI	50.1294	119.4314	50.0889	**-0.0405**	0.0548	0.0163	-	**0.0572**
	50.1240	119.4265	50.0762	**-0.0478**	0.0548	0.0137	-	**0.0565**
	50.1148	119.4293	50.0836	**-0.0312**	0.0548	0.0137	-	**0.0565**
	50.1191	119.4299	50.0852	**-0.0339**	0.0548	0.0147	-	**0.0567**
CETIAT	49.6578	119.2094	49.5126	**-0.1452**	0.0157	0.0045	-	**0.0163**
	49.6568	119.2036	49.4974	**-0.1594**	0.0157	0.0046	-	**0.0164**
	49.6569	119.1987	49.4847	**-0.1722**	0.0157	0.0068	-	**0.0171**
	49.6574	119.1973	49.4811	**-0.1763**	0.0157	0.0055	-	**0.0166**
INTA 1	50.0313	119.3282	49.8211	**-0.2102**	0.0168	0.0020	-	**0.0169**
	50.0305	119.3272	49.8185	**-0.2120**	0.0168	0.0022	-	**0.0169**
	50.0281	119.3260	49.8153	**-0.2129**	0.0168	0.0026	-	**0.0170**
	50.0271	119.3256	49.8144	**-0.2127**	0.0168	0.0036	-	**0.0172**
TUBITAK	50.1073	119.3976	50.0012	**-0.1061**	0.0383	0.0042	0.0029	**0.0387**
	49.8763	119.3075	49.7670	**-0.1093**	0.0383	0.0053	0.0029	**0.0388**
	49.9179	119.3266	49.8168	**-0.1011**	0.0383	0.0042	0.0029	**0.0387**
	49.9131	119.3250	49.8127	**-0.1004**	0.0383	0.0042	0.0029	**0.0387**
MIRS/UL-FE/LMK	49.9550	119.3162	49.7899	**-0.1651**	0.0205	0.0071	-	**0.0217**
	49.9530	119.3191	49.7974	**-0.1556**	0.0205	0.0043	-	**0.0209**
	49.9530	119.3161	49.7896	**-0.1634**	0.0205	0.0018	-	**0.0206**
	49.9410	119.3119	49.7786	**-0.1624**	0.0205	0.0059	-	**0.0213**
EIM	50.0820	119.3461	49.8675	**-0.2144**	0.0280	0.0023	0.0007	**0.0282**
	50.1223	119.3589	49.9006	**-0.2217**	0.0280	0.0033	0.0007	**0.0282**
	50.2039	119.3928	49.9888	**-0.2151**	0.0280	0.0032	0.0007	**0.0282**
	50.0494	119.3338	49.8355	**-0.2140**	0.0280	0.0062	0.0007	**0.0287**
FSB-LPM	50.0340	119.3463	49.8680	**-0.1660**	0.0316	0.0023	-	**0.0317**
	50.0000	119.3375	49.8450	**-0.1550**	0.0317	0.0042	-	**0.0320**
	50.0160	119.3399	49.8510	**-0.1650**	0.0317	0.0042	-	**0.0320**
	49.9830	119.3270	49.8180	**-0.1650**	0.0318	0.0042	-	**0.0320**
BEV/E+E 2	49.9695	119.3135	49.7828	**-0.1867**	0.0133	0.0005	-	**0.0133**
	49.9683	119.3152	49.7873	**-0.1810**	0.0137	0.0013	-	**0.0137**
	49.9692	119.3143	49.7850	**-0.1842**	0.0136	0.0007	-	**0.0136**
	49.9702	119.3154	49.7877	**-0.1825**	0.0134	0.0012	-	**0.0135**

Table 21 Results and uncertainty budget loop 2, 50 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP in °C	resistance output in ohm	output in °C	difference in °C	reference	short term DUT	resolution DUT	combined
BEV/E+E 3	49.9776	119.3288	49.8226	**-0.1550**	0.0133	0.0021	-	**0.0134**
	49.9755	119.3283	49.8212	**-0.1544**	0.0133	0.0010	-	**0.0133**
	49.9998	119.3390	49.8491	**-0.1507**	0.0109	0.0013	-	**0.0110**
	49.9868	119.3358	49.8409	**-0.1459**	0.0105	0.0007	-	**0.0105**
METAS	50.0111	119.3358	49.8407	**-0.1704**	0.0155	0.0031	-	**0.0158**
	50.0113	119.3362	49.8419	**-0.1694**	0.0155	0.0040	-	**0.0160**
	50.0117	119.3350	49.8388	**-0.1729**	0.0154	0.0069	-	**0.0169**
	50.0118	119.3346	49.8377	**-0.1741**	0.0154	0.0054	-	**0.0164**
INRIM	49.8172	119.2216	49.5442	**-0.2730**	0.0213	0.0057	0.0001	**0.0220**
	49.8102	119.2171	49.5324	**-0.2778**	0.0213	0.0047	0.0001	**0.0218**
	49.8102	119.2164	49.5308	**-0.2794**	0.0213	0.0045	0.0001	**0.0217**
	49.8192	119.2208	49.5422	**-0.2770**	0.0213	0.0049	0.0001	**0.0218**
VSL	50.0557	119.3462	49.8678	**-0.1879**	0.0169	0.0063	0.0065	**0.0192**
	50.0299	119.3337	49.8353	**-0.1945**	0.0169	0.0052	0.0065	**0.0189**
	50.0227	119.3333	49.8344	**-0.1883**	0.0169	0.0071	0.0065	**0.0195**
	50.0233	119.3347	49.8378	**-0.1855**	0.0169	0.0053	0.0065	**0.0189**
INTA 2	50.0315	119.3451	49.8648	**-0.1667**	0.0168	0.0033	-	**0.0171**
	50.0307	119.3444	49.8629	**-0.1677**	0.0168	0.0025	-	**0.0170**
	50.0284	119.3434	49.8605	**-0.1678**	0.0168	0.0037	-	**0.0172**
	50.0273	119.3432	49.8600	**-0.1673**	0.0168	0.0031	-	**0.0171**
VTT	50.0574	119.3553	49.8915	**-0.1659**	0.0220	0.0003	-	**0.0220**
	50.0642	119.3523	49.8836	**-0.1805**	0.0220	0.0003	-	**0.0220**
	50.0656	119.3584	49.8995	**-0.1662**	0.0220	0.0003	-	**0.0220**
	50.0738	119.3597	49.9028	**-0.1710**	0.0220	0.0003	-	**0.0220**
NPL	49.7207	119.2251	49.5534	**-0.1673**	0.0120	0.0052	0.0029	**0.0134**
	49.8620	119.2863	49.7121	**-0.1499**	0.0110	0.0009	0.0029	**0.0114**
	50.5941	119.5598	50.4224	**-0.1717**	0.0110	0.0033	0.0029	**0.0118**
	50.4625	119.5073	50.2861	**-0.1764**	0.0110	0.0006	0.0029	**0.0114**
GUM	49.9513	119.3144	49.7852	**-0.1661**	0.0274	0.0006	-	**0.0274**
	49.9656	119.3244	49.8112	**-0.1544**	0.0274	0.0004	-	**0.0274**
	49.9604	119.3259	49.8152	**-0.1453**	0.0274	0.0008	-	**0.0274**
	49.8881	119.2931	49.7300	**-0.1582**	0.0274	0.0004	-	**0.0274**
BEV/E+E 4	49.9695	119.3245	49.8115	**-0.1580**	0.0133	0.0007	-	**0.0133**
	49.9683	119.3274	49.8190	**-0.1494**	0.0137	0.0008	-	**0.0137**
	49.9692	119.3250	49.8127	**-0.1565**	0.0136	0.0007	-	**0.0136**
	49.9702	119.3275	49.8191	**-0.1511**	0.0134	0.0006	-	**0.0134**
PTB	50.0120	119.3337	49.8354	**-0.1766**	0.0160	0.0005	-	**0.0160**
	49.9994	119.3287	49.8223	**-0.1771**	0.0160	0.0002	-	**0.0160**
	50.0111	119.3331	49.8336	**-0.1775**	0.0155	0.0002	-	**0.0155**
	49.9959	119.3270	49.8180	**-0.1779**	0.0155	0.0002	-	**0.0155**

Table 22 Results and uncertainty budget loop 1, 65 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 1	64.9723	125.0729	64.7730	**-0.1993**	0.0142	0.0010	-	**0.0142**
	64.9713	125.0734	64.7742	**-0.1971**	0.0142	0.0015	-	**0.0143**
	65.0055	125.0862	64.8077	**-0.1979**	0.0138	0.0013	-	**0.0139**
	64.9641	125.0696	64.7642	**-0.1999**	0.0110	0.0015	-	**0.0111**
FORCE	65.2279	125.0717	64.7697	**-0.4582**	0.0897	0.0254	-	**0.0932**
	65.2275	125.1339	64.9320	**-0.2955**	0.0897	0.0159	-	**0.0911**
	65.2002	125.1399	64.9478	**-0.2524**	0.0897	0.0164	-	**0.0912**
	64.7098	124.9374	64.4194	**-0.2904**	0.0897	0.0161	-	**0.0911**
NML/NSAI	65.2250	125.2212	65.1597	**-0.0653**	0.0868	0.0147	-	**0.0880**
	65.2176	125.2201	65.1570	**-0.0606**	0.0868	0.0155	-	**0.0882**
	65.2069	125.2209	65.1591	**-0.0478**	0.0868	0.0184	-	**0.0887**
	65.2079	125.2247	65.1688	**-0.0391**	0.0868	0.0150	-	**0.0881**
CETIAT	64.5790	124.9280	64.3950	**-0.1840**	0.0216	0.0137	-	**0.0255**
	64.5753	124.9262	64.3902	**-0.1851**	0.0216	0.0143	-	**0.0259**
	64.5746	124.9225	64.3805	**-0.1940**	0.0216	0.0186	-	**0.0285**
	64.5746	124.9202	64.3745	**-0.2000**	0.0216	0.0159	-	**0.0268**
INTA 1	65.0149	125.0806	64.7931	**-0.2218**	0.0180	0.0014	-	**0.0180**
	65.0103	125.0791	64.7889	**-0.2214**	0.0180	0.0023	-	**0.0181**
	65.0020	125.0759	64.7807	**-0.2213**	0.0180	0.0032	-	**0.0182**
	64.9992	125.0747	64.7775	**-0.2217**	0.0180	0.0021	-	**0.0181**
TUBITAK	64.7814	125.0408	64.6892	**-0.0922**	0.0476	0.0052	0.0029	**0.0480**
	64.7770	125.0404	64.6881	**-0.0889**	0.0476	0.0057	0.0029	**0.0481**
	64.8776	125.0795	64.7901	**-0.0874**	0.0476	0.0057	0.0029	**0.0481**
	64.8802	125.0794	64.7899	**-0.0904**	0.0476	0.0082	0.0029	**0.0484**
MIRS/UL-FE/LMK	64.9240	125.0639	64.7493	**-0.1747**	0.0184	0.0018	-	**0.0184**
	64.9150	125.0573	64.7323	**-0.1827**	0.0184	0.0024	-	**0.0185**
	64.9170	125.0605	64.7405	**-0.1765**	0.0184	0.0020	-	**0.0185**
	64.9170	125.0600	64.7393	**-0.1777**	0.0184	0.0014	-	**0.0184**
EIM	64.8653	125.0233	64.6436	**-0.2217**	0.0305	0.0021	0.0007	**0.0306**
	64.8796	125.0287	64.6576	**-0.2220**	0.0305	0.0033	0.0007	**0.0307**
	64.9831	125.0680	64.7602	**-0.2229**	0.0305	0.0079	0.0007	**0.0315**
	65.0057	125.0765	64.7824	**-0.2233**	0.0305	0.0078	0.0007	**0.0315**
FSB-LPM	65.0020	125.0958	64.8330	**-0.1690**	0.0395	0.0042	-	**0.0398**
	64.9240	125.0661	64.7550	**-0.1690**	0.0396	0.0065	-	**0.0402**
	64.9570	125.0742	64.7760	**-0.1810**	0.0396	0.0044	-	**0.0398**
	64.9330	125.0647	64.7510	**-0.1820**	0.0396	0.0044	-	**0.0398**
BEV/E+E 2	64.9646	125.0761	64.7813	**-0.1833**	0.0145	0.0009	-	**0.0145**
	64.9636	125.0750	64.7784	**-0.1852**	0.0143	0.0004	-	**0.0143**
	64.9622	125.0731	64.7735	**-0.1887**	0.0140	0.0004	-	**0.0140**
	64.9643	125.0748	64.7778	**-0.1865**	0.0155	0.0005	-	**0.0155**

Table 23 Results and uncertainty budget loop 2, 65 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 3	64.9723	125.0883	64.8131	**-0.1593**	0.0142	0.0007	-	**0.0142**
	64.9713	125.0893	64.8158	**-0.1555**	0.0142	0.0010	-	**0.0142**
	65.0055	125.1020	64.8489	**-0.1566**	0.0138	0.0022	-	**0.0140**
	64.9641	125.0867	64.8090	**-0.1550**	0.0110	0.0016	-	**0.0111**
METAS	65.0214	125.0999	64.8434	**-0.1780**	0.0161	0.0065	-	**0.0174**
	65.0260	125.1016	64.8478	**-0.1782**	0.0172	0.0062	-	**0.0183**
	65.0267	125.0994	64.8420	**-0.1846**	0.0165	0.0077	-	**0.0182**
	65.0262	125.0992	64.8414	**-0.1848**	0.0181	0.0146	-	**0.0232**
INRIM	64.9827	125.0433	64.6956	**-0.2871**	0.0259	0.0128	0.0001	**0.0289**
	64.8877	124.9899	64.5563	**-0.3314**	0.0259	0.0168	0.0001	**0.0309**
	64.9077	125.0120	64.6140	**-0.2937**	0.0259	0.0121	0.0001	**0.0286**
	64.8947	125.0038	64.5925	**-0.3022**	0.0259	0.0113	0.0001	**0.0283**
VSL	65.0922	125.1156	64.8842	**-0.2080**	0.0222	0.0107	0.0065	**0.0255**
	65.0411	125.1007	64.8453	**-0.1958**	0.0222	0.0091	0.0065	**0.0249**
	65.0454	125.1021	64.8491	**-0.1963**	0.0222	0.0032	0.0065	**0.0234**
	64.9825	125.0802	64.7920	**-0.1905**	0.0222	0.0098	0.0065	**0.0251**
INTA 2	65.0149	125.0958	64.8326	**-0.1823**	0.0180	0.0022	-	**0.0181**
	65.0105	125.0941	64.8282	**-0.1823**	0.0180	0.0025	-	**0.0181**
	65.0020	125.0910	64.8201	**-0.1819**	0.0180	0.0041	-	**0.0184**
	64.9992	125.0900	64.8175	**-0.1817**	0.0180	0.0026	-	**0.0181**
VTT	65.0092	125.0971	64.8360	**-0.1732**	0.0230	0.0012	-	**0.0230**
	65.0400	125.1006	64.8452	**-0.1948**	0.0230	0.0012	-	**0.0230**
	65.0482	125.1097	64.8690	**-0.1792**	0.0230	0.0012	-	**0.0230**
	65.0589	125.1080	64.8646	**-0.1943**	0.0230	0.0012	-	**0.0230**
NPL	64.6667	124.9623	64.4843	**-0.1825**	0.0110	0.0026	0.0029	**0.0117**
	65.3232	125.2124	65.1368	**-0.1864**	0.0110	0.0015	0.0029	**0.0115**
	65.0962	125.1287	64.9185	**-0.1777**	0.0110	0.0004	0.0029	**0.0114**
	64.9861	125.0793	64.7896	**-0.1965**	0.0110	0.0015	0.0029	**0.0115**
GUM	64.9990	125.0953	64.8313	**-0.1677**	0.0317	0.0010	-	**0.0317**
	65.0097	125.1177	64.8897	**-0.1200**	0.0317	0.0003	-	**0.0317**
	64.9169	125.0860	64.8072	**-0.1097**	0.0317	0.0006	-	**0.0317**
	64.9407	125.0777	64.7854	**-0.1553**	0.0317	0.0005	-	**0.0317**
BEV/E+E 4	64.9646	125.0863	64.8078	**-0.1568**	0.0145	0.0003	-	**0.0145**
	64.9636	125.0863	64.8079	**-0.1557**	0.0143	0.0005	-	**0.0143**
	64.9622	125.0836	64.8009	**-0.1613**	0.0140	0.0004	-	**0.0140**
	64.9643	125.0862	64.8077	**-0.1566**	0.0155	0.0006	-	**0.0155**
PTB	64.9962	125.0867	64.8090	**-0.1872**	0.0192	0.0005	-	**0.0192**
	64.9994	125.0881	64.8125	**-0.1869**	0.0192	0.0007	-	**0.0193**
	64.9942	125.0866	64.8086	**-0.1856**	0.0192	0.0004	-	**0.0192**
	64.9927	125.0857	64.8063	**-0.1865**	0.0192	0.0004	-	**0.0192**

Table 24 Results and uncertainty budget loop 1, 80 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 1	79.9668	130.8061	79.7623	**-0.2045**	0.0149	0.0012	-	**0.0150**
	79.9683	130.8087	79.7692	**-0.1991**	0.0149	0.0011	-	**0.0150**
	79.9557	130.8041	79.7571	**-0.1986**	0.0135	0.0011	-	**0.0135**
	79.9896	130.8161	79.7884	**-0.2012**	0.0124	0.0020	-	**0.0126**
FORCE	80.1175	130.8540	79.8878	**-0.2297**	0.0897	0.0122	-	**0.0905**
	80.2809	130.8113	79.7759	**-0.5050**	0.0897	0.0101	-	**0.0903**
	80.0557	130.8193	79.7881	**-0.2676**	0.0897	0.0164	-	**0.0912**
	79.5974	130.5913	79.1996	**-0.3979**	0.0897	0.0430	-	**0.0995**
NML/NSAI	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
CETIAT	79.5065	130.6252	79.2883	**-0.2182**	0.0306	0.0225	-	**0.0380**
	79.5007	130.6240	79.2853	**-0.2154**	0.0306	0.0202	-	**0.0367**
	79.4990	130.6219	79.2796	**-0.2194**	0.0306	0.0192	-	**0.0361**
	79.4980	130.6235	79.2838	**-0.2142**	0.0306	0.0218	-	**0.0376**
INTA 1	79.9744	130.8001	79.7465	**-0.2279**	0.0191	0.0019	-	**0.0192**
	79.9909	130.8069	79.7643	**-0.2265**	0.0191	0.0022	-	**0.0192**
	80.0141	130.8170	79.7910	**-0.2231**	0.0191	0.0024	-	**0.0193**
	80.0004	130.8142	79.7834	**-0.2170**	0.0191	0.0010	-	**0.0191**
TUBITAK	-	-	-	-	-	-	-	**0.0000**
	-	-	-	-	-	-	-	**0.0000**
	-	-	-	-	-	-	-	**0.0000**
	-	-	-	-	-	-	-	**0.0000**
MIRS/UL-FE/LMK	79.9960	130.8188	79.7956	**-0.2004**	0.0239	0.0017	-	**0.0239**
	79.9850	130.8169	79.7906	**-0.1944**	0.0239	0.0039	-	**0.0242**
	79.9800	130.8116	79.7766	**-0.2034**	0.0239	0.0026	-	**0.0240**
	79.9800	130.8173	79.7917	**-0.1883**	0.0239	0.0023	-	**0.0240**
EIM	79.8898	130.7687	79.6643	**-0.2254**	0.0359	0.0053	0.0007	**0.0363**
	79.8542	130.7570	79.6335	**-0.2207**	0.0359	0.0057	0.0007	**0.0363**
	79.8921	130.7713	79.6711	**-0.2210**	0.0359	0.0084	0.0007	**0.0369**
	79.8624	130.7589	79.6386	**-0.2238**	0.0359	0.0093	0.0007	**0.0371**
FSB-LPM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
BEV/E+E 2	79.9605	130.8105	79.7739	**-0.1866**	0.0153	0.0006		**0.0153**
	79.9594	130.8088	79.7695	**-0.1899**	0.0149	0.0005		**0.0149**
	79.9581	130.8077	79.7666	**-0.1915**	0.0157	0.0010		**0.0157**
	79.9629	130.8100	79.7726	**-0.1903**	0.0152	0.0015		**0.0153**

Table 25 Results and uncertainty budget loop 2, 80 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP in °C	resistance output in ohm	output in °C	difference in °C	reference	short term DUT	resolution DUT	combined
BEV/E+E 3	79.9668	130.8218	79.8034	**-0.1634**	0.0149	0.0010	-	**0.0150**
	79.9683	130.8250	79.8118	**-0.1565**	0.0149	0.0010	-	**0.0150**
	79.9557	130.8202	79.7993	**-0.1564**	0.0135	0.0009	-	**0.0135**
	79.9896	130.8326	79.8318	**-0.1578**	0.0124	0.0010	-	**0.0125**
METAS	79.9697	130.8126	79.7793	**-0.1904**	0.0329	0.0097	-	**0.0343**
	79.9689	130.8118	79.7771	**-0.1918**	0.0331	0.0197	-	**0.0385**
	79.9660	130.8125	79.7791	**-0.1869**	0.0330	0.0150	-	**0.0362**
	79.9687	130.8117	79.7769	**-0.1918**	0.0328	0.0187	-	**0.0378**
INRIM	79.7190	130.6574	79.3730	**-0.3460**	0.0266	0.0191	0.0001	**0.0327**
	79.7750	130.7037	79.4940	**-0.2810**	0.0266	0.0175	0.0001	**0.0318**
	79.9040	130.7725	79.6740	**-0.2300**	0.0266	0.0095	0.0001	**0.0283**
	79.9300	130.7954	79.7340	**-0.1960**	0.0266	0.0060	0.0001	**0.0273**
VSL	80.1621	130.8850	79.9691	**-0.1930**	0.0325	0.0084	0.0066	**0.0342**
	80.1646	130.8848	79.9686	**-0.1961**	0.0325	0.0197	0.0066	**0.0386**
	80.1345	130.8777	79.9498	**-0.1846**	0.0325	0.0144	0.0066	**0.0362**
	80.1577	130.8826	79.9629	**-0.1948**	0.0325	0.0123	0.0066	**0.0354**
INTA 2	79.9751	130.8143	79.7837	**-0.1913**	0.0191	0.0016	-	**0.0192**
	79.9910	130.8221	79.8042	**-0.1868**	0.0191	0.0035	-	**0.0194**
	80.0141	130.8306	79.8264	**-0.1876**	0.0191	0.0022	-	**0.0192**
	80.0004	130.8255	79.8132	**-0.1872**	0.0191	0.0041	-	**0.0195**
VTT	79.9858	130.8222	79.8045	**-0.1814**	0.0230	0.0004	-	**0.0230**
	79.9907	130.8222	79.8045	**-0.1862**	0.0230	0.0004	-	**0.0230**
	80.0028	130.8389	79.8483	**-0.1545**	0.0230	0.0004	-	**0.0230**
	79.9009	130.7913	79.7235	**-0.1774**	0.0230	0.0004	-	**0.0230**
NPL	79.4931	130.6315	79.3047	**-0.1884**	0.0210	0.0133	0.0029	**0.0250**
	80.2371	130.9170	80.0530	**-0.1840**	0.0160	0.0017	0.0029	**0.0163**
	80.2392	130.9198	80.0602	**-0.1790**	0.0160	0.0022	0.0029	**0.0164**
	80.0370	130.8394	79.8497	**-0.1873**	0.0160	0.0017	0.0029	**0.0163**
GUM	79.9634	130.8421	79.8567	**-0.1067**	0.0305	0.0007	-	**0.0305**
	79.9644	130.8334	79.8337	**-0.1307**	0.0305	0.0004	-	**0.0305**
	79.9819	130.8558	79.8926	**-0.0893**	0.0305	0.0007	-	**0.0305**
	79.9007	130.8096	79.7715	**-0.1292**	0.0305	0.0005	-	**0.0305**
BEV/E+E 4	79.9605	130.8203	79.7995	**-0.1610**	0.0153	0.0006	-	**0.0153**
	79.9594	130.8195	79.7974	**-0.1620**	0.0149	0.0005	-	**0.0149**
	79.9581	130.8166	79.7899	**-0.1682**	0.0157	0.0006	-	**0.0157**
	79.9629	130.8211	79.8016	**-0.1613**	0.0152	0.0007	-	**0.0153**
PTB	79.9861	130.8202	79.7993	**-0.1868**	0.0329	0.0007	-	**0.0329**
	79.9962	130.8228	79.8062	**-0.1900**	0.0329	0.0006	-	**0.0330**
	79.9970	130.8245	79.8106	**-0.1864**	0.0329	0.0004	-	**0.0329**
	79.9981	130.8244	79.8102	**-0.1879**	0.0330	0.0005	-	**0.0330**

Table 26 Results and uncertainty budget loop 1, 85 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP in °C	resistance output in ohm	output in °C	difference in °C	reference	short term DUT	resolution DUT	combined
BEV/E+E 1	84.9710	132.7138	84.7650	**-0.2060**	0.0154	0.0009	-	**0.0154**
	84.9692	132.7128	84.7623	**-0.2069**	0.0154	0.0014	-	**0.0155**
	85.0021	132.7280	84.8025	**-0.1996**	0.0156	0.0025	-	**0.0158**
	84.9829	132.7200	84.7813	**-0.2016**	0.0132	0.0013	-	**0.0133**
FORCE	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
NML/NSAI	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
INTA 1	84.9803	132.7097	84.7543	**-0.2260**	0.0188	0.0016	-	**0.0189**
	84.9115	132.6859	84.6920	**-0.2195**	0.0188	0.0023	-	**0.0190**
	84.8982	132.6827	84.6835	**-0.2147**	0.0188	0.0036	-	**0.0192**
	84.8924	132.6803	84.6772	**-0.2152**	0.0188	0.0018	-	**0.0189**
TUBITAK	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
MIRS/UL-FE/LMK	84.9730	132.7081	84.7500	**-0.2230**	0.0271	0.0025	-	**0.0272**
	84.9700	132.7076	84.7487	**-0.2213**	0.0271	0.0105	-	**0.0290**
	84.9660	132.7067	84.7465	**-0.2195**	0.0271	0.0173	-	**0.0321**
	84.9660	132.7079	84.7496	**-0.2164**	0.0271	0.0009	-	**0.0271**
EIM	84.9310	132.6928	84.7100	**-0.2210**	0.0364	0.0065	0.0007	**0.0370**
	84.9173	132.6839	84.6866	**-0.2307**	0.0364	0.0104	0.0007	**0.0379**
	84.9856	132.7129	84.7628	**-0.2227**	0.0364	0.0127	0.0007	**0.0386**
	84.9965	132.7213	84.7848	**-0.2117**	0.0364	0.0101	0.0007	**0.0378**
FSB-LPM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
BEV/E+E 2	84.9626	132.7170	84.7736	**-0.1890**	0.0156	0.0007		**0.0156**
	84.9617	132.7159	84.7707	**-0.1911**	0.0156	0.0005		**0.0156**
	84.9620	132.7153	84.7689	**-0.1931**	0.0158	0.0009		**0.0158**
	84.9616	132.7158	84.7703	**-0.1913**	0.0152	0.0012		**0.0152**

Table 27 Results and uncertainty budget loop 2, 85 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 3	84.9710	132.7290	84.8049	**-0.1661**	0.0154	0.0008	-	**0.0154**
	84.9692	132.7287	84.8041	**-0.1651**	0.0154	0.0012	-	**0.0154**
	85.0021	132.7438	84.8437	**-0.1584**	0.0156	0.0026	-	**0.0158**
	84.9829	132.7360	84.8234	**-0.1595**	0.0132	0.0010	-	**0.0132**
METAS	84.9723	132.7158	84.7703	**-0.2020**	0.0338	0.0129	-	**0.0362**
	84.9705	132.7158	84.7702	**-0.2003**	0.0338	0.0057	-	**0.0342**
	84.9589	132.7157	84.7701	**-0.1888**	0.0341	0.0125	-	**0.0363**
	84.9628	132.7165	84.7722	**-0.1906**	0.0340	0.0081	-	**0.0350**
INRIM	84.6032	132.5360	84.2986	**-0.3046**	0.0333	0.0129	0.0001	**0.0357**
	84.7302	132.5824	84.4202	**-0.3100**	0.0333	0.0147	0.0001	**0.0364**
	84.6202	132.5354	84.2968	**-0.3234**	0.0333	0.0092	0.0001	**0.0346**
	84.6812	132.5648	84.3741	**-0.3071**	0.0333	0.0161	0.0001	**0.0370**
VSL	85.1433	132.7827	84.9458	**-0.1975**	0.0354	0.0036	0.0066	**0.0362**
	85.1910	132.8050	85.0043	**-0.1867**	0.0354	0.0155	0.0066	**0.0392**
	85.1817	132.8016	84.9954	**-0.1863**	0.0354	0.0087	0.0066	**0.0370**
	85.1746	132.7950	84.9783	**-0.1963**	0.0354	0.0069	0.0066	**0.0367**
INTA 2	84.9806	132.7228	84.7886	**-0.1920**	0.0188	0.0026	-	**0.0190**
	84.9116	132.6989	84.7261	**-0.1855**	0.0188	0.0043	-	**0.0193**
	84.8984	132.6951	84.7161	**-0.1822**	0.0188	0.0027	-	**0.0190**
	84.8926	132.6933	84.7113	**-0.1813**	0.0188	0.0023	-	**0.0190**
VTT	84.9658	132.7114	84.7588	**-0.2070**	0.0240	0.0009	-	**0.0240**
	84.9791	132.7270	84.7998	**-0.1794**	0.0240	0.0009	-	**0.0240**
	84.9913	132.7338	84.8175	**-0.1738**	0.0240	0.0009	-	**0.0240**
	84.8755	132.6873	84.6956	**-0.1798**	0.0240	0.0009	-	**0.0240**
NPL	85.1165	132.7757	84.9275	**-0.1890**	0.0290	0.0038	0.0029	**0.0294**
	85.2286	132.8111	85.0206	**-0.2080**	0.0360	0.0037	0.0029	**0.0363**
	85.1496	132.7833	84.9475	**-0.2021**	0.0290	0.0052	0.0029	**0.0296**
	85.0367	132.7332	84.8159	**-0.2208**	0.0290	0.0008	0.0029	**0.0292**
GUM	84.9492	132.7348	84.8203	**-0.1289**	0.0309	0.0012	-	**0.0309**
	84.9417	132.7347	84.8200	**-0.1218**	0.0309	0.0004	-	**0.0309**
	84.9618	132.7453	84.8478	**-0.1140**	0.0309	0.0007	-	**0.0309**
	84.8843	132.7188	84.7783	**-0.1060**	0.0309	0.0006	-	**0.0309**
BEV/E+E 4	84.9626	132.7269	84.7995	**-0.1631**	0.0156	0.0008	-	**0.0156**
	84.9617	132.7263	84.7979	**-0.1638**	0.0156	0.0009	-	**0.0156**
	84.9620	132.7254	84.7956	**-0.1664**	0.0158	0.0009	-	**0.0158**
	84.9616	132.7265	84.7985	**-0.1631**	0.0152	0.0017	-	**0.0153**
PTB	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Table 28 Results and uncertainty budget loop 1, 90 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 1	89.9685	134.6163	89.7619	**-0.2066**	0.0164	0.0012	-	**0.0164**
	89.9715	134.6171	89.7638	**-0.2076**	0.0164	0.0009	-	**0.0164**
	89.9922	134.6278	89.7921	**-0.2001**	0.0145	0.0025	-	**0.0147**
	89.9670	134.6186	89.7677	**-0.1993**	0.0138	0.0062	-	**0.0151**
FORCE	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
NML/NSAI	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
INTA 1	89.9690	134.6135	89.7544	**-0.2146**	0.0200	0.0024	-	**0.0201**
	89.9141	134.5930	89.7006	**-0.2135**	0.0200	0.0036	-	**0.0203**
	89.8915	134.5853	89.6802	**-0.2112**	0.0200	0.0028	-	**0.0202**
	89.9029	134.5894	89.6912	**-0.2117**	0.0200	0.0035	-	**0.0203**
TUBITAK	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
MIRS/UL-FE/LMK	89.9710	134.6098	89.7448	**-0.2262**	0.0263	0.0092	-	**0.0279**
	89.9580	134.6114	89.7490	**-0.2090**	0.0263	0.0178	-	**0.0318**
	89.9900	134.6151	89.7586	**-0.2314**	0.0263	0.0023	-	**0.0264**
	89.9680	134.6065	89.7359	**-0.2321**	0.0263	0.0019	-	**0.0264**
EIM	89.9842	134.6137	89.7550	**-0.2292**	0.0397	0.0029	0.0007	**0.0398**
	89.9051	134.5838	89.6764	**-0.2288**	0.0397	0.0069	0.0007	**0.0403**
	89.9719	134.6114	89.7490	**-0.2228**	0.0397	0.0117	0.0007	**0.0414**
	89.9205	134.5941	89.7034	**-0.2170**	0.0397	0.0101	0.0007	**0.0410**
FSB-LPM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
BEV/E+E 2	89.9625	134.6199	89.7712	**-0.1914**	0.0172	0.0008	-	**0.0172**
	89.9549	134.6167	89.7627	**-0.1922**	0.0161	0.0011	-	**0.0161**
	89.9619	134.6182	89.7668	**-0.1951**	0.0158	0.0011	-	**0.0158**
	89.9619	134.6181	89.7664	**-0.1955**	0.0178	0.0012	-	**0.0178**

