Final report to the CCT on key comparison CCT-K8 – Comparison of local realisations of dew-point temperature of humid gas in the range 30 °C to 95 °C

Final Report

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CONTENT

1 INTRODUCTION

Under the Mutual Recognition Arrangement (MRA) [MRA99] the metrological equivalence of national measurement standards will be determined by a set of key comparisons chosen and organized by the Consultative Committees of the CIPM working closely with the Regional Metrology Organizations (RMOs).

At the 24th Meeting of the CCT in May 2008, it was agreed to organize a CCT Comparison in dew point temperature (high range) as a follow-up of the existing CCT-K6 frost/dew-point temperature comparison, as proposed by CCT-WG6, now known as WG-Hu.

The completed registration form for the proposed CCT-Kx high range dew-point key comparison was submitted on 26/09/2008 and registered in the KCDB database on 29/09/2008.

The technical protocol [TPR16] was drawn up by the coordinator (INTA) in consultation with all participants and it was based on the protocol developed by CCT-WG6 to be consistent between CCT-K8 and the corresponding RMO.T-K8s. The CCT-K8 protocol was approved by K8 participants in November 2016, with agreed minor changes.

Technical operations to be followed during measurement of the travelling standards were described in the technical protocol, which follows the guidelines established by the BIPM [Quin99, CIPM16], is based on current best practice in the use of dew/frost-point hygrometers and takes account of the experience collected from the CCT-K6 [Bel15], EURAMET.T-K6 [Hei08], EURAMET.T-K8 [Des23] and APMP.T-K8 [Abe21].

Once the measurement phase had finished in November 2017, there was a significant delay until starting to write draft. This was mainly due to the need to approve a mathematical and statistical consistency analysis method aligned with corresponding RMO K8 comparison, together time limitations due to changes in staff responsibilities at INTA.

2 ORGANIZATION

The main target of this comparison was to obtain the degree of equivalence (DoE) between realizations of local scales of dew point temperature of humid gas (air), in the range from 30 °C to 95 °C, among the participating national metrology institutes (NMI). To fully meet this objective, this comparison was designed to provide the following information for each nominal value of dew point:

- Estimates of bilateral equivalence between every pair of participants.
- A key comparison reference value (KCRV).
- Estimates of equivalence of each participant to the KCRV.

According to the approved technical protocol [TPR16], the comparison was carried out by means of circulation of a pair of travelling transfer standards. Each transfer standard was used to independently measure dew-point temperature of a sample of humid gas produced using the same measuring process and the own standard generator system of each participant.

Measurements were done at seven dew-point temperature nominal values of 30 °C, 50 °C, 65 °C, 80 °C, 85 °C, 90 °C and 95 °C in rising order. For those laboratories whose scope did not cover the whole range of this comparison, they were allowed to limit the highest nominal dew-point temperature to that within their scope. The small interval steps of 5 °C between the top four values is mainly caused by constraints of the CMC review protocol [CCT24] in this range.

2.1 PARTICIPANTS

Ten participants were divided into two groups. Each group to 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.

INTA is the coordinator of the comparison and the Pilot for both loops, taking main responsibility for running the comparison. NIST is Assistant Pilot. The third, common participant is BEV/E+E who also covers the full range of the comparison, complementing the capability of NIST.

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

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

Table 2.1.1 List of ten participants (*C* = Coordinator, *P* = Pilot, *L* = Linking laboratory). More details about mailing and electronic addresses are given in Section 12.5.

RMO	NMI	COUNTRY	ROLE
APMP	Korea Research Institute of Standards and Science (KRISS)	KR	
	National Metrology Centre (NMC, A*STAR)	SG	
	National Metrology Institute of Japan (NMIJ), AIST	JP	
COOMET	---	--	
EURAMET	Instituto Nacional de Técnica Aeroespacial (INTA)	ES	***C, P***
	Istituto Nazionale di Ricerca Metrologica (INRiM)	IT	
	National Physical Laboratory (NPL)	GB	
	Physikalisch-Technische Bundesanstalt (PTB)	DE	
	E+E Elektronik Ges.m.b.H. (BEV/E+E)	AT	***L***
SIM	National Institute for Standards and Technology (NIST)	US	***P***

2.2 COMPARISON SCHEME

The key comparison is a comparison of the measurand “realization of local scale of dew-point temperature” at the participating NMIs.

The comparison was made by calibration of travelling standards purchased by Centro Español de Metrología (CEM) and deposited at INTA as part of the Spanish humidity national metrology infrastructure. The travelling standards measured dew point temperature of a sample of moist gas produced by a participant’s standard humidity generator.