Table 29 Results and uncertainty budget loop 2, 90 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP in °C	resistance output in ohm	output in °C	difference in °C	reference	short term DUT	resolution DUT	combined
BEV/E+E 3	89.9685	134.6324	89.8042	**-0.1643**	0.0164	0.0015	-	**0.0164**
	89.9715	134.6321	89.8033	**-0.1682**	0.0164	0.0007	-	**0.0164**
	89.9922	134.6435	89.8333	**-0.1589**	0.0145	0.0021	-	**0.0146**
	89.9670	134.6328	89.8051	**-0.1620**	0.0138	0.0065	-	**0.0153**
METAS	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
INRIM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
VSL	90.1356	134.6842	89.9402	**-0.1954**	0.0387	0.0093	0.0066	**0.0403**
	90.1487	134.6896	89.9545	**-0.1942**	0.0387	0.0119	0.0066	**0.0410**
	90.1557	134.6881	89.9505	**-0.2052**	0.0387	0.0060	0.0066	**0.0397**
	90.1523	134.6858	89.9445	**-0.2078**	0.0387	0.0053	0.0066	**0.0396**
INTA 2	89.9690	134.6253	89.7855	**-0.1835**	0.0200	0.0018	-	**0.0200**
	89.9141	134.6055	89.7335	**-0.1806**	0.0200	0.0043	-	**0.0204**
	89.8914	134.5971	89.7113	**-0.1801**	0.0200	0.0033	-	**0.0202**
	89.9029	134.6006	89.7206	**-0.1823**	0.0200	0.0038	-	**0.0203**
VTT	89.9388	134.6041	89.7298	**-0.2090**	0.0260	0.0017	-	**0.0261**
	89.9617	134.6131	89.7534	**-0.2083**	0.0260	0.0017	-	**0.0261**
	89.9756	134.6209	89.7739	**-0.2017**	0.0260	0.0017	-	**0.0261**
	89.8867	134.5798	89.6658	**-0.2210**	0.0260	0.0017	-	**0.0261**
NPL	90.0685	134.6570	89.8688	**-0.1997**	0.0340	0.0014	0.0029	**0.0342**
	90.4695	134.8101	90.2711	**-0.1984**	0.0350	0.0068	0.0029	**0.0358**
	90.3926	134.7806	90.1937	**-0.1989**	0.0360	0.0098	0.0029	**0.0374**
	90.0406	134.6435	89.8333	**-0.2073**	0.0340	0.0028	0.0029	**0.0342**
GUM	89.9330	134.6391	89.8217	**-0.1113**	0.0324	0.0005	-	**0.0324**
	89.9283	134.6314	89.8015	**-0.1267**	0.0324	0.0007	-	**0.0324**
	89.8587	134.6105	89.7466	**-0.1121**	0.0324	0.0006	-	**0.0324**
	89.8673	134.6121	89.7508	**-0.1165**	0.0324	0.0006	-	**0.0324**
BEV/E+E 4	89.9625	134.6295	89.7964	**-0.1661**	0.0172	0.0014	-	**0.0173**
	89.9549	134.6272	89.7905	**-0.1644**	0.0161	0.0006	-	**0.0161**
	89.9619	134.6284	89.7935	**-0.1683**	0.0158	0.0009	-	**0.0158**
	89.9619	134.6287	89.7944	**-0.1675**	0.0178	0.0014	-	**0.0178**
PTB	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Table 30 Results and uncertainty budget loop 1, 95 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 1	94.9739	136.5197	94.7686	**-0.2053**	0.0160	0.0018	-	**0.0161**
	94.9733	136.5181	94.7642	**-0.2091**	0.0160	0.0020	-	**0.0161**
	94.9583	136.5146	94.7551	**-0.2031**	0.0155	0.0042	-	**0.0160**
	95.0015	136.5313	94.7989	**-0.2026**	0.0151	0.0038	-	**0.0155**
FORCE	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
NML/NSAI	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
CETIAT	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
INTA 1	94.9011	136.4894	94.6888	**-0.2124**	0.0216	0.0079	-	**0.0230**
	94.8951	136.4885	94.6862	**-0.2089**	0.0216	0.0122	-	**0.0249**
	94.9825	136.5216	94.7736	**-0.2089**	0.0216	0.0109	-	**0.0243**
	94.8872	136.4836	94.6734	**-0.2138**	0.0216	0.0073	-	**0.0229**
TUBITAK	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
MIRS/UL-FE/LMK	94.9860	136.5059	94.7320	**-0.2540**	0.0329	0.0074	-	**0.0337**
	94.9870	136.5064	94.7335	**-0.2535**	0.0329	0.0087	-	**0.0340**
	94.9460	136.5089	94.7399	**-0.2061**	0.0329	0.0068	-	**0.0336**
	94.9910	136.5089	94.7399	**-0.2511**	0.0329	0.0103	-	**0.0345**
EIM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
FSB-LPM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
BEV/E+E 2	94.9731	136.5219	94.7742	**-0.1989**	0.0169	0.0014	-	**0.0169**
	94.9689	136.5203	94.7700	**-0.1988**	0.0164	0.0017	-	**0.0165**
	94.9717	136.5202	94.7699	**-0.2018**	0.0161	0.0026	-	**0.0163**
	94.9714	136.5207	94.7711	**-0.2002**	0.0164	0.0024	-	**0.0165**

Table 31 Results and uncertainty budget loop 2, 95 °C dew-point temperature

Lab	measured values				uncertainity			
	applied DP	resistance output	output	difference	reference	short term	resolution	
	in °C	in ohm	in °C	in °C		DUT	DUT	combined
BEV/E+E 3	94.9739	136.5340	94.8062	**-0.1677**	0.0160	0.0031	-	**0.0163**
	94.9733	136.5327	94.8028	**-0.1705**	0.0160	0.0011	-	**0.0160**
	94.9583	136.5283	94.7912	**-0.1671**	0.0155	0.0050	-	**0.0162**
	95.0015	136.5454	94.8362	**-0.1653**	0.0151	0.0052	-	**0.0159**
METAS	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
INRIM	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
VSL	95.1134	136.5754	94.9150	**-0.1984**	0.0431	0.0085	0.0066	**0.0444**
	95.1823	136.5853	94.9411	**-0.2413**	0.0431	0.0140	0.0066	**0.0458**
	95.1500	136.5816	94.9315	**-0.2185**	0.0431	0.0114	0.0066	**0.0451**
	-	-	-	-	-	-	-	-
INTA 2	94.9008	136.5041	94.7273	**-0.1734**	0.0216	0.0115	-	**0.0245**
	94.8948	136.5017	94.7210	**-0.1738**	0.0216	0.0078	-	**0.0230**
	94.9821	136.5318	94.8003	**-0.1818**	0.0216	0.0055	-	**0.0223**
	94.8868	136.4956	94.7050	**-0.1818**	0.0216	0.0067	-	**0.0226**
VTT	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
NPL	94.9054	136.4978	94.7108	**-0.1946**	0.0530	0.0040	0.0029	**0.0532**
	95.2116	136.6043	94.9911	**-0.2205**	0.0530	0.0042	0.0029	**0.0532**
	95.0872	136.5518	94.8529	**-0.2344**	0.0530	0.0074	0.0029	**0.0536**
	94.9450	136.5081	94.7380	**-0.2070**	0.0590	0.0262	0.0029	**0.0646**
GUM	94.8466	136.5105	94.7443	**-0.1023**	0.0336	0.0004	-	**0.0336**
	94.8409	136.5074	94.7361	**-0.1048**	0.0336	0.0007	-	**0.0336**
	94.8435	136.4998	94.7160	**-0.1275**	0.0336	0.0010	-	**0.0336**
	94.8433	136.5046	94.7286	**-0.1147**	0.0336	0.0011	-	**0.0337**
BEV/E+E 4	94.9731	136.5304	94.7967	**-0.1764**	0.0169	0.0010	-	**0.0169**
	94.9689	136.5302	94.7962	**-0.1727**	0.0164	0.0017	-	**0.0165**
	94.9717	136.5308	94.7976	**-0.1741**	0.0161	0.0018	-	**0.0162**
	94.9714	136.5317	94.7999	**-0.1715**	0.0164	0.0028	-	**0.0166**
PTB	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Appendix B Detailed uncertainty budget reported by all participants

Appendix B.1BEV/E+E

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**unit**	**Degrees of freedom components evaluated by a type A method *** ν_i	**unit**	**Sensitivity coefficient** c_i	**unit**	**Uncertainty contribution** u_i	**unit**	**Calculation of degrees of freedom**
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.964	K/K	0.0072	°C	5.46834E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.964	K/K	0.0010	°C	1.72827E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.964	K/K	0.0010	°C	1.72827E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.964	K/K	0.0022	°C	4.8364E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.964	K/K	0.0019	°C	2.76522E-13
	Temperature stability	0.0005	°C	>50	-	0.964	K/K	0.0005	°C	1.20131E-15
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.06	hPa	50	-	0.013	K/hPa	0.0008	°C	7.53338E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.013	K/hPa	0.0038	°C	4.26124E-12
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.013	K/hPa	0.0013	°C	6.02482E-14
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.013	K/hPa	0.0040	°C	4.8801E-12
	Stability of the pressure	0.10	hPa	>50	-	0.013	K/hPa	0.0014	°C	7.12875E-14
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.013	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.04	hPa	50	-	0.017	K/hPa	0.0008	°C	7.53338E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.017	K/hPa	0.0051	°C	1.32568E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.017	K/hPa	0.0017	°C	1.87433E-13
	Stability of the pressure	0.09	hPa	>50	-	0.017	K/hPa	0.0016	°C	1.2835E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.017	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.008	K/(l/min)	0.0002	°C	1.41309E-17
	Reproducibility	0.01	l/min	50	-	0.008	K/(l/min)	0.0001	°C	8.83182E-19
Saturation efficiency										
	Saturation efficiency	0.0021	hPa	50	-	0.409	K/hPa	0.0009	°C	1.14747E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0017	hPa	50	-	0.409	K/hPa	0.0007	°C	5.19459E-15
	Water vapour enhancement formula(e)	0.0043	hPa	50	-	0.409	K/hPa	0.0018	°C	1.94489E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0120	°C	
Effective degrees of freedom				255	-				°C	8.0171E-11
Expanded uncertainty					-			0.0239	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.017	K/hPa	0.0004	°C	7.32159E-16
	Other				-				°C	
Combined uncertainty					-			0.0120	°C	
Effective degrees of freedom				255	-				°C	8.01717E-11
Expanded uncertainty					-			0.0239	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 16 Uncertainty budget reported by BEV/E+E at 30 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**		**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.877	K/K	0.0066	°C	3.73585E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.877	K/K	0.0009	°C	1.18071E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.877	K/K	0.0009	°C	1.18071E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.877	K/K	0.0020	°C	3.30412E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.877	K/K	0.0018	°C	1.88914E-13
	Temperature stability	0.0001	°C	>50	-	0.877	K/K	0.0001	°C	2.29589E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.11	hPa	50	-	0.008	K/hPa	0.0009	°C	1.32841E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.008	K/hPa	0.0023	°C	5.78138E-13
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.008	K/hPa	0.0008	°C	8.1741E-15
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.008	K/hPa	0.0024	°C	6.62102E-13
	Stability of the pressure	0.04	hPa	>50	-	0.008	K/hPa	0.0003	°C	1.45038E-16
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.008	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.04	hPa	50	-	0.020	K/hPa	0.0009	°C	1.32841E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.020	K/hPa	0.0059	°C	2.40139E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.020	K/hPa	0.0020	°C	3.39524E-13
	Stability of the pressure	0.02	hPa	>50	-	0.020	K/hPa	0.0005	°C	1.266E-15
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.020	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.011	K/(l/min)	0.0002	°C	4.60121E-17
	Reproducibility	0.01	l/min	50	-	0.011	K/(l/min)	0.0001	°C	2.87575E-18
Saturation efficiency										
	Saturation efficiency	0.0062	hPa	50	-	0.162	K/hPa	0.0010	°C	2.0525E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0020	hPa	50	-	0.162	K/hPa	0.0003	°C	2.028E-16
	Water vapour enhancement formula(e)	0.0137	hPa	50	-	0.162	K/hPa	0.0022	°C	4.83141E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0109	°C	
Effective degrees of freedom				218	-				°C	6.56551E-11
Expanded uncertainty					-			0.0219	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.020	K/hPa	0.0005	°C	1.32627E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0109	°C	
Effective degrees of freedom				218	-				°C	6.56565E-11
Expanded uncertainty					-			0.0219	°C	

Figure 17 Uncertainty budget reported by BEV/E+E at 50 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature — Nominal value: 65 °C — Lab name: BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * v_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.969	K/K	0.0073	°C	5.57407E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.969	K/K	0.0010	°C	1.76168E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.969	K/K	0.0010	°C	1.76168E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.969	K/K	0.0022	°C	4.9299E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.969	K/K	0.0019	°C	2.81869E-13
	Temperature stability	0.0001	°C	>50	-	0.969	K/K	0.0001	°C	7.65964E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.06	hPa	50	-	0.018	K/hPa	0.0010	°C	1.98001E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.018	K/hPa	0.0051	°C	1.38292E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.018	K/hPa	0.0018	°C	1.95527E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.018	K/hPa	0.0053	°C	1.58377E-11
	Stability of the pressure	0.13	hPa	>50	-	0.018	K/hPa	0.0023	°C	5.22845E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.018	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.022	K/hPa	0.0010	°C	1.98001E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.022	K/hPa	0.0064	°C	3.34091E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.022	K/hPa	0.0022	°C	4.72359E-13
	Stability of the pressure	0.10	hPa	>50	-	0.022	K/hPa	0.0022	°C	4.35735E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.022	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.014	K/(l/min)	0.0003	°C	1.27294E-16
	Reproducibility	0.01	l/min	50	-	0.014	K/(l/min)	0.0001	°C	7.95588E-18
Saturation efficiency										
	Saturation efficiency	0.0126	hPa	50	-	0.089	K/hPa	0.0011	°C	3.11539E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations		hPa				K/hPa		K		
	Saturation vapour pressure formula(e)	0.0030	hPa	50	-	0.089	K/hPa	0.0003	°C	1.04666E-16
	Water vapour enhancement formula(e)	0.0163	hPa	50	-	0.089	K/hPa	0.0014	°C	8.6526E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0138	°C	
Effective degrees of freedom				296	-				°C	1.23031E-10
Expanded uncertainty					-			0.0276	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.022	K/hPa	0.0006	°C	1.84515E-15
	Other				-				°C	
Combined uncertainty					-			0.0138	°C	
Effective degrees of freedom				297	-				°C	1.23033E-10
Expanded uncertainty					-			0.0277	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 18 Uncertainty budget reported by BEV/E+E at 65 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature		Nominal value:	80	°C			Lab name	BEV / E+E		
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.941	K/K	0.0071	°C	4.96593E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.941	K/K	0.0009	°C	1.56948E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.941	K/K	0.0009	°C	1.56948E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.941	K/K	0.0022	°C	4.39204E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.941	K/K	0.0019	°C	2.51117E-13
	Temperature stability	0.0002	°C	>50	-	0.941	K/K	0.0001	°C	9.33092E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.07	hPa	50	-	0.016	K/hPa	0.0011	°C	2.89782E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.016	K/hPa	0.0047	°C	1.01792E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.016	K/hPa	0.0016	°C	1.4392E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.016	K/hPa	0.0049	°C	1.16575E-11
	Stability of the pressure	0.06	hPa	>50	-	0.016	K/hPa	0.0009	°C	1.44253E-14
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.016	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.024	K/hPa	0.0011	°C	2.89782E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.024	K/hPa	0.0071	°C	4.95419E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.024	K/hPa	0.0024	°C	7.00456E-13
	Stability of the pressure	0.02	hPa	>50	-	0.024	K/hPa	0.0005	°C	9.38592E-16
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.024	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.023	K/(l/min)	0.0005	°C	8.44939E-16
	Reproducibility	0.01	l/min	50	-	0.023	K/(l/min)	0.0002	°C	5.28087E-17
Saturation efficiency										
	Saturation efficiency	0.0238	hPa	50	-	0.052	K/hPa	0.0012	°C	4.68543E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0062	hPa	50	-	0.052	K/hPa	0.0003	°C	2.22514E-16
	Water vapour enhancement formula(e)	0.0298	hPa	50	-	0.052	K/hPa	0.0015	°C	1.14653E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0135	°C	
Effective degrees of freedom				265	-				°C	1.2446E-10
Expanded uncertainty					-			0.0270	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.024	K/hPa	0.0006	°C	2.73615E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0135	°C	
Effective degrees of freedom				266	-				°C	1.24463E-10
Expanded uncertainty					-			0.0270	°C	

Figure 19 Uncertainty budget reported by BEV/E+E at 80 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**		**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**v_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.971	K/K	0.0073	°C	5.61563E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.971	K/K	0.0010	°C	1.77482E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.971	K/K	0.0010	°C	1.77482E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.971	K/K	0.0022	°C	4.96667E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.971	K/K	0.0019	°C	2.83971E-13
	Temperature stability	0.0002	°C	>50	-	0.971	K/K	0.0002	°C	1.53677E-17
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.021	K/hPa	0.0011	°C	3.27695E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.021	K/hPa	0.0060	°C	2.61122E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.021	K/hPa	0.0021	°C	3.69191E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.021	K/hPa	0.0062	°C	2.99045E-11
	Stability of the pressure	0.15	hPa	>50	-	0.021	K/hPa	0.0031	°C	1.87385E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.021	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.04	hPa	50	-	0.025	K/hPa	0.0011	°C	3.27695E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0073	°C	5.66112E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	8.00406E-13
	Stability of the pressure	0.16	hPa	>50	-	0.025	K/hPa	0.0040	°C	5.20046E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.025	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.029	K/(l/min)	0.0006	°C	2.15455E-15
	Reproducibility	0.01	l/min	50	-	0.029	K/(l/min)	0.0003	°C	1.34659E-16
Saturation efficiency										
	Saturation efficiency	0.0291	hPa	50	-	0.044	K/hPa	0.0013	°C	5.38128E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0079	hPa	50	-	0.044	K/hPa	0.0003	°C	2.92059E-16
	Water vapour enhancement formula(e)	0.0316	hPa	50	-	0.044	K/hPa	0.0014	°C	7.48004E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0156	°C	
Effective degrees of freedom				331	-				°C	1.79661E-10
Expanded uncertainty					-			0.0312	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.025	K/hPa	0.0006	°C	3.12659E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0156	°C	
Effective degrees of freedom				332	-				°C	1.79664E-10
Expanded uncertainty					-			0.0313	°C	

Figure 20 Uncertainty budget reported by BEV/E+E at 85 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature		Nominal value:	90	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**		**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.943	K/K	0.0071	°C	5.01156E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.943	K/K	0.0009	°C	1.5839E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.943	K/K	0.0009	°C	1.5839E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.943	K/K	0.0022	°C	4.43241E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.943	K/K	0.0019	°C	2.53424E-13
	Temperature stability	0.0002	°C	>50	-	0.943	K/K	0.0002	°C	1.98857E-17
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.06	hPa	50	-	0.018	K/hPa	0.0012	°C	3.70495E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.018	K/hPa	0.0052	°C	1.50939E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.018	K/hPa	0.0018	°C	2.13407E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.018	K/hPa	0.0054	°C	1.7286E-11
	Stability of the pressure	0.09	hPa	>50	-	0.018	K/hPa	0.0016	°C	1.33404E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.018	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.04	hPa	50	-	0.026	K/hPa	0.0012	°C	3.70495E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.026	K/hPa	0.0076	°C	6.61435E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.026	K/hPa	0.0026	°C	9.35179E-13
	Stability of the pressure	0.09	hPa	>50	-	0.026	K/hPa	0.0023	°C	5.83911E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.026	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.041	K/(l/min)	0.0008	°C	9.25245E-15
	Reproducibility	0.01	l/min	50	-	0.041	K/(l/min)	0.0004	°C	5.78278E-16
Saturation efficiency										
	Saturation efficiency	0.0352	hPa	50	-	0.038	K/hPa	0.0013	°C	6.18335E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0140	hPa	50	-	0.038	K/hPa	0.0005	°C	1.56013E-15
	Water vapour enhancement formula(e)	0.0407	hPa	50	-	0.038	K/hPa	0.0015	°C	1.10419E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0145	°C	
Effective degrees of freedom				287	-				°C	1.53111E-10
Expanded uncertainty					-			0.0290	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.026	K/hPa	0.0007	°C	3.65304E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0145	°C	
Effective degrees of freedom				288	-				°C	1.53115E-10
Expanded uncertainty					-			0.0290	°C	

Figure 21 Uncertainty budget reported by BEV/E+E at 90 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature Nominal value: 95 °C Lab name: BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.971	K/K	0.0073	°C	5.63215E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.971	K/K	0.0010	°C	1.78004E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.971	K/K	0.0010	°C	1.78004E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.971	K/K	0.0022	°C	4.98128E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	0.971	K/K	0.0019	°C	2.84806E-13
	Temperature stability	0.0002	°C	>50	-	0.971	K/K	0.0002	°C	5.29525E-17
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.06	hPa	50	-	0.021	K/hPa	0.0012	°C	4.1642E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.021	K/hPa	0.0060	°C	2.58966E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.021	K/hPa	0.0021	°C	3.66143E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.021	K/hPa	0.0062	°C	2.96576E-11
	Stability of the pressure	0.11	hPa	>50	-	0.021	K/hPa	0.0022	°C	4.52634E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.021	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.025	K/hPa	0.0012	°C	4.1642E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0072	°C	5.38794E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	7.61782E-13
	Stability of the pressure	0.15	hPa	>50	-	0.025	K/hPa	0.0038	°C	4.22918E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.025	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.064	K/(l/min)	0.0013	°C	5.25541E-14
	Reproducibility	0.01	l/min	50	-	0.064	K/(l/min)	0.0006	°C	3.28463E-15
Saturation efficiency										
	Saturation efficiency	0.0424	hPa	50	-	0.032	K/hPa	0.0014	°C	7.07775E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0180	hPa	50	-	0.032	K/hPa	0.0006	°C	2.3293E-15
	Water vapour enhancement formula(e)	0.0469	hPa	50	-	0.032	K/hPa	0.0015	°C	1.0588E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0154	°C	
Effective degrees of freedom				326	-				°C	1.74322E-10
Expanded uncertainty					-			0.0309	°C	

Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.025	K/hPa	0.0006	°C	2.97571E-15
	Other				-				°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty					-			0.0155	°C	
Effective degrees of freedom				327	-				°C	1.74325E-10
Expanded uncertainty					-			0.0309	°C	

Figure 22 Uncertainty budget reported by BEV/E+E at 90 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature Nominal value: 95 °C Lab name BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * v_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit		Calculation of degrees of freedom
Primary dew-point generator											
Saturation temperature											
	Thermometer										
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	0.971	K/K	0.0073	°C		5.63215E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	0.971	K/K	0.0010	°C		1.78004E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	0.971	K/K	0.0010	°C		1.78004E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	0.971	K/K	0.0022	°C		4.98128E-13
	Saturator:										
	Temperature homogeneity	0.0020	°C	50	-	0.971	K/K	0.0019	°C		2.84806E-13
	Temperature stability	0.0002	°C	>50	-	0.971	K/K	0.0002	°C		5.29525E-17
Saturation pressure											
	Pressure gaug										
	Calibration uncertainty (sensor and indicator unit)	0.06	hPa	50	-	0.021	K/hPa	0.0012	°C		4.1642E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.021	K/hPa	0.0060	°C		2.58966E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.021	K/hPa	0.0021	°C		3.66143E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.021	K/hPa	0.0062	°C		2.96576E-11
	Stability of the pressure	0.11	hPa	>50	-	0.021	K/hPa	0.0022	°C		4.52634E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.021	K/hPa	0.0000	°C		0
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.025	K/hPa	0.0012	°C		4.1642E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0072	°C		5.38794E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C		7.61782E-13
	Stability of the pressure	0.15	hPa	>50	-	0.025	K/hPa	0.0038	°C		4.22918E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.025	K/hPa	0.0000	°C		0
Flow measurement:											
	Flow meter [L/min]										
	Stability of the flow	0.02	l/min	50	-	0.064	K/(l/min)	0.0013	°C		5.25541E-14
	Reproducibility	0.01	l/min	50	-	0.064	K/(l/min)	0.0006	°C		3.28463E-15
Saturation efficiency											
	Saturation efficiency	0.0424	hPa	50	-	0.032	K/hPa	0.0014	°C		7.07775E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0180	hPa	50	-	0.032	K/hPa	0.0006	°C		2.3293E-15
	Water vapour enhancement formula(e)	0.0469	hPa	50	-	0.032	K/hPa	0.0015	°C		1.0588E-13
Other uncertainties											
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C		1.62E-12
					-				°C		
					-				°C		
Combined uncertainty					-			0.0154	°C		
Effective degrees of freedom				326	-				°C		1.74322E-10
Expanded uncertainty					-			0.0309	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.025	K/hPa	0.0006	°C		2.97571E-15
	Other				-				°C		
Combined uncertainty					-			0.0155	°C		
Effective degrees of freedom				327	-				°C		1.74325E-10
Expanded uncertainty					-			0.0309	°C		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 23 Uncertainty budget reported by BEV/E+E at 95 °C nominal dew-point temperature (BEV/E+E 1 and BEV/+E 3)

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	BEV / E+E			Calculation of degrees of freedom
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**unit**	**Degrees of freedom components evaluated by a type A method *** ν_i	**unit**	**Sensitivity coefficient** c_i	**unit**	**Uncertainty contribution** u_i	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32813E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	2E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	2E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59682E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.2E-13
	Temperature stability	0.0007	°C	>50	-	1.000	K/K	0.0007	°C	5.30958E-15
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.016	K/hPa	0.0008	°C	6.78561E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.016	K/hPa	0.0046	°C	9.12159E-12
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.016	K/hPa	0.0016	°C	1.28967E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.016	K/hPa	0.0048	°C	1.04463E-11
	Stability of the pressure	0.16	hPa	>50	-	0.016	K/hPa	0.0026	°C	9.23458E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.016	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.016	K/hPa	0.0008	°C	6.77386E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.016	K/hPa	0.0046	°C	9.15756E-12
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.016	K/hPa	0.0016	°C	1.29476E-13
	Stability of the pressure	0.16	hPa	>50	-	0.016	K/hPa	0.0026	°C	9.23427E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.016	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.007	K/(l/min)	0.0001	°C	9.76141E-18
	Reproducibility	0.01	l/min	50	-	0.007	K/(l/min)	0.0001	°C	6.10088E-19
Saturation efficiency										
	Saturation efficiency	0.0021	hPa	50	-	0.409	K/hPa	0.0009	°C	1.14697E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0019	hPa	50	-	0.409	K/hPa	0.0008	°C	7.91127E-15
	Water vapour enhancement formula(e)	0.0041	hPa	50	-	0.409	K/hPa	0.0017	°C	1.58719E-13
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0129	°C	
Effective degrees of freedom				287	-				°C	9.68487E-11
Expanded uncertainty					-			0.0258	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.016	K/hPa	0.0004	°C	5.05764E-16
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0129	°C	
Effective degrees of freedom				288	-				°C	9.68492E-11
Expanded uncertainty					-			0.0258	°C	

Figure 24 Uncertainty budget reported by BEV/E+E at 30 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature — Nominal value: 50 °C — Lab name: BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32446E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99884E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99884E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59358E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19815E-13
	Temperature stability	0.0003	°C	>50	-	1.000	K/K	0.0003	°C	1.31535E-16
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.018	K/hPa	0.0009	°C	1.18728E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.018	K/hPa	0.0053	°C	1.59188E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.018	K/hPa	0.0018	°C	2.2507E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.018	K/hPa	0.0055	°C	1.82307E-11
	Stability of the pressure	0.03	hPa	>50	-	0.018	K/hPa	0.0006	°C	2.97576E-15
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.018	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.018	K/hPa	0.0009	°C	1.18541E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.018	K/hPa	0.0053	°C	1.59864E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.018	K/hPa	0.0018	°C	2.26026E-13
	Stability of the pressure	0.03	hPa	>50	-	0.018	K/hPa	0.0006	°C	2.72267E-15
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.018	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.010	K/(l/min)	0.0002	°C	3.06308E-17
	Reproducibility	0.01	l/min	50	-	0.010	K/(l/min)	0.0001	°C	1.91443E-18
Saturation efficiency										
	Saturation efficiency	0.0062	hPa	50	-	0.162	K/hPa	0.0010	°C	2.05033E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0024	hPa	50	-	0.162	K/hPa	0.0004	°C	4.31927E-16
	Water vapour enhancement formula(e)	0.0091	hPa	50	-	0.162	K/hPa	0.0015	°C	9.64196E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0133	°C	
Effective degrees of freedom				265	-				°C	1.16518E-10
Expanded uncertainty					-			0.0265	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.020	K/hPa	0.0005	°C	1.32627E-15
	Other				-				°C	
Combined uncertainty					-			0.0109	°C	
Effective degrees of freedom				218	-				°C	1.16519E-10
Expanded uncertainty					-			0.0219	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 25 Uncertainty budget reported by BEV/E+E at 50 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature Nominal value: 65 °C Lab name BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * v_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32424E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99877E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99877E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59339E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19804E-13
	Temperature stability	0.0001	°C	>50	-	1.000	K/K	0.0001	°C	5.42871E-19
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.020	K/hPa	0.0010	°C	1.78198E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.020	K/hPa	0.0059	°C	2.34475E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.020	K/hPa	0.0020	°C	3.31516E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.020	K/hPa	0.0061	°C	2.68528E-11
	Stability of the pressure	0.13	hPa	>50	-	0.020	K/hPa	0.0026	°C	8.57693E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.020	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.020	K/hPa	0.0010	°C	1.77919E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.020	K/hPa	0.0059	°C	2.35478E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.020	K/hPa	0.0020	°C	3.32934E-13
	Stability of the pressure	0.13	hPa	>50	-	0.020	K/hPa	0.0027	°C	9.97988E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.020	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.013	K/(l/min)	0.0003	°C	8.97208E-17
	Reproducibility	0.01	l/min	50	-	0.013	K/(l/min)	0.0001	°C	5.60755E-18
Saturation efficiency										
	Saturation efficiency	0.0126	hPa	50	-	0.089	K/hPa	0.0011	°C	3.11012E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0031	hPa	50	-	0.089	K/hPa	0.0003	°C	1.20049E-16
	Water vapour enhancement formula(e)	0.0157	hPa	50	-	0.089	K/hPa	0.0014	°C	7.59309E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0144	°C	
Effective degrees of freedom				306	-				°C	1.42293E-10
Expanded uncertainty					-			0.0289	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.020	K/hPa	0.0005	°C	1.30052E-15
	Other				-				°C	
Combined uncertainty					-			0.0145	°C	
Effective degrees of freedom				307	-				°C	1.42294E-10
Expanded uncertainty					-			0.0289	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 26 Uncertainty budget reported by BEV/E+E at 65 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature		Nominal value:	80	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**		**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**v_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32348E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99853E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99853E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59271E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19765E-13
	Temperature stability	0.0001	°C	>50	-	1.000	K/K	0.0001	°C	2.40557E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.022	K/hPa	0.0011	°C	2.53305E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.022	K/hPa	0.0064	°C	3.39021E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.022	K/hPa	0.0022	°C	4.7933E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.022	K/hPa	0.0066	°C	3.88257E-11
	Stability of the pressure	0.12	hPa	>50	-	0.022	K/hPa	0.0027	°C	1.00067E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.022	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.022	K/hPa	0.0011	°C	2.53017E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.022	K/hPa	0.0064	°C	3.40677E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.022	K/hPa	0.0022	°C	4.81671E-13
	Stability of the pressure	0.12	hPa	>50	-	0.022	K/hPa	0.0027	°C	9.94616E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.022	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.021	K/(l/min)	0.0004	°C	5.81025E-16
	Reproducibility	0.01	l/min	50	-	0.021	K/(l/min)	0.0002	°C	3.63141E-17
Saturation efficiency										
	Saturation efficiency	0.0238	hPa	50	-	0.052	K/hPa	0.0012	°C	4.67841E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0055	hPa	50	-	0.052	K/hPa	0.0003	°C	1.34313E-16
	Water vapour enhancement formula(e)	0.0260	hPa	50	-	0.052	K/hPa	0.0014	°C	6.70191E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0153	°C	
Effective degrees of freedom				309	-				°C	1.75691E-10
Expanded uncertainty					-			0.0305	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.022	K/hPa	0.0006	°C	1.88153E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0153	°C	
Effective degrees of freedom				309	-				°C	1.75693E-10
Expanded uncertainty					-			0.0305	°C	

Figure 27 Uncertainty budget reported by BEV/E+E at 80 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**		**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**v_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**	
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32385E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99865E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99865E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59304E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19784E-13
	Temperature stability	0.0001	°C	>50	-	1.000	K/K	0.0001	°C	6.20492E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.023	K/hPa	0.0011	°C	2.94619E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.023	K/hPa	0.0066	°C	3.85005E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.023	K/hPa	0.0023	°C	5.44346E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.023	K/hPa	0.0069	°C	4.4092E-11
	Stability of the pressure	0.11	hPa	>50	-	0.023	K/hPa	0.0026	°C	9.30948E-13
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.023	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.023	K/hPa	0.0011	°C	2.94149E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.023	K/hPa	0.0066	°C	3.86708E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.023	K/hPa	0.0023	°C	5.46754E-13
	Stability of the pressure	0.13	hPa	>50	-	0.023	K/hPa	0.0029	°C	1.33559E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.023	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.026	K/(l/min)	0.0005	°C	1.47176E-15
	Reproducibility	0.01	l/min	50	-	0.026	K/(l/min)	0.0003	°C	9.1985E-17
Saturation efficiency										
	Saturation efficiency	0.0290	hPa	50	-	0.044	K/hPa	0.0013	°C	5.36162E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0073	hPa	50	-	0.044	K/hPa	0.0003	°C	2.12835E-16
	Water vapour enhancement formula(e)	0.0309	hPa	50	-	0.044	K/hPa	0.0014	°C	6.87979E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0156	°C	
Effective degrees of freedom				310	-				°C	1.90582E-10
Expanded uncertainty					-			0.0312	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.023	K/hPa	0.0006	°C	2.13576E-15
	Other				-				°C	
* for type B method the number of degrees of freedom will be considered as being larger than 50.										
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)										
Combined uncertainty					-			0.0156	°C	
Effective degrees of freedom				311	-				°C	1.90584E-10
Expanded uncertainty					-			0.0312	°C	

Figure 28 Uncertainty budget reported by BEV/E+E at 85 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature		Nominal value:	90	°C		Lab name	BEV / E+E			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8										
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature										

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32363E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99858E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99858E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59285E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19773E-13
	Temperature stability	0.0001	°C	>50	-	1.000	K/K	0.0001	°C	2.05928E-18
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.024	K/hPa	0.0011	°C	3.39708E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.024	K/hPa	0.0069	°C	4.51428E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.024	K/hPa	0.0024	°C	6.38259E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.024	K/hPa	0.0071	°C	5.1699E-11
	Stability of the pressure	0.21	hPa	>50	-	0.024	K/hPa	0.0051	°C	1.31878E-11
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.024	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.024	K/hPa	0.0011	°C	3.3927E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.024	K/hPa	0.0069	°C	4.53493E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.024	K/hPa	0.0024	°C	6.41179E-13
	Stability of the pressure	0.23	hPa	>50	-	0.024	K/hPa	0.0054	°C	1.68772E-11
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.024	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.038	K/(l/min)	0.0008	°C	6.34368E-15
	Reproducibility	0.01	l/min	50	-	0.038	K/(l/min)	0.0004	°C	3.9648E-16
Saturation efficiency										
	Saturation efficiency	0.0352	hPa	50	-	0.038	K/hPa	0.0013	°C	6.15492E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0102	hPa	50	-	0.038	K/hPa	0.0004	°C	4.35905E-16
	Water vapour enhancement formula(e)	0.0362	hPa	50	-	0.038	K/hPa	0.0014	°C	6.92117E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0172	°C	
Effective degrees of freedom				365	-				°C	2.39517E-10
Expanded uncertainty					-			0.0344	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.024	K/hPa	0.0006	°C	2.5046E-15
	Other				-				°C	
Combined uncertainty					-			0.0172	°C	
Effective degrees of freedom				366	-				°C	2.39519E-10
Expanded uncertainty					-			0.0344	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 29 Uncertainty budget reported by BEV/E+E at 90 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Uncertainty analysis of dew point temperature — Nominal value: 95 °C — Lab name: BEV / E+E

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit	Calculation of degrees of freedom
Primary dew-point generator										
Saturation temperature										
	Thermometer									
	Calibration uncertainty (sensor and indicator unit)	0.0075	°C	50	-	1.000	K/K	0.0075	°C	6.32323E-11
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99845E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99845E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59249E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19753E-13
	Temperature stability	0.0003	°C	>50	-	1.000	K/K	0.0003	°C	2.61174E-16
Saturation pressure										
	Pressure gaug									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.025	K/hPa	0.0012	°C	3.76802E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0071	°C	5.0997E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	7.21029E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.025	K/hPa	0.0074	°C	5.84034E-11
	Stability of the pressure	0.16	hPa	>50	-	0.025	K/hPa	0.0038	°C	4.28247E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.025	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.025	K/hPa	0.0012	°C	3.76125E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0071	°C	5.12474E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	7.24569E-13
	Stability of the pressure	0.17	hPa	>50	-	0.025	K/hPa	0.0041	°C	5.81001E-12
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.025	K/hPa	0.0000	°C	0
Flow measurement:										
	Flow meter [L/min]									
	Stability of the flow	0.02	l/min	50	-	0.063	K/(l/min)	0.0013	°C	4.99868E-14
	Reproducibility	0.01	l/min	50	-	0.063	K/(l/min)	0.0006	°C	3.12418E-15
Saturation efficiency										
	Saturation efficiency	0.0424	hPa	50	-	0.032	K/hPa	0.0014	°C	7.08617E-14
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant				-				°C	
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)	0.0153	hPa	50	-	0.032	K/hPa	0.0005	°C	1.19165E-15
	Water vapour enhancement formula(e)	0.0424	hPa	50	-	0.032	K/hPa	0.0014	°C	7.09194E-14
Other uncertainties										
comment	effect of temperature difference between saturator and outlet-line	0.0030	°C	50	-	1.000	K/K	0.0030	°C	1.62E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0169	°C	
Effective degrees of freedom				339	-				°C	2.38229E-10
Expanded uncertainty					-			0.0337	°C	
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	0.0250	hPa	>50	-	0.025	K/hPa	0.0006	°C	2.83035E-15
	Other				-				°C	
Combined uncertainty					-			0.0169	°C	
Effective degrees of freedom				340	-				°C	2.38232E-10
Expanded uncertainty					-			0.0337	°C	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 30 Uncertainty budget reported by BEV/E+E at 95 °C nominal dew-point temperature (BEV/E+E 2 and BEV/+E 4)

Appendix B.2FORCE

Uncertainty analysis of dewpoint temperature		Nominal value:	30	°C		Lab name	DELTA				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0250	°C		-	1.000		0.0250	°C		#DIV/0!
	Long-term stability (See "Reference hygrometer, Measurment" below)				-				°C		#DIV/0!
	Effect of thermal conditions (Same)				-				°C		#DIV/0!
	Resolution and linearity (Same)				-				°C		#DIV/0!
	Effect of non-ideal condensed layer (Same)				-				°C		#DIV/0!
	Short-term stability (Same)				-				°C		#DIV/0!
Pressure difference (Assumed insignificant)											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement: (Assumed insignificant)											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations (Assumed insignificant)											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
	Reference hygrometer, Measurement	0.0580	°C		-	1.000		0.0580	°C		#DIV/0!
	Resistance measurement, Measurement (DELTA Michell Pt100 output)	0.0160	Ohm		-	2.630	°C/Ohm	0.0421	°C		#DIV/0!
	Chamber, Stability ("time & space" = "temporal & spatial")	0.0290	°C		-	1.000		0.0290	°C		#DIV/0!
	DMM, readout from travelling standard (External Pt100)	0.0130	Ohm		-	2.630	°C/Ohm	0.0342	°C		#DIV/0!
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty					-			0.0881	°C		
Effective degrees of freedom					-			Infinite	°C	sum	#DIV/0!
Expanded uncertainty					-			0.1763	°C		

Figure 31 Uncertainty budget reported by FORCE at 30 °C nominal dew-point temperature

Uncertainty analysis of dewpoint temperature		Nominal value:	50	°C		Lab name	DELTA				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0250	°C		-	1.000		0.0250	°C		#DIV/0!
	Long-term stability (See "Reference hygrometer, Measurment" below)				-				°C		#DIV/0!
	Effect of thermal conditions (Same)				-				°C		#DIV/0!
	Resolution and linearity (Same)				-				°C		#DIV/0!
	Effect of non-ideal condensed layer (Same)				-				°C		#DIV/0!
	Short-term stability (Same)				-				°C		#DIV/0!
Pressure difference (Assumed insignificant)											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement: (Assumed insignificant)											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations (Assumed insignificant)											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
	Reference hygrometer, Measurement	0.0580	°C		-	1.000		0.0580	°C		#DIV/0!
	Resistance measurement, Measurement (DELTA Michell Pt100 output)	0.0160	Ohm		-	2.630	°C/Ohm	0.0421	°C		#DIV/0!
	Chamber, Stability ("time & space" = "temporal & spatial")	0.0290	°C		-	1.000		0.0290	°C		#DIV/0!
	DMM, readout from travelling standard (External Pt100)	0.0130	Ohm		-	2.630	°C/Ohm	0.0342	°C		#DIV/0!
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	**sum**	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty					-			0.0881	°C		
Effective degrees of freedom					-			Infinite	°C	**sum**	#DIV/0!
Expanded uncertainty					-			0.1763	°C		

Figure 32 Uncertainty budget reported by FORCE at 50 °C nominal dew-point temperature

Uncertainty analysis of dewpoint temperature		Nominal value:	65	°C		Lab name	DELTA				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0300	°C		-	1.000		0.0300	°C		#DIV/0!
	Long-term stability (See "Reference hygrometer, Measurment" below)				-				°C		#DIV/0!
	Effect of thermal conditions (Same)				-				°C		#DIV/0!
	Resolution and linearity (Same)				-				°C		#DIV/0!
	Effect of non-ideal condensed layer (Same)				-				°C		#DIV/0!
	Short-term stability (Same)				-				°C		#DIV/0!
Pressure difference (Assumed insignificant)											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement: (Assumed insignificant)											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations (Assumed insignificant)											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
	Reference hygrometer, Measurement	0.0580	°C		-	1.000		0.0580	°C		#DIV/0!
	Resistance measurement, Measurement (DELTA Michell Pt100 output)	0.0160	Ohm		-	2.630	°C/Ohm	0.0421	°C		#DIV/0!
	Chamber, Stability ("time & space" = "temporal & spatial")	0.0290	°C		-	1.000		0.0290	°C		#DIV/0!
	DMM, readout from travelling standard (External Pt100)	0.0130	Ohm		-	2.630	°C/Ohm	0.0342	°C		#DIV/0!
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	**sum**	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty					-			0.0897	°C		
Effective degrees of freedom					-			Infinite	°C	**sum**	#DIV/0!
Expanded uncertainty					-			0.1794	°C		

Figure 33 Uncertainty budget reported by FORCE at 65 °C nominal dew-point temperature

Uncertainty analysis of dewpoint temperature Nominal value: 80 °C Lab name: DELTA

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit		Calculation of degrees of freedom
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0300	°C		-	1.000		0.0300	°C		#DIV/0!
	Long-term stability (See "Reference hygrometer, Measurment" below)				-				°C		#DIV/0!
	Effect of thermal conditions (Same)				-				°C		#DIV/0!
	Resolution and linearity (Same)				-				°C		#DIV/0!
	Effect of non-ideal condensed layer (Same)				-				°C		#DIV/0!
	Short-term stability (Same)				-				°C		#DIV/0!
Pressure difference (Assumed insignificant)											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement: (Assumed insignificant)											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations (Assumed insignificant)											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
	Reference hygrometer, Measurement	0.0580	°C		-	1.000		0.0580	°C		#DIV/0!
	Resistance measurement, Measurement (DELTA Michell Pt100 output)	0.0160	Ohm		-	2.630	°C/Ohm	0.0421	°C		#DIV/0!
	Chamber, Stability ("time & space" = "temporal & spatial")	0.0290	°C		-	1.000		0.0290	°C		#DIV/0!
	DMM, readout from travelling standard (External Pt100)	0.0130	Ohm		-	2.630	°C/Ohm	0.0342	°C		#DIV/0!
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty					-			0.0897	°C		
Effective degrees of freedom					-			Infinite	°C	sum	#DIV/0!
Expanded uncertainty					-			0.1794	°C		

Figure 34 Uncertainty budget reported by FORCE at 80 °C nominal dew-point temperature

Appendix B.3NML/NSAI

Uncertainty analysis of dewpoint temperature		Nominal value:	30	°C		Lab name	NSAI -IRELAND				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0800	°C	50	-	1.000	°C	0.0400	°C		5.12E-08
	Long-term stability	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Effect of thermal conditions	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Resolution and linearity	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Effect of non-ideal condensed layer	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Short-term stability	0.0016	°C	50	-	1.000	°C	0.0016	°C		1.3107E-13
Pressure difference											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties: Chub-E4 1529											
	Calibration Uncertainty (sensor and indicator unit)	0.0002	ohm	50	-	2.500		0.0003	°C		1.1438E-16
	Long-term stability (sensor and indicator)(Drift	0.0028	ohm	50	-	2.500		0.0040	°C		5.3609E-12
	Resolution/Linearity	0.0001	ohm	50	-	2.500		0.0001	°C		8.7218E-18
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		

Figure 35 Uncertainty budget reported by NML/NSAI at 30 °C nominal dew-point temperature

Uncertainty analysis of dewpoint temperature — Nominal value: 50 °C — Lab name: NSAI -IRELAND

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit		Calculation of degrees of freedom
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.0800	°C	50	-	1.000	°C	0.0400	°C		5.12E-08
	Long-term stability	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Effect of thermal conditions	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Resolution and linearity	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Effect of non-ideal condensed layer	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Short-term stability	0.0026	°C	50	-	1.000	°C	0.0026	°C		9.1395E-13
Pressure difference											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties: Chub-E4 1529											
	Calibration Uncertainty (sensor and indicator unit)	0.0002	ohm	50	-	2.500		0.0003	°C		1.62E-16
	Long-term stability (sensor and indicator)(Drift	0.0030	ohm	50	-	2.500		0.0043	°C		7.0646E-12
	Resolution/Linearity	0.0001	ohm	50	-	2.500		0.0001	°C		8.7218E-18
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	sum	#DIV/0!
Expanded uncertainty					-				°C		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 36 Uncertainty budget reported by NML/NSAI at 50 °C nominal dew-point temperature

Uncertainty analysis of dewpoint temperature		Nominal value:	65	°C		Lab name	NSAI -IRELAND				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_stand t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Calibration system with a standard hygrometer											
Humidity standard: Chilled mirror hygrometer											
	Calibration uncertainty	0.1400	°C	50	-	1.000	°C	0.0700	°C		4.802E-07
	Long-term stability	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Effect of thermal conditions	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Resolution and linearity	0.0100	°C	50	-	1.000	°C	0.0058	°C		2.2328E-11
	Effect of non-ideal condensed layer	0.0200	°C	50	-	1.000	°C	0.0116	°C		3.5724E-10
	Short-term stability	0.0037	°C	50	-	1.000	°C	0.0037	°C		3.7483E-12
Pressure difference											
Gas pressure in the standard hygrometer:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Pressure differences across the dew-point cell				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the standard hygrometer and the pressure gauge				-				°C		#DIV/0!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		#DIV/0!
	Long-term stability (sensor and indicator)				-				°C		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)				-				°C		#DIV/0!
	Stability of the pressure				-				°C		#DIV/0!
	Effect of the tubing between the test hygrometer and the pressure gauge				-				°C		#DIV/0!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties: Chub-E4 1529											
	Calibration Uncertainty (sensor and indicator unit)	0.0003		50	-	2.500		0.0003	°C		1.9073E-16
	Long-term stability (sensor and indicator)(Drift	0.0032		50	-	2.500		0.0046	°C		9.1455E-12
	Resolution/Linearity	0.0001		50	-	2.500		0.0001	°C		8.7218E-18
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	**sum**	#DIV/0!
Expanded uncertainty					-				°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument				-				°C		#DIV/0!
	Other				-				°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty					-				°C		
Effective degrees of freedom					-				°C	**sum**	#DIV/0!
Expanded uncertainty					-				°C		

Figure 37 Uncertainty budget reported by NML/NSAI at 65 °C nominal dew-point temperature

Appendix B.4CETIAT

Uncertainty analysis of dew-point temperature		Nominal value:		30	°C	Lab name	LNE-CETIAT	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$		**Degrees of freedom components evaluated by a type A method *** ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**	Calculatio of degrees of freedom
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.003	°C	100	1.000E+00		0.003	3.91E-13
	Long-term stability (sensor and indicator)	0.001	°C	100	1.000E+00		0.001	1.11E-15
	Self-heating and residual heat fluxes (sensor)	0.002	°C	100	1.000E+00		0.002	9.00E-14
	Resolution and linearity (indicator unit)	0.000	°C	100	1.000E+00		0.000	6.94E-17
	Saturator:							
	Temperature homogeneity	0.012	°C	100	1.000E+00		0.012	1.78E-10
	Temperature stability	0.002	°C	100	1.000E+00		0.002	1.60E-13
Saturation pressure								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	7.500	Pa	100	-1.798E-04	°C/Pa	-0.001	3.31E-14
	Long-term stability (sensor and indicator)	5.774	Pa	100	-1.798E-04	°C/Pa	-0.001	1.16E-14
	Resolution and accuracy or linearity (indicator unit)	0.289	Pa	100	-1.798E-04	°C/Pa	0.000	7.26E-20
	Linearity (over a range of +70 hPa against the calibration point)	2.887	Pa	100	-1.798E-04	°C/Pa	-0.001	7.26E-16
	Pressure differences in the saturator cell	1.732	Pa	100	-1.798E-04	°C/Pa	0.000	9.42E-17
	Stability of the pressure	22.000	Pa	40	-1.798E-04	°C/Pa	-0.004	6.13E-12
	Effect of the tubing between the saturator and the pressure gauge	1.732	Pa	100	-1.798E-04	°C/Pa	0.000	9.42E-17
Gas pressure at the generator outlet								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							#DIV/0!
	Long-term stability (sensor and indicator)							#DIV/0!
	Resolution (indicator unit)							#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)							#DIV/0!
	Stability of the pressure							#DIV/0!
	Effect of the tubing between the saturator and the pressure gauge							#DIV/0!
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)							#DIV/0!
	Reproducibility of the flow (through the generator)							#DIV/0!
Saturation efficiency								
	Saturation efficiency	0.003	°C	100	1.000E+00		0.003	6.94E-13
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)							#DIV/0!
	Water vapour enhancement formula(e)							#DIV/0!
Other uncertainties								
	Multimeter calibration and linearity	0.003	°C	100	1.000E+00		0.003	
	Multimeter resolution	0.001	°C	100	1.000E+00		0.001	
	Multimeter long term drift	0.000	°C	100	1.000E+00		0.000	
Combined uncertainty							0.014	
Effective degrees of freedom								#DIV/0!
Expanded uncertainty							0.027	
Additional uncertainty in applied condition at point of use								
	Pressure drop between point of realisation and measuring instrument	1620.00	Pa					#DIV/0!
	Accuracy of the pressure drop measurements	0.01		100	1.000		0.008	4.10E-11
* for type B method the number of degrees of freedom will be considered as being larger than 50.								
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)								
Combined uncertainty							0.016	
Effective degrees of freedom				#DIV/0!				#DIV/0!
Expanded uncertainty							0.031	

Figure 38 Uncertainty budget reported by CETIAT at 30 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		50	°C	Lab name	LNE-CETIAT		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method** *	**Sensitivity coefficient**		**Uncertainty contribution**		Calculatio of degrees of freedom
Q_i		**$u_{(Qi)}$**		**ν_i**	**c_i**		**u_i in °C**		
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.003	°C	100	1.000E+00		0.003		3.91E-13
	Long-term stability (sensor and indicator)	0.001	°C	100	1.000E+00		0.001		1.11E-15
	Self-heating and residual heat fluxes (sensor)	0.002	°C	100	1.000E+00		0.002		9.00E-14
	Resolution and linearity (indicator unit)	0.000	°C	100	1.000E+00		0.000		6.94E-17
	Saturator:								
	Temperature homogeneity	0.012	°C	100	1.000E+00		0.012		1.78E-10
	Temperature stability	0.002	°C	100	1.000E+00		0.002		1.60E-13
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	7.500	Pa	100	-3.035E-04	°C/Pa	-0.002		2.69E-13
	Long-term stability (sensor and indicator)	5.774	Pa	100	-3.035E-04	°C/Pa	-0.002		9.43E-14
	Resolution and accuracy or linearity (indicator unit)	0.289	Pa	100	-3.035E-04	°C/Pa	0.000		5.89E-19
	Linearity (over a range of +70 hPa against the calibration point)	2.887	Pa	100	-3.035E-04	°C/Pa	-0.001		5.89E-15
	Pressure differences in the saturator cell	1.732	Pa	100	-3.035E-04	°C/Pa	-0.001		7.64E-16
	Stability of the pressure	10.000	Pa	32	-3.035E-04	°C/Pa	-0.003		2.65E-12
	Effect of the tubing between the saturator and the pressure gauge	1.732	Pa	100	-3.035E-04	°C/Pa	-0.001		7.64E-16
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)								#DIV/0!
	Long-term stability (sensor and indicator)								#DIV/0!
	Resolution (indicator unit)								#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)								#DIV/0!
	Stability of the pressure								#DIV/0!
	Effect of the tubing between the saturator and the pressure gauge								#DIV/0!
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)								#DIV/0!
	Reproducibility of the flow (through the generator)								#DIV/0!
Saturation efficiency									
	Saturation efficiency	0.003	°C	100	1.000E+00		0.003		6.94E-13
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)								#DIV/0!
	Water vapour enhancement formula(e)								#DIV/0!
Other uncertainties									
	Multimeter calibration and linearity	0.003	°C	100	1.000E+00		0.003		
	Multimeter resolution	0.001	°C	100	1.000E+00		0.001		
	Multimeter long term drift	0.000	°C	100	1.000E+00		0.000		
Combined uncertainty							0.014		
Effective degrees of freedom									#DIV/0!
Expanded uncertainty							0.027		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	1620.00							#DIV/0!
	Accuracy of the pressure drop measurements	0.01		100	1.000		0.008		4.10E-11
Combined uncertainty							0.016		
Effective degrees of freedom				#DIV/0!					#DIV/0!
Expanded uncertainty							0.031		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 39 Uncertainty budget reported by CETIAT at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		65	°C	Lab name	LNE-CETIAT		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***	**Sensitivity coefficient**		**Uncertainty contribution**		Calculatio of degrees of freedom
Q_i		**$u_{(Qi)}$**		**ν_i**	**c_i**		**u_i in °C**		
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.003	°C	100	1.000E+00		0.003		3.91E-13
	Long-term stability (sensor and indicator)	0.001	°C	100	1.000E+00		0.001		1.11E-15
	Self-heating and residual heat fluxes (sensor)	0.002	°C	100	1.000E+00		0.002		9.00E-14
	Resolution and linearity (indicator unit)	0.000	°C	100	1.000E+00		0.000		6.94E-17
	Saturator:								
	Temperature homogeneity	0.012	°C	100	1.000E+00		0.012		1.78E-10
	Temperature stability	0.002	°C	100	1.000E+00		0.002		1.60E-13
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	7.500	Pa	100	-3.915E-04	°C/Pa	-0.003		7.44E-13
	Long-term stability (sensor and indicator)	5.774	Pa	100	-3.915E-04	°C/Pa	-0.002		2.61E-13
	Resolution and accuracy or linearity (indicator unit)	0.289	Pa	100	-3.915E-04	°C/Pa	0.000		1.63E-18
	Linearity (over a range of +70 hPa against the calibration point)	2.887	Pa	100	-3.915E-04	°C/Pa	-0.001		1.63E-14
	Pressure differences in the saturator cell	1.732	Pa	100	-3.915E-04	°C/Pa	-0.001		2.12E-15
	Stability of the pressure	38.000	Pa	41	-3.915E-04	°C/Pa	-0.015		1.20E-09
	Effect of the tubing between the saturator and the pressure gauge	1.732	Pa	100	-3.915E-04	°C/Pa	-0.001		2.12E-15
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)								#DIV/0!
	Long-term stability (sensor and indicator)								#DIV/0!
	Resolution (indicator unit)								#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)								#DIV/0!
	Stability of the pressure								#DIV/0!
	Effect of the tubing between the saturator and the pressure gauge								#DIV/0!
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)								#DIV/0!
	Reproducibility of the flow (through the generator)								#DIV/0!
Saturation efficiency									
	Saturation efficiency	0.003	°C	100	1.000E+00		0.003		6.94E-13
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)								#DIV/0!
	Water vapour enhancement formula(e)								#DIV/0!
Other uncertainties									
	Multimeter calibration and linearity	0.003	°C	100	1.000E+00		0.003		
	Multimeter resolution	0.001	°C	100	1.000E+00		0.001		
	Multimeter long term drift	0.000	°C	100	1.000E+00		0.000		
Combined uncertainty							0.020		
Effective degrees of freedom									#DIV/0!
Expanded uncertainty							0.039		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	1700.00							#DIV/0!
	Accuracy of the pressure drop measurements	0.01		100	1.000		0.008		4.10E-11
* for type B method the number of degrees of freedom will be considered as being larger than 50.									
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)									
Combined uncertainty							0.022		
Effective degrees of freedom				#DIV/0!					#DIV/0!
Expanded uncertainty							0.042		

Figure 40 Uncertainty budget reported by CETIAT at 65 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		80	°C	Lab name	LNE-CETIAT		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method** *	**Sensitivity coefficient**		**Uncertainty contribution**		Calculatio of degrees of freedom
Q_i		$u_{(Qi)}$		ν_i	c_i		u_i in °C		
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.003	°C	100	1.000E+00		0.003		3.91E-13
	Long-term stability (sensor and indicator)	0.001	°C	100	1.000E+00		0.001		1.11E-15
	Self-heating and residual heat fluxes (sensor)	0.002	°C	100	1.000E+00		0.002		9.00E-14
	Resolution and linearity (indicator unit)	0.000	°C	100	1.000E+00		0.000		6.94E-17
	Saturator:								
	Temperature homogeneity	0.012	°C	100	1.000E+00		0.012		1.78E-10
	Temperature stability	0.002	°C	100	1.000E+00		0.002		1.60E-13
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	7.500	Pa	100	-6.152E-04	°C/Pa	-0.005		4.53E-12
	Long-term stability (sensor and indicator)	5.774	Pa	100	-6.152E-04	°C/Pa	-0.004		1.59E-12
	Resolution and accuracy or linearity (indicator unit)	0.289	Pa	100	-6.152E-04	°C/Pa	0.000		9.95E-18
	Linearity (over a range of +70 hPa against the calibration point)	2.887	Pa	100	-6.152E-04	°C/Pa	-0.002		9.95E-14
	Pressure differences in the saturator cell	1.732	Pa	100	-6.152E-04	°C/Pa	-0.001		1.29E-14
	Stability of the pressure	42.000	Pa	34	-6.152E-04	°C/Pa	-0.026		1.31E-08
	Effect of the tubing between the saturator and the pressure gauge	1.732	Pa	100	-6.152E-04	°C/Pa	-0.001		1.29E-14
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)								#DIV/0!
	Long-term stability (sensor and indicator)								#DIV/0!
	Resolution (indicator unit)								#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)								#DIV/0!
	Stability of the pressure								#DIV/0!
	Effect of the tubing between the saturator and the pressure gauge								#DIV/0!
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)								#DIV/0!
	Reproducibility of the flow (through the generator)								#DIV/0!
Saturation efficiency									
	Saturation efficiency	0.003	°C	100	1.000E+00		0.003		6.94E-13
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)								#DIV/0!
	Water vapour enhancement formula(e)								#DIV/0!
Other uncertainties									
	Multimeter calibration and linearity	0.003	°C	100	1.000E+00		0.003		
	Multimeter resolution	0.001	°C	100	1.000E+00		0.001		
	Multimeter long term drift	0.000	°C	100	1.000E+00		0.000		
Combined uncertainty							0.030		
Effective degrees of freedom									#DIV/0!
Expanded uncertainty							0.058		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	1740.00							#DIV/0!
	Accuracy of the pressure drop measurements	0.01		100	1.000		0.008		4.10E-11
* for type B method the number of degrees of freedom will be considered as being larger than 50.									
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)									
Combined uncertainty							0.031		
Effective degrees of freedom				#DIV/0!					#DIV/0!
Expanded uncertainty							0.060		

Figure 41 Uncertainty budget reported by CETIAT at 80 °C nominal dew-point temperature

Appendix B.5INTA

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0025	°C	50	-	0.963		0.0024	°C		6.72254E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.963		0.0018	°C		1.56734E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.963		0.0017	°C		1.54886E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.963		0.0004	°C		4.60306E-16
	Saturator:										
	Temperature homogeneity	0.0058	°C	50	-	0.963		0.0056	°C		1.91217E-11
	Temperature stability	0.0100	°C	14	-	0.963		0.0096	°C		6.14625E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.29E-04		-0.0008	°C		9.75602E-15
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.29E-04		-0.0023	°C		5.6082E-13
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.29E-04		-0.0001	°C		6.07263E-19
	Pressure differences in the saturator cell	29	Pa	50	-	-1.29E-04		-0.0037	°C		3.79539E-12
	Stability of the pressure	60	Pa	14	-	-1.29E-04		-0.0077	°C		2.52968E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.29E-04		-0.0007	°C		6.07263E-15
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	1.71E-04		0.0010	°C		2.2303E-14
	Long-term stability (sensor and indicator)	15	Pa	50	-	1.71E-04		0.0026	°C		9.0099E-13
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	1.71E-04		0.0010	°C		1.91212E-14
	Stability of the pressure	20	Pa	14	-	1.71E-04		0.0034	°C		9.83375E-12
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	1.71E-04		0.0010	°C		1.91212E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency				-				°C		
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e) at ts	0.00003	%	50	-	17.34		0.0005	°C		1.25701E-15
	Water vapour enhancement formula(f) at ts, ps	0.00007	%	50	-	17.41		0.0012	°C		4.85709E-14
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-17.41		-0.0005	°C		1.27525E-15
	Water vapour enhancement formula(f) at tc, pc	0.00003	%	50	-	-17.41		-0.0005	°C		1.72225E-15
					-				°C		
Combined uncertainty					-			0.015	°C		
Effective degrees of freedom					-	63			°C	sum	9.0292E-10
Expanded uncertainty					-	2.040		**0.032**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		1.71E-04		0.0003	°C		1.82265E-16
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.015	°C		
Effective degrees of freedom						63			°C	sum	9.0292E-10
Expanded uncertainty						2.040		**0.032**	°C		

Figure 42 Uncertainty budget reported by INTA at 30 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.965		0.0025	°C		6.79694E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.965		0.0018	°C		1.58116E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.965		0.0017	°C		1.56205E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.965		0.0004	°C		4.75764E-16
	Saturator:										
	Temperature homogeneity	0.0058	°C	50	-	0.965		0.0056	°C		1.92846E-11
	Temperature stability	0.0100	°C	14	-	0.965		0.0097	°C		6.19863E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.54E-04		-0.0010	°C		2.0264E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.54E-04		-0.0028	°C		1.16487E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.54E-04		-0.0001	°C		1.26133E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-1.54E-04		-0.0045	°C		7.88333E-12
	Stability of the pressure	60	Pa	14	-	-1.54E-04		-0.0093	°C		5.25435E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.54E-04		-0.0009	°C		1.26133E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	1.98E-04		0.0012	°C		3.97877E-14
	Long-term stability (sensor and indicator)	15	Pa	50	-	1.98E-04		0.0030	°C		1.60734E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	1.98E-04		0.0011	°C		3.41116E-14
	Stability of the pressure	20	Pa	14	-	1.98E-04		0.0040	°C		1.75431E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	1.98E-04		0.0011	°C		3.41116E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency				-				°C		
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e) at ts	0.00003	%	50	-	20.06		0.0006	°C		2.25099E-15
	Water vapour enhancement formula(f) at ts, ps	0.00005	%	50	-	20.13		0.0010	°C		2.1321E-14
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-20.13		-0.0006	°C		2.28225E-15
	Water vapour enhancement formula(f) at tc, pc	0.00004	%	50	-	-20.13		-0.0008	°C		8.38071E-15
					-				°C		
Combined uncertainty					-			0.017	°C		
Effective degrees of freedom					-	67			°C	sum	1.19395E-09
Expanded uncertainty					-	2.039		**0.034**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		1.98E-04		0.0004	°C		3.25155E-16
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.017	°C		
Effective degrees of freedom						67			°C	sum	1.19395E-09
Expanded uncertainty						2.039		**0.034**	°C		

Figure 43 Uncertainty budget reported by INTA at 50 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature		Nominal value:	65	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.966		0.0025	°C		6.82846E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.966		0.0018	°C		1.58878E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.966		0.0017	°C		1.56923E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.966		0.0004	°C		4.86837E-16
	Saturator:										
	Temperature homogeneity	0.0058	°C	50	-	0.966		0.0056	°C		1.93732E-11
	Temperature stability	0.0100	°C	14	-	0.966		0.0097	°C		6.22709E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.75E-04		-0.0011	°C		3.35932E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.75E-04		-0.0031	°C		1.93109E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.75E-04		-0.0001	°C		2.09101E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-1.75E-04		-0.0051	°C		1.30688E-11
	Stability of the pressure	60	Pa	14	-	-1.75E-04		-0.0105	°C		8.71053E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.75E-04		-0.0010	°C		2.09101E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.20E-04		0.0013	°C		6.02975E-14
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.20E-04		0.0033	°C		2.43588E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.20E-04		0.0013	°C		5.16953E-14
	Stability of the pressure	20	Pa	14	-	2.20E-04		0.0044	°C		2.65862E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.20E-04		0.0013	°C		5.16953E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency				-				°C		
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.00003	%	50	-	22.25		0.0006	°C		3.40349E-15
	Water vapour enhancement formula(e)	0.00004	%	50	-	22.34		0.0009	°C		1.14956E-14
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-22.34		-0.0006	°C		3.46183E-15
	Water vapour enhancement formula(f) at tc, pc	0.00003	%	50	-	-22.34		-0.0007	°C		4.99674E-15
					-						
Combined uncertainty					-			0.018	°C		
Effective degrees of freedom					-	67			°C	sum	1.5584E-09
Expanded uncertainty					-	2.039		**0.037**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		2.20E-04		0.0004	°C		4.92765E-16
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.018	°C		
Effective degrees of freedom						67			°C	sum	1.5584E-09
Expanded uncertainty						2.039		**0.037**	°C		

Figure 44 Uncertainty budget reported by INTA at 65 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature		Nominal value:	80	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											

Quantity (symbol)	Components	Standard uncertainty		Degrees of freedom components evaluated by a type A method *		Sensitivity coefficient		Uncertainty contribution			Calculation of degrees of freedom
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.949		0.0024	°C		6.36583E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.966		0.0017	°C		1.48145E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	13.000		0.0016	°C		1.46283E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.949		0.0004	°C		4.63889E-16
	Saturator:										
	Temperature homogeneity	0.0087	°C	50	-	0.949		0.0082	°C		9.14266E-11
	Temperature stability	0.0100	°C	14	-	0.949		0.0095	°C		5.80486E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.77E-04		-0.0011	°C		3.46593E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.77E-04		-0.0032	°C		1.99237E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.77E-04		-0.0001	°C		2.15736E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-1.75E-04		-0.0051	°C		1.34835E-11
	Stability of the pressure	60	Pa	14	-	-1.77E-04		-0.0106	°C		8.98697E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.77E-04		-0.0010	°C		2.15736E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.43E-04		0.0015	°C		8.99115E-14
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.43E-04		0.0037	°C		3.63223E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.43E-04		0.0014	°C		7.70846E-14
	Stability of the pressure	20	Pa	14	-	2.43E-04		0.0049	°C		3.96435E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.43E-04		0.0014	°C		7.70846E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency				-				°C		
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.00003	%	50	-	24.56		0.0007	°C		5.04988E-15
	Water vapour enhancement formula(e)	0.00003	%	50	-	24.74		0.0008	°C		9.26874E-15
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-24.74		-0.0007	°C		5.20649E-15
	Water vapour enhancement formula(f) at tc, pc	0.00003	%	50	-	-24.74		-0.0006	°C		2.94969E-15
					-						
Combined uncertainty					-			0.019	°C		
Effective degrees of freedom					-	82			°C	sum	1.63062E-09
Expanded uncertainty					-	2.031		**0.039**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		2.43E-04		0.0004	°C		7.34779E-16
	Other								°C		
Combined uncertainty								0.019	°C		
Effective degrees of freedom						82			°C	sum	1.63062E-09
Expanded uncertainty						2.031		0.039	°C		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 45 Uncertainty budget reported by INTA at 80 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.937		0.0024	°C		6.04727E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.937		0.0017	°C		1.40744E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.937		0.0016	°C		1.38959E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.937		0.0004	°C		4.44515E-16
	Saturator:										
	Temperature homogeneity	0.0087	°C	50	-	0.937		0.0081	°C		8.68494E-11
	Temperature stability	0.0100	°C	14	-	0.937		0.0094	°C		5.51425E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.71E-04		-0.0011	°C		3.03831E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.71E-04		-0.0031	°C		1.74656E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.71E-04		-0.0001	°C		1.89119E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-1.71E-04		-0.0049	°C		1.182E-11
	Stability of the pressure	60	Pa	14	-	-1.71E-04		-0.0102	°C		7.87817E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.71E-04		-0.0010	°C		1.89119E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.51E-04		0.0015	°C		1.03199E-13
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.51E-04		0.0038	°C		4.16903E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.51E-04		0.0015	°C		8.84769E-14
	Stability of the pressure	20	Pa	14	-	2.51E-04		0.0050	°C		4.55024E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.51E-04		0.0015	°C		8.84769E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency				-				°C		
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.00003	%	50	-	25.35		0.0007	°C		5.73708E-15
	Water vapour enhancement formula(e)	0.00003	%	50	-	25.61		0.0008	°C		9.65234E-15
Other uncertainties											
		0.00003	%	50	-	-25.61		-0.0007	°C		5.97212E-15
		0.00002	%	50	-	-25.61		-0.0006	°C		2.44748E-15
					-						
Combined uncertainty					-			0.019	°C		
Effective degrees of freedom					-	84			°C	sum	1.49057E-09
Expanded uncertainty					-	2.030		**0.038**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		2.51E-04		0.0005	°C		8.43371E-16
	Other										

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 46 Uncertainty budget reported by INTA at 85 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature Nominal value: 90 °C Lab name: INTA

CCT Key Comparison in humidity (dew-point temperature) CCT-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol)	Components	Standard uncertainty		Degrees of freedom components evaluated by a type A method *		Sensitivity coefficient		Uncertainty contribution			Calculation of degrees of freedom
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.950		0.0024	°C		6.37318E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.950		0.0017	°C		1.48335E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.950		0.0016	°C		1.46447E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.950		0.0004	°C		4.70174E-16
	Saturator:										
	Temperature homogeneity	0.0087	°C	50	-	0.950		0.0082	°C		9.15291E-11
	Temperature stability	0.0100	°C	14	-	0.950		0.0095	°C		5.81137E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.92E-04		-0.0012	°C		4.82135E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-1.92E-04		-0.0034	°C		2.77153E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.92E-04		-0.0001	°C		3.00105E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-1.92E-04		-0.0055	°C		1.87565E-11
	Stability of the pressure	60	Pa	14	-	-1.92E-04		-0.0115	°C		1.25015E-09
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.92E-04		-0.0011	°C		3.00105E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.59E-04		0.0016	°C		1.16266E-13
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.59E-04		0.0039	°C		4.69688E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.59E-04		0.0015	°C		9.96791E-14
	Stability of the pressure	20	Pa	14	-	2.59E-04		0.0052	°C		5.12635E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.59E-04		0.0015	°C		9.96791E-14
Flow measurement:											
	Flow meter										
	Stability of the flow				-						
	Reproducibility				-						
Saturation efficiency											
	Saturation efficiency				-						
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-						
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.00003	%	50	-	26.19		0.0008	°C		6.53517E-15
	Water vapour enhancement formula(e)	0.00003	%	50	-	26.51		0.0007	°C		6.05162E-15
Other uncertainties											
		0.00003	%	50	-	-26.51		-0.0008	°C		6.85672E-15
		0.00002	%	50	-	-26.51		-0.0006	°C		2.08002E-15
					-						
Combined uncertainty					-			0.020	°C		
Effective degrees of freedom					-	79			°C	sum	2.00165E-09
Expanded uncertainty					-	2.032		**0.041**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		2.59E-04		0.0005	°C		9.50151E-16
	Other										

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty								0.020	°C		
Effective degrees of freedom						79			°C	sum	2.00165E-09
Expanded uncertainty						2.032		0.041	°C		

Figure 47 Uncertainty budget reported by INTA at 90 °C nominal dew-point temperature (INTA 1 and 2)