The travelling standards are used as comparators of measured dew point temperatures realized by means of the humidity generator systems used by each participant, described in Section 5.

The comparison was carried out in two parallel loops with separate travelling standards. Measurements started in the Pilot and Assistant Pilot laboratories. The other participants in the loop then performed comparison measurements at the dew point temperatures required. The last participant returned the travelling standard to the Pilot to carry out final measurements to monitor drift.

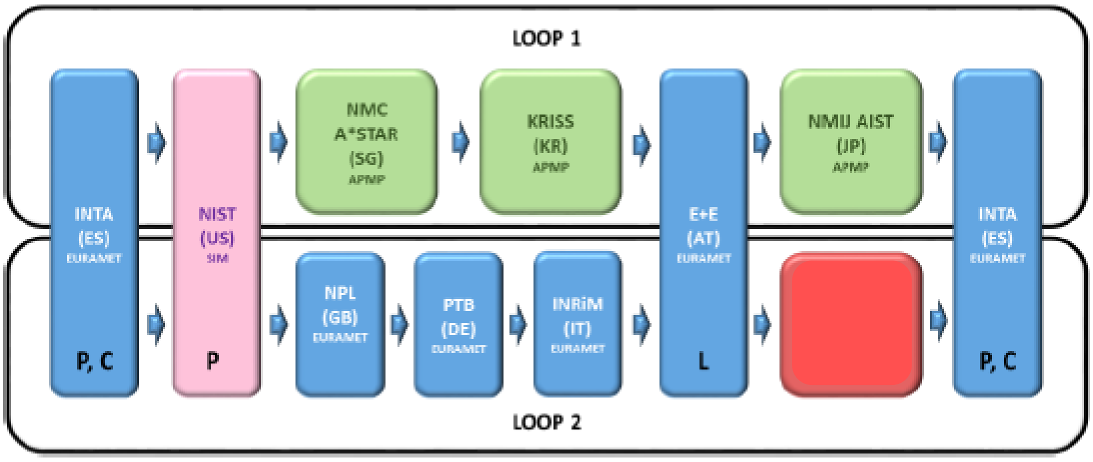


Fig. 2.2.a Original circulation scheme of travelling standards.

However, the original circulation scheme depicted in the above figure was slightly modified after BEV/E+E, adding another data set of INTA for both standards. The reason why this was done was because the ATA Carnets had to come back to Spain to solve some formal issues regarding the absence of some signatures or stamps at customs. So meanwhile INTA took advantage to perform another measurement set to check the performance of the travelling standards.

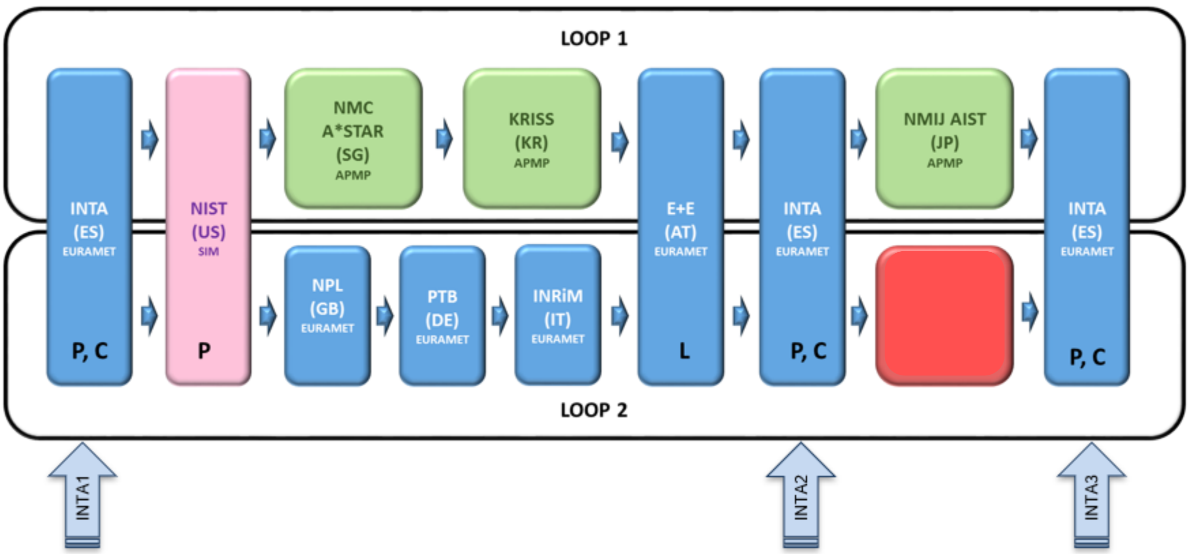


Fig. 2.2.b Final circulation scheme of travelling standards actually carried on after including "INTA 2" measurement set.

2.3 COMPARISON SCHEDULE

The provisional time schedule for this comparison was defined in Appendix B of Technical Protocol [TPR16]. Allowing between 4 and 6 weeks per set of measurements (including shipping) for each participant. It was estimated that comparison would have a duration of approximately 10 months.

However, because of the problems of completing the ATA Carnets and the need to increase their period of validity for one more year, in case there was a delay in the intercomparison after the measurement set performed by BEV/E+E laboratory, new Carnets were obtained and the schedule updated.

The following figures, show the comparison between the estimated and actual time schedule, and the cumulative final delay during the measurement phase of the comparison.

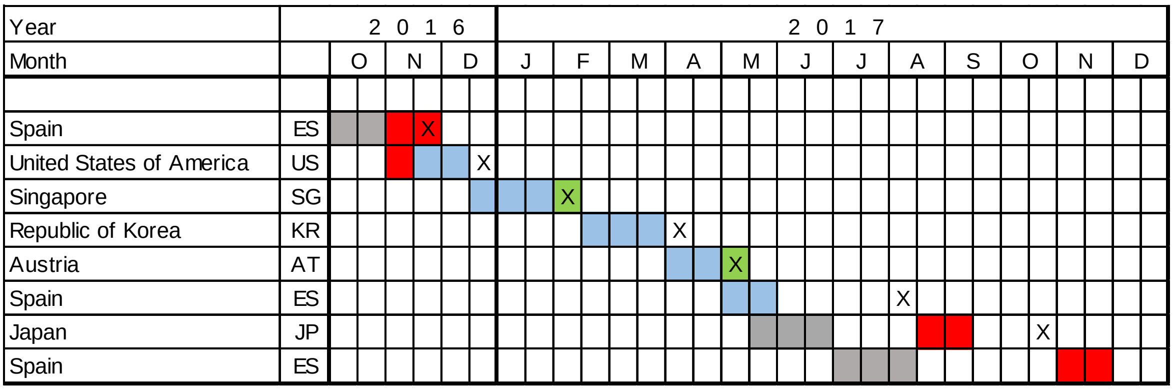


Fig. 2.3.a Final time schedule for the comparison in Loop 1. Each column is equivalent to two weeks. Legend used is as follows: ▒ = measurement, X = measurement / transportation, ▒ =at time; ▒ = before estimation, ▒ = delay

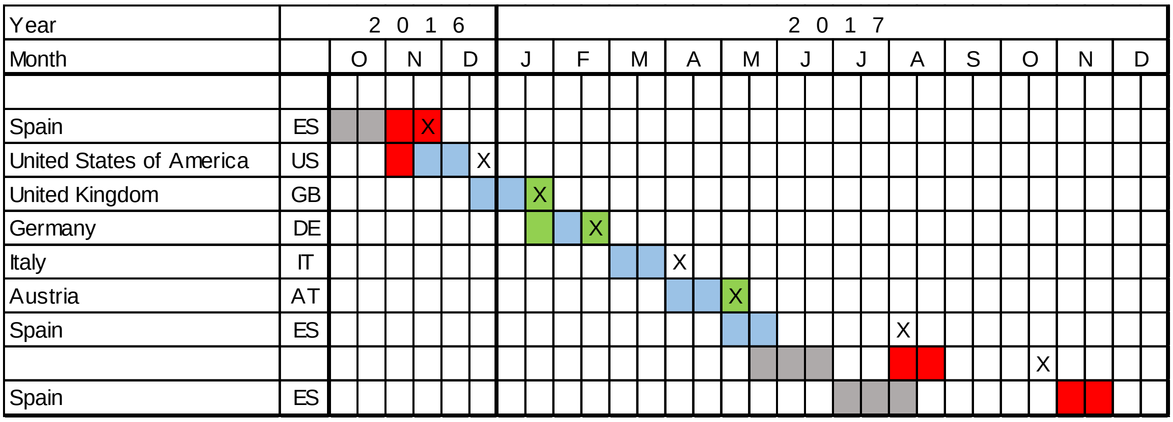


Fig. 2.3.b Final time schedule for the comparison in Loop 2. Each column is equivalent to two weeks. Legend used is the next: ▒ = measurement, X = measurement / transportation, ▒ =at time; ▒ = before estimation, ▒ = delay

As can be seen in the above figures, there was a delay in both loops after the second measurement set performed by INTA. This was not due to technical or metrological issues, but it was the required to solve the formal issue problems previously mentioned in both ATA carnets, as well as manage the shipment to the last participants in both loops simultaneously.