Uncertainty analysis of dew point temperature		Nominal value:	95	°C		Lab name	INTA				
CCT Key Comparison in humidity (dew-point temperature) CCT-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0026	°C	55	-	0.968		0.0025	°C		6.86924E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.968		0.0018	°C		1.59884E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.968		0.0017	°C		1.57844E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.968		0.0004	°C		5.08018E-16
	Saturator:										
	Temperature homogeneity	0.0087	°C	50	-	0.968		0.0084	°C		9.86528E-11
	Temperature stability	0.0100	°C	14	-	0.968		0.0097	°C		6.26367E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-2.22E-04		-0.0014	°C		8.67499E-14
	Long-term stability (sensor and indicator)	17.9	Pa	50	-	-2.22E-04		-0.0040	°C		4.98677E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-2.22E-04		-0.0001	°C		5.39974E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-2.22E-04		0.0000	°C		0
	Stability of the pressure	20	Pa	14	-	-2.22E-04		0.0053	°C		5.84963E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-2.22E-04		-0.0013	°C		5.39974E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.67E-04		0.0016	°C		1.3267E-13
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.67E-04		0.0040	°C		5.35956E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.67E-04		0.0015	°C		1.13743E-13
	Stability of the pressure	6	Pa	14	-	2.67E-04		0.0017	°C		6.28365E-13
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.67E-04		0.0015	°C		1.13743E-13
Flow measurement:											
	Flow meter										
	Stability of the flow				-						
	Reproducibility				-						
Saturation efficiency											
	Saturation efficiency				-						
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-						
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.00003	%	50	-	27.06		0.0008	°C		7.44477E-15
	Water vapour enhancement formula(e)	0.00002	%	50	-	27.45		0.0006	°C		3.38532E-15
Other uncertainties											
		0.00003	%	50	-	-27.45		-0.0008	°C		7.88179E-15
		0.00002	%	50	-	-27.45		-0.0005	°C		1.73766E-15
					-						
Combined uncertainty					-			0.022	°C		
Effective degrees of freedom					-	71			°C	sum	7.96017E-10
Expanded uncertainty					-	2.036		0.044	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	1.8040	Pa	50		2.67E-04		0.0005	°C		1.08421E-15
	Other										
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.022	°C		
Effective degrees of freedom						71			°C	sum	7.96018E-10
Expanded uncertainty						2.036		0.044	°C		

Figure 48 Uncertainty budget reported by INTA at 95 °C nominal dew-point temperature (INTA 1 and 2)

Appendix B.6TUBITAK

Uncertainty analysis of dew point temperature — Nominal value: 30 °C — Lab name: TUBITAK UME

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	unit	Degrees of freedom components evaluated by a type A method * ν_i	unit	Sensitivity coefficient c_i	unit	Uncertainty contribution u_i	unit		Calculation of degrees of freedom
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0100	°C	5.00E+01	-	9.249E-01	°C / °C	8.555E-05	°C		1.071E-18
	Long-term stability (sensor and indicator)	0.0020	°C	5.00E+01	-	9.249E-01	°C / °C	3.422E-06	°C		2.743E-24
	Self-heating and residual heat fluxes (sensor)	0.0015	°C	5.00E+01	-	9.249E-01	°C / °C	1.925E-06	°C		2.746E-25
	Resolution and accuracy or linearity (indicator unit)	0.0010	°C	5.00E+01	-	9.249E-01	°C / °C	8.555E-07	°C		1.07146E-26
	Saturator:										
	Temperature homogeneity	0.0050	°C	5.00E+01	-	9.249E-01	°C / °C	2.139E-05	°C		4.185E-21
	Temperature stability	0.0020	°C	9	-	9.249E-01	°C / °C	3.519E-06	°C		1.70422E-23
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	5.8606	hPa	5.00E+01	-	1.144E-04	hPa / °C	4.498E-07	°C		8.184E-28
	Long-term stability (sensor and indicator)	-88.7699	hPa	5.00E+01	-	1.144E-04	hPa / °C	1.032E-04	°C		2.268E-18
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	5.00E+01	-	1.144E-04	hPa / °C	1.208E-07	°C		4.256E-30
	Pressure differences in the saturator cell				-				°C		
	Stability of the pressure	16.6089	hPa	9	-	1.144E-04	hPa / °C	3.612E-06	°C		1.89183E-23
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	4.1369	hPa	5.00E+01	-	1.143E-04	hPa / °C	2.237E-07	°C		5.004E-29
	Long-term stability (sensor and indicator)	-88.7699	hPa	5.00E+01	-	1.143E-04	hPa / °C	1.030E-04	°C		2.250E-18
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	5.00E+01	-	1.143E-04	hPa / °C	1.205E-07	°C		4.223E-30
	Stability of the pressure	1.0910	hPa	9	-	1.143E-04	hPa / °C	1.556E-08	°C		6.50512E-33
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	-4.949E-04	%	5.00E+01	-	1.953E+01	% / °C	9.337E-05	°C		1.51976E-18
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0050	hPa	5.00E+01	-	2.645E-03	hPa / °C	1.749E-10	°C		1.87164E-41
	Water vapour enhancement formula(e)	0.0001	°C hPa	5.00E+01	-	1.940E+01	°C hPa / °C	9.409E-07	°C		1.56729E-26
Other uncertainties											
					-				°C		
					-				°C		
					-				°C		
Combined uncertainty					-			0.0205	°C		
Effective degrees of freedom					-				°C	sum	7.1126E-18
Expanded uncertainty					-			0.0413	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		
	Other								°C		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty								0.0205	°C		
Effective degrees of freedom				2.50E+10					°C	sum	7.113E-18
Expanded uncertainty								0.0413	°C		

Figure 49 Uncertainty budget reported by TUBITAK at 30 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	TUBITAK UME				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**v_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0100	°C	50	-	0.938	°C / °C	8.793E-05	°C		1.196E-18
	Long-term stability (sensor and indicator)	0.0020	°C	50	-	0.938	°C / °C	3.517E-06	°C		3.06086E-24
	Self-heating and residual heat fluxes (sensor)	0.0015	°C	50	-	0.938	°C / °C	1.978E-06	°C		3.06432E-25
	Resolution and accuracy or linearity (indicator unit)	0.0010	°C	50	-	0.938	°C / °C	8.793E-07	°C		1.19565E-26
	Saturator:										
	Temperature homogeneity	0.0050	°C	50	-	0.938	°C / °C	2.198E-05	°C		4.67051E-21
	Temperature stability	0.0020	°C	9	-	0.938	°C / °C	3.617E-06	°C		1.90175E-23
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	5.8606	hPa	50	-	0.000	hPa / °C	3.660E-07	°C		3.59042E-28
	Long-term stability (sensor and indicator)	-88.7699	hPa	50	-	0.000	hPa / °C	8.398E-05	°C		9.94829E-19
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	50	-	0.000	hPa / °C	9.830E-08	°C		1.86737E-30
	Pressure differences in the saturator cell			0	-				°C		
	Stability of the pressure	16.6089	hPa	9	-	0.000	hPa / °C	2.940E-06	°C		8.2998E-24
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	4.1369	hPa	50	-	0.000	hPa / °C	1.819E-07	°C		2.19171E-29
	Long-term stability (sensor and indicator)	-88.7699	hPa	50	-	0.000	hPa / °C	8.378E-05	°C		9.85207E-19
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	50	-	0.000	hPa / °C	9.806E-08	°C		1.84931E-30
	Stability of the pressure	1.0910	hPa	9	-	0.000	hPa / °C	1.265E-08	°C		2.84892E-33
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	-0.0005		50	-	17.077		7.141E-05	°C		5.20173E-19
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0050		50	-	0.001		1.835E-11	°C		2.26691E-45
	Water vapour enhancement formula(e)	0.00005		50	-	16.949		7.182E-07	°C		5.32131E-27
Other uncertainties											
					-				°C		
					-				°C		
					-				°C		
Combined uncertainty					-			0.0191	°C		
Effective degrees of freedom					-				°C	sum	3.70056E-18
Expanded uncertainty					-			0.0383	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.0191	°C		
Effective degrees of freedom				35704489203					°C	sum	3.70056E-18
Expanded uncertainty								0.0383	°C		

Figure 50 Uncertainty budget reported by TUBITAK at 50 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	65	°C			Lab name	TUBITAK UME			
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0100	°C	50	-	0.970	°C / °C	0.0001	°C		1.57175E-18
	Long-term stability (sensor and indicator)	0.0020	°C	50	-	0.970	°C / °C	0.0000	°C		4.02369E-24
	Self-heating and residual heat fluxes (sensor)	0.0015	°C	50	-	0.970	°C / °C	0.0000	°C		4.02823E-25
	Resolution and accuracy or linearity (indicator unit)	0.0010	°C	50	-	0.970	°C / °C	0.0000	°C		1.57175E-26
	Saturator:										
	Temperature homogeneity	0.0050	°C	50	-	0.970	°C / °C	0.0000	°C		6.13966E-21
	Temperature stability	0.0020	°C	9	-	0.970	°C / °C	0.0000	°C		2.49997E-23
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	5.8606	hPa	50	-	0.000	hPa / °C	0.0000	°C		6.401E-27
	Long-term stability (sensor and indicator)	-88.7699	hPa	50	-	0.000	hPa / °C	0.0002	°C		1.77358E-17
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	50	-	0.000	hPa / °C	0.0000	°C		3.32914E-29
	Pressure differences in the saturator cell				-				°C		
	Stability of the pressure	16.6089	hPa	9	-	0.000	hPa / °C	0.0000	°C		1.47969E-22
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	4.1369	hPa	50	-	0.000	hPa / °C	0.0000	°C		3.93298E-28
	Long-term stability (sensor and indicator)	-88.7699	hPa	50	-	0.000	hPa / °C	0.0002	°C		1.76793E-17
	Resolution and accuracy or linearity (indicator unit)	3.0370	hPa	50	-	0.000	hPa / °C	0.0000	°C		3.31854E-29
	Stability of the pressure	1.0910	hPa	9	-	0.000	hPa / °C	0.0000	°C		5.11233E-32
	Effect of the tubing between the saturator and the pressure gauge				-				°C		
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	-0.0005		50	-	18.672		0.0001	°C		1.06288E-18
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0050		50	-	0.001		0.0000	°C		1.83002E-46
	Water vapour enhancement formula(e)	0.0001		50	-	18.544		0.0000	°C		1.09247E-26
Other uncertainties											
					-				°C		
					-				°C		
					-				°C		
Combined uncertainty					-			0.0238	°C		
Effective degrees of freedom					-				°C	sum	3.80561E-17
Expanded uncertainty					-			0.0476	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.0238	°C		
Effective degrees of freedom				8454468914					°C	sum	3.80561E-17
Expanded uncertainty								0.0467	°C		

Figure 51 Uncertainty budget reported by TUBITAK at 65 °C nominal dew-point temperature

Appendix B.7MIRS/UL-FE/LMK

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	**unit**	ν_i	**unit**	c_i	**unit**	u_i	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	μΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	μΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	μΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0003	°C	inf	-	1		0.0003	°C		#WERT!
	Temperature stability	0.0007	°C	59	-	1		0.0007	°C		4.06949E-15
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.178	mK/Pa	0.0053	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.178	mK/Pa	0.0005	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.178	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.178	mK/Pa	0.0005	°C		#WERT!
	Stability of the pressure	5.56	Pa	59	-	0.178	mK/Pa	0.0010	°C		1.62602E-14
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.178	mK/Pa	0.0015	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.0000	Pa	inf	-	0.178	mK/Pa	0.0053	°C		#WERT!
	Long-term stability (sensor and indicator)	2.8868	Pa	inf	-	0.178	mK/Pa	0.0005	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.2887	Pa	inf	-	0.178	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	10.6000	Pa	59	-	0.178	mK/Pa	0.0019	°C		2.14808E-13
	Effect of the tubing between the saturator and the pressure gauge	8.6603	Pa	inf	-	0.178	mK/Pa	0.0015	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0083	°C		
Effective degrees of freedom					-			20,540	°C	sum	#WERT!
Expanded uncertainty					-			0.017	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	25.11	Pa	inf		0.178	mK/Pa	0.0045	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.009	°C		
Effective degrees of freedom				20,540					°C	sum	#WERT!
Expanded uncertainty								0.019	°C		

Figure 52 Uncertainty budget reported by MIRS/UL-FE/LMK at 30 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	μΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	μΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	μΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0002	°C	inf	-	1		0.0002	°C		#WERT!
	Temperature stability	0.0006	°C	59	-	1		0.0006	°C		2.19661E-15
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.206	mK/Pa	0.0062	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.206	mK/Pa	0.0006	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.206	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.206	mK/Pa	0.0006	°C		#WERT!
	Stability of the pressure	6.34	Pa	59	-	0.206	mK/Pa	0.0013	°C		4.93144E-14
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.206	mK/Pa	0.0018	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.206	mK/Pa	0.0062	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.206	mK/Pa	0.0006	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.206	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	4.21	Pa	59	-	0.206	mK/Pa	0.0009	°C		9.58838E-15
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.206	mK/Pa	0.0018	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0094	°C		
Effective degrees of freedom					-			128,110	°C	sum	#WERT!
Expanded uncertainty					-			0.019	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	28.43	Pa	inf		0.206	mK/Pa	0.0059	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.011	°C		
Effective degrees of freedom				128,110					°C	sum	#WERT!
Expanded uncertainty								0.022	°C		

Figure 53 Uncertainty budget reported by MIRS/UL-FE/LMK at 50 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	65	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	μΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	μΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	μΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0003	°C	inf	-	1		0.0003	°C		#WERT!
	Temperature stability	0.0018	°C	59	-	1		0.0018	°C		1.77925E-13
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.228	mK/Pa	0.0068	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.228	mK/Pa	0.0007	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.228	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.228	mK/Pa	0.0007	°C		#WERT!
	Stability of the pressure	13.01	Pa	59	-	0.228	mK/Pa	0.0030	°C		1.31219E-12
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.228	mK/Pa	0.0020	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.228	mK/Pa	0.0068	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.228	mK/Pa	0.0007	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.228	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	8.63	Pa	59	-	0.228	mK/Pa	0.0020	°C		2.54057E-13
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.228	mK/Pa	0.0020	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0110	°C		
Effective degrees of freedom					-			8,321	°C	sum	#WERT!
Expanded uncertainty					-			0.022	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	26.70	Pa	inf		0.228	mK/Pa	0.0061	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.013	°C		
Effective degrees of freedom				8,321					°C	sum	#WERT!
Expanded uncertainty								0.025	°C		

Figure 54 Uncertainty budget reported by MIRS/UL-FE/LMK at 65 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature Nominal value: 80 °C Lab name: MIRS/UL-FE/LMK

EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8

- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature

Quantity (symbol)	Components	Standard uncertainty		Degrees of freedom components evaluated by a type A method *		Sensitivity coefficient		Uncertainty contribution			Calculation of degrees of freedom
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	μΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	μΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	μΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0003	°C	inf	-	1		0.0003	°C		#WERT!
	Temperature stability	0.0008	°C	59	-	1		0.0008	°C		6.94237E-15
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.252	mK/Pa	0.0076	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.252	mK/Pa	0.0007	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.252	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.252	mK/Pa	0.0007	°C		#WERT!
	Stability of the pressure	12.77	Pa	59	-	0.252	mK/Pa	0.0032	°C		1.81766E-12
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.252	mK/Pa	0.0022	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.252	mK/Pa	0.0076	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.252	mK/Pa	0.0007	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.252	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	6.56	Pa	59	-	0.252	mK/Pa	0.0017	°C		1.2658E-13
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.252	mK/Pa	0.0022	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0119	°C		
Effective degrees of freedom					-			10,195	°C	sum	#WERT!
Expanded uncertainty					-			0.024	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	35.34	Pa	inf		0.252	mK/Pa	0.0089	°C		#WERT!
	Other								°C		#DIV/0!

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty								0.015	°C		
Effective degrees of freedom				10,195					°C	sum	#WERT!
Expanded uncertainty								0.029	°C		

Figure 55 Uncertainty budget reported by MIRS/UL-FE/LMK at 80 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	µΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	µΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	µΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0006	°C	inf	-	1		0.0006	°C		#WERT!
	Temperature stability	0.0013	°C	59	-	1		0.0013	°C		4.84085E-14
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.260	mK/Pa	0.0078	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.260	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.260	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.260	mK/Pa	0.0008	°C		#WERT!
	Stability of the pressure	18.10	Pa	59	-	0.260	mK/Pa	0.0047	°C		8.31296E-12
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.260	mK/Pa	0.0023	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.260	mK/Pa	0.0078	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.260	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.260	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	9.67	Pa	59	-	0.260	mK/Pa	0.0025	°C		6.77247E-13
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.260	mK/Pa	0.0023	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0129	°C		
Effective degrees of freedom					-			3,042	°C	sum	#WERT!
Expanded uncertainty					-			0.026	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	42.61	Pa	inf		0.260	mK/Pa	0.0111	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.017	°C		
Effective degrees of freedom				3,042					°C	sum	#WERT!
Expanded uncertainty								0.033	°C		

Figure 56 Uncertainty budget reported by MIRS/UL-FE/LMK at 85 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	90	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	µΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	µΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	µΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0011	°C	inf	-	1		0.0011	°C		#WERT!
	Temperature stability	0.0015	°C	59	-	1		0.0015	°C		8.58051E-14
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.269	mK/Pa	0.0081	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.269	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.269	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.269	mK/Pa	0.0008	°C		#WERT!
	Stability of the pressure	17.78	Pa	59	-	0.269	mK/Pa	0.0048	°C		8.86919E-12
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.269	mK/Pa	0.0023	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.269	mK/Pa	0.0081	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.269	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.269	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	8.13	Pa	59	-	0.269	mK/Pa	0.0022	°C		3.87721E-13
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.269	mK/Pa	0.0023	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0133	°C		
Effective degrees of freedom					-			3,309	°C	sum	#WERT!
Expanded uncertainty					-			0.026	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	26.64	Pa	inf		0.269	mK/Pa	0.0072	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.015	°C		
Effective degrees of freedom				3,309					°C	sum	#WERT!
Expanded uncertainty								0.030	°C		

Figure 57 Uncertainty budget reported by MIRS/UL-FE/LMK at 90 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	95	°C		Lab name	MIRS/UL-FE/LMK				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.00125	°C	inf	-	1		0.0013	°C		#WERT!
	Long-term stability (sensor and indicator)	16	μΩ	inf	-	10	K/Ω	0.0002	°C		#WERT!
	Self-heating and residual heat fluxes (sensor)	28	μΩ	inf	-	10	K/Ω	0.0003	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	36	μΩ	inf	-	10	K/Ω	0.0004	°C		#WERT!
	Saturator:										
	Temperature homogeneity	0.0003	°C	inf	-	1		0.0003	°C		#WERT!
	Temperature stability	0.0028	°C	59	-	1		0.0028	°C		1.04179E-12
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.277	mK/Pa	0.0083	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.277	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.277	mK/Pa	0.0001	°C		#WERT!
	Pressure differences in the saturator cell	2.89	Pa	inf	-	0.277	mK/Pa	0.0008	°C		#WERT!
	Stability of the pressure	20.53	Pa	59	-	0.277	mK/Pa	0.0057	°C		1.77265E-11
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.277	mK/Pa	0.0024	°C		#WERT!
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	30.00	Pa	inf	-	0.277	mK/Pa	0.0083	°C		#WERT!
	Long-term stability (sensor and indicator)	2.89	Pa	inf	-	0.277	mK/Pa	0.0008	°C		#WERT!
	Resolution and accuracy or linearity (indicator unit)	0.29	Pa	inf	-	0.277	mK/Pa	0.0001	°C		#WERT!
	Stability of the pressure	6.14	Pa	59	-	0.277	mK/Pa	0.0017	°C		1.41821E-13
	Effect of the tubing between the saturator and the pressure gauge	8.66	Pa	inf	-	0.277	mK/Pa	0.0024	°C		#WERT!
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		#DIV/0!
	Reproducibility				-				°C		#DIV/0!
Saturation efficiency											
	Saturation efficiency				-				°C		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		#DIV/0!
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		#DIV/0!
	Water vapour enhancement formula(e)				-				°C		#DIV/0!
Other uncertainties											
					-				°C		#DIV/0!
					-				°C		#DIV/0!
					-				°C		#DIV/0!
Combined uncertainty					-			0.0140	°C		
Effective degrees of freedom					-			2,042	°C	sum	#WERT!
Expanded uncertainty					-			0.028	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	23.49	Pa	inf		0.277	mK/Pa	0.0065	°C		#WERT!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.015	°C		
Effective degrees of freedom				2,042					°C	sum	#WERT!
Expanded uncertainty								0.030	°C		

Figure 58 Uncertainty budget reported by MIRS/UL-FE/LMK at 95 °C nominal dew-point temperature

Appendix B.8EIM

Uncertainty analysis of dew-point temperature

Nominal value: 30 °C   Lab name: Hellenic Institute of Metrology (EIM)

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i	Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.007	50	1	0.007	4.80E-11
	Temperature stability (in °C)	0.003	9	1	0.003	9.00E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000165	0.001	4.73E-14
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000165	0.001	9.81E-14
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000165	0.000	1.21E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000165	0.001	9.34E-15
	Pressure differences in the saturator cell (in Pa)	5	50	0.000165	0.001	9.34E-15
	Stability of the pressure (in Pa)	12	9	0.000165	0.002	1.72E-12
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000165	0.001	9.34E-15
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000165	0.017	1.49E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000165	0.002	1.49E-13
	Resolution (indicator unit, in Pa)	3	50	0.000165	0.000	1.21E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000165	0.001	9.34E-15
	Stability of the pressure (in Pa)	12	9	0.000165	0.002	1.72E-12
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000165	0.002	1.49E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.01	9	0.2	0.001	2.30E-13
	Reproducibility of the flow (through the generator, in l/min)	0.02	3	0.2	0.004	1.25E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.022	
Effective degrees of freedom			139			1.75E-09
Expanded uncertainty					0.045	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	9	0.000165	0.008	5.19E-10
	Accuracy of the pressure drop measurements	10.00	50	0.000165	0.002	1.49E-13
Combined uncertainty					0.024	
Effective degrees of freedom			140			2.27E-09
Expanded uncertainty					0.048	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 59 Uncertainty budget reported by EIM at 30 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature

Nominal value: 50 °C   Lab name: Hellenic Institute of Metrology (EIM)

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i	Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.009	50	1	0.009	1.31E-10
	Temperature stability (in °C)	0.003	9	1	0.003	9.00E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000193	0.001	8.80E-14
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000193	0.002	1.83E-13
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000193	0.001	2.25E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000193	0.001	1.74E-14
	Pressure differences in the saturator cell (in Pa)	5	50	0.000193	0.001	1.74E-14
	Stability of the pressure (in Pa)	33	9	0.000193	0.006	1.78E-10
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000193	0.001	1.74E-14
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000193	0.019	2.78E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000193	0.002	2.78E-13
	Resolution (indicator unit, in Pa)	3	50	0.000193	0.001	2.25E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000193	0.001	1.74E-14
	Stability of the pressure (in Pa)	26	9	0.000193	0.005	7.19E-11
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000193	0.002	2.78E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.01	9	0.2	0.001	2.78E-13
	Reproducibility of the flow (through the generator, in l/min)	0.02	3	0.2	0.005	1.73E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.026	
Effective degrees of freedom			139			3.41E-09
Expanded uncertainty					0.053	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	9	0.000193	0.010	9.66E-10
	Accuracy of the pressure drop measurements	10.00	50	0.000193	0.002	2.78E-13
Combined uncertainty					0.028	
Effective degrees of freedom			141			4.38E-09
Expanded uncertainty					0.057	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 60 Uncertainty budget reported by EIM at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:	65 °C	Lab name:	Hellenic Institute of Metrology (EIM)	
EUROMET Key Comparison in humidity (dew-point temperature) P717						
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison						
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i	**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.011	50	1	0.011	2.93E-10
	Temperature stability (in °C)	0.002	10	1	0.002	3.30E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000215	0.002	1.35E-13
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000215	0.002	2.79E-13
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000215	0.001	3.44E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000215	0.001	2.66E-14
	Pressure differences in the saturator cell (in Pa)	5	50	0.000215	0.001	2.66E-14
	Stability of the pressure (in Pa)	30	10	0.000215	0.006	1.64E-10
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000215	0.001	2.66E-14
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000215	0.021	4.25E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000215	0.002	4.25E-13
	Resolution (indicator unit, in Pa)	3	50	0.000215	0.001	3.44E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000215	0.001	2.66E-14
	Stability of the pressure (in Pa)	16	10	0.000215	0.003	1.38E-11
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000215	0.002	4.25E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.02	10	0.2	0.003	9.25E-12
	Reproducibility of the flow (through the generator, in l/min)	0.02	3	0.2	0.005	1.54E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.028	
Effective degrees of freedom			133			4.96E-09
Expanded uncertainty					0.058	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	9	0.000215	0.011	1.48E-09
	Accuracy of the pressure drop measurements	10.00	50	0.000215	0.002	4.25E-13
* for type B method the number of degrees of freedom will be considered as being larger than 50.						
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)						
Combined uncertainty					0.031	
Effective degrees of freedom			135			6.44E-09
Expanded uncertainty					0.062	

Figure 61 Uncertainty budget reported by EIM at 65 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature Nominal value: 80 °C Lab name: Hellenic Institute of Metrology (EIM)

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i	Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.013	50	1	0.013	5.71E-10
	Temperature stability (in °C)	0.003	9	1	0.003	7.04E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000237	0.002	2.00E-13
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000237	0.002	4.15E-13
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000237	0.001	5.12E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000237	0.001	3.95E-14
	Pressure differences in the saturator cell (in Pa)	5	50	0.000237	0.001	3.95E-14
	Stability of the pressure (in Pa)	52	9	0.000237	0.012	2.55E-09
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000237	0.001	3.95E-14
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000237	0.024	6.33E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000237	0.002	6.33E-13
	Resolution (indicator unit, in Pa)	3	50	0.000237	0.001	5.12E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000237	0.001	3.95E-14
	Stability of the pressure (in Pa)	29	9	0.000237	0.007	2.39E-10
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000237	0.002	6.33E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.03	9	0.2	0.005	8.40E-11
	Reproducibility of the flow (through the generator, in l/min)	0.03	3	0.2	0.006	3.22E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.034	
Effective degrees of freedom			128			1.02E-08
Expanded uncertainty					0.068	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	9	0.000237	0.012	2.20E-09
	Accuracy of the pressure drop measurements	10.00	50	0.000237	0.002	6.33E-13
Combined uncertainty					0.036	
Effective degrees of freedom			134			1.24E-08
Expanded uncertainty					0.072	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 62 Uncertainty budget reported by EIM at 80 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:	85 °C	Lab name: Hellenic Institute of Metrology (EIM)		
EUROMET Key Comparison in humidity (dew-point temperature) P717						
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison						
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i	**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.014	50	1	0.014	7.68E-10
	Temperature stability (in °C)	0.002	9	1	0.002	2.31E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000242	0.002	2.17E-13
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000242	0.002	4.51E-13
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000242	0.001	5.57E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000242	0.001	4.29E-14
	Pressure differences in the saturator cell (in Pa)	5	50	0.000242	0.001	4.29E-14
	Stability of the pressure (in Pa)	47	9	0.000242	0.011	1.84E-09
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000242	0.001	4.29E-14
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000242	0.024	6.87E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000242	0.002	6.87E-13
	Resolution (indicator unit, in Pa)	3	50	0.000242	0.001	5.57E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000242	0.001	4.29E-14
	Stability of the pressure (in Pa)	21	9	0.000242	0.005	7.08E-11
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000242	0.002	6.87E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.04	9	0.2	0.007	2.71E-10
	Reproducibility of the flow (through the generator, in l/min)	0.03	3	0.2	0.006	4.60E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.034	
Effective degrees of freedom			133			1.04E-08
Expanded uncertainty					0.069	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	9	0.000242	0.012	2.39E-09
	Accuracy of the pressure drop measurements	10.00	50	0.000242	0.002	6.87E-13
Combined uncertainty					0.036	
Effective degrees of freedom			138			1.27E-08
Expanded uncertainty					0.074	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 63 Uncertainty budget reported by EIM at 85 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature Nominal value: 90 °C Lab name: Hellenic Institute of Metrology (EIM)

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i	Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit, in °C)	0.005	50	1	0.005	1.25E-11
	Long-term stability (sensor and indicator, in °C)	0.003	50	1	0.003	1.62E-12
	Self-heating and residual heat fluxes (sensor, in °C)	0.003	50	1	0.003	1.62E-12
	Resolution and linearity (indicator unit, in °C)	0.006	50	1	0.006	2.59E-11
	Saturator:					
	Temperature homogeneity (in °C)	0.015	50	1	0.015	1.01E-09
	Temperature stability (in °C)	0.003	10	1	0.003	5.59E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	8	50	0.000252	0.002	2.57E-13
	Long-term stability (sensor and indicator, in Pa)	9	50	0.000252	0.002	5.33E-13
	Resolution and accuracy or linearity (indicator unit, in Pa)	3	50	0.000252	0.001	6.58E-15
	Linearity (over a range of +70 hPa against the calibration point, in Pa)	5	50	0.000252	0.001	5.08E-14
	Pressure differences in the saturator cell (in Pa)	5	50	0.000252	0.001	5.08E-14
	Stability of the pressure (in Pa)	51	10	0.000252	0.013	2.72E-09
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	5	50	0.000252	0.001	5.08E-14
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit, in Pa)	100	50	0.000252	0.025	8.12E-09
	Long-term stability (sensor and indicator, in Pa)	10	50	0.000252	0.003	8.12E-13
	Resolution (indicator unit, in Pa)	3	50	0.000252	0.001	6.58E-15
	Linearity (over a range of ±10 hPa against the calibration point, in Pa)	5	50	0.000252	0.001	5.08E-14
	Stability of the pressure (in Pa)	46	10	0.000252	0.012	1.78E-09
	Effect of the tubing between the saturator and the pressure gauge (in Pa)	10	50	0.000252	0.003	8.12E-13
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator, in l/min)	0.03	10	0.2	0.007	2.25E-10
	Reproducibility of the flow (through the generator, in l/min)	0.03	3	0.2	0.007	7.25E-10
Saturation efficiency						
	Saturation efficiency (in °C)	0.006	50	1	0.006	2.59E-11
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant	0	50	1	0.000	
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e) (in °C)	0.002	50	1	0.002	3.20E-13
	Water vapour enhancement formula(e) (in °C)	0.000	50	1	0.000	0.00E+00
Other uncertainties						
	Contamination of water in generator (in °C)	0.001	50	1	0.001	
Combined uncertainty					0.038	
Effective degrees of freedom			136			1.47E-08
Expanded uncertainty					0.076	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	50.00	10	0.000252	0.013	2.54E-09
	Accuracy of the pressure drop measurements	10.00	50	0.000252	0.003	8.12E-13
Combined uncertainty					0.040	
Effective degrees of freedom			145			1.72E-08
Expanded uncertainty					0.080	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 64 Uncertainty budget reported by EIM at 90 °C nominal dew-point temperature

Appendix B.9FSB-LPM

Uncertainty analysis of dew-point temperature — Nominal value: 30 °C — Lab name: HMI/FSB-LPM - Laboratory for Process M

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i	Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit)	0.015		1	0.015	#DIV/0!
	Long-term stability (sensor and indicator)	0.006		1	0.006	#DIV/0!
	Self-heating and residual heat fluxes (sensor)	0.006		1	0.006	#DIV/0!
	Resolution and linearity (indicator unit)	0.001		1	0.001	#DIV/0!
	Saturator:					
	Temperature homogeneity	0.002		1	0.002	#DIV/0!
	Temperature stability	0.011	30	1	0.011	4.88E-10
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit)	0.04		0.017	0.001	#DIV/0!
	Long-term stability (sensor and indicator)	0.12		0.017	0.002	#DIV/0!
	Resolution and accuracy or linearity (indicator unit)	0.01		0.017	0.000	#DIV/0!
	Linearity (over a range of +70 hPa against the calibration point)	0.03		0.017	0.001	#DIV/0!
	Pressure differences in the saturator cell	0.10		0.017	0.002	#DIV/0!
	Stability of the pressure	0.23	120	0.017	0.004	1.95E-12
	Effect of the tubing between the saturator and the pressure gauge	0.20		0.017	0.003	#DIV/0!
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit)	0.04		0.017	0.001	#DIV/0!
	Long-term stability (sensor and indicator)	0.12		0.017	0.002	#DIV/0!
	Resolution (indicator unit)	0.01		0.017	0.000	#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)	0.03		0.017	0.001	#DIV/0!
	Stability of the pressure	0.22	120	0.017	0.004	1.63E-12
	Effect of the tubing between the saturator and the pressure gauge	0.20		0.017	0.003	#DIV/0!
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator)	0.07	120	0.0200	0.001	4.00E-14
	Reproducibility of the flow (through the generator)	0.06		0.0200	0.001	#DIV/0!
Saturation efficiency						
	Saturation efficiency	0.02		1.0000	0.020	#DIV/0!
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant					
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e)	0.002		0.42	0.001	#DIV/0!
	Water vapour enhancement formula(e)	0.000		18	0.001	#DIV/0!
Other uncertainties						
Combined uncertainty						
Effective degrees of freedom						#DIV/0!
Expanded uncertainty						
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	0.06		0.017	0.001	#DIV/0!
	Accuracy of the pressure drop measurements	0.30		0.017	0.005	#DIV/0!
Combined uncertainty					0.030	
Effective degrees of freedom			#DIV/0!			#DIV/0!
Expanded uncertainty					0.059	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 65 Uncertainty budget reported by FSB-LPM at 30 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		30	°C	Lab name	HMI/FSB-LPM	- Laboratory for Process M	
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$		**Degrees of freedom components evaluated by a type A method *** ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**		Calculation of degrees of freedom
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.015			1		0.015		#DIV/0!
	Long-term stability (sensor and indicator)	0.006			1		0.006		#DIV/0!
	Self-heating and residual heat fluxes (sensor)	0.006			1		0.006		#DIV/0!
	Resolution and linearity (indicator unit)	0.001			1		0.001		#DIV/0!
	Saturator:								
	Temperature homogeneity	0.005			1		0.005		#DIV/0!
	Temperature stability	0.009		30	1		0.009		2.19E-10
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.04			0.020		0.001		#DIV/0!
	Long-term stability (sensor and indicator)	0.12			0.020		0.002		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)	0.01			0.020		0.000		#DIV/0!
	Linearity (over a range of +70 hPa against the calibration point)	0.03			0.020		0.001		#DIV/0!
	Pressure differences in the saturator cell	0.10			0.020		0.002		#DIV/0!
	Stability of the pressure	0.35		120	0.020		0.007		2.00E-11
	Effect of the tubing between the saturator and the pressure gauge	0.20			0.020		0.004		#DIV/0!
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.04			0.020		0.001		#DIV/0!
	Long-term stability (sensor and indicator)	0.12			0.020		0.002		#DIV/0!
	Resolution (indicator unit)	0.01			0.020		0.000		#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)	0.03			0.020		0.001		#DIV/0!
	Stability of the pressure	0.35		120	0.020		0.007		2.00E-11
	Effect of the tubing between the saturator and the pressure gauge	0.20			0.020		0.004		#DIV/0!
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)	0.05		120	0.0200		0.001		8.33E-15
	Reproducibility of the flow (through the generator)	0.10			0.0200		0.002		#DIV/0!
Saturation efficiency									
	Saturation efficiency	0.02			1.0000		0.020		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)	0.006			0.17		0.001		#DIV/0!
	Water vapour enhancement formula(e)	0.000			21		0.001		#DIV/0!
Other uncertainties									
Combined uncertainty									
Effective degrees of freedom									#DIV/0!
Expanded uncertainty									
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	0.09			0.020		0.002		#DIV/0!
	Accuracy of the pressure drop measurements	0.30			0.020		0.006		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.									
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)									
Combined uncertainty							0.032		
Effective degrees of freedom				#DIV/0!					#DIV/0!
Expanded uncertainty							0.062		

Figure 66 Uncertainty budget reported by FSB-LPM at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature — Nominal value: 30 °C — Lab name: HMI/FSB-LPM - Laboratory for Process M