3 COMPARISON METHOD

3.1 TRAVELLING STANDARDS

Centro Español de Metrología (CEM), the Spanish NMI, supplied one travelling standard per loop for the key comparison which were state-of-the-art, commercially available chilled-mirror type of dew point hygrometers when the comparison was approved. The two travelling standards were new and of the same model and their main features can be seen in the following table:

Table 3.1.1 Details of travelling standards

Model	MBW 373 HX
Size (in packing case)	75 x 55 x 58 cm
Weight (in packing case)	40 kg
Manufacturer:	MBW Calibration AG
Owner:	Centro Español de Metrología (CEM)
Electrical supply:	230 V / 50 Hz
Electrical connection:	Instrument socket IEC/EN 60320-2-2 (socket C14/plug C13) The instrument is 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, pressure measurement insert, condensation trap, flowmeter, operating manual
Approximate value for insurance and customs declaration:	40.000 EUR
Serial numbers of the instruments are:	
Loop 1: 08-1215	Loop 2: 08-1216

Both travelling standards were supplied with theirs shipping containers, which were sufficiently robust to ensure safe transportation. In addition, each standard was shipped together with an ATA Carnet and all equipment included in the packing list, which had been described in the technical protocol together with packing and unpacking instructions.

3.2 REPORTING

Each laboratory summarized and reported:

- Seven dew point temperature values, except for those participants whose range does not cover some of the higher nominal values.
- each nominal dew point was reproduced 4 times forming a new condensate layer each time. Measured values by the participants had to be within 0.5 °C of the comparison nominal values.

- each participant measured one travelling standard, except three laboratories (NIST, BEV/E+E and INTA – see Fig. 2.2.b) who measured both standards simultaneously, resulting in thirteen individual transfer standard results.

Participants reported:

- applied dew point from the participant standard generator.
- measured values (both travelling standards simultaneously where applicable).
- difference (measured dew point – applied dew point) for the travelling standards.
- uncertainties associated with these (including short-term standard deviation of travelling standards).
- Difference values (results compared and analyzed in this comparison).

Supporting information was reported, including pressure, temperature and flow rates of sample gas supplied to the hygrometers, and other relevant background information. All measurements were made at nominally (just above) atmospheric pressure and at flow rates after the condensation traps according to the approved version of Protocol.

The dew point values obtained from standard hygrometers were determined based on their measured resistance of the mirror PRT, which was likewise reported for each measured condition of the instrument. This resistance value was converted to a nominal temperature indication by using the nominal PRT resistance-temperature characteristic in the international standard IEC 60751:2008 [IEC08], defined in Annex 12.8.

3.3 IMPARTIALITY

The impartiality of the comparison was ensured by the pilots conserving the confidentiality of the data during the whole intercomparison, that includes no exchange of results between partners. This essential premise was fulfilled for both instruments, during the measurement period and circulation of standards, and during any decisions that had to be taken by the pilots. Any limited data shared during the comparison for the purpose of discussing concerns about the instruments (See Section 4.2) was strictly in coded terms, not absolute values.

Most participants have taken part in their corresponding RMO comparisons, such as: EURAMET.T-K8 whose measurement period was from August 2008 to June 2011; and APMP.T-K8 from January 2012 to December 2015. The following laboratories involved in this situation were: BEV/E+E, INRIM, INTA, PTB and NPL; and KRISS, NMC, A*STAR and NMIJ, respectively. However, there is not a period overlapping with this key comparison and even a time frame long enough to suggest that this affected the blindness of CCT-K8.

4 PERFORMANCE OF THE TRAVELLING STANDARDS

This section details the choice of the travelling standards and the characterization performed before running the comparison. In addition, the problems that appeared during the comparison and their possible influence on the results, are listed.

Finally, a detailed analysis of the performance of the standards during the comparison is included, putting the focus mainly in the standards drift, as one of the best suitability indicators in their choice.

4.1 CHARACTERIZATION AND CHOICE OF TRANSFER STANDARDS

One of the most important decisions to guarantee the success of any comparison is a correct choice of travelling standards. For this comparison two dew point hygrometers based on chilled mirror technology were chosen because they were representative of the state of the art of instruments commonly used by the NMIs worldwide (see Section 3.1).

The main influence quantities that affect the performance of temperature sensors incorporated in the dew point hygrometer are considerable heat flux and conduction effects within an assembly with reduced dimensions and a compact configuration. Hence, these factors need to be considered to mitigate their consequences through careful design and material selection [Ben12a].

An experimental investigation was performed to characterize and choose the most appropriate platinum resistance thermometers (PRT) embedded behind the polished surface on which condensate forms. The work involved evaluating the performance of several probes with two different encapsulation materials (glass and ceramic) to determine their behavior after hysteresis and aging tests. The PRT´s were subjected to thermal treatments, consisting of cycles at temperatures between 0 °C and 150 °C, simulating the performance that the travelling standards would have during the entire intercomparison. Differences of relative stability of probes at 50 °C between the first measurement and those collected after each cycle, was the parameter used to assess their drift behavior [Ben12a].

It was concluded that the most suitable solution was to use PRT probes with ceramic encapsulation of a design that had previously demonstrated excellent results for over two decades [Ben12b]. The manufacturer had switched from ceramic to glass encapsulated probes, because in the low-temperature range hygrometers some these sensors were damaged due to the condensation of ambient water on the porous ceramic of the sensors and subsequent breakage after freezing due to expansion. However, this disadvantage should not be a problem because this comparison is focused on the high dew-point temperature range [Ben12a]. The final set of ceramic encapsulated sensors was also measured at NIST, and the most stable sensors were chosen for the PRT to be measured by the participants and the next best were destined for use as the control sensor used for the digital display.

4.2 PROBLEMS WITH THE TRANSFER STANDARDS

As explained in the previous section, both travelling standards represented the state of the art when the comparison started and incorporated selected sensors after several tests, to guarantee the best steady and reliable behavior. Nevertheless, there were some minor problems throughout the measurement phase of the comparison. The following table details the problems encountered and the adopted solution

Table 4.2.1 List of problems and complications that appeared on travelling standards throughout the whole intercomparison together with solutions adopted.

LOOP	REPORTED BY	FAILURE REPROTED	SOLUTION
1	KRISS	Flow meter digital measurement was failing and reading 1.6 L/min (internal limit)	Flowmeter replaced during second measurement set at INTA.
1	KRISS	Endoscope has some internal condensation; a minor problem but should be fixed.	Endoscope replaced during second measurement set at INTA.
1	BEV/E+E	Photodiode did not come back to 4 V after finishing measurement and turning “mirror control” off. It stayed at 6.5 V.	Detector assembly substituted.
1	BEV/E+E	“Block temperature” goes only up to 103 °C with oscillations of about 0.5 °C instead of 115 °C.	Excess temperature switch was bypassed by soldering a circuit bridge on the board of heating box.
1 & 2	INTA	ATA Carnets: both sent to INTA to correct formal customs issues.	Absence of some stamps and dates corrected.
1	NMIJ	Rotameter Glass tube was broken.	NMIJ used its own rotameter for checking the flow after vapor trap.

The repairs and those interruptions provoked by formal issues relating to international transport, already explained in Section 2.3, caused a 3-month delay on the original comparison schedule (see Fig. 2.3.a and Fig. 2.3.b). However, no significant effect on the long-term features and performances of either instrument was observed, fact verified by means of the stability study carried described in the following section.

4.3 STABILITY STUDY

One of the lessons learned from CCT-K6 was that stability must be one of the issues related to the instruments of greatest concern, mainly in those intercomparisons with long duration and several interventions made to diagnose and repair problems in the travelling standards [Bel15].

Stability of the transfer standards is one of the main components of the uncertainty budget of DoE, KCRV and all NMI differences with respect to these, is a key point to ensure validity of all the comparison parameters between participants.

Hence, it was decided that each travelling standard circulated within only one loop and only linking laboratories measured both instruments. This way, the comparison time was halved compared to the method that all instruments were measured by all participants, as was done in CCT-K6, decreasing risks and consequences from a possible drift.

On the other hand, the performance of the transfer standards during the comparison was monitored on receipt of the instruments, because every participant had to report to the Pilot the first measurement at a nominal dew point temperature of 30 °C within 48 h of it being measured, to check the correct performance of the transfer standard(s) [TPR16].