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$		Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C		Calculation of degrees of freedom
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.015			1		0.015		#DIV/0!
	Long-term stability (sensor and indicator)	0.006			1		0.006		#DIV/0!
	Self-heating and residual heat fluxes (sensor)	0.006			1		0.006		#DIV/0!
	Resolution and linearity (indicator unit)	0.001			1		0.001		#DIV/0!
	Saturator:								
	Temperature homogeneity	0.009			1		0.009		#DIV/0!
	Temperature stability	0.008		30	1		0.008		1.37E-10
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.04			0.022		0.001		#DIV/0!
	Long-term stability (sensor and indicator)	0.12			0.022		0.003		#DIV/0!
	Resolution and accuracy or linearity (indicator unit)	0.01			0.022		0.000		#DIV/0!
	Linearity (over a range of +70 hPa against the calibration point)	0.03			0.022		0.001		#DIV/0!
	Pressure differences in the saturator cell	0.10			0.022		0.002		#DIV/0!
	Stability of the pressure	0.33		120	0.022		0.007		2.32E-11
	Effect of the tubing between the saturator and the pressure gauge	0.20			0.022		0.004		#DIV/0!
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.04			0.022		0.001		#DIV/0!
	Long-term stability (sensor and indicator)	0.12			0.022		0.003		#DIV/0!
	Resolution (indicator unit)	0.01			0.022		0.000		#DIV/0!
	Linearity (over a range of ±10 hPa against the calibration point)	0.03			0.022		0.001		#DIV/0!
	Stability of the pressure	0.33		120	0.022		0.007		2.32E-11
	Effect of the tubing between the saturator and the pressure gauge	0.20			0.022		0.004		#DIV/0!
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)	0.05		120	0.0200		0.001		8.33E-15
	Reproducibility of the flow (through the generator)	0.10			0.0200		0.002		#DIV/0!
Saturation efficiency									
	Saturation efficiency	0.03			1.0000		0.030		#DIV/0!
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)	0.013			0.09		0.001		#DIV/0!
	Water vapour enhancement formula(e)	0.000			23		0.001		#DIV/0!
Other uncertainties									
Combined uncertainty									
Effective degrees of freedom									#DIV/0!
Expanded uncertainty									
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	0.06			0.022		0.001		#DIV/0!
	Accuracy of the pressure drop measurements	0.30			0.022		0.007		#DIV/0!
Combined uncertainty							0.040		
Effective degrees of freedom				#DIV/0!					#DIV/0!
Expanded uncertainty							0.077		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 67 Uncertainty budget reported by FSB-LPM at 65 °C nominal dew-point temperature

Appendix B.10 METAS

Uncertainty analysis of dew-point temperature		Nominal value:		30	°C Lab name		METAS	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
	Generator THUNDER 2500 : 2 pressures, 1 temperature							
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$		**Degrees of freedom components evaluated by a type A method *** ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**	
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	1	°C	0.005	1.25E-11
	Long-term stability (sensor and indicator)	0.006	°C	50	1	°C	0.006	2.22E-11
	Self-heating and residual heat fluxes (sensor)	0.003	°C	50	1	°C	0.003	2.88E-12
	Resolution and linearity (indicator unit)	0.001	°C	50	1	°C	0.001	2.00E-14
	Saturator:							
	Temperature homogeneity	0.006	°C	50	1	°C	0.006	2.22E-11
	Temperature stability	0.002	°C	50	1	°C	0.002	3.20E-13
Saturation pressure**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.001	°C/hPa	0.000	3.56E-18
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.001	°C/hPa	0.000	1.13E-18
	Resolution and accuracy or linearity (indicator unit)	0.01	hPa	50	0.001	°C/hPa	0.000	2.00E-22
	Linearity (over a range of +70 hPa against the calibration point)	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
	Pressure differences in the saturator cell	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
	Stability of the pressure	0.11	hPa	50	0.001	°C/hPa	0.000	2.93E-18
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
Gas pressure at the generator outlet**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.018	°C/hPa	0.002	3.73E-13
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.018	°C/hPa	0.002	1.18E-13
	Resolution (indicator unit)	0.01	hPa	50	0.018	°C/hPa	0.000	2.10E-17
	Linearity (over a range of ±10 hPa against the calibration point)	0.01	hPa	50	0.018	°C/hPa	0.000	1.18E-17
	Stability of the pressure	0.05	hPa	50	0.018	°C/hPa	0.001	1.31E-14
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.018	°C/hPa	0.001	2.33E-14
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)	0.50	l/min	50	0.0033	°C/(l/min)	0.002	1.48E-13
	Reproducibility of the flow (through the generator)	0.58	l/min	50	0.0033	°C/(l/min)	0.002	2.64E-13
Saturation efficiency								
	Saturation efficiency	99.95	% rH	50	0.1751	°C/% rH	0.005	1.31E-11
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)	0.006	°C	50	1	°C/°C	0.006	2.22E-11
	Water vapour enhancement formula(e)	0.001	°C	50	1	°C/°C	0.001	2.22E-15
Other uncertainties								
Combined uncertainty							0.014	
Effective degrees of freedom				347				9.64E-11
Expanded uncertainty							0.027	

Figure 68 Uncertainty budget reported by METAS at 30 °C nominal dew-point temperature

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$		Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C		
Uncertainty analysis of dew-point temperature		Nominal value:		50	°C	Lab name	METAS		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
	Generator THUNDER 2500 : 2 pressures, 1 temperature								
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	1	°C	0.005		1.25E-11
	Long-term stability (sensor and indicator)	0.006	°C	50	1	°C	0.006		2.22E-11
	Self-heating and residual heat fluxes (sensor)	0.003	°C	50	1	°C	0.003		2.88E-12
	Resolution and linearity (indicator unit)	0.001	°C	50	1	°C	0.001		2.00E-14
	Saturator:								
	Temperature homogeneity	0.006	°C	50	1	°C	0.006		2.22E-11
	Temperature stability	0.002	°C	50	1	°C	0.002		3.20E-13
Saturation pressure**									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.001	°C/hPa	0.000		3.56E-18
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.001	°C/hPa	0.000		1.13E-18
	Resolution and accuracy or linearity (indicator unit)	0.01	hPa	50	0.001	°C/hPa	0.000		2.00E-22
	Linearity (over a range of +70 hPa against the calibration point)	0.06	hPa	50	0.001	°C/hPa	0.000		2.22E-19
	Pressure differences in the saturator cell	0.06	hPa	50	0.001	°C/hPa	0.000		2.22E-19
	Stability of the pressure	0.11	hPa	50	0.001	°C/hPa	0.000		2.93E-18
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.001	°C/hPa	0.000		2.22E-19
Gas pressure at the generator outlet**									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.021	°C/hPa	0.002		6.91E-13
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.021	°C/hPa	0.002		2.19E-13
	Resolution (indicator unit)	0.01	hPa	50	0.021	°C/hPa	0.000		3.89E-17
	Linearity (over a range of ±10 hPa against the calibration point)	0.01	hPa	50	0.021	°C/hPa	0.000		2.19E-17
	Stability of the pressure	0.05	hPa	50	0.021	°C/hPa	0.001		2.43E-14
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.021	°C/hPa	0.001		4.32E-14
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)	0.50	l/min	50	0.0033	°C/(l/min)	0.002		1.48E-13
	Reproducibility of the flow (through the generator)	0.58	l/min	50	0.0033	°C/(l/min)	0.002		2.64E-13
Saturation efficiency									
	Saturation efficiency	99.95	% rH	50	0.2021	°C/% rH	0.006		2.32E-11
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)	0.006	°C	50	1	°C/°C	0.006		2.22E-11
	Water vapour enhancement formula(e)	0.001	°C	50	1	°C/°C	0.001		2.22E-15
Other uncertainties									
Combined uncertainty							0.014		
Effective degrees of freedom				354					1.07E-10
Expanded uncertainty							0.027		

Figure 69 Uncertainty budget reported by METAS at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		65	°C	Lab name	METAS	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
	Generator THUNDER 2500 : 2 pressures, 1 temperature							
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***	**Sensitivity coefficient**		**Uncertainty contribution**	
Q_i		$u_{(Qi)}$		ν_i	c_i		u_i in °C	
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	1	°C	0.005	1.25E-11
	Long-term stability (sensor and indicator)	0.006	°C	50	1	°C	0.006	2.22E-11
	Self-heating and residual heat fluxes (sensor)	0.003	°C	50	1	°C	0.003	2.88E-12
	Resolution and linearity (indicator unit)	0.001	°C	50	1	°C	0.001	2.00E-14
	Saturator:							
	Temperature homogeneity	0.006	°C	50	1	°C	0.006	2.22E-11
	Temperature stability	0.002	°C	50	1	°C	0.002	3.20E-13
Saturation pressure**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.001	°C/hPa	0.000	3.56E-18
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.001	°C/hPa	0.000	1.13E-18
	Resolution and accuracy or linearity (indicator unit)	0.01	hPa	50	0.001	°C/hPa	0.000	2.00E-22
	Linearity (over a range of +70 hPa against the calibration point)	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
	Pressure differences in the saturator cell	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
	Stability of the pressure	0.11	hPa	50	0.001	°C/hPa	0.000	2.93E-18
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.001	°C/hPa	0.000	2.22E-19
Gas pressure at the generator outlet**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	0.12	hPa	50	0.023	°C/hPa	0.003	9.95E-13
	Long-term stability (sensor and indicator)	0.09	hPa	50	0.023	°C/hPa	0.002	3.15E-13
	Resolution (indicator unit)	0.01	hPa	50	0.023	°C/hPa	0.000	5.60E-17
	Linearity (over a range of ±10 hPa against the calibration point)	0.01	hPa	50	0.023	°C/hPa	0.000	3.15E-17
	Stability of the pressure	0.05	hPa	50	0.023	°C/hPa	0.001	3.50E-14
	Effect of the tubing between the saturator and the pressure gauge	0.06	hPa	50	0.023	°C/hPa	0.001	6.22E-14
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)	0.50	l/min	50	0.0033	°C/(l/min)	0.002	1.48E-13
	Reproducibility of the flow (through the generator)	0.58	l/min	50	0.0033	°C/(l/min)	0.002	2.64E-13
Saturation efficiency								
	Saturation efficiency	99.95	% rH	50	0.2245	°C/% rH	0.006	3.53E-11
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)	0.006	°C	50	1	°C/°C	0.006	2.22E-11
	Water vapour enhancement formula(e)	0.001	°C	50	1	°C/°C	0.001	2.22E-15
Other uncertainties								
Combined uncertainty							0.014	
Effective degrees of freedom				351				1.19E-10
Expanded uncertainty							0.028	

Figure 70 Uncertainty budget reported by METAS at 65 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		80	°C	Lab name	METAS	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
	Generator CETIAT 1 : 1 pressure, 1 temperature							
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***	**Sensitivity coefficient**		**Uncertainty contribution**	
Q_i		$u_{(Qi)}$		ν_i	c_i		u_i in °C	
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	1	°C	0.005	1.25E-11
	Long-term stability (sensor and indicator)	0.006	°C	50	1	°C	0.006	2.22E-11
	Self-heating and residual heat fluxes (sensor)	0.003	°C	50	1	°C	0.003	2.88E-12
	Resolution and linearity (indicator unit)	0.001	°C	50	1	°C	0.001	2.00E-14
	Saturator:							
	Temperature homogeneity	0.012	°C	50	1	°C	0.012	3.56E-10
	Temperature stability	0.004	°C	50	1	°C	0.004	5.12E-12
Saturation pressure**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							
	Long-term stability (sensor and indicator)							
	Resolution and accuracy or linearity (indicator unit)							
	Linearity (over a range of +70 hPa against the calibration point)							
	Pressure differences in the saturator cell							
	Stability of the pressure							
	Effect of the tubing between the saturator and the pressure gauge							
Gas pressure at the generator outlet**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							
	Long-term stability (sensor and indicator)							
	Resolution (indicator unit)							
	Linearity (over a range of ±10 hPa against the calibration point)							
	Stability of the pressure							
	Effect of the tubing between the saturator and the pressure gauge							
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)	0.50	l/min	50	0.0033	°C/(l/min)	0.002	1.48E-13
	Reproducibility of the flow (through the generator)	0.58	l/min	50	0.0033	°C/(l/min)	0.002	2.64E-13
Saturation efficiency								
	Saturation efficiency	99.9	% rH	50	0.2486	°C/% rH	0.025	7.64E-09
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)							
	Water vapour enhancement formula(e)							
Other uncertainties								
Combined uncertainty							0.029	
Effective degrees of freedom				89				8.03E-09
Expanded uncertainty							0.057	

Figure 71 Uncertainty budget reported by METAS at 80 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		85	°C	Lab name	METAS	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
	Generator CETIAT 1 : 1 pressure, 1 temperature							
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***	**Sensitivity coefficient**		**Uncertainty contribution**	
Q_i		$u_{(Qi)}$		ν_i	c_i		u_i in °C	
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	1	°C	0.005	1.25E-11
	Long-term stability (sensor and indicator)	0.006	°C	50	1	°C	0.006	2.22E-11
	Self-heating and residual heat fluxes (sensor)	0.003	°C	50	1	°C	0.003	2.88E-12
	Resolution and linearity (indicator unit)	0.001	°C	50	1	°C	0.001	2.00E-14
	Saturator:							
	Temperature homogeneity	0.012	°C	50	1	°C	0.012	3.56E-10
	Temperature stability	0.005	°C	50	1	°C	0.005	1.25E-11
Saturation pressure**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							
	Long-term stability (sensor and indicator)							
	Resolution and accuracy or linearity (indicator unit)							
	Linearity (over a range of +70 hPa against the calibration point)							
	Pressure differences in the saturator cell							
	Stability of the pressure							
	Effect of the tubing between the saturator and the pressure gauge							
Gas pressure at the generator outlet**								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							
	Long-term stability (sensor and indicator)							
	Resolution (indicator unit)							
	Linearity (over a range of ±10 hPa against the calibration point)							
	Stability of the pressure							
	Effect of the tubing between the saturator and the pressure gauge							
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)	0.50	l/min	50	0.0033	°C/(l/min)	0.002	1.48E-13
	Reproducibility of the flow (through the generator)	0.58	l/min	50	0.0033	°C/(l/min)	0.002	2.64E-13
Saturation efficiency								
	Saturation efficiency	99.9	% rH	50	0.2571	°C/% rH	0.026	8.74E-09
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)							
	Water vapour enhancement formula(e)							
Other uncertainties								
Combined uncertainty							0.030	
Effective degrees of freedom				88				9.14E-09
Expanded uncertainty							0.059	

Figure 72 Uncertainty budget reported by METAS at 85 °C nominal dew-point temperature

Appendix B.11 INRIM

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	INRIM				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Long-term stability (sensor and indicator)	0.012	°C	50	-	1.00	°C/°C	0.012	°C		4.1472E-10
	Self-heating and residual heat fluxes (sensor)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Resolution and accuracy or linearity (indicator unit)	0.004	°C	50	-	1.00	°C/°C	0.004	°C		3.36177E-12
	Saturator:										
	Temperature homogeneity	0.0014	°C	50	-	1.00	°C/°C	0.001	°C		8.59963E-14
	Temperature stability	0.0010	°C	20	-	1.00	°C/°C	0.001	°C		5E-14
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	20.0	Pa	50	-	-1.6E-04	°C/Pa	-0.003	°C		2.17254E-12
	Long-term stability (sensor and indicator)	50.0	Pa	50	-	-1.6E-04	°C/Pa	-0.008	°C		8.48649E-11
	Resolution and accuracy or linearity (indicator unit)	0.2	Pa	50	-	-1.6E-04	°C/Pa	0.000	°C		2.17254E-20
	Pressure differences in the saturator cell	35.0	Pa	20	-	-1.6E-04	°C/Pa	-0.006	°C		5.09402E-11
	Stability of the pressure	28.0	Pa	40	-	-1.6E-04	°C/Pa	-0.005	°C		1.04325E-11
	Effect of the tubing between the saturator and the pressure gauge	0.1	Pa	20	-	-1.6E-04	°C/Pa	0.000	°C		3.3946E-21
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.3	Pa	50	-	-1.6E-04	°C/Pa	-0.001	°C		1.61029E-15
	Long-term stability (sensor and indicator)	2.5	Pa	50	-	-1.6E-04	°C/Pa	0.000	°C		5.30406E-16
	Resolution and accuracy or linearity (indicator unit)	0.4	Pa	50	-	-1.6E-04	°C/Pa	0.000	°C		3.47607E-19
	Stability of the pressure	3.1	Pa	20	-	-1.6E-04	°C/Pa	-0.001	°C		3.13498E-15
	Effect of the tubing between the saturator and the pressure gauge	0.0	Pa	20	-	-1.6E-04	°C/Pa	0.000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.000	l/min	10	-	0.013	°C/l/min	0.000	°C		0
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	0.001	°C	50	-	1.00	°C/°C	0.001	°C		4.43067E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		
	Water vapour enhancement formula(e)				-				°C		
Other uncertainties											
	Desorption Effect	0.0000	°C	50	-	1.000	°C/°C	0.0000	°C		0
	Saturator thermometer interpolation curve	0.0040	°C	50	-	1.000	°C/°C	0.0040	°C		5.12E-12
	Std uncertainty due to Self-Heating	0.003	°C	50	-	1.000	°C/°C	0.0030	°C		1.62E-12
	Std uncertainty due tonon-linearity of travelling standard measurement system	0.0036	°C	50	-	1.000	°C/°C	0.0036	°C		3.35923E-12
	Flow meter - Resolution	0.0050	l/min	50	-	0.013	°C/l/min	0.0001	°C		3.57013E-19
Combined uncertainty					-			0.019	°C		
Effective degrees of freedom				238	-				°C	sum	6.01777E-10
Expanded uncertainty					-			0.0389	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	5.3	Pa	50		-1.6E-04	°C/Pa	-0.001	°C		1.0714E-14
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.019	°C		
Effective degrees of freedom				238					°C	sum	6.01787E-10
Expanded uncertainty								0.039	°C		

Figure 73 Uncertainty budget reported by INRIM at 30 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	INRIM				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Long-term stability (sensor and indicator)	0.012	°C	50	-	1.00	°C/°C	0.012	°C		4.1472E-10
	Self-heating and residual heat fluxes (sensor)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Resolution and accuracy or linearity (indicator unit)	0.004	°C	50	-	1.00	°C/°C	0.004	°C		3.36177E-12
	Saturator:										
	Temperature homogeneity	0.0015	°C	50	-	1.00	°C/°C	0.001	°C		9.85769E-14
	Temperature stability	0.0010	°C	20	-	1.00	°C/°C	0.001	°C		5E-14
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	20.0	Pa	50	-	-1.9E-04	°C/Pa	-0.004	°C		3.8915E-12
	Long-term stability (sensor and indicator)	50.0	Pa	50	-	-1.9E-04	°C/Pa	-0.009	°C		1.52012E-10
	Resolution and accuracy or linearity (indicator unit)	0.2	Pa	50	-	-1.9E-04	°C/Pa	0.000	°C		3.8915E-20
	Pressure differences in the saturator cell	35.0	Pa	20	-	-1.9E-04	°C/Pa	-0.007	°C		9.1245E-11
	Stability of the pressure	38.0	Pa	40	-	-1.9E-04	°C/Pa	-0.007	°C		6.3393E-11
	Effect of the tubing between the saturator and the pressure gauge	0.1	Pa	20	-	-1.9E-04	°C/Pa	0.000	°C		6.08047E-21
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.3	Pa	50	-	-1.9E-04	°C/Pa	-0.001	°C		2.88438E-15
	Long-term stability (sensor and indicator)	2.5	Pa	50	-	-1.9E-04	°C/Pa	0.000	°C		9.50073E-16
	Resolution and accuracy or linearity (indicator unit)	0.4	Pa	50	-	-1.9E-04	°C/Pa	0.000	°C		6.2264E-19
	Stability of the pressure	3.1	Pa	20	-	-1.9E-04	°C/Pa	-0.001	°C		5.61544E-15
	Effect of the tubing between the saturator and the pressure gauge	0.0	Pa	20	-	-1.9E-04	°C/Pa	0.000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.000	l/min	10	-	0.015	°C/l/min	0.000	°C		0
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	0.003	°C	50	-	1.00	°C/°C	0.003	°C		1.22931E-12
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		
	Water vapour enhancement formula(e)				-				°C		
Other uncertainties											
	Desorption Effect	0.00	°C	50	-	1.00	°C/°C	0.000	°C		0
	Saturator thermometer interpolation curve	0.004	°C	50	-	1.00	°C/°C	0.004	°C		5.12E-12
	Std uncertainty due to Self-Heating	0.003	°C	50	-	1.000	°C/°C	0.0030	°C		1.62E-12
	Std uncertainty due tonon-linearity of travelling standard measurement sys	0.0036	°C	50	-	1.000	°C/°C	0.0036	°C		3.35923E-12
	Flow meter - Resolution	0.005	l/min	50	-	0.015	°C/l/min	0.000	°C		6.32813E-19
Combined uncertainty					-			0.021	°C		
Effective degrees of freedom				266	-				°C	sum	7.6511E-10
Expanded uncertainty					-			0.0425	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	5.3	Pa	50		-1.9E-04	°C/Pa	-0.001	°C		1.91911E-14
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.021	°C		
Effective degrees of freedom				267					°C	sum	7.65129E-10
Expanded uncertainty								0.043	°C		

Figure 74 Uncertainty budget reported by INRIM at 50 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	65	°C		Lab name	INRIM				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Long-term stability (sensor and indicator)	0.012	°C	50	-	1.00	°C/°C	0.012	°C		4.1472E-10
	Self-heating and residual heat fluxes (sensor)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Resolution and accuracy or linearity (indicator unit)	0.004	°C	50	-	1.00	°C/°C	0.004	°C		3.36177E-12
	Saturator:										
	Temperature homogeneity	0.0123	°C	50	-	1.00	°C/°C	0.012	°C		4.50375E-10
	Temperature stability	0.0050	°C	20	-	1.00	°C/°C	0.005	°C		3.125E-11
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	20.0	Pa	50	-	-2.1E-04	°C/Pa	-0.004	°C		5.89643E-12
	Long-term stability (sensor and indicator)	50.0	Pa	50	-	-2.1E-04	°C/Pa	-0.010	°C		2.30329E-10
	Resolution and accuracy or linearity (indicator unit)	0.2	Pa	50	-	-2.1E-04	°C/Pa	0.000	°C		5.89643E-20
	Pressure differences in the saturator cell	35.0	Pa	20	-	-2.1E-04	°C/Pa	-0.007	°C		1.38255E-10
	Stability of the pressure	40.0	Pa	40	-	-2.1E-04	°C/Pa	-0.008	°C		1.17929E-10
	Effect of the tubing between the saturator and the pressure gauge	0.1	Pa	20	-	-2.1E-04	°C/Pa	0.000	°C		9.21318E-21
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.3	Pa	50	-	-2.1E-04	°C/Pa	-0.001	°C		4.37044E-15
	Long-term stability (sensor and indicator)	2.5	Pa	50	-	-2.1E-04	°C/Pa	-0.001	°C		1.43956E-15
	Resolution and accuracy or linearity (indicator unit)	0.4	Pa	50	-	-2.1E-04	°C/Pa	0.000	°C		9.43429E-19
	Stability of the pressure	3.1	Pa	20	-	-2.1E-04	°C/Pa	-0.001	°C		8.50856E-15
	Effect of the tubing between the saturator and the pressure gauge	0.0	Pa	20	-	-2.1E-04	°C/Pa	0.000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.000	l/min	10	-	0.017	°C/l/min	0.000	°C		0
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	0.002	°C	50	-	1.00	°C/°C	0.002	°C		3.2E-13
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		
	Water vapour enhancement formula(e)				-				°C		
Other uncertainties											
	Desorption Effect	0.00	°C	50	-	1.00	°C/°C	0.000	°C		0
	Saturator thermometer interpolation curve	0.004	°C	50	-	1.00	°C/°C	0.004	°C		5.12E-12
	Std uncertainty due to Self-Heating	0.003	°C	50	-	1.000	°C/°C	0.0030	°C		1.62E-12
	Std uncertainty due tonon-linearity of travelling standard measurement sys	0.0036	°C	50	-	1.000	°C/°C	0.0036	°C		3.35923E-12
	Flow meter - Resolution	0.005	l/min	50	-	0.017	°C/l/min	0.000	°C		1.04401E-18
Combined uncertainty					-			0.026	°C		
Effective degrees of freedom				315	-				°C	sum	1.42755E-09
Expanded uncertainty					-			0.0518	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	5.3	Pa	50		-2.1E-04	°C/Pa	-0.001	°C		2.90786E-14
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.026	°C		
Effective degrees of freedom				316					°C	sum	1.42758E-09
Expanded uncertainty								0.052	°C		

Figure 75 Uncertainty budget reported by INRIM at 65 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	80	°C		Lab name	INRIM				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Long-term stability (sensor and indicator)	0.012	°C	50	-	1.00	°C/°C	0.012	°C		4.1472E-10
	Self-heating and residual heat fluxes (sensor)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Resolution and accuracy or linearity (indicator unit)	0.004	°C	50	-	1.00	°C/°C	0.004	°C		3.36177E-12
	Saturator:										
	Temperature homogeneity	0.0102	°C	50	-	1.00	°C/°C	0.010	°C		2.16486E-10
	Temperature stability	0.0085	°C	20	-	1.00	°C/°C	0.009	°C		2.61003E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	20.0	Pa	50	-	-2.3E-04	°C/Pa	-0.005	°C		8.77913E-12
	Long-term stability (sensor and indicator)	50.0	Pa	50	-	-2.3E-04	°C/Pa	-0.011	°C		3.42935E-10
	Resolution and accuracy or linearity (indicator unit)	0.2	Pa	50	-	-2.3E-04	°C/Pa	0.000	°C		8.77913E-20
	Pressure differences in the saturator cell	35.0	Pa	20	-	-2.3E-04	°C/Pa	-0.008	°C		2.05847E-10
	Stability of the pressure	30.0	Pa	40	-	-2.3E-04	°C/Pa	-0.007	°C		5.55554E-11
	Effect of the tubing between the saturator and the pressure gauge	0.1	Pa	20	-	-2.3E-04	°C/Pa	0.000	°C		1.37174E-20
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.3	Pa	50	-	-2.3E-04	°C/Pa	-0.001	°C		6.5071E-15
	Long-term stability (sensor and indicator)	2.5	Pa	50	-	-2.3E-04	°C/Pa	-0.001	°C		2.14334E-15
	Resolution and accuracy or linearity (indicator unit)	0.4	Pa	50	-	-2.3E-04	°C/Pa	0.000	°C		1.40466E-18
	Stability of the pressure	3.1	Pa	20	-	-2.3E-04	°C/Pa	-0.001	°C		1.26683E-14
	Effect of the tubing between the saturator and the pressure gauge	0.0	Pa	20	-	-2.3E-04	°C/Pa	0.000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.000	l/min	10	-	0.018	°C/l/min	0.000	°C		0
	Reproducibility				-				°C		
Saturation efficiency											
	Saturation efficiency	0.005	°C	50	-	1.00	°C/°C	0.005	°C		8.20125E-12
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		
	Water vapour enhancement formula(e)				-				°C		
Other uncertainties											
	Desorption Effect	0.00	°C	50	-	1.00	°C/°C	0.000	°C		0
	Saturator thermometer interpolation curve	0.004	°C	50	-	1.00	°C/°C	0.004	°C		5.12E-12
	Std uncertainty due to Self-Heating	0.003	°C	50	-	1.000	°C/°C	0.0030	°C		1.62E-12
	Std uncertainty due tonon-linearity of travelling standard measurement sys	0.0036	°C	50	-	1.000	°C/°C	0.0036	°C		3.35923E-12
	Flow meter - Resolution	0.005	l/min	50	-	0.018	°C/l/min	0.000	°C		1.3122E-18
Combined uncertainty					-			0.027	°C		
Effective degrees of freedom				321	-				°C	sum	1.55201E-09
Expanded uncertainty					-			0.0531	°C		

Figure 76 Uncertainty budget reported by INRIM at 80 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	INRIM				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Long-term stability (sensor and indicator)	0.012	°C	50	-	1.00	°C/°C	0.012	°C		4.1472E-10
	Self-heating and residual heat fluxes (sensor)	0.005	°C	50	-	1.00	°C/°C	0.005	°C		1.25E-11
	Resolution and accuracy or linearity (indicator unit)	0.004	°C	50	-	1.00	°C/°C	0.004	°C		3.36177E-12
	Saturator:										
	Temperature homogeneity	0.0190	°C	50	-	1.00	°C/°C	0.019	°C		2.60642E-09
	Temperature stability	0.0060	°C	20	-	1.00	°C/°C	0.006	°C		6.48E-11
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	20.0	Pa	50	-	-2.4E-04	°C/Pa	-0.005	°C		9.98706E-12
	Long-term stability (sensor and indicator)	50.0	Pa	50	-	-2.4E-04	°C/Pa	-0.012	°C		3.90119E-10
	Resolution and accuracy or linearity (indicator unit)	0.2	Pa	50	-	-2.4E-04	°C/Pa	0.000	°C		9.98706E-20
	Pressure differences in the saturator cell	35.0	Pa	20	-	-2.4E-04	°C/Pa	-0.008	°C		2.34169E-10
	Stability of the pressure	45.0	Pa	40	-	-2.4E-04	°C/Pa	-0.011	°C		3.19947E-10
	Effect of the tubing between the saturator and the pressure gauge	0.1	Pa	20	-	-2.4E-04	°C/Pa	0.000	°C		1.56048E-20
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.3	Pa	50	-	-2.4E-04	°C/Pa	-0.001	°C		7.40241E-15
	Long-term stability (sensor and indicator)	2.5	Pa	50	-	-2.4E-04	°C/Pa	-0.001	°C		2.43825E-15
	Resolution and accuracy or linearity (indicator unit)	0.4	Pa	50	-	-2.4E-04	°C/Pa	0.000	°C		1.59793E-18
	Stability of the pressure	3.1	Pa	20	-	-2.4E-04	°C/Pa	-0.001	°C		1.44113E-14
	Effect of the tubing between the saturator and the pressure gauge	0.0	Pa	20	-	-2.4E-04	°C/Pa	0.000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.000	l/min	10	-	0.019	°C/l/min	0.000	°C		0
	Reproducibility	0.0000			-				°C		
Saturation efficiency											
	Saturation efficiency	0.011	°C	50	-	1.00	°C/°C	0.011	°C		2.9282E-10
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant				-				°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)				-				°C		
	Water vapour enhancement formula(e)				-				°C		
Other uncertainties											
	Desorption Effect	0.00	°C	50	-	1.00	°C/°C	0.000	°C		0
	Saturator thermometer interpolation curve	0.004	°C	50	-	1.00	°C/°C	0.004	°C		5.12E-12
	Std uncertainty due to Self-Heating	0.003	°C	50	-	1.000	°C/°C	0.0030	°C		1.62E-12
	Std uncertainty due tonon-linearity of travelling standard measurement sys	0.0036	°C	50	-	1.000	°C/°C	0.0036	°C		3.35923E-12
	Flow meter - Resolution	0.005	l/min	50	-	0.019	°C/l/min	0.000	°C		1.62901E-18
Combined uncertainty					-			0.033	°C		
Effective degrees of freedom				281	-				°C	sum	4.37147E-09
Expanded uncertainty					-			0.0666	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	5.3	Pa	50		-2.4E-04	°C/Pa	-0.001	°C		4.92517E-14
	Other								°C		
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty								0.033	°C		
Effective degrees of freedom				282					°C	sum	4.37152E-09
Expanded uncertainty								0.067	°C		

Figure 77 Uncertainty budget reported by INRIM at 85 °C nominal dew-point temperature

Appendix B.12 VSL

		Uncertainty @ 30 °C			Uncertainty @ 50 °C			Uncertainty @ 65 °C		
Quantity	**Components**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**
Q_i		$u_{(Qi)}$		u_i in °C	$u_{(Qi)}$		u_i in °C	$u_{(Qi)}$		u_i in °C
Primary dew-point generator										
Saturation temperature										
	Thermometer:									
	Calibration uncertainty (sensor and indicator unit)	0.0025	1	0.0025	0.0025	1	0.0025	0.0025	1	0.0025
	Long-term stability (sensor)	0.001	1	0.001	0.001	1	0.001	0.001	1	0.001
	Self-heating and residual heat fluxes (sensor)	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005
	Calibration uncertainty (indicator unit)	0.0025	2.582	0.006	0.0025	2.597	0.006	0.0025	2.609	0.007
	Resolution and accuracy or linearity (indicator unit)	2.89E-05	2.582	0.000	2.89E-05	2.597	0.000	2.89E-05	2.609	0.000
	Saturator:									
	Temperature homogeneity	0.001	1	0.001	0.001	1	0.001	0.001	1	0.001
	Temperature stability	0.009	1	0.009	0.005	1	0.005	0.006	1	0.006
Saturation pressure										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)									
	Long-term stability (sensor and indicator)									
	Resolution and accuracy or linearity (indicator unit)									
	Pressure differences in the saturator cell									
	Stability of the pressure									
	Effect of the tubing between the saturator and the pressure gauge									
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)									
	Long-term stability (sensor and indicator)									
	Resolution (indicator unit)									
	Stability of the pressure									
	Effect of the tubing between the saturator and the pressure gauge									
Flow measurement:										
	Flow meter									
	Stability of the flow									
	Reproducibility									
Saturation efficiency										
	Saturation efficiency	0.003	1	0.003	0.009	1	0.009	0.016	1	0.016
Correlation between pressure and temperature measurement (if relevant)										
	Correlation between pressure and temperature measurement if relevant									
Uncertainty due to formulae/calculations										
	Saturation vapour pressure formula(e)									
	Water vapour enhancement formula(e)									
Other uncertainties										
	Contaminations	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005
Combined uncertainty				0.014			0.014			0.020
Expanded uncertainty				0.027			0.029			0.041
Additional uncertainty in applied condition at point of use										
	Pressure drop between point of realisation and measuring instrument	45	2.00E-04	0.009	45	2.00E-04	0.009	45	2.00E-04	0.009
	Other									
Combined uncertainty				0.016			0.017			0.022
Expanded uncertainty				0.033			0.034			0.044

Figure 78 Uncertainty budget reported by VSL at 30 °C, 50 °C, and 65 °C nominal dew-point temperature

		Uncertainty @ 80 °C			Uncertainty @ 85 °C			Uncertainty @ 90 °C			Uncertainty @ 95 °C		
Quantity	**Components**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**	**Standard Uncertainty**	**Sensitivity coefficient**	**Uncertainty contribution**
Q_i		**$u_{(Qi)}$**		**u_i in °C**	**$u_{(Qi)}$**		**u_i in °C**	**$u_{(Qi)}$**		**u_i in °C**	**$u_{(Qi)}$**		**u_i in °C**
Primary dew-point generator													
Saturation temperature													
	Thermometer:												
	Calibration uncertainty (sensor and indicator unit)	0.0025	1	0.0025	0.0025	1	0.0025	0.0025	1	0.0025	0.0025	1	0.0025
	Long-term stability (sensor)	0.001	1	0.001	0.001	1	0.001	0.001	1	0.001	0.001	1	0.001
	Self-heating and residual heat fluxes (sensor)	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005
	Calibration uncertainty (indicator unit)	0.0025	2.621	0.007	0.0025	2.625	0.007	0.0025	2.629	0.007	0.0025	2.633	0.007
	Resolution and accuracy or linearity (indicator unit)	2.89E-05	2.621	0.000	2.89E-05	2.625	0.000	2.89E-05	2.629	0.000	2.89E-05	2.633	0.000
	Saturator:												
	Temperature homogeneity	0.001	1	0.001	0.002	1	0.002	0.002	1	0.002	0.003	1	0.003
	Temperature stability	0.014	1	0.014	0.008	1	0.008	0.007	1	0.007	0.010	1	0.010
Saturation pressure													
	Pressure gauge:												
	Calibration uncertainty (sensor and indicator unit)												
	Long-term stability (sensor and indicator)												
	Resolution and accuracy or linearity (indicator unit)												
	Pressure differences in the saturator cell												
	Stability of the pressure												
	Effect of the tubing between the saturator and the pressure gauge												
Gas pressure at the generator outlet:													
	Pressure gauge:												
	Calibration uncertainty (sensor and indicator unit)												
	Long-term stability (sensor and indicator)												
	Resolution (indicator unit)												
	Stability of the pressure												
	Effect of the tubing between the saturator and the pressure gauge												
Flow measurement:													
	Flow meter												
	Stability of the flow												
	Reproducibility												
Saturation efficiency													
	Saturation efficiency	0.026	1	0.026	0.030	1	0.030	0.034	1	0.034	0.038	1	0.038
Correlation between pressure and temperature measurement (if relevant)													
	Correlation between pressure and temperature measurement if relevant												
Uncertainty due to formulae/calculations													
	Saturation vapour pressure formula(e)												
	Water vapour enhancement formula(e)												
Other uncertainties													
	Contaminations	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005	0.005	1	0.005
Combined uncertainty				0.031			0.033			0.036			0.041
Expanded uncertainty				0.063			0.065			0.072			0.082
Additional uncertainty in applied condition at point of use													
	Pressure drop between point of realisation and measuring instrument	45	2.00E-04	0.009	45	3.00E-04	0.014	45	3.00E-04	0.014	45	3.00E-04	0.014
	Other												
Combined uncertainty				0.033			0.035			0.039			0.043
Expanded uncertainty				0.065			0.071			0.077			0.086