In addition, drift of both instruments throughout the entire comparison measurement phase was assessed by means of the pilots and link laboratories at the beginning, intermediate and end of the comparison (see Fig. 2.2.b). Regarding that matter, Fig. 4.3.a shows differences between both travelling standards (s/n. 08-1215 and 08-1216) for those laboratories that measured both transfer standards simultaneously. The figure depicts the arithmetic mean of differences of the *n* repeated measurements of each participant measured at each nominal dewpoint, Δt_d^{lab}; together with its corresponding expanded uncertainty, denoted as $U\left(\Delta t_d^{lab}\right)$, which was obtained by multiplying by a coverage factor k = 2, providing a coverage probability higher than 95 %.

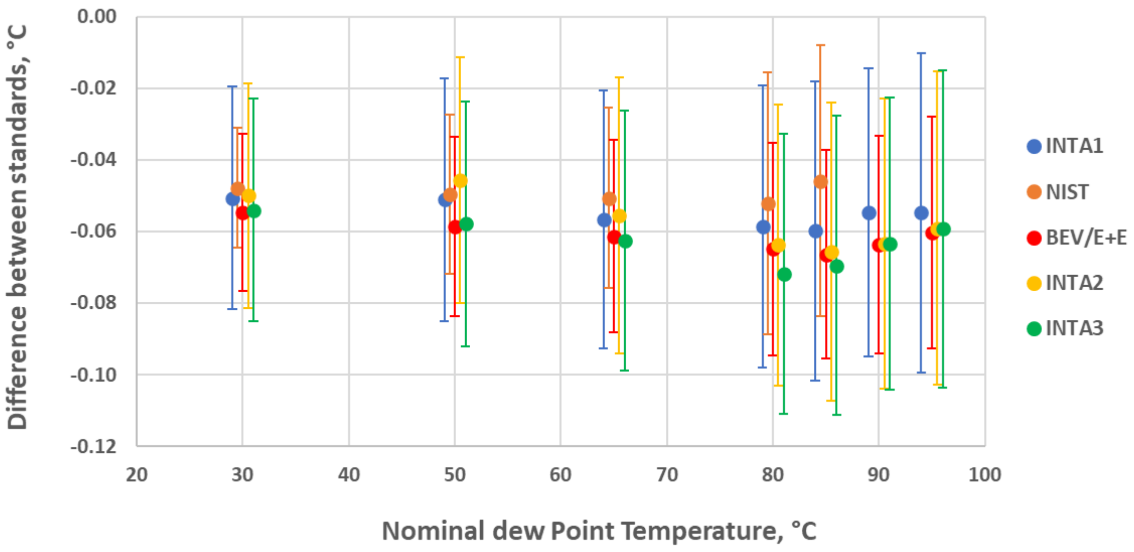
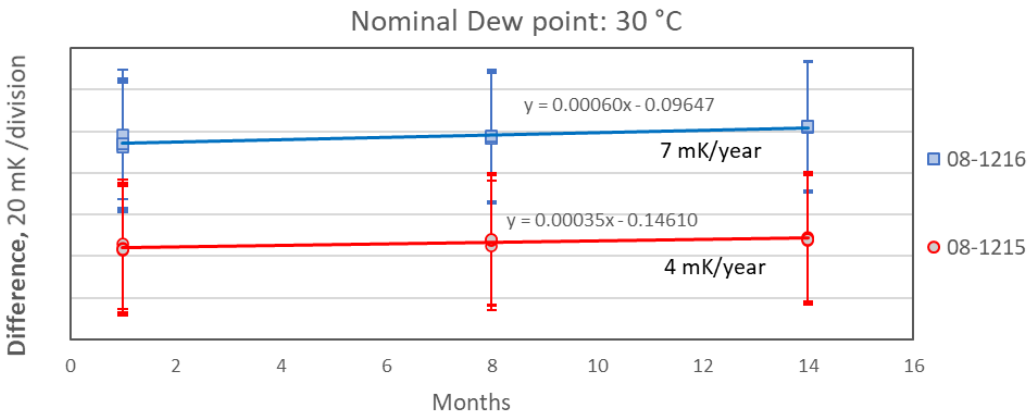


Fig. 4.3.a Difference betweeen both travelling standards measured by all linking laboratories together with their corresponding expanded uncertainty obtained by multiplying by a coverage factor *k* = 2. The three measurement sets performed by INTA were included and denoted by its name followed by a number chronologically chosen. At every nominal dew point data set from each participant has been scattered in 0.50 °C for easy viewing.

As can be seen in the previous figure, the highest differences among the five measurement sets performed by three different participants thought the whole comparison, were practically in all cases less than 20 mK. Considering that the lowest uncertainties reported by these participants were the same order, it seems reasonable to assume that the relative behaviour between both travelling standards did not show any remarkable drift effects or at least could not be recognized according to the measurement capabilities demonstrated by the participants.

To be able to confirm this assumption another study was carried out but, in this case, only those measurement sets performed by INTA were considered because they covered the entire comparison period: beginning, intermediate and end. Potential drift effects coming from transfer standards were evaluated by means of the slope obtained from the linear fit of the differences measured over time, for each hygrometer and at seven nominal dew-point temperatures. The following figures show examples at the extremes of the range:



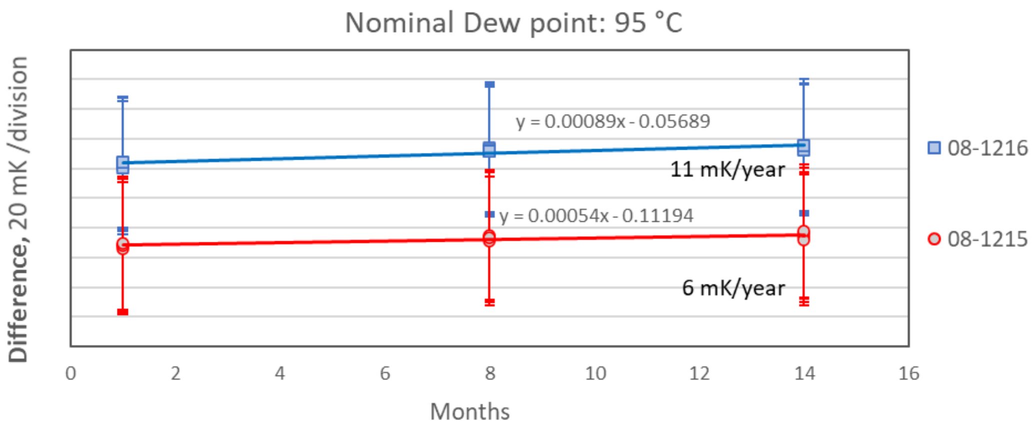


Fig. 4.3.b Drift study performed from differences together with their corresponding expanded uncertainty obtained by multiplying by a coverage factor *k* = 2, collected on three measurement sets of INTA that cover the whole comparison time, allowing the analysis of the drift behaviour of both travelling standards. Two examples at lowest (30 °C) and highest (95 °C) nominal dew-point temperatures are shown.

From the slopes obtained for the fourteen months that the comparison lasted, it is easy to quantify the annual drift of each standard. All slopes obtained from the previous figures are summarized in the following table, for each nominal dew-point temperature. The first conclusion that can be reached is that there is not a clear trend in the drift behaviour as a function of the dew-point temperature in either standard and that the highest drift occurred at the highest nominal dew-point temperature.

Table 4.3.1 Summary table of the drift behaviour shown by the two travelling standards at all nominal dew point temperatures. A colour shading is used as an aid to detect potential drift trends as a function of nominal dew point generated. Lighter shading for lower drift and darker for higher drift.

Nominal DP	Loop 1 08-1215	Loop 2 08-1216
°C	*mK/year*	*mK/year*
30	4.2	7.2
50	3.4	9.1
65	1.7	7.0
80	-6.2	5.8
85	-4.0	4.9
90	-3.5	4.8
95	6.5	10.7
MAX	6.5	10.7
MIN	-6.2	4.8

Using maximum and minimum values of the table, both instruments had a drift within -7 mK/year and 11 mK/year. These variations are of the order of the reproducibility of the instruments and, consistent with the reproducibility in setting the flow rate after the condensation trap according to the measurement instructions described in the protocol [TPR16]. On the other hand, the expanded uncertainties declared by INTA for a confidence level higher than 95 % were between 30 mK and 45 mK, which were in any cases more than three times the variation shown by both instruments.

The uncertainty component due to the stability was considered and calculated as follows:

$$u_{stab(i,j)} = \sqrt{u_{stab,loop1}^2 + u_{stab,loop2}^2} \qquad \text{Eq. 4.3.a}$$

where $u_{stab,loopi}^2 = \frac{|\delta_{stab,max}|}{\sqrt{12}}$, where $|\delta_{stab,max}|$ is the maximum value of the magnitude obtained in each loop from Table 4.3.1.

The table below lists the uncertainty due to the drift in the worst case in both loops, which does not mean that the same behavior was exhibited at all nominal dew point temperatures but was considered as the most representative value of this uncertainty component.