Figure 79 Uncertainty budget reported by VSL at 80 °C, 85 °C, 90 °C, and 95 °C nominal dew-point temperature

Appendix B.13 VTT

Uncertainty analysis of dew-point temperature Nominal value: 30 °C Lab name MIKES

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0042	50	1		0.0042	6.48E-12
	Long-term stability (sensor and indicator)	0.0036	50	1		0.0036	3.39E-12
	Self-heating and residual heat fluxes (sensor)	0.0058	50	1		0.0058	2.22E-11
	Resolution and linearity (indicator unit)	0.0001	50	1		0.0001	4.00E-18
	Saturator:						
	Temperature homogeneity	0.0058	10	1		0.0058	1.12E-10
	Temperature stability	0.0002	10	1		0.0002	1.97E-16
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	3.0000	50	0.0003	°C/Pa	0.0010	1.88E-14
	Long-term stability (sensor and indicator)	4.0000	50	0.0003	°C/Pa	0.0013	5.95E-14
	Resolution and accuracy or linearity (indicator unit)	1.0000	50	0.0003	°C/Pa	0.0003	2.32E-16
	Linearity (over a range of +70 hPa against the calibration point)	1.1547	50	0.0003	°C/Pa	0.0004	4.13E-16
	Pressure differences in the saturator cell	9.2203	50	0.0002	°C/Pa	0.0015	1.05E-13
	Stability of the pressure	3.4641	50	0.0003	°C/Pa	0.0011	3.34E-14
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0002	°C/Pa	0.0015	1.05E-13
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)						
	Long-term stability (sensor and indicator)						
	Resolution (indicator unit)						
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure						
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0003	°C/Pa	0.0030	1.68E-12
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)	0.0200	50	0.0800	°C /(l/min)	0.0016	1.31E-13
	Reproducibility of the flow (through the generator)	0.0200	50	0.0800	°C /(l/min)	0.0016	1.31E-13
Saturation efficiency							
	Saturation efficiency	0.0173	50	1.0000		0.0173	1.80E-09
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)	0.0080	50	1.0000		0.0080	8.19E-11
	Water vapour enhancement formula(e)						
Other uncertainties							
Combined uncertainty						0.022	
Effective degrees of freedom							2.03E-09
Expanded uncertainty						0.044	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	27.3865	50	0.0002	°C/Pa	0.0045	8.16E-12
	Accuracy of the pressure drop measurements						
Combined uncertainty						0.022	
Effective degrees of freedom			125				2.04E-09
Expanded uncertainty						0.044	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 80 Uncertainty budget reported by VTT at 30 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature Nominal value: 50 °C Lab name MIKES

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$		Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C		Calculation of degrees of freedom
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.0042		50	1		0.0042		6.48E-12
	Long-term stability (sensor and indicator)	0.0036		50	1		0.0036		3.39E-12
	Self-heating and residual heat fluxes (sensor)	0.0058		50	1		0.0058		2.22E-11
	Resolution and linearity (indicator unit)	0.0001		50	1		0.0001		4.00E-18
	Saturator:								
	Temperature homogeneity	0.0058		10	1		0.0058		1.12E-10
	Temperature stability	0.0002		10	1		0.0002		1.97E-16
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	3.0000		50	0.0003	°C/Pa	0.0010		1.88E-14
	Long-term stability (sensor and indicator)	4.0000		50	0.0003	°C/Pa	0.0013		5.95E-14
	Resolution and accuracy or linearity (indicator unit)	1.0000		50	0.0003	°C/Pa	0.0003		2.32E-16
	Linearity (over a range of +70 hPa against the calibration point)	1.1547		50	0.0003	°C/Pa	0.0004		4.13E-16
	Pressure differences in the saturator cell	9.2203		50	0.0002	°C/Pa	0.0015		1.05E-13
	Stability of the pressure	3.4641		50	0.0003	°C/Pa	0.0011		3.34E-14
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0002	°C/Pa	0.0015		1.05E-13
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)								
	Long-term stability (sensor and indicator)								
	Resolution (indicator unit)								
	Linearity (over a range of ±10 hPa against the calibration point)								
	Stability of the pressure								
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0003	°C/Pa	0.0030		1.68E-12
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016		1.31E-13
	Reproducibility of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016		1.31E-13
Saturation efficiency									
	Saturation efficiency	0.0173		50	1.0000		0.0173		1.80E-09
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)	0.0080		50	1.0000		0.0080		8.19E-11
	Water vapour enhancement formula(e)								
Other uncertainties									
Combined uncertainty							0.022		
Effective degrees of freedom									2.03E-09
Expanded uncertainty							0.044		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	27.3865		50	0.0002	°C/Pa	0.0045		8.16E-12
	Accuracy of the pressure drop measurements								
Combined uncertainty							0.022		
Effective degrees of freedom				125					2.04E-09
Expanded uncertainty							0.044		

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 81 Uncertainty budget reported by VTT at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		65	°C	Lab name	MIKES		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$		**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**		Calculation of degrees of freedom
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.0042		50	1		0.0042		6.48E-12
	Long-term stability (sensor and indicator)	0.0036		50	1		0.0036		3.39E-12
	Self-heating and residual heat fluxes (sensor)	0.0058		50	1		0.0058		2.22E-11
	Resolution and linearity (indicator unit)	0.0001		50	1		0.0001		4.18E-18
	Saturator:								
	Temperature homogeneity	0.0060		10	1		0.0060		1.29E-10
	Temperature stability	0.0014		10	1		0.0014		4.21E-13
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	3.0000		50	0.0004	°C/Pa	0.0012		4.78E-14
	Long-term stability (sensor and indicator)	4.0000		50	0.0004	°C/Pa	0.0017		1.51E-13
	Resolution and accuracy or linearity (indicator unit)	1.0000		50	0.0004	°C/Pa	0.0004		5.90E-16
	Linearity (over a range of +70 hPa against the calibration point)	1.1547		50	0.0004	°C/Pa	0.0005		1.05E-15
	Pressure differences in the saturator cell	9.2203		50	0.0002	°C/Pa	0.0019		2.66E-13
	Stability of the pressure	3.4641		50	0.0004	°C/Pa	0.0014		8.49E-14
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0002	°C/Pa	0.0019		2.66E-13
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)								
	Long-term stability (sensor and indicator)								
	Resolution (indicator unit)								
	Linearity (over a range of ±10 hPa against the calibration point)								
	Stability of the pressure								
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0004	°C/Pa	0.0038		4.26E-12
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016		1.31E-13
	Reproducibility of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016		1.31E-13
Saturation efficiency									
	Saturation efficiency	0.0173		50	1.0000		0.0173		1.80E-09
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)	0.0080		50	1.0000		0.0080		8.19E-11
	Water vapour enhancement formula(e)								
Other uncertainties									
Combined uncertainty							0.022		
Effective degrees of freedom									2.05E-09
Expanded uncertainty							0.045		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	27.3865		50	0.0002	°C/Pa	0.0045		8.16E-12
	Accuracy of the pressure drop measurements								
* for type B method the number of degrees of freedom will be considered as being larger than 50.									
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)									
Combined uncertainty							0.023		
Effective degrees of freedom				132					2.06E-09
Expanded uncertainty							0.045		

Figure 82 Uncertainty budget reported by VTT at 65 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		80	°C	Lab name	MIKES	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$		Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.0042		50	1		0.0042	6.48E-12
	Long-term stability (sensor and indicator)	0.0036		50	1		0.0036	3.39E-12
	Self-heating and residual heat fluxes (sensor)	0.0058		50	1		0.0058	2.22E-11
	Resolution and linearity (indicator unit)	0.0001		50	1		0.0001	4.18E-18
	Saturator:							
	Temperature homogeneity	0.0060		10	1		0.0060	1.29E-10
	Temperature stability	0.0014		10	1		0.0014	4.21E-13
Saturation pressure								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	3.0000		50	0.0004	°C/Pa	0.0012	4.78E-14
	Long-term stability (sensor and indicator)	4.0000		50	0.0004	°C/Pa	0.0017	1.51E-13
	Resolution and accuracy or linearity (indicator unit)	1.0000		50	0.0004	°C/Pa	0.0004	5.90E-16
	Linearity (over a range of +70 hPa against the calibration point)	1.1547		50	0.0004	°C/Pa	0.0005	1.05E-15
	Pressure differences in the saturator cell	9.2203		50	0.0002	°C/Pa	0.0019	2.66E-13
	Stability of the pressure	3.4641		50	0.0004	°C/Pa	0.0014	8.49E-14
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0002	°C/Pa	0.0019	2.66E-13
Gas pressure at the generator outlet								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)							
	Long-term stability (sensor and indicator)							
	Resolution (indicator unit)							
	Linearity (over a range of ±10 hPa against the calibration point)							
	Stability of the pressure							
	Effect of the tubing between the saturator and the pressure gauge	9.2203		50	0.0004	°C/Pa	0.0038	4.26E-12
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016	1.31E-13
	Reproducibility of the flow (through the generator)	0.0200		50	0.0800	°C /(l/min)	0.0016	1.31E-13
Saturation efficiency								
	Saturation efficiency	0.0173		50	1.0000		0.0173	1.80E-09
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)	0.0080		50	1.0000		0.0080	8.19E-11
	Water vapour enhancement formula(e)							
Other uncertainties								
Combined uncertainty							0.022	
Effective degrees of freedom								2.05E-09
Expanded uncertainty							0.045	
Additional uncertainty in applied condition at point of use								
	Pressure drop between point of realisation and measuring instrument	27.3865		50	0.0002	°C/Pa	0.0045	8.16E-12
	Accuracy of the pressure drop measurements							
Combined uncertainty							0.023	
Effective degrees of freedom				132				2.06E-09
Expanded uncertainty							0.045	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 83 Uncertainty budget reported by VTT at 80 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature — Nominal value: 85 °C — Lab name: MIKES

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0042	50	1		0.0042	6.48E-12
	Long-term stability (sensor and indicator)	0.0036	50	1		0.0036	3.39E-12
	Self-heating and residual heat fluxes (sensor)	0.0058	50	1		0.0058	2.22E-11
	Resolution and linearity (indicator unit)	0.0001	50	1		0.0001	4.29E-18
	Saturator:						
	Temperature homogeneity	0.0058	10	1		0.0058	1.13E-10
	Temperature stability	0.0013	10	1		0.0013	3.01E-13
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	3.0000	50	0.0005	°C/Pa	0.0015	8.93E-14
	Long-term stability (sensor and indicator)	4.0000	50	0.0005	°C/Pa	0.0019	2.82E-13
	Resolution and accuracy or linearity (indicator unit)	1.0000	50	0.0005	°C/Pa	0.0005	1.10E-15
	Linearity (over a range of +70 hPa against the calibration point)	1.1547	50	0.0005	°C/Pa	0.0006	1.96E-15
	Pressure differences in the saturator cell	9.2203	50	0.0002	°C/Pa	0.0022	4.98E-13
	Stability of the pressure	3.4641	50	0.0005	°C/Pa	0.0017	1.59E-13
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0002	°C/Pa	0.0022	4.98E-13
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)						
	Long-term stability (sensor and indicator)						
	Resolution (indicator unit)						
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure						
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0005	°C/Pa	0.0045	7.97E-12
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)	0.0500	50	0.0800	°C /(l/min)	0.0040	5.12E-12
	Reproducibility of the flow (through the generator)	0.0500	50	0.0800	°C /(l/min)	0.0040	5.12E-12
Saturation efficiency							
	Saturation efficiency	0.0173	50	1.0000		0.0173	1.80E-09
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)	0.0080	50	1.0000		0.0080	8.19E-11
	Water vapour enhancement formula(e)						
Other uncertainties							
Combined uncertainty						0.023	
Effective degrees of freedom							2.05E-09
Expanded uncertainty						0.046	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	37.6344	50	0.0002	°C/Pa	0.0062	2.91E-11
	Accuracy of the pressure drop measurements						
Combined uncertainty						0.024	
Effective degrees of freedom			158				2.08E-09
Expanded uncertainty						0.047	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 84 Uncertainty budget reported by VTT at 85 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature

Nominal value: 90 °C   Lab name: MIKES

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0042	50	1		0.0042	6.48E-12
	Long-term stability (sensor and indicator)	0.0041	50	1		0.0041	5.56E-12
	Self-heating and residual heat fluxes (sensor)	0.0058	50	1		0.0058	2.22E-11
	Resolution and linearity (indicator unit)	0.0001	50	1		0.0001	4.29E-18
	Saturator:						
	Temperature homogeneity	0.0058	10	1		0.0058	1.13E-10
	Temperature stability	0.0013	10	1		0.0013	3.01E-13
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	3.0000	50	0.0005	°C/Pa	0.0015	8.93E-14
	Long-term stability (sensor and indicator)	4.0000	50	0.0005	°C/Pa	0.0019	2.82E-13
	Resolution and accuracy or linearity (indicator unit)	1.0000	50	0.0005	°C/Pa	0.0005	1.10E-15
	Linearity (over a range of +70 hPa against the calibration point)	1.1547	50	0.0005	°C/Pa	0.0006	1.96E-15
	Pressure differences in the saturator cell	9.2203	50	0.0002	°C/Pa	0.0022	4.98E-13
	Stability of the pressure	3.4641	50	0.0005	°C/Pa	0.0017	1.59E-13
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0002	°C/Pa	0.0022	4.98E-13
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)						
	Long-term stability (sensor and indicator)						
	Resolution (indicator unit)						
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure						
	Effect of the tubing between the saturator and the pressure gauge	9.2203	50	0.0005	°C/Pa	0.0045	7.97E-12
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)	0.1000	50	0.0800	°C /(l/min)	0.0080	8.19E-11
	Reproducibility of the flow (through the generator)	0.1000	50	0.0800	°C /(l/min)	0.0080	8.19E-11
Saturation efficiency							
	Saturation efficiency	0.0173	50	1.0000		0.0173	1.80E-09
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)	0.0080	50	1.0000		0.0080	8.19E-11
	Water vapour enhancement formula(e)						
Other uncertainties							
Combined uncertainty						0.025	
Effective degrees of freedom							2.20E-09
Expanded uncertainty						0.050	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	37.6344	50	0.0002	°C/Pa	0.0062	2.91E-11
	Accuracy of the pressure drop measurements						
Combined uncertainty						0.026	
Effective degrees of freedom			203				2.23E-09
Expanded uncertainty						0.051	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 85 Uncertainty budget reported by VTT at 90 °C nominal dew-point temperature

Appendix B.14 NPL

Generated dew-point	CONTRIBUTIONS TO COMBINED STANDARD UNCERTAINTY														
	Standard uncertainty of component												Combined standard uncertainty	Degrees of freedom	Dew point
	Platinum resistance thermometers			Resistance bridge	Contamin-ation	Saturator efficiency	Draw-off rate	Temperature conditioning of gas	Pressure gradient in saturator	Temperature gradients in bath	De-sorption & leaks	Standard deviation of 10 readings	Contribution from instrument Under test			
	calibration	self-heating	temporal drift													
°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C			
Degrees of Freedom	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	9	9	°C		°C
95	0.005	0.003	0.003	0.0016	0.001	0.05	0.003	0	0.003	0.015	0	0.005	0.059	0.079	30	95
90	0.005	0.003	0.003	0.0016	0.001	0.03	0.003	0	0.0026	0.012	0	0.005	0.031	0.045	40	90
85	0.005	0.003	0.003	0.0016	0.001	0.015	0.003	0	0.00255	0.0115	0	0.005	0.018	0.028	52	85
80	0.005	0.003	0.003	0.0016	0.001	0.003	0.003	0	0.0025	0.011	0	0.005	0.010	0.018	89	80
65	0.005	0.003	0.003	0.0016	0.001	0.003	0.003	0	0.00225	0.0055	0	0.005	0.007	0.013	85	65
50	0.005	0.003	0.003	0.0016	0.001	0.003	0.003	0	0.0021	0.004	0	0.005	0.006	0.013	134	50
30	0.005	0.003	0.003	0.0016	0.001	0.003	0.003	0	0.0018	0.005	0	0.005	0.006	0.013	134	30

Figure 86 Uncertainty budget reported by NPL at 30 °C up to 95 °C nominal dew-point temperature

Appendix B.15 GUM

Uncertainty analysis of dew-point temperature Nominal value: 30 °C Lab name GUM/PL

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$	Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0072	1000	1 °C/°C		0.0072	2.62E-12
	Long-term stability (sensor and indicator)	0.0130	50	1 year		0.0130	5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029	50	1 °C/°C		0.0029	1.41E-12
	Resolution and linearity (indicator unit)	0.0001	50	1 °C/°C		0.0001	6.46E-19
	Saturator:		50				
	Temperature homogeneity	0.0012	50	1 °C/°C		0.0012	3.62E-14
	Temperature stability	0.0044	50	1 °C/°C		0.0044	7.16E-12
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	1.8E-04		0.002	1.05E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Linearity (over a range of +70 hPa against the calibration point)						
	Pressure differences in the saturator cell						
	Stability of the pressure	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Effect of the tubing between the saturator and the pressure gauge						
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	1.8E-04		0.002	1.60E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Resolution (indicator unit)	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure	5,8 Pa	50	1.8E-04		0.001	2.00E-14
	Effect of the tubing between the saturator and the pressure gauge					,	
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)						
	Reproducibility of the flow (through the generator)						
Saturation efficiency							
	Saturation efficiency	0.00116	50	1.0000		0.001	2.00E-14
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)						
	Water vapour enhancement formula(e)						
Other uncertainties							
		0.017	50	1		0.017	1.67E-09
						0.000552732	
Combined uncertainty						0.023510257	
Effective degrees of freedom					k=	2	2.26E-09
Expanded uncertainty						0.047020514	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	100 Pa	50	1.8E-04		0.018	2.10E-09
	Accuracy of the pressure drop measurements	5,8 Pa	50	1.8E-04		0.001	2.00E-14
Combined uncertainty			50			0.030	
Effective degrees of freedom			177		k=	2.000	4.36E-09
Expanded uncertainty						0.058	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 87 Uncertainty budget reported by GUM at 30 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:	50	°C	Lab name	GUM/PL	
EUROMET Key Comparison in humidity (dew-point temperature) P717							
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison							

Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0072	1000	1 °C/°C		0.0072	2.62E-12
	Long-term stability (sensor and indicator)	0.0130	50	1 year		0.0130	5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029	50	1 °C/°C		0.0029	1.41E-12
	Resolution and linearity (indicator unit)	0.0001	50	1 °C/°C		0.0001	6.46E-19
	Saturator:						
	Temperature homogeneity	0.0012	50	1 °C/°C		0.0012	3.62E-14
	Temperature stability	0.0044	50	1 °C/°C		0.0044	7.16E-12
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.0E-04		0.002	1.60E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Linearity (over a range of +70 hPa against the calibration point)						
	Pressure differences in the saturator cell						
	Stability of the pressure	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Effect of the tubing between the saturator and the pressure gauge						
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.0E-04		0.002	1.60E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Resolution (indicator unit)	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure	5,8 Pa	50	2.0E-04		0.001	4.15E-14
	Effect of the tubing between the saturator and the pressure gauge						
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)						
	Reproducibility of the flow (through the generator)						
Saturation efficiency							
	Saturation efficiency	0.00116	50	1.0000		0.00116	3.62E-14
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)						
	Water vapour enhancement formula(e)						
Other uncertainties							
		0.009	50	1		0.009	1.31E-10
						0.000348478	
Combined uncertainty						0.01866756	
Effective degrees of freedom						2	7.18E-10
Expanded uncertainty						0.037335119	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	100.00	50	2.0E-04		0.020	3.20E-09
	Accuracy of the pressure drop measurements	5,8 Pa	50	2.0E-04		0.001	4.15E-14
Combined uncertainty						0.027	
Effective degrees of freedom			144		k=	2.000	3.92E-09
Expanded uncertainty						0.054	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 88 Uncertainty budget reported by GUM at 50 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		65 °C	Lab name		GUM/PL	
EUROMET Key Comparison in humidity (dew-point temperature) P717								
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison								
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$		**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator								
Saturation temperature								
	Thermometer:							
	Calibration uncertainty (sensor and indicator unit)	0.0072		1000	1 °C/°C		0.0072	2.62E-12
	Long-term stability (sensor and indicator)	0.0130		50	1 year		0.0130	5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029		50	1 °C/°C		0.0029	1.41E-12
	Resolution and linearity (indicator unit)	0.0001		50	1 °C/°C		0.0001	6.46E-19
	Saturator:							
	Temperature homogeneity	0.0012		50	1 °C/°C		0.0012	3.62E-14
	Temperature stability	0.0044		50	1 °C/°C		0.0044	7.16E-12
Saturation pressure								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.3E-04		0.002	2.80E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Linearity (over a range of +70 hPa against the calibration point)							
	Pressure differences in the saturator cell							
	Stability of the pressure	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Effect of the tubing between the saturator and the pressure gauge							
Gas pressure at the generator outlet								
	Pressure gauge:							
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.3E-04		0.002	2.80E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Resolution (indicator unit)	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Linearity (over a range of ±10 hPa against the calibration point)							
	Stability of the pressure	5,8 Pa		50	2.3E-04		0.001	5.71E-14
	Effect of the tubing between the saturator and the pressure gauge							
Flow measurement:								
	Flow meter							
	Stability of the flow (through the generator)							
	Reproducibility of the flow (through the generator)							
Saturation efficiency								
	Saturation efficiency	0.00116		50		1	0.00116	3.62E-14
Correlation between pressure and temperature measurement (if relevant)								
	Correlation between pressure and temperature measurement if relevant							
Uncertainty due to formulae/calculations								
	Saturation vapour pressure formula(e)							
	Water vapour enhancement formula(e)							
Other uncertainties								
		0.014		50		1	0.014	7.68E-10
							0.000467558	
Combined uncertainty							0.021623084	
Effective degrees of freedom							2	1.36E-09
Expanded uncertainty							0.043246169	
Additional uncertainty in applied condition at point of use								
	Pressure drop between point of realisation and measuring instrument	100 Pa		50	2.3E-04		0.023	5.60E-09
	Accuracy of the pressure drop measurements	5,8 Pa		50	2.3E-04		0.002	5.60E-13
Combined uncertainty							0.032	
Effective degrees of freedom				144		k=	2.000	6.95E-09
Expanded uncertainty							0.062	

* for type B method the number of degrees of freedom will be considered as being larger than 50.
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 89 Uncertainty budget reported by GUM at 65 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:	80 °C	Lab name	GYM/PL	
EUROMET Key Comparison in humidity (dew-point temperature) P717						
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison						
Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i	**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator						
Saturation temperature						
	Thermometer:					
	Calibration uncertainty (sensor and indicator unit)	0.0072	1000	1 °C/°C	0.0072	2.62E-12
	Long-term stability (sensor and indicator)	0.0130	50	1 year	0.0130	5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029	50	1 °C/°C	0.0029	1.41E-12
	Resolution and linearity (indicator unit)	0.0001	50	1 °C/°C	0.0001	6.46E-19
	Saturator:					
	Temperature homogeneity	0.0012	50	1 °C/°C	0.0012	3.62E-14
	Temperature stability	0.0044	50	1 °C/°C	0.0044	7.16E-12
Saturation pressure						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.5E-04	0.003	3.91E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Linearity (over a range of +70 hPa against the calibration point)					
	Pressure differences in the saturator cell					
	Stability of the pressure	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Effect of the tubing between the saturator and the pressure gauge					
Gas pressure at the generator outlet						
	Pressure gauge:					
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.5E-04	0.003	3.91E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Resolution (indicator unit)	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Linearity (over a range of ±10 hPa against the calibration point)					
	Stability of the pressure	5,8 Pa	50	2.5E-04	0.002	1.01E-13
	Effect of the tubing between the saturator and the pressure gauge					
Flow measurement:						
	Flow meter					
	Stability of the flow (through the generator)					
	Reproducibility of the flow (through the generator)					
Saturation efficiency						
	Saturation efficiency	0.00116	50	1	0.00116	3.62E-14
Correlation between pressure and temperature measurement (if relevant)						
	Correlation between pressure and temperature measurement if relevant					
Uncertainty due to formulae/calculations						
	Saturation vapour pressure formula(e)					
	Water vapour enhancement formula(e)					
Other uncertainties						
		0.005	50	1	0.005	1.25E-11
					0.000301838	
Combined uncertainty					0.017373479	
Effective degrees of freedom					2	6.00E-10
Expanded uncertainty					0.034746959	
Additional uncertainty in applied condition at point of use						
	Pressure drop between point of realisation and measuring instrument	100 Pa	50	2.5E-04	0.025	7.81E-09
	Accuracy of the pressure drop measurements	5,8 Pa	50	2.5E-04	0.002	1.01E-13
Combined uncertainty					0.030	
Effective degrees of freedom			103			8.41E-09
Expanded uncertainty					0.060	

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 90 Uncertainty budget reported by GUM at 80 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:		85	°C	Lab name	GUM/PL		
EUROMET Key Comparison in humidity (dew-point temperature) P717									
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison									
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***	**Sensitivity coefficient**		**Uncertainty contribution**		Calculation of degrees of freedom
Q_i		**$u_{(Qi)}$**		**ν_i**	**c_i**		**u_i in °C**		
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.0072		1000	1 °C/°C		0.0072		2.62E-12
	Long-term stability (sensor and indicator)	0.0130		50	1 year		0.0130		5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029		50	1 °C/°C		0.0029		1.41E-12
	Resolution and linearity (indicator unit)	0.0001		50	1 °C/°C		0.0001		6.46E-19
	Saturator:								
	Temperature homogeneity	0.0012		50	1 °C/°C		0.0012		3.62E-14
	Temperature stability	0.0044		50	1 °C/°C		0.0044		7.16E-12
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.6E-04		0.003		4.57E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Linearity (over a range of +70 hPa against the calibration point)								
	Pressure differences in the saturator cell								
	Stability of the pressure	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Effect of the tubing between the saturator and the pressure gauge								
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.6E-04		0.003		4.57E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Resolution (indicator unit)	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Linearity (over a range of ±10 hPa against the calibration point)								
	Stability of the pressure	5,8 Pa		50	2.6E-04		0.002		1.01E-13
	Effect of the tubing between the saturator and the pressure gauge								
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)								
	Reproducibility of the flow (through the generator)								
Saturation efficiency									
	Saturation efficiency	0.00116		50			0.00116		3.62E-14
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)								
	Water vapour enhancement formula(e)								
Other uncertainties									
		0.011		50					0.00E+00
							0.000277858		
Combined uncertainty							0.016669067		
Effective degrees of freedom							2		5.88E-10
Expanded uncertainty							0.033338133		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	100 Pa		50	2.6E-04		0.026		9.14E-09
	Accuracy of the pressure drop measurements	5,8 Pa		50	2.6E-04		0.002		1.01E-13
* for type B method the number of degrees of freedom will be considered as being larger than 50.									
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)									
Combined uncertainty							0.031		
Effective degrees of freedom				94					9.73E-09
Expanded uncertainty							0.061		

Figure 91 Uncertainty budget reported by GUM at 85 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature		Nominal value:	90	°C	Lab name	GUM/PL	
EUROMET Key Comparison in humidity (dew-point temperature) P717							
- each participant submits one spreadsheet summary per nominal dew point measured in the comparison							

Quantity (symbol) Q_i	**Components**	**Standard uncertainty** $u_{(Qi)}$	**Degrees of freedom components evaluated by a type A method** * ν_i	**Sensitivity coefficient** c_i		**Uncertainty contribution** u_i **in °C**	Calculation of degrees of freedom
Primary dew-point generator							
Saturation temperature							
	Thermometer:						
	Calibration uncertainty (sensor and indicator unit)	0.0072	1000	1 °C/°C		0.0072	2.62E-12
	Long-term stability (sensor and indicator)	0.0130	50	1 year		0.0130	5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029	50	1 °C/°C		0.0029	1.41E-12
	Resolution and linearity (indicator unit)	0.0001	50	1 °C/°C		0.0001	6.46E-19
	Saturator:						
	Temperature homogeneity	0.0012	50	1 °C/°C		0.0012	3.62E-14
	Temperature stability	0.0044	50	1 °C/°C		0.0044	7.16E-12
Saturation pressure							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.7E-04		0.003	5.31E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Linearity (over a range of +70 hPa against the calibration point)						
	Pressure differences in the saturator cell						
	Stability of the pressure	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Effect of the tubing between the saturator and the pressure gauge						
Gas pressure at the generator outlet							
	Pressure gauge:						
	Calibration uncertainty (sensor and indicator unit)	10 Pa	1000	2.7E-04		0.003	5.31E-14
	Long-term stability (sensor and indicator)	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Resolution (indicator unit)	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Linearity (over a range of ±10 hPa against the calibration point)						
	Stability of the pressure	5,8 Pa	50	2.7E-04		0.002	1.31E-13
	Effect of the tubing between the saturator and the pressure gauge						
Flow measurement:							
	Flow meter						
	Stability of the flow (through the generator)						
	Reproducibility of the flow (through the generator)						
Saturation efficiency							
	Saturation efficiency	0.00116	50	1.0000		0.00116	3.62E-14
Correlation between pressure and temperature measurement (if relevant)							
	Correlation between pressure and temperature measurement if relevant						
Uncertainty due to formulae/calculations							
	Saturation vapour pressure formula(e)						
	Water vapour enhancement formula(e)						
Other uncertainties							
		0.006	50	1		0.006	
						0.000316778	
Combined uncertainty						0.017798252	
Effective degrees of freedom						2	5.88E-10
Expanded uncertainty						0.035596504	
Additional uncertainty in applied condition at point of use							
	Pressure drop between point of realisation and measuring instrument	100 Pa	50	2.7E-04		0.027	1.06E-08
	Accuracy of the pressure drop measurements	5,8 Pa	50	2.7E-04		0.002	1.31E-13

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Combined uncertainty						0.032	
Effective degrees of freedom			98		k=	2	1.12E-08
Expanded uncertainty						0.063	

Figure 92 Uncertainty budget reported by GUM at 90 °C nominal dew-point temperature

Uncertainty analysis of dew-point temperature

Nominal value: 95 °C   Lab name: GUM/PL

EUROMET Key Comparison in humidity (dew-point temperature) P717

- each participant submits one spreadsheet summary per nominal dew point measured in the comparison

Quantity (symbol) Q_i	Components	Standard uncertainty $u_{(Qi)}$		Degrees of freedom components evaluated by a type A method * ν_i	Sensitivity coefficient c_i		Uncertainty contribution u_i in °C		Calculation of degrees of freedom
Primary dew-point generator									
Saturation temperature									
	Thermometer:								
	Calibration uncertainty (sensor and indicator unit)	0.0072		1000	1 °C/°C		0.0072		2.62E-12
	Long-term stability (sensor and indicator)	0.0130		50	1 year		0.0130		5.76E-10
	Self-heating and residual heat fluxes (sensor)	0.0029		50	1 °C/°C		0.0029		1.41E-12
	Resolution and linearity (indicator unit)	0.0001		50	1 °C/°C		0.0001		6.46E-19
	Saturator:								
	Temperature homogeneity	0.0012		50	1 °C/°C		0.0012		3.62E-14
	Temperature stability	0.0044		50	1 °C/°C		0.0044		7.16E-12
Saturation pressure									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.8E-04		0.003		6.15E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Resolution and accuracy or linearity (indicator unit)	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Linearity (over a range of +70 hPa against the calibration point)								
	Pressure differences in the saturator cell								
	Stability of the pressure	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Effect of the tubing between the saturator and the pressure gauge								
Gas pressure at the generator outlet									
	Pressure gauge:								
	Calibration uncertainty (sensor and indicator unit)	10 Pa		1000	2.8E-04		0.003		6.15E-14
	Long-term stability (sensor and indicator)	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Resolution (indicator unit)	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Linearity (over a range of ±10 hPa against the calibration point)								
	Stability of the pressure	5,8 Pa		50	2.8E-04		0.002		1.31E-13
	Effect of the tubing between the saturator and the pressure gauge								
Flow measurement:									
	Flow meter								
	Stability of the flow (through the generator)								
	Reproducibility of the flow (through the generator)								
Saturation efficiency									
	Saturation efficiency	0.00116		50		1	0.000		2.00E-18
Correlation between pressure and temperature measurement (if relevant)									
	Correlation between pressure and temperature measurement if relevant								
Uncertainty due to formulae/calculations									
	Saturation vapour pressure formula(e)								
	Water vapour enhancement formula(e)								
Other uncertainties									
		0.008		50			0.008		8.19E-11
							0.000344542		
Combined uncertainty							0.018561847		
Effective degrees of freedom							2		6.70E-10
Expanded uncertainty							0.037123695		
Additional uncertainty in applied condition at point of use									
	Pressure drop between point of realisation and measuring instrument	100 Pa		50	2.8E-04		0.028		1.23E-08
	Accuracy of the pressure drop measurements	5,8 Pa		50	2.8E-04		0.002		1.31E-13
Combined uncertainty							0.034		
Effective degrees of freedom				99		k=	2		1.30E-08
Expanded uncertainty							0.066		

* for type B method the number of degrees of freedom will be considered as being larger than 50.

(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)

Figure 93 Uncertainty budget reported by GUM at 95 °C nominal dew-point temperature

Appendix B.16 PTB

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	PTB				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0008	°C	50	-	1.000	K/K	0.0008	°C		6.71409E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C		5.61235E-11
	Self-heating and residual heat fluxes (sensor)	0.0025	°C	50	-	1.000	K/K	0.0025	°C		7.59734E-13
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.000	K/K	0.0003	°C		1.38889E-16
	Saturator:										
	Temperature homogeneity	0.0043	°C	50	-	1.000	K/K	0.0043	°C		7.03125E-12
	Temperature stability	0.0002	°C	109	-	1.000	K/K	0.0002	°C		6.04376E-18
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.4768	hPa	50	-	-0.002	K/hPa	-0.0009	°C		1.24405E-14
	Long-term stability (sensor and indicator)	1.9630	hPa	50	-	-0.002	K/hPa	-0.0037	°C		3.57317E-12
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.002	K/hPa	-0.0001	°C		1.67116E-19
	Pressure differences in the saturator cell	-	-		-	-	-	-	°C		
	Stability of the pressure	0.0426	hPa	109	-	-0.002	K/hPa	-0.0001	°C		3.62628E-19
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.002	K/hPa	-0.0002	°C		2.50779E-17
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.0399	hPa	50	-	0.017	K/hPa	0.0007	°C		4.59235E-15
	Long-term stability (sensor and indicator)	0.1501	hPa	50	-	0.017	K/hPa	0.0026	°C		9.17007E-13
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.017	K/hPa	0.0001	°C		1.25418E-19
	Stability of the pressure	0.0090	hPa	109	-	0.017	K/hPa	0.0002	°C		5.48912E-18
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.017	K/hPa	0.0003	°C		2.6816E-16
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0000	l/min	109	-	-0.011	K/(l/min)	0.0000	°C		0
	Reproducibility	0.0289	l/min	50	-	-0.011	K/(l/min)	-0.0003	°C		2.29542E-16
Saturation efficiency											
	Saturation efficiency	0.0010	K	50	-	1.000	K	0.0010	°C		2E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	-	-		-	-	-	-	°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0030	hPa	50	-	0.072	K/hPa	0.0002	°C		4.27742E-17
	Water vapour enhancement formula(e)	0.0006	-	50	-	0.072	K/hPa	0.0000	°C		5.23661E-20
Other uncertainties											
	Pressure drop between point of realisation and measuring instrument	0.0006	K	50		1.000	K/K	0.0006	°C		2.74715E-15
					-				°C		
					-				°C		
Combined uncertainty					-			0.010	°C		
Effective degrees of freedom				151	-				°C	sum	6.84519E-11
Expanded uncertainty					-			0.020	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		#DIV/0!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty									°C		
Effective degrees of freedom									°C	sum	#DIV/0!
Expanded uncertainty									°C		

Figure 94 Uncertainty budget reported by PTB at 30 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	50	°C		Lab name	PTB				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		$u_{(Qi)}$	unit	ν_i	unit	c_i	unit	u_i	unit		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0008	°C	50	-	1.000	K/K	0.0008	°C		6.71409E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C		5.61235E-11
	Self-heating and residual heat fluxes (sensor)	0.0025	°C	50	-	1.000	K/K	0.0025	°C		7.59734E-13
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.000	K/K	0.0003	°C		1.38889E-16
	Saturator:										
	Temperature homogeneity	0.0043	°C	50	-	1.000	K/K	0.0043	°C		7.03125E-12
	Temperature stability	0.0001	°C	109	-	1.000	K/K	0.0001	°C		4.50373E-18
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.4768	hPa	50	-	-0.006	K/hPa	-0.0030	°C		1.67026E-12
	Long-term stability (sensor and indicator)	1.9630	hPa	50	-	-0.006	K/hPa	-0.0124	°C		4.79732E-10
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.006	K/hPa	-0.0002	°C		2.24369E-17
	Pressure differences in the saturator cell	-	-		-	-	-	-	°C		
	Stability of the pressure	0.0195	hPa	109	-	-0.006	K/hPa	-0.0001	°C		2.14284E-18
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.006	K/hPa	-0.0006	°C		3.36694E-15
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.0399	hPa	50	-	0.020	K/hPa	0.0008	°C		8.12663E-15
	Long-term stability (sensor and indicator)	0.1501	hPa	50	-	0.020	K/hPa	0.0030	°C		1.62273E-12
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.020	K/hPa	0.0001	°C		2.21939E-19
	Stability of the pressure	0.0328	hPa	109	-	0.020	K/hPa	0.0007	°C		1.70525E-15
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.020	K/hPa	0.0004	°C		4.74537E-16
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0000	l/min	109	-	-0.013	K/(l/min)	0.0000	°C		0
	Reproducibility	0.0289	l/min	50	-	-0.013	K/(l/min)	-0.0004	°C		3.65521E-16
Saturation efficiency											
	Saturation efficiency	0.0010	K	50	-	1.000	K	0.0010	°C		2E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	-	-		-	-	-	-	°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0087	hPa	50	-	0.083	K/hPa	0.0007	°C		5.4072E-15
	Water vapour enhancement formula(e)	0.0002	-	50	-	0.083	K/hPa	0.0000	°C		1.52976E-21
Other uncertainties											
	Pressure drop between point of realisation and measuring instrument	0.0007	K	50		1.000	K/K	0.0007	°C		4.86136E-15
					-				°C		
					-				°C		
Combined uncertainty					-			0.016	°C		
Effective degrees of freedom				119	-				°C	sum	5.46991E-10
Expanded uncertainty					-			0.032	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		#DIV/0!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty									°C		
Effective degrees of freedom									°C	sum	#DIV/0!
Expanded uncertainty									°C		

Figure 95 Uncertainty budget reported by PTB at 50 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	65	°C		Lab name	PTB				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0008	°C	50	-	1.000	K/K	0.0008	°C		6.71409E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C		5.61235E-11
	Self-heating and residual heat fluxes (sensor)	0.0025	°C	50	-	1.000	K/K	0.0025	°C		7.59734E-13
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.000	K/K	0.0003	°C		1.38889E-16
	Saturator:										
	Temperature homogeneity	0.0092	°C	50	-	1.000	K/K	0.0092	°C		1.45636E-10
	Temperature stability	0.0006	°C	109	-	1.000	K/K	0.0006	°C		9.63859E-16
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.4768	hPa	50	-	-0.007	K/hPa	-0.0034	°C		2.67327E-12
	Long-term stability (sensor and indicator)	1.9630	hPa	50	-	-0.007	K/hPa	-0.0140	°C		7.67816E-10
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.007	K/hPa	-0.0002	°C		3.59105E-17
	Pressure differences in the saturator cell	-	-		-	-	-	-	°C		
	Stability of the pressure	0.0305	hPa	109	-	-0.007	K/hPa	-0.0002	°C		2.04381E-17
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.007	K/hPa	-0.0007	°C		5.38882E-15
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.0399	hPa	50	-	0.022	K/hPa	0.0009	°C		1.15386E-14
	Long-term stability (sensor and indicator)	0.1501	hPa	50	-	0.022	K/hPa	0.0033	°C		2.30405E-12
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.022	K/hPa	0.0001	°C		3.15122E-19
	Stability of the pressure	0.0056	hPa	109	-	0.022	K/hPa	0.0001	°C		2.11066E-18
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.022	K/hPa	0.0004	°C		6.73774E-16
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0000	l/min	109	-	-0.013	K/(l/min)	0.0000	°C		0
	Reproducibility	0.0289	l/min	50	-	-0.013	K/(l/min)	-0.0004	°C		4.57215E-16
Saturation efficiency											
	Saturation efficiency	0.0010	K	50	-	1.000	K	0.0010	°C		2E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	-	-		-	-	-	-	°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0177	hPa	50	-	0.091	K/hPa	0.0016	°C		1.35688E-13
	Water vapour enhancement formula(e)	0.0002	-	50	-	0.091	K/hPa	0.0000	°C		8.61541E-22
Other uncertainties											
	Pressure drop between point of realisation and measuring instrument	0.0008	K	50		1.000	K/K	0.0008	°C		6.90243E-15
					-				°C		
					-				°C		
Combined uncertainty					-			0.019	°C		
Effective degrees of freedom				140	-				°C	sum	9.75501E-10
Expanded uncertainty					-			0.038	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		#DIV/0!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty									°C		
Effective degrees of freedom									°C	sum	#DIV/0!
Expanded uncertainty									°C		

Figure 96 Uncertainty budget reported by PTB at 65 °C nominal dew-point temperature

Uncertainty analysis of dew point temperature		Nominal value:	80	°C		Lab name	PTB				
EUROMET Key Comparison in humidity (dew-point temperature) P717 / EURAMET.T-K8											
- each participant submits **one spreadsheet summary per nominal dew-point** measured in the comparison; labeled "U_gen t°C", where "t" should be replaced by the nominal dew-point temperature											
Quantity (symbol)	**Components**	**Standard uncertainty**		**Degrees of freedom components evaluated by a type A method ***		**Sensitivity coefficient**		**Uncertainty contribution**			**Calculation of degrees of freedom**
Q_i		**$u_{(Qi)}$**	**unit**	**ν_i**	**unit**	**c_i**	**unit**	**u_i**	**unit**		
Primary dew-point generator											
Saturation temperature											
	Thermometer:										
	Calibration uncertainty (sensor and indicator unit)	0.0008	°C	50	-	1.000	K/K	0.0008	°C		6.71409E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C		5.61235E-11
	Self-heating and residual heat fluxes (sensor)	0.0025	°C	50	-	1.000	K/K	0.0025	°C		7.59734E-13
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.000	K/K	0.0003	°C		1.38889E-16
	Saturator:										
	Temperature homogeneity	0.0092	°C	50	-	1.000	K/K	0.0092	°C		1.45636E-10
	Temperature stability	0.0006	°C	109	-	1.000	K/K	0.0006	°C		1.31253E-15
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.4768	hPa	50	-	-0.015	K/hPa	-0.0071	°C		5.12956E-11
	Long-term stability (sensor and indicator)	1.9630	hPa	50	-	-0.015	K/hPa	-0.0293	°C		1.47331E-08
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.015	K/hPa	-0.0004	°C		6.89064E-16
	Pressure differences in the saturator cell	-	-		-	-	-	-	°C		
	Stability of the pressure	0.0247	hPa	109	-	-0.015	K/hPa	-0.0004	°C		1.69049E-16
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.015	K/hPa	-0.0015	°C		1.03403E-13
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.0399	hPa	50	-	0.024	K/hPa	0.0010	°C		1.68958E-14
	Long-term stability (sensor and indicator)	0.1501	hPa	50	-	0.024	K/hPa	0.0036	°C		3.37377E-12
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.024	K/hPa	0.0001	°C		4.61426E-19
	Stability of the pressure	0.0075	hPa	109	-	0.024	K/hPa	0.0002	°C		9.84541E-18
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.024	K/hPa	0.0005	°C		9.86593E-16
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0000	l/min	109	-	-0.014	K/(l/min)	0.0000	°C		0
	Reproducibility	0.0289	l/min	50	-	-0.014	K/(l/min)	-0.0004	°C		5.54584E-16
Saturation efficiency											
	Saturation efficiency	0.0010	K	50	-	1.000	K	0.0010	°C		2E-14
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	-	-		-	-	-	-	°C		
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0335	hPa	50	-	0.100	K/hPa	0.0034	°C		2.54592E-12
	Water vapour enhancement formula(e)	0.0001	-	50	-	0.100	K/hPa	0.0000	°C		1.42835E-22
Other uncertainties											
	Pressure drop between point of realisation and measuring instrument	0.0008	K	50		1.000	K/K	0.0008	°C		1.01071E-14
					-				°C		
					-				°C		
Combined uncertainty					-			0.033	°C		
Effective degrees of freedom				78	-				°C	sum	1.4993E-08
Expanded uncertainty					-			0.066	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		#DIV/0!
	Other								°C		#DIV/0!
* for type B method the number of degrees of freedom will be considered as being larger than 50.											
(Degrees of freedom of 50 for a component of type B corresponds 10 % in relative uncertainty of the uncertainty estimate u_{Qi}; see Annex G of the ISO Guide)											
Combined uncertainty									°C		
Effective degrees of freedom									°C	sum	#DIV/0!
Expanded uncertainty									°C		

Figure 97 Uncertainty budget reported by PTB at 80 °C nominal dew-point temperature

Appendix C Laboratory code and status of equipment

Table 32 summarizes all laboratories and lists the used laboratory codes in the text. Additionally, in the last column there is a categorization of the changes which were done to the reference equipment of the laboratories between the time of measurement (2008 to 2011) and today (2023). The pilot made a survey among the participants during preparing Draft A3. The survey was refined for some participants during the review process of draft B. The three possible categories were as follows:

- Equipment in unchanged.
- Equipment was changed slightly (e.g. new reference sensors).
- Complete new equipment (e.g. new generator, another principal).

Table 32 Laboratory codes and changes to the equipment between the time of measurement and today (2023)

Name of laboratory	**Abbreviation**	**Country**	**Lab Code**	**Changes to Reference**
Central Office of Meaures	GUM	Poland	P	Equipment is slightly changed.[a)]
National Metrology Institute VTT MIKES (former Centre for Metrology and Accreditation)	MIKES / VTT	Finland	N	Equipment is unchanged.
Centre Technique des Industries Aérauliques et Thermiques	CETIAT	France	E	Complete new equipment is used.[b)]
FORCE Technology (former DELTA Danish Electronics, Lights & Acoustics)	FORCE (former DELTA)	Denmark	C	Equipment is slightly changed.[c)]
BEV/E+E Elektronik	BEV/E+E	Austria	B	Equipment is unchanged.
Federal Institute of Metrology (former Federal Office of Metrology)	METAS	Switzerland	K	30 °C up to 65 °C: Equipment is unchanged. 80 °C up to 85 °C: Generator exits no longer.[d)]
Hellenic Institute of Metrology	EIM	Greece	I	Equipment is unchanged.
Instituto Nacional de Téchnica Aeroespacial	INTA	Spain	F	Equipment is unchanged.
Instituto Nazionale die Ricerca Metrologica	INRIM	Italy	L	Equipment is slightly changed.[e)]
National Metrology Laboratory	NML/NSAI	Ireland	D	Equipment is changed.
National Physical Laboratory	NPL	UK	O	Equipment is unchanged.
VSL National Metrology Institute (former VSL Dutch Metrology Institute and Nederlands Meetinstituut)	VSL (former NMi-VSL)	The Netherlands	M	Equipment is slightly changed.[f)]
Physikalisch-Technische Bundesanstalt	PTB	Germany	A	Equipment is slightly changed.[g)]
TUBITAK Ulusal Metroloji Enstitüsü	TUBITAK UME	Turkey	G	Equipment is slightly changed.[h)]
Univeristy of Ljubljana	FE-LMK	Slovenia	H	Equipment is slightly changed.[i)]
University of Zagreb	FSB-LPM	Croatia	J	Equipment is unchanged.

Remarks

a) GUM

The laboratory has new SPRT and PRT sensors (AccuMac AM1751, 5683 Fluke).

b) CETIAT

Since the measurements in 2008/2011, the generator used is no longer in operation in the laboratory. A completely new equipment is used (i.e., a new generator with a mixed flow principle).

c) FORCE

The laboratory has new reference sensors.

d) METAS

The Thunder 2500 (METAS No. 6674) still exists at METAS and is regularly maintained, validated, and calibrated.

The generator CETIAT1 (METAS No. 1823) no longer exists at METAS and was discontinued in 2011.

e) INRIM

The laboratory performed slightly changes: new temperature bath, new pressure controller and gas circulation layout, new saturator's PRTs.

f) VSL

The chalk-filter pre-saturator was replaced with a simple container where gas enters at the bottom of a water column through a small grid. The equivalence was shown in [10].

g) PTB

The laboratory has new pressure sensors.

h) TUBITAK

The current status of the equipment is described in chapter 5.

i) FE-LMK

The laboratory has improved the heating.

Appendix D Change history Draft A to Draft B

The main changes between the first version of Draft A and Draft B are listed below:

- Calculation of aggregated lab result: The correlation of the four measurements of each lab was neglected in the first version of Draft A. This led to an underestimation of the uncertainty which was one of the main reasons for the huge number of outliers and therefore for the problems of the calculation of ERV. The four measurements of a laboratory at a certain temperature are partly correlated (see chapter 6.1). This correlation was considered in the second version of Draft A leading to senseful results.
- Linkage of both loops: Since all link laboratories measured the two transfer standards at the same time and with symmetrical setup, it is possible to separate the correlated and uncorrelated parts of the uncertainty for the single measurements. The linkage of the two loops is treated like the four aggregated lab results and consequently a weighted mean with correct consideration of the correlations is calculated.
- Difference to the ERV and Bilateral DoE: The bilateral DoE and the difference to the ERV are calculated using the aforementioned procedure of the linkage.
- Treatment of stability of the transfer standards: The stability is not included in the linkage anymore but treated as separate term. This guarantees that the stability of the transfer standard is the minimum of uncertainty between two laboratories (bilateral DoE).
- The use of the chi-squared test was restricted to the check of the final results, i.e., the difference of the lab result and the to the loop reference value (LRV). The chi-squared test is now used in the sense of Cox [15].
- The results for the degree of equivalence and the difference of the lab result and the to the loop reference value (LRV) for laboratories with multiple measurements (link laboratories) are now averaged. For each laboratory only one result is depicted.
- The correlation due to the link laboratories were considered consequently in all calculation.

Appendix E Additional calculations

Appendix E.1 Mean values with correlation

For the given values of x_i and the uncertainty u_i for the properties X_i $(i = 1, \ldots, n)$ and the covariance $u(x_i, x_j) = cov(x_i, x_j) = corr_{i,j} u_i u_j$ with the correlation coefficient $corr_{i,j}$ the mean value with a known weight α_i for $i = 1, \ldots, n$ is given by the following equation:

$$Y = \sum_{i=1}^{n} \alpha_i X_i \tag{12.1}$$

The estimate y and the uncertainty $u(y)$ according to GUM is then

$$y = \sum_{i=1}^{n} \alpha_i x_i \tag{12.2}$$

$$u^2(y) = \sum_{i=1}^{n} \alpha_i^2 u_i^2 + \sum_{i \neq j} \alpha_i \alpha_j \, corr_{i,j} u_i u_j \tag{12.3}$$

The last term in Eq. (12.3) is the covariance term. Two different means are used in the report.

a) Arithmetic mean with correlation

The uncertainty of the arithmetic mean is

$$u^2(y) = \frac{1}{n^2} \sum_{i=1}^{n} u_i^2 + \sum_{i \neq j} corr_{i,j} u_i u_j \tag{12.4}$$

with the weight α_i given by Eq. (12.5)

$$\alpha_i = \frac{1}{n} \,. \tag{12.5}$$

b) Weighted mean with correlation

The uncertainty of the weighted mean is

$$u^2(y) = \left(\frac{1}{\sum_{i=1}^{n} \frac{1}{u_i^2}} \right)^2 \left[\sum_{i=1}^{n} \frac{1}{u_i^2} + \sum_{i \neq j} \frac{corr_{i,j}}{u_i u_j} \right] \tag{12.6}$$

$$= \left(\frac{1}{\sum_{i=1}^{n} \frac{1}{u_i^2}} \right)^2 \left[\sum_{i=1}^{n} \frac{1}{u_i^2} + 2 \sum_{i > j} \frac{corr_{i,j}}{u_i u_j} \right]$$

with the weight α_i given by Eq. (12.7)

$$\alpha_i = \frac{1}{u_i^2 \sum_{j=1}^{n} \frac{1}{u_j^2}} \,. \tag{12.7}$$

The correlation coefficient $corr_{i,j}$ is calculated by Eq. (12.8)

$$corr_{i,j} = \frac{u_{corr,i} \cdot u_{corr,j}}{u_i \cdot u_j} \tag{12.8}$$

with $u_{corr,i}$ and $u_{corr,j}$ as the correlated parts of u_i and u_j.

Appendix E.2 Uncertainty deviation with two parameters

In chapter 8 the difference of the lab result to the loop corrected reference value (LRV) is calculated. For laboratories which contribute to the LRV both terms of the difference are correlated. The problem can be formulated as follows:

A given function $y = F(a,b)$ has two parameters a and b which depend on several variables. One of these variables z is the same for both parameters a and b. The uncertainty $u(y)$ is formulated with the covariance of the common parameter z as shown in Eq. (12.9):

$$u^2(y) = \left(\frac{\partial F}{\partial a} \cdot u(a)\right)^2 + \left(\frac{\partial F}{\partial b} \cdot u(b)\right)^2 + 2 \cdot \frac{\partial F}{\partial a} \cdot \frac{\partial F}{\partial b} \left[\frac{\partial a}{\partial z} \cdot \frac{\partial b}{\partial z} \cdot u^2(z)\right] \tag{12.9}$$

with the covariance term $cov(a,b)$

$$cov\ (a,b) = \left[\frac{\partial a}{\partial z} \cdot \frac{\partial b}{\partial z} \cdot u^2(z)\right]. \tag{12.10}$$

Due to the symmetry of the covariance matrix, it is: $cov(a,b) = \ cov(b,a)$, i.e., when a is correlated with b, then also b is correlated with a. This leads to the factor 2 before the covariance in Eq. (12.9).

Eq. (12.9) is applied to Eq. (8.1) with $F(\Delta t_d^{(lab)}, \Delta t_d^{(LRV)})$ for the calculation of the uncertainty of the difference of the lab result to the loop corrected reference value (LRV). The deviations leads to the “-“ in Eq.(8.6) for laboratories contributing to the LRV compared to the “+” in Eq. (8.7) for laboratories which do not contribute to the LRV.

Appendix E.3 Calculation of aggregated lab result

The following two methods describe the use of the arithmetic mean value with different considerations of correlation.

a) Arithmetic mean value with uncorrelated uncertainty and additional reproducibility term (EURAMET.T-K6 and EURAMET.T-K8 first version of Draft A)

The procedure is based on the evaluation EURAMET.T-K6 [1]:

The single result Δt_d^{lab} of laboratory *lab* is the mean of the *n* (generally 4) repeated measurements of each participant measured at each nominal dew-point temperature:

$$\Delta t_d^{lab} = \mu_{arith}\left(\Delta t_d^{lab}\right) = \frac{1}{n}\left(\sum_{i=1}^{n} \Delta t_{d,i}^{lab}\right) + \delta_{rep} \tag{12.11}$$

where δ_{rep} is the correction due to non-ideal reproducibility of the results. Its expectation is zero and its standard uncertainty is given by:

$$u\left(\delta_{rep}\right) = \frac{1}{2\sqrt{3}}\left[\max\left(\Delta t_{d,i}^{lab}\right) - \min\left(\Delta t_{d,i}^{lab}\right)\right]. \tag{12.12}$$

The uncertainty of the result for each laboratory is calculated by

$$u^2\left(\Delta t_d^{lab}\right) = \frac{1}{n^2}\left(\sum_{i=1}^{n} u^2\left(\Delta t_{d,i}^{lab}\right)\right) + \frac{1}{12}\left[\max\left(\Delta t_{d,i}^{lab}\right) - \min\left(\Delta t_{d,i}^{lab}\right)\right]^2 \tag{12.13}$$

This method was investigated as one option in the first version of Draft A of EURAMET.T-K8

b) Arithmetic mean value and fully correlated uncertainty

The arithmetic mean value is calculated by Eq. (12.11).

In contrast to method a) the uncertainties of the single measurements of a laboratory at a certain temperature are treated as fully correlated.

$$u^2\left(\Delta t_d^{lab}\right) = \frac{1}{n}\left(\sum_{i=1}^{n} u^2\left(\Delta t_{d,i}^{lab}\right)\right) + \frac{1}{12}\left[\max\left(\Delta t_{d,i}^{lab}\right) - \min\left(\Delta t_{d,i}^{lab}\right)\right]^2 \tag{12.14}$$

The difference is the factor bevor the sum: in case of assumption of fully correlated results it is n^{-1} and in the case of the assumption of uncorrelated results it is n^{-2}.

Figure 98 shows the comparison of both methods.

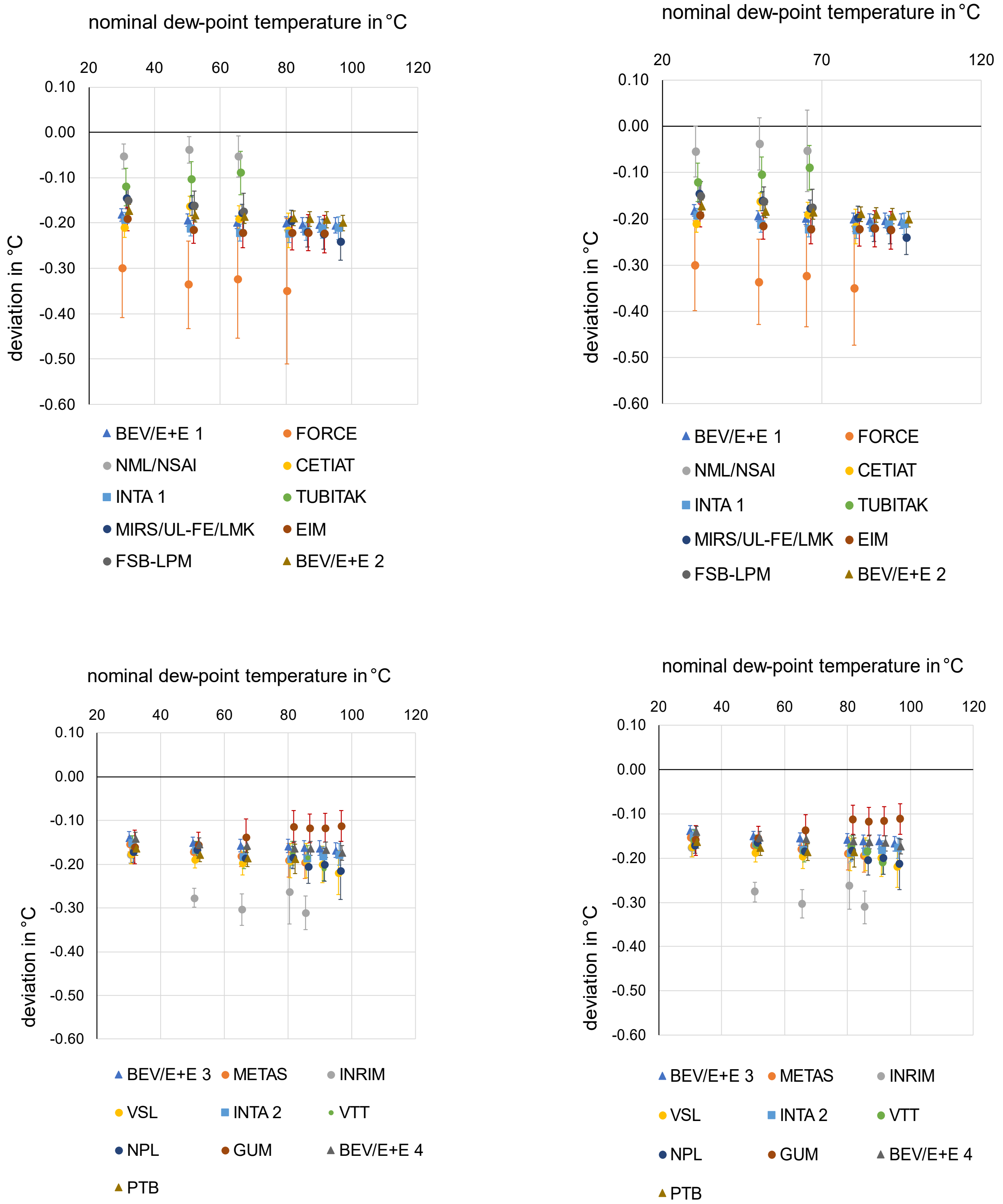

Figure 98 Comparison aggregated lab results version a) arithmetic mean value with uncorrelated uncertainty and additional reproducibility term (left) and version b) arithmetic mean value and fully correlated uncertainty (right) for loop 1 (upper row) and loop 2 (lower row), uncertainty k = 1

The comparison shows clearly that the assumption of uncorrelated measurement uncertainties leads to smaller values for the uncertainties. Neglecting the correlation caused the main problems in the first version of Draft A. Beside this, version b) on the right hand side of Figure 98 shows that even by considering the correlation the measurements of FORCE and NML/NSAI of loop 1 in the range of 30 °C up to 65 °C respectively 80 °C dew-point temperature and INRIM of loop 2 in the range from 50 °C up to 85 °C as well as GUM in loop 2 shows larger deviations. The agreement at nominal dew-point temperature of 30 °C is very good.

Appendix E.4 Correlation coefficient for aggregated lab result

The chosen version in the main text is the partially correlated weighted mean value for the aggregated lab result. Table 33 shows the average value for the correlation coefficient $corr_{i,j}$ in Eq. (6.9).

Table 33 Average value of the correlation coefficient in Eq. (6.9) for the aggregated lab result for all nominal dew-point temperatures

Lab code	30 °C	50 °C	65 °C	80 °C	85 °C	90 °C	95 °C
BEV/E+E 1	0.98	0.99	0.99	0.99	0.99	0.95	0.96
FORCE	0.99	0.98	0.96	0.94	-	-	-
NML/NSAI	0.91	0.93	0.97	-	-	-	-
CETIAT	0.93	0.89	0.66	0.68	-	-	-
INTA 1	0.96	0.98	0.98	0.99	0.98	0.98	0.83
TUBITAK	0.98	0.98	0.98	-	-	-	-
MIRS/UL-FE/LMK	0.84	0.94	0.99	0.99	0.89	0.88	0.94
EIM	0.98	0.98	0.96	0.96	0.93	0.96	-
FSB-LPM	1.00	0.99	0.98	-	-	-	-
BEV/E+E 2	1.00	0.99	1.00	1.00	1.00	1.00	0.98
BEV/E+E 3	0.98	0.99	0.99	1.00	0.99	0.94	0.94
METAS	0.74	0.90	0.79	0.81	0.92	-	-
INRIM	0.98	0.95	0.79	0.79	0.86	-	-
VSL	0.69	0.79	0.81	0.81	0.90	0.93	0.91
INTA 2	0.95	0.97	0.97	0.98	0.97	0.97	0.88
VTT	1.00	1.00	1.00	1.00	1.00	1.00	
NPL	0.89	0.88	0.92	0.89	0.98	0.96	0.95
GUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BEV/E+E 4	0.99	1.00	1.00	1.00	0.99	1.00	0.99
PTB	1.00	1.00	1.00	1.00	-	-	-

Appendix E.5 (Modified) Birge ratio within the calculation of P_{si} and $B(i,j)$

Table 34 to Table 36 show the values for the modified Birge ratio applied to the four single differences of the measurement BEV/E+E 1 and BEV/E+E 3, INTA 1 and INTA 2, and BEV/E+E 2 and BEV/E+E 4 within the calculation of P_{si} based on Eq. (7.12) and (7.13). In cases with values smaller than one the modified Birge ratio is set to one. The calculated value is set into brackets for information.

Table 34 Modified Birge ratio for the four single differences of measurements BEV/E+E 1 and BEV/E+E 3, in cases with values smaller than one the calculated value of the Birge ratio is shown in brackets.

	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
Modified Birge ratio	1.3053	1.6325	1.9368	(0.9146) 1	1.2166	1.3352	(0.4287) 1

Table 35 Modified Birge ratio for the four single differences of measurements INTA 1 and INTA 2, in cases with values smaller than one the calculated value of the Birge ratio is shown in brackets.

	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
Modified Birge ratio	(0.5127) 1	(0.3450) 1	(0.1871) 1	1.7535	(0.2985) 1	(0.4595) 1	(0.6626) 1

Table 36 Modified Birge ratio for the four single differences of measurements BEV/E+E 2 and BEV/E+E 4, in cases with values smaller than one the calculated value of the Birge ratio is shown in brackets.

	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
Modified Birge ratio	1.0244	2.7504	3.7222	3.8223	1.1736	1.3794	1.9979

Table 37 lists the values for the Birge ratio applied to the uncertainty of the three link differences within the calculation of $B(i,j)$ based on Eq. (7.14).

Table 37 Birge ratio applied to the uncertainty within the calculation of $B(i,j)$ based on Eq. (7.14)

	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
Birge ratio	5.4266	5.5430	4.8488	5.6279	8.0530	6.4719	3.1218

Appendix F Technical protocol

Details of participating institutes

The following list is an updated list of May 2024, compared to technical protocol Appendix B.

Central Office of Measure (GUM)

Adress: ul. Elektoralna 2, 00-139 Warszawa

Contact: Rafał Jarosz

Phone: +48 22 581 93 99

E-mail: rafal.jarosz@gum.gov.pl

VTT Technical Research Centre of Finland Ltd, Centre for Metrology MIKES (MIKES)

Adress: Tekniikantie 1, FIN-02151 Espoo

Contact: Richard Högström

Phone: +358 50 303 9341

E-mail: richard.hogstrom@vtt.fi

Centre Technique des Industries Aérauliques et Thermiques (LNE-CETIAT)

Address: Domaine Scientifique de la Doua, 25, avenue des Arts,
F-69603 Villeurbanne Cedex

Contact: Dr Eric Georgin

Phone: +33 4 72 444 989

E-mail: eric.georgin@cetiat.fr

FORCE Technology (FORCE)

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Contact: Anders B. Kentved

Phone: +45 25 16 18 03

E-mail: abk@delta.dk

E+E Elektronik (BEV/E+E)

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Phone: +43 7235 605 320

E-mail: helmut.mitter@epluse.com

Federal Institute of Metrology (METAS)

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Contact: Remo Senn

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E-mail: remo.senn@metas.ch

Hellenic Institute of Metrology (EIM)

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Instituto Nacional de Técnica Aeroespacial (INTA)

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E-mail: benyonpr@inta.es

Istituto Nazionale di Ricerca Metrologica (I.N.RI.M)

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Contact: Dr Vito Fernicola

Phone: +39 011 3919 737 or 746

E-mail: v.fernicola@inrim.it

NSAI National Metrology Laboratory (NSAI NML)

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Contact: Dubhaltach MacLochlainn

Phone: +353 1 8082647

E-mail: Dubhaltach.MacLochlainn@nsai.ie

National Physical Laboratory (NPL)

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Contact: Mark Stevens / Dr Stephanie Bell

Phone: +44 20 8943 6402

E-mail: mark.stevens@npl.co.uk

E-mail: stephanie.bell@npl.co.uk

VSL National Metrology Institute (VSL)

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P.O. Box 654, NL-2600 AR Delft

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TUBITAK - Ulusal Metroloji Enstitüsü (UME)

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Metrology Institute of the Republic of Slovenia/University of Ljubljana-Faculty of Electrical Engineering/Laboratory of Metrology and Quality (MIRS/UL-FE/LMK)

Address: Tržaška 25, 1000 Ljubljana

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P717 EUROMET Comparison in Humidity (dew-point temperature high range)

Dew Point Temperature +30 °C to +95 °C

Technical protocol (Final 20090202)

Contents

1. INTRODUCTION

1.1 At the EUROMET TC-THERM meeting in April 2003 in Wabern, Switzerland, it was agreed to organise an EUROMET Comparison in dew point temperature (high range) (minutes of the meeting, section 7.1.3.) as follow-up of the existing project P621 for high dew point temperatures up to +95 °C.

1.2 This technical protocol has been drawn up by the Coordinator in consultation with the nominated participants listed in Section 2.

1.3 The procedures outlined in this document cover the technical procedure to be followed during measurement of the travelling standards. The procedure, which follows the guidelines established by the BIPM[1] and EUROMET[2], is based on current best practice in the use of dew/frost-point hygrometers and takes account of the experience gained from the regional comparisons over the years.

1.4 This comparison is aimed at establishing the degree of equivalence between realisations of local scales of dew point temperature of humid gas, in the range from +30 °C to +95 °C, among the participating national metrology institutes.

2. ORGANIZATION

2.1 Participants

2.1.1 A list of participants representing is given in table 1. Details of mailing and electronic addresses are given in Appendix B.

2.1.2 The participants are divided into two groups. Each group will form a comparison loop. To link the loops to each other, the loops have besides the two Pilots one common participant who measures also both travelling standards.

2.1.3 PTB is the Coordinator of the comparison and the Pilot for loop 1, taking main responsibility for running the comparison. BEV/E+E is Co-Pilot being responsible for running loop 2.

2.1.4 By their declared intention to participate in this key comparison, the laboratories accept the general instructions and the technical protocol written down in this document and commit themselves to follow strictly the procedures of this protocol as well as the version of the "Guidelines for Key Comparisons" in effect at the time of the initiation of the Key Comparison.

[1] T.J. Quinn, "Guidelines for key comparisons carried out by Consultative Committees", Appendix F to the MRA, BIPM, Paris.

[2] EUROMET Guide 3, EUROMET Guidelines on Conducting Comparisons

2.1.5 Once the protocol and list of participants have been approved, no change to the protocol or list of participants may be made without prior agreement of all participants.

2.1.6 All participants must be able to submit an uncertainty budget of their humidity standards.

Table 1 List of participants (*C*=Coordinator, *P*=Pilot, *L*=Linking laboratory)

Central Office of Measures (GUM)	Poland	
Centre for Metrology and Accreditation (MIKES)	Finland	
Centre Technique des Industries Aérauliques et Thermiques (CETIAT)	France	
DELTA Danish Electronics (DELTA)	Denmark	
E+E Elektronik Ges.m.b.H. (BEV/E+E)	Austria	***P***
Federal Office of Metrology (METAS)	Switzerland	
Hellenic Institute of Metrology (EIM)	Greece	
Instituto Nacional de Técnica Aeroespacial (CEM/INTA)	Spain	***L***
Istituto Nazionale di Ricerca Metrologica (INRIM)	Italy	
National Metrology Laboratory (NML)	Ireland	
National Physical Laboratory (NPL)	UK	
Nederlands Meetinstituut (NMi-VSL)	Netherlands	
Physikalisch-Technische Bundesanstalt (PTB)	Germany	***C,P***
TUBITAK - Ulusal Metroloji Enstitüsü (UME)	Turkey	
University of Ljubljana (FE-LMK)	Slovenia	

2.2 Method of comparison

2.2.1 The comparison is of the type of the realisations of local scales of dew point temperature at the participating national institutes.