Table 4.3.2 Summary table of the standard uncertainties due to drift for the worst case in both loops for *k* = 1.

	in *mK*
u_{stab} =	3.6
$u_{stab.loop\,1}$ =	1.9
$u_{stab.loop2}$ =	3.1

Thus, according to Table 4.3.1, it can be assumed that both travelling standards did not exhibit significant drift during the comparison period and therefore this effect was considered negligible and, no corrections were performed in this sense throughout the entire data analysis, and the uncertainties showed in Table 4.3.2. were used.

5 LOCAL DEW POINT TEMPERATURE SCALES

A brief description of the humidity generation system used by the participants is summarized below according to the information reported. These systems are still currently used to maintain the local dew-point temperature scales at the date of issue of this report, unless otherwise stated.

5.1 BEV/E+E

The BEV/E+E standard humidity generator is based on the two-pressure generator of the Physikalisch-Technische Bundesanstalt (PTB), with a number of design improvements that lead to an extended range and improved stability and flexibility. In this design, the first level of saturation is provided by a downward helix, followed by two condensers stacked horizontally (as opposed to the vertical position of the original PTB design). This has several advantages for condensate level adjustment within the condensers and also for defining a vertical bath gradient to ensure that the final point of saturation is located in the lower condenser, where little heat transfer is required and the immersion conditions are optimum for temperature measurement and control. The measurement of saturator pressure has also been optimized to avoid the well-known problems associated with humid air in contact with precision pressure sensors. The generator can be operated in the two-pressure mode over the range of dew/frost-point temperatures from −80 °C to +90 °C, and from −60 °C to 95 °C in the single-pressure mode.

The measurements of temperature, pressure, and electrical quantities are traceable to the SI via the Austrian National Standards maintained at BEV. The standard humidity generator used by BEV/E+E is described extensively in [Mit06].

5.2 INRiM

The comparison was made between the 1-P recirculating-type INRIM-01 generator and the transfer standard model MBW 373 HX.

The INRIM-01 primary humidity standard operates according to the principle of a single-pressure, recirculating-type, generator. It covers the dew/frost point temperature range from -25 °C to 95 °C.

The total pressure is kept constant to better than 0.05% at any value between 1000 hPa and 1200 hPa, typically at 1050 hPa, by means of an electronic pressure controller. The pressure controller keeps the pressure stable and constant even when a small gas flow, in the range between 0,5 l/min and 4 l/min in normal conditions, is drawn from the generator to feed dew-point hygrometers under calibration and vented to the ambient. The small flow vented through the dew-point hygrometers is replaced by the same amount of dry gas coming from a pressurized nitrogen/air gas source.

The reference dew-point is established within an isothermal saturator as sole function of its temperature which is measured at the saturator outlet by means of a pair of calibrated PRTs traceable to ITS-90 immersed in the liquid and in the gas flow, respectively. Neglecting any possible difference between the evaporation and condensation temperatures, which for pure water (demineralized water) is below 0.001 °C in both liquid and solid phases, the dew point temperature is the parameter describing the saturation of a gas stream over water and the frost point temperature that for the saturation over ice.

The hygrometer under calibration was connected to the generator outlet by means of a 1.5-m length, 6-mm o.d., heated flexible hose held at a temperature at least 10 °C higher than dew-point temperature. The applied condition to the hygrometer under calibration was estimated from the generated dew point temperature in the saturator after applying a correction to compensate for the pressure drop between the saturator outlet and the hygrometer point of measurement as indicated in the protocol. The correction was experimentally determined during the comparison by means of a calibrated differential pressure gauge and never exceeded 100 Pa.

The mirror PRT of the transfer standard hygrometer was measured by means of a calibrated temperature bridge, model Corradi RP7000, operating with a DC-reversed and pulsed current of 1 mA (with duty-cycle 20 %). The resulting self-heating effect was more than ten times lower than that produced by a DC current of equal magnitude.

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

5.3 INTA

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) [B&M08]. The main saturator in placed in a temperature-controlled bath. The humid gas from the generator was supplied to the transfer standards via 4 mm inner diameter electropolished stainless steel tubes.

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 an 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. Auxiliary 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, pressure).

5.4 KRISS

The KRISS Two-pressure High Dew-point Generator (HDPG) was used to provide the reference dew-point temperature. The humid gas from the generator was supplied to the transfer standards via electropolished stainless steel heated tubes. Saturation temperature was measured using a Hart Scientific model 5686 Standard Platinum Resistance Thermometer. Saturation pressure and pressure at the chilled mirror hygrometer were monitored with Paroscientific model 745 pressure transducers