2.2.2 The comparison will be made by calibration of a travelling standard lent by MBW Calibration Ltd (Switzerland). The travelling standard will measure dew point temperature of a sample of moist gas produced by a participant's standard generator.

2.2.3 The comparison is carried out in two parallel loops with separate travelling standards. Measurements will start in the Pilot/co-Pilot laboratory. The other participants in the loop will then perform comparison measurements at the dew point temperatures required. The last participant will then return the travelling standard to the Pilot of the loop to carry out final measurements to monitor drift. The draft of a time schedule for this comparison can be found in Appendix A. Allowing between 5 and 6 weeks per set of measurements (including shipping), this set of measurements will take a time of about 20 months.

2.2.4 All results are to be communicated directly to the Pilot of the corresponding loop within six weeks after the completion of the measurements by a laboratory. If this time is seriously exceeded without coordination with the Pilot, the results of this laboratory may be excluded from the comparison.

2.2.5 If for some reason, the measurement facility is not ready or customs clearance takes too much time in a country, the participating laboratory must contact the Pilot laboratory immediately. Exclusion of a participant's results from the report may occur if the results are not available in time to prepare the draft report.

2.2.6 In case of serious difficulty with customs, or other delays which might over-run the time period of the ATA Carnet, the Pilot may request the instruments be returned to the holder of the ATA Carnet (MBW Calibration Ltd) or to the Pilot laboratory, or the sequence of participation may be changed to the most practical arrangement.

2.2.7 Within ten weeks after the completion of the last measurements in the loop, the Pilot sends all the results obtained in the loop to the Coordinator.

2.2.8 The Pilot informs the Coordinator about the progress in the loop. In particular, the Coordinator must be informed about delays in the schedule and the completion of the last measurements in the loop.

2.3 Handling of artefacts

2.3.1 The artefacts should be examined immediately upon receipt at the laboratory. All participants are expected to follow all instructions in the operator's manual provided by the instrument manufacturer for proper unpacking, subsequent packing and shipping to the next participant. During packing and unpacking, all participants should check the contents with the packing list.

2.3.2 The travelling standards should only be handled by authorized persons and stored in such a way as to prevent damage.

2.3.3 During operation of the travelling standards, if there is any unusual occurrence, e.g., loss of heating control, the Pilot laboratory should be notified immediately before proceeding.

2.4 Transport of artefacts

2.4.1 The transportation process begins when the artefact leaves the sending laboratory and does not end until it reaches the destination laboratory. All participants should follow the following general guidelines:

(1) Plan the shipment well in advance. The recipient should be aware of any customs issues in their country that would delay the testing schedule. The shipping laboratory must be aware of any national regulations covering the travelling standard to be exported;

(2) Mark the shipping container "**FRAGILE SCIENTIFIC INSTRUMENTS**" “**TO BE OPENED ONLY BY LABORATORY STAFF**” and with arrows showing "**THIS WAY UP**"; attach tip and shock indicators if such devices are available and seal the container (e.g. with old calibration marks etc.)

(3) Determine the best way to ship the travelling standard to the next participant. In general ground transportation by truck with an approved courier must be preferred.

(4) Obtain the recipient's exact shipping address. If possible, have it shipped directly to the laboratory. Note that the addresses in Appendix B may be outdated.

(5) Coordinate the shipping schedule with the recipient. The sending laboratory should provide the recipient with the details of the carrier, the tracking number (AWB or other reference), the exact travel mode, and the estimated time of arrival.

(6) Instruct the recipient to confirm receipt and condition upon arrival to the sender and the Pilot. A form for reporting on the receipt of the travelling standards is shown in Appendix C.

2.4.2 Each travelling standard is supplied with its shipping container, which is sufficiently robust to ensure safe transportation.

2.4.3 The artefacts will be accompanied by a suitable customs ATA Carnet. Care should be taken with the timing of the ATA Carnet, which only lasts for one year.

2.5. Costs

2.5.1 Each laboratory is responsible for the cost of shipping to the next participant including any customs charges. The insurance of the instruments is arranged by MBW Calibration Ltd.

2.5.2 Each laboratory pays its share of the services provided by MBW Calibration Ltd (which lends the travelling standards). The participants will be invoiced by MBW Calibration Ltd after completion of the comparison.

3. DESCRIPTION OF THE TRAVELLING STANDARDS

3.1. Artefacts

3.1.1 MBW Calibration Ltd lends one travelling standards per loop for the key comparison. The instruments are state-of-the-art, commercially available chilled-mirror type of dew point hygrometers.

3.1.2 Details of travelling standards:
The two travelling standards are new and of the same type:

Model:	MBW 373 HX
Size (in packing case):	75 x 69 x 41 cm
Weight (in packing case):	36 kg
Manufacturer:	MBW Calibration Ltd
Owner:	MBW Calibration Ltd
Electrical supply:	230 V / 50 Hz
Electrical connection:	Instrument socket IEC/EN 60320-2-2 (socket C14/plug C13) The instrument will be supplied with a Schuko (Continental Europe) plug Standard CEE 7/VII
Power consumption:	300 W
Tube connectors:	Swagelok® 6 mm
Accessories:	Endoscope, 4-wire cable for resistance measurements (3 m), heated flexible hose with 6 mm Swagelok® connectors, operating manual
Approximate value for insurance and customs declaration:	40 000 EUR

Serial numbers of the instruments are:

Loop 1	Loop2
08-0413	08-0414

4. MEASUREMENT INSTRUCTIONS

4.1. Measurement process

4.1.1 All participants should refer to the operating manuals for instructions and precautions for using the travelling standards. Participants may perform any initial checks of the operation of the hygrometers that would be performed for a normal calibration. In the case of an unexpected instrument failure at a participant institute, the Pilot institute should be informed in order to revise the time schedule, if necessary, as early as possible.

4.1.2 Sample gas generated by a participant's standard generator, is introduced into the inlet of a travelling standard hygrometer through the supplied heated flexible hose terminated with Swagelok® 6 mm connectors. The electrical connector of the hose is plugged into the appropriate socket near the gas inlet terminal. For all dew points normal precautions (heating) should be used to protect against condensation in sample lines. Special care has to be taken with the connection between the end of the heated hose and the input terminal of the instrument. This point has to be heated externally to prevent condensation at high dew points.

4.1.3 Measurements are carried out at nominal dew point temperatures of 30 °C, 50 °C, 65 °C, 80 °C, 85 °C, 90 °C and 95 °C (refer to 4.1.4 for limited range at high dew points). These values are chosen in accordance with the maximal dew point, participants can generate.

4.1.4 If the scope of a laboratory does not cover the whole range of this comparison, the laboratory is allowed to limit measurements to the highest nominal dew point temperature specified in 4.1.3 that is within the scope.

4.1.5 Measurements should be done in rising order of dew point temperature.

4.1.6 The values of dew point temperature applied to the travelling standards should be within ±0.5 °C of the agreed nominal values for the comparison, and ideally closer than this. Deviations greater than this may increase the uncertainty in the comparison, for a particular result.

4.1.7 If the type of generator used (e.g. two pressure generator) requires a precise pressure measurement at the point of condensation (mirror), pressure should be measured as close as possible to the outlet terminal of the hygrometer. The hygrometers are **NOT** equipped with a gas pump, so the outlet of the measuring cell is directly connected to the rear outlet terminal. The remaining pressure drop between the point of condensation and the point of pressure measurement shall be determined as good as possible. A possible value for this pressure drop found during the initial tests in the two Pilot laboratories is 0.2 hPa at a flow rate of the wet gas of 0.5 l/min. This should be verified with own measurements by each participant.
Important: For the purpose of this comparison the reference point for all measurements is taken as the point of condensation (mirror). Therefore, the applied reference dew point temperature should be given for this condition, making due allowance for any pressure drops between the point of saturation and the point of condensation.

4.1.8 Special care has to be taken to avoid condensation and subsequently plugging by water in the outlet lines. A suitable heating and tubes with a greater inner diameter while measuring high dew points will help prevent this fault.

4.1.9 A float-type flow meter enclosed with the instrument should be connected between the hygrometer outlet and a flow meter of the laboratory. Due to dew points above ambient temperature the condensing water from the outlet of the hygrometer must be separated before entering the float-type flow meter e.g. by a water trap (use hoses or tubes with big inner diameter). Doing this, the water content exceeding saturation conditions at room temperature is removed. This requires a correction of the flow rate indicated by the float-type flow meter and the laboratory's flow measurement. The following table shows this correction assuming saturation condition at 20 °C (room temperature), volume expansion according to the temperature of the heated head and tube and is calculated for a wet gas flow of 0.5 l/min.

Dew point °C	Volume of water %	Indicated flow rate after the water trap l/min
30	4,2	0,44
50	12,3	0,38
65	24,9	0,31
80	47,1	0,21
85	57,4	0,17
90	69,5	0,12
95	83,7	0,06

Table 2: Indicated flow rate after the water trap for the selected dew points

4.1.10 Four repeated full set of measurements are carried out, i.e. each nominal dew point temperature should be separately repeated (reproduced) four times to reduce the effect of any irreproducibility of the travelling standards.

4.1.11 The condensate on the mirror should be cleared and re-formed for each value or repetition of dew point temperature performing a "Manual Mirror Check" (fixed function key at the bottom bar). The "Automatic Mirror Check" must be disabled (Menu Keys: "Control Setup" → "Mirror Check")

4.1.12 Operation with the travelling standards

Before any humidity measurements, initial actions should be taken:

1) Read the manual "Operating Instructions" delivered by the manufacturer (a copy of the manual is in the transport case).

2) At a flow rate of 0.5 l/min, the flow rate indications of the hygrometer, the float-type flow meter and the laboratory flow meter are compared to each other (at a pressure corresponding to the sample gas pressure during dew point measurements). It is highly recommended to carry out the test in the generator system used in the comparison. In a case of strongly fluctuating sample gas flow, the flow indicator of the hygrometer may show incorrect value. For this test, the dew point should not exceed room temperature to avoid condensation.

3) When the hygrometer is in a standby mode (i.e. mirror temperature control is switched off), the dew point temperature indication, resistance of a PRT embedded in the mirror and mirror temperature reading from the RS-232 port are recorded during ten minutes (at least ten measurements).

4) Set the hygrometer ready for cleaning with "Mirror Cleaning".

5) Remove the endoscope carefully following the instructions.

6) Open the measuring head carefully according to the instructions given in the operating manual.

7) Clean the mirror surface using a suitable lint-free tissue or cloth or cotton tips with distilled or de-ionised water preceded by initial cleaning with pure ethanol of p.a. grade if necessary. As the last act of the cleaning procedure it is advantageous to rinse pure distilled water over the mirror which is collected with a cloth below the mirror.

8) Close the measuring head carefully according to the instructions given in the operating manual.

9) Replace the endoscope carefully.

10) Press “OK” for successfully performed mirror cleaning.

Dew point temperature measurements:

1) Clean the mirror if needed according to the instructions above (no sample gas flow).

2) Set the heater control for the measuring head and the inlet tube to ‘Fixed Mode’ with the target value 30 K **above** the nominal dew point temperature (Menu Keys: “Control Setup” → “Heater”→”Fixed Mode Target”) and switch on the Heater with the fixed function key at the bottom bar. **Note:** The maximal selectable head temperature is 115 °C. This applies also for dew points of 90 °C and above.

3) Wait until the head temperature has stabilized to the preset value. To watch this stabilization process, the ‘head temperature’ and the ‘external tube temperature’ should be displayed each on a display line.

4) Set the flow rate of wet sample gas at 0.5 l/min according to an indication by the supplied float-type flow meter taken from the table 2 in section 4.1.9.

5) **Important:** Press and hold the 0-key (the numerical button for 0) for about 3 seconds until a short beep sounds. This is a special need with both transfer standards to indicate a clean mirror at the right temperature. We have decided to switch off the AUTOLAMP parameter in the instrument setup as this process of manual setting the reflected light intensity to zero gives more stable results over a long period.

6) Start measurements with “Dew/Frost Control” key at the bottom bar (Fixed Function Keys)

7) A homogenous condensate should appear on the mirror; if not, the condensate should be cleared and re-formed with “Mirror Check” (Fixed Function Keys). If necessary, the mirror is cleaned again according to the instructions above. If you experience an oscillating layer thickness

with oscillation of the indicated value at very high dew points, a new cleaning process may be necessary.

8) After appropriate time of stabilisation, measurements are carried out. The process of collecting data is described below (chapter 4.2). At this time the head temperature and the tube temperature must not increase or decrease.

9) Before changing the sample gas dew point temperature, make sure that the head temperature and the tube temperature are high enough for the new desired dew point (see instructions 2 above).

10) Before measuring at the next measurement point, the condensate should be cleared and re-formed with “Mirror Check” (Fixed Function Keys)

4.1.13 Participants should avoid lengthy additional measurements, except those necessary to give confidence in the results of this comparison.

4.1.14 The travelling standards used in this comparison must not be modified, adjusted, or used for any purpose other than described in this document, nor given to any party other than the participants in the comparison.
Important: Instrument parameters available in the Extended-Access-Menu or via command line on the serial interface of the instrument, must **NOT** be amended without prior written permission of the Pilot.

4.1.15 The Pilot will make an assessment of any drift in the travelling standards during the comparison, based on measurements at the Pilot laboratory at the beginning and end of the comparison period. If drift is found, this will be taken into account in the final analysis of the comparison results.

4.1.16 If poor performance or failure of a travelling standard is detected, the Pilot of the loop will propose a course of action, subject to agreement of the participants.

4.2. Data collection

4.2.1 In the travelling standards, there are two 100-ohm platinum resistance thermometers (PRT) embedded beneath the surface of the chilled-mirror to measure the dew/frost-point temperature. One is used for system measurement and control. The resistance of the other one is measured via a Lemo connector in the rear panel. Dew point temperature readings used primarily in this comparison are obtained from the resistance of the second PRT. The current applied to the PRT should be nominally 1 mA. The resistance of the PRT should be measured using a calibrated multi-meter or a resistance bridge, and then converted to a corresponding dew point temperature. The calculation of the temperature is done according to IEC 60751 and is described in Appendix D.
Note: The internal parameters also of the first PRT used for the display and the data communication via RS-232 have been set to the nominal values

according to IEC 60751. No individual calibration coefficients are stored in the instruments.

4.2.2 Each measured value (incl. its experimental standard uncertainty) is obtained calculating the mean and standard deviation of at least 10 readings of the resistance of the PRT recorded during 10 to 20 minutes.

4.2.3 Participants may apply their own criteria of stability for acceptance of measurements consistent with their declared CMC's.

4.2.4 As a supporting measurement, the digital display readings (and/or digital signal through a serial port in the rear panel) for dew point temperature, head temperature, flow rate and head pressure in the travelling standard should be monitored. The mean and standard deviation of a set of at least 10 readings, taken over the same period as the dew point measurements should be reported.

4.2.4 Values reported for dew point temperatures produced by a participant's standard generator should be the value applied to the instruments, after any allowances for pressure and temperature differences between the point of realisation (laboratory standard generator or reference hygrometer) and the point of use (travelling standards).

5. REPORTING OF MEASUREMENT RESULTS

5.1 Participants must report their measurement results of four repeated experiments, within six weeks of completing their measurements to the Pilot (refer to section 2.2.4).

5.2 The Pilot of the loop should accumulate data continually and should analyse the results for possible anomalies in the travelling standard. If problems arise, the Pilot should consult with the participant that submitted the data as soon as possible, and certainly before the distribution of Draft A of the Report of the comparison. If the participant is a link between the loops, the Pilot must consult also with the Coordinator. The Pilots must inform the Coordinator of all problems.

5.3 The parameter to be compared between the laboratories in this comparison is the difference found between the travelling standards and the laboratory dew point temperature standard. Note that the values of dew point temperature reported are "arbitrary" values calculated from the measured resistance output. The travelling standards are used simply as comparators.

5.4 Participants should report results to the Pilot in terms of dew point temperature. The main measurement results comprise:

- values of dew point applied to the travelling standard, and associated standard uncertainty

- values measured using the travelling standard (and the associated uncertainties derived from standard deviation of the set of readings)
- values of difference between applied dew point and measured dew point.

Participants shall submit their results in electronic form, using the Excel template provided in Appendix F. Use of this format, including calculations of means and differences, allows participants to see clearly the values and uncertainties of the parameters they are submitting for comparison.

5.5 From the data measured by each participant, results will be analysed in terms of differences between applied and measured dew point temperatures. In each case, the difference will be taken between the applied (realised) value and the mean (mid-point) between the hygrometer value.

5.6 In addition, the difference between the hygrometer reading on all occasions will be analysed and will serve as a check of consistency.

5.7 The participants should report the conditions of realisation and measurement, as background information to support the main results. These conditions may include, pressure and temperature in saturator or reference hygrometer, pressure difference between saturator or reference hygrometer and travelling standards, measurement traceability, frequency of AC (or DC) resistance measurement, and other items. A template for reporting conditions of measurement is included in the Excel workbook provided in Appendix F.

5.8 Participants should provide a description of the operation of their dew point facilities used in the comparison.

5.9 Participants should also provide an example plot of equilibrium condition (resistance versus time) at a nominal dew point temperature of 50 °C over at least one hour.

5.10 Any information obtained relating to the use of any results obtained by a participant during the course of the comparison shall be sent only to the Pilot laboratory and as quickly as possible. The Pilot laboratory will be responsible for coordinating how the information should be disseminated to other participants. The Pilot laboratory informs the Coordinator about the progress and results obtained in the Pilot's loop. No communication whatsoever regarding any details of the comparison other than the general conditions described in this protocol shall occur between any of the participants or any party external to the comparison without the written consent of the Coordinator. The Coordinator will in turn seek permission of all the participants. This is to ensure that no bias from whatever accidental means can occur. These constraints on communication apply until the circulation of Draft A of the report of the comparisons.

5.11 If a participant significantly delays reporting of results to the Pilot, then a deadline will be agreed among the participants. If that deadline is not met, then inclusion of those results in the comparison report will not be guaranteed.

5.12 The Pilots must send the measurement results obtained in their loop to the Coordinator within ten weeks of completing the last measurements of the loop. The Pilots will also send an estimation on the uncertainty due to any drift of the travelling standard over the period of the comparison.

6. UNCERTAINTY OF MEASUREMENT

6.1 The uncertainty of the key comparison results will be derived from:

- the quoted uncertainty of the dew point realisation (applied dew point temperature)
- the estimated uncertainty relating to the short-term stability of the travelling standard at the time of measurement
- the estimated uncertainty due to any drift of the travelling standard over the period of the comparison (estimated by the Pilots)
- the estimated uncertainty in mean values due to dispersion of repeated results (reflecting the combined reproducibility of laboratory standard and travelling standards)
- the estimated uncertainty due to non-linearity of the travelling standards in any case where measurements are significantly away from the agreed nominal value
- the estimated covariance between applied (laboratory standard) and measured (travelling standard) values of dew point temperature (if found significant)
- any other components of uncertainty that are thought to be significant

6.2 Participants are required to submit detailed analyses of uncertainty for their dew point standards. Uncertainty analysis should be according to the approach given in the ISO Guide to the Expression of Uncertainty of Measurement. A list of the all significant components of the uncertainty budget should be evaluated, and should support the quoted uncertainties. Type B estimates of uncertainty may be regarded as having infinite degrees of freedom, or an alternative estimate of the number of degrees of freedom may be made following the methods in the ISO Guide. A template for reporting uncertainty of measurement is included in the Excel workbook provided in Appendix F. Individual institutes may add to the template any additional uncertainties they consider relevant.

6.3 The Pilot laboratories will collect draft uncertainty budgets as background information to the uncertainties quoted by participants for the comparison measurements. The Pilots and the Coordinator will review the uncertainty budgets for consistency among participants.

6.4 The uncertainty budget stated by the participating laboratory should be referenced to an internal report and/or a published article.

7. THE EUROMET COMPARISON REFERENCE VALUE (ERV)

7.1 The outputs of the key comparison are expected to be:

- Results of individual participants for comparison of the hygrometers against their dew point reference in terms of mean values for each hygrometer at each measured value, estimated standard uncertainty of each mean result and estimated standard uncertainty of comparison process (e.g. effect of long-term stability and non-linearity of the travelling standards) if necessary.
- Estimates of bilateral equivalence between every pair of participants at each measured dew point temperature.
- A EUROMET comparison reference value (ERV) for each nominal value of dew point temperature in the comparison. The ERV might be calculated as the mean of all valid results, or a weighted mean.
- Estimates of equivalence of each participant to the ERV. This might be expressed in terms of the Degree of Equivalence (DOE) given as a difference and its uncertainty (Δ ±U), in °C.

7.2 In the field of dew point standards, the ERV does not have any absolute significance. It is calculated only for purposes such as the presentation and inter-relation of key comparison data for the MRA.

7.3 The Pilots will make an assessment of any drift in the travelling standards during the comparison. The assessment will be based on initial and final measurements done by the Pilots. If drift is found, this will be taken into account in the final analysis of the comparison results. If the drift is small compared with uncertainty values reported by the participants, an estimate for the drift may be set to zero with a standard uncertainty calculated according to the ISO Guide. In a case of a significant drift, the effect is taken into account by assigning a time-dependent value to ERV, or by other suitable method so that the estimates of equivalence can be meaningfully calculated between results taken at different times.

7.4 If a travelling standard fails or performs poorly during the comparison, the Coordinator and Pilots will propose a course of action, subject to agreement of the participants.

APPENDIX A. PROVISIONAL TIME SCHEDULE FOR THE COMPARISON

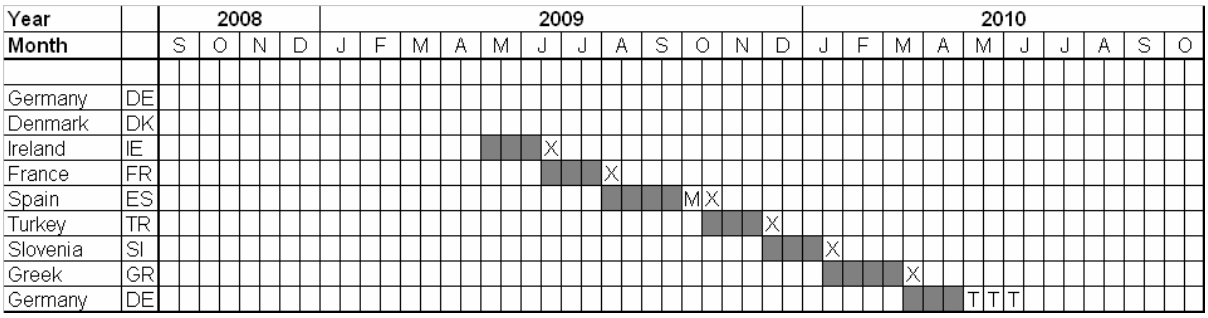

Figure 1 Comparison scheme of loop 1 (One column corresponds to two weeks; M = transportation to MBW Calibration Ltd / Swiss customs for a new ATA Carnet, ■ = measurement, X = measurement / transportation, T = testing the instrument)

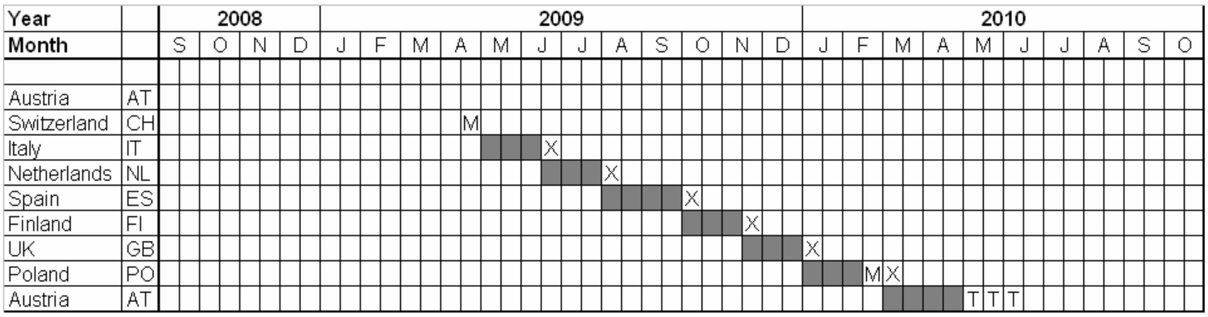

Figure 2 Comparison scheme of loop 2 (One column corresponds to two weeks; M = transportation to MBW Calibration Ltd / Swiss customs for a new ATA Carnet, ■ = measurement, X = measurement / transportation, T = testing the instrument)

Activity	Start Month	Provisional date
Draft of technical protocol completed by the Coordinator and sent to participants		Apr. 2008
All comments received from participants		Dec. 2008
Submission of a revised protocol to participants for unanimous approval		Dec. 2008
Submission of revised protocol to CCT/WG6 and TC THERM Chairman		Jun. 2009
Travelling standards characterized by the Pilots		Jul. 2008 - Nov. 2008
The fist set of key comparison measurements according to the protocol at the Pilot laboratories	Month 1	Nov. 2008
Travelling standards sent to participant by Pilots	Month 3	Jan. 2009
Completion of measurements	Month 18 approx.	Apr. 2010
Draft A ready	Month 22 approx.	3Q. 2010
Deadline for comments on draft A	Month 24	4Q. 2010
Draft B ready and submitted to TC THERM	Month 27	1Q. 2011

APPENDIX B. DETAILS OF PARTICIPATING INSTITUTES

Central Office of Measures (GUM) Poland

Address:	ul. Elektoralna 2, 00-139 Warszawa
Contact:	Krzysztof Flakiewicz
Phone:	+48 22 581 93 99
Fax:	+48 22 620 83 78
E-mail:	physchem@gum.gov.pl

Centre for Metrology and Accreditation (MIKES) Finland

Address:	Tekniikantie 1, FIN-02151 Espoo
Contact;	Dr Martti Heinonen
Phone:	+358 10 6054 402
Fax:	+358 10 6054 498
E-mail:	martti.heinonen@mikes.fi

Centre Technique des Industries Aérauliques et Thermiques (CETIAT) France

Address:	Domaine Scientifique de la Doua, 25, avenue des Arts, F-69603 Villeurbanne Cedex
Contact	Dr Eric Georgin
Phone:	+33 4 72 444 989
Fax:	+33 4 72 444 990
E-mail:	eric.georgin@cetiat.fr

DELTA Danish Electronics, Lights & Acoustics (DELTA) Denmark

Address:	Venlighedsvej 4, DK-2970 Hørsholm
Contact:	Anders B. Kentved
Phone:	+45 72 19 45 75
Fax:	+45 72 19 40 01
E-mail:	abk@delta.dk

E+E Elektronik (BEV/E+E) Austria

Address:	Langwiesen 7, A-4209 Engerwitzdorf, Austria
Contact:	Dr Helmut Mitter
Phone:	+43 7235 605 320
Fax:	+43 7235 605 383
E-mail:	helmut.mitter@epluse.at

Federal Office of Metrology (METAS) Switzerland

Address: Lindenweg 50, CH-3003 Bern-Wabern
Contact: Dr Anton Steiner
Phone: +41 31 323 33 71
Fax: +41 31 323 32 10
E-mail: anton.steiner@metas.ch

Hellenic Institute of Metrology (EIM) Greece

Address: Industrial Area of Thessaloniki, Block 45, GR-57022 Sindos
Contact: Miltiadis Anagnostou
Phone: +30 2310 569 950
Fax: +30 2310 569 996
E-mail: miltiadis.anagnostou@eim.org.gr

Instituto Nacional de Técnica Aeroespacial (INTA) Spain

Address: Centro de Metrologia y Calibración, Ctra. a Ajalvir, km. 4
ES-28850 Torrejon de Ardoz
Contact: Dr Robert Benyon
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Istituto Nazionale di Ricerca Metrologica (I.N.RI.M) Italy

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Contact: Dr Vito Fernicola
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Fax: +39 011 3977 347
E-mail: v.fernicola@inrim.it

National Metrology Laboratory (NML) Ireland

Address: Enterprise Ireland Campus, Glasnevin, Dublin 9
Contact: Plunkett Cromwell
Phone: +353 1 80 82 622
Fax: +353 1 80 82 603
E-mail: plunkett.cromwell@nsai.ie

National Physical Laboratory (NPL) UK

Address: Queens Road, Teddington, Middlesex, TW11 0LW
Contact: Mark Stevens / Dr Stephanie Bell
Phone: +44 20 8943 6402
Fax: +44 20 8943 6306
E-mail: mark.stevens@npl.co.uk
E-mail: stephanie.bell@npl.co.uk

Nederlands Meetinstituut (NMi-VSL) Netherlands
Address: Van Swinden Laboratium, Thijsseweg 11, NL-2629 JA Delft
P.O. Box 654, NL-2600 AR Delft
Contact: Rien Bosma
Phone: +31 15 269 1663
Fax: +31 15 261 2971
E-mail: rbosma@nmi.nl

Physikalisch-Technische Bundesanstalt (PTB) Germany
Address: Bundesallee 100, D-38116 Braunschweig
Contact: Dr Norbert Böse
Phone: +49 531 592 3231
Fax: +49 531 592 3369
E-mail: norbert.boese@ptb.de

TUBITAK - Ulusal Metroloji Enstitüsü (UME) Turkey
Address: TUBITAK Gebze Yerleskesi, Anibal Cad., Besevler mevkii
41470 TR-Gebze – Kocaeli
Contact: Aliye Kartal Dogan
Tel: +90 262 679 5000 / 3450
Fax: +90 262 679 5001
E-mail: aliye.kartal@ume.tubitak.gov.tr

University of Ljubljana (FE-LMK) Slovenia
Address: Faculty of Electrical Engineering, Laboratory of
Metrology and Quality, Trzaska 25, SI-1000 Ljubljana
Contact: Dr Jovan Bojkovski
Phone: +386 1 4768 224
Fax: +386 1 4264 633
E-mail: jovan.bojkovski@fe.uni-lj.si

APPENDIX C. FORM FOR REPORTING ON RECEIPT OF TRAVELLING STANDARDS

TO: *(Pilot Laboratory)*

Fax:

FROM: *(Participating Laboratory)*

Fax:

We confirm having received the travelling standards of the EUROMET Comparison of Dew Point Temperature (EUROMET P717)

on: __________________ (date)

After visual inspection

- ☐ No damage has been noticed;
- ☐ The following damage must be reported:

Have the hygrometer transportation packages been opened during transit ?
e.g., Customs …

☐ No

☐ Don't know (no seals applied)

☐ Yes: Please give details:

Is there any damage to the transportation packages?

☐ No

☐ Yes: Please give details:

Are there any visible signs of damage to the instruments?

☐ No

☐ Yes: Please give details:

Do you believe the travelling standards are functioning correctly?

☐ Yes

☐ No: Please indicate your concerns:

PACKING LIST

Received	**Items**	**Dispatched**
	Dew point hygrometer MBW 373 HX S/N 08-041____* with 2 Swagelok® caps on gas in- and outlet	
	Endoscope in separate box	
	Flexible hose (heatable) with Swagelok® 6 mm fittings and 2 Swagelok® plugs	
	Float-type flow meter with 6 mm Teflon hose	
	4-wire cable with Lemo-connector for 2nd PRT	
	Power cord with Standard CEE 7/VII plug	
	Operators manual	
	Transport case	
	(additional items may be added later)	

*) Please add last digit of serial number

Laboratory: ....

Date: .... Signature: ....

APPENDIX D. IEC 60751 RELATIONSHIP

Based on the IEC 60751 (1995-07), a nominal resistance-temperature characteristic of the PRT in the travelling standard can be defined as follows:

$$R_t = R_0 (1 + At + Bt^2)$$

where:

t	= Temperature (ITS-90) in °C,
R_t	= Resistance of the PRT at temperature t in Ω
R_0	= Nominal resistance of 100 Ω at 0 °C,
A	= 3.9083×10^{-3} °C^{-1} and
B	= -5.775×10^{-7} °C^{-2}

Solving the quadratic equation, the temperature can be calculated with

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R_0 - R_t}{BR_0}}$$

APPENDIX E. MAXIMUM DEW POINT CAPABILITIES OF PARTICIPANTS

On the meeting of the TC-Therm subfield humidity in 2007 in Berlin representatives of the participating countries have stated the maximum dew point temperature the specific NMI is able to generate for the calibration of dew point meters. These values are given in figure 3:

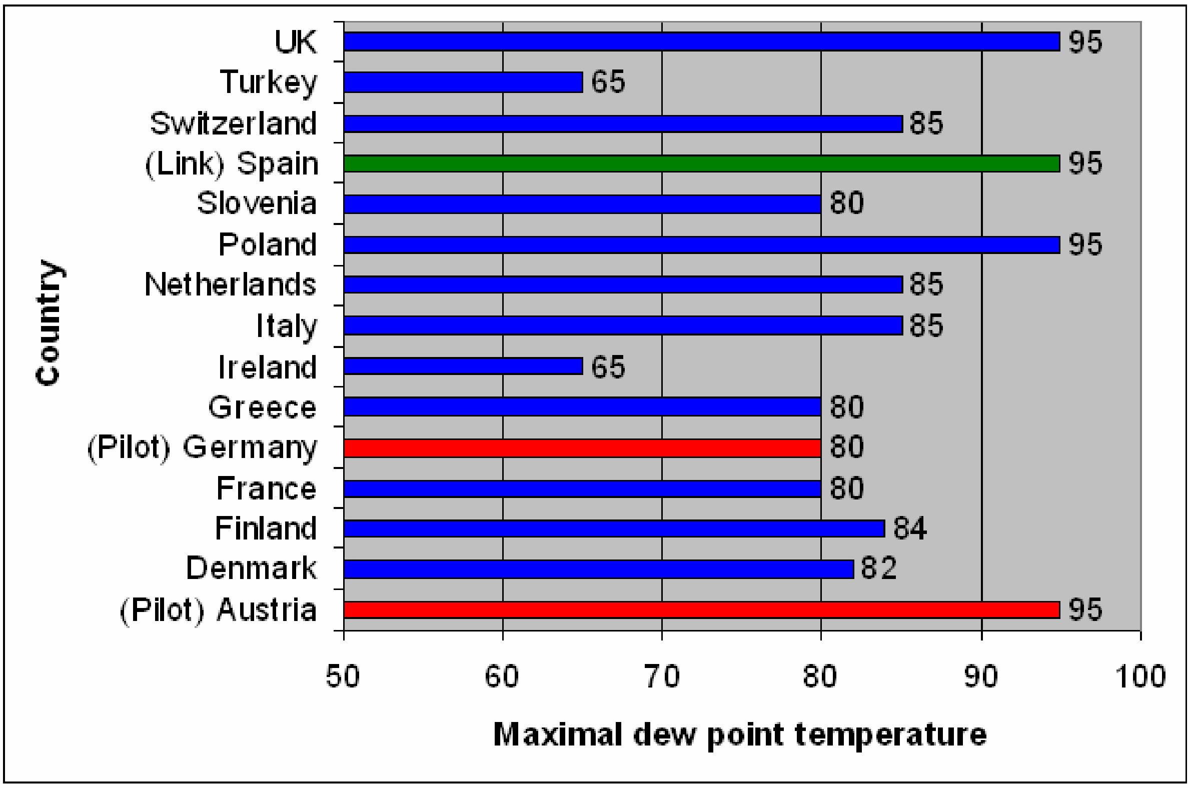

Figure 3: Maximal dew point temperature of participating countries which can be generated for calibration.

These values have been used in the selection of the nominal dew point temperatures for this comparison (see section 4.1.3) and are also the basis for the number of dew points, each NMI has to measure in this comparison. For example, Germany measures dew points of 30 °C, 50 °C, 65 °C and 80 °C, while Austria measures dew points of 30 °C, 50 °C, 65 °C, 80 °C, 85 °C, 90 °C and 95 °C.

APPENDIX F. TEMPLATE FOR SUBMISSION OF RESULTS

The template for submission of results is available in electronic form only (Excel workbook). It consists of three worksheets (Results, Conditions and Uncertainty). It will be sent to the participants during the comparison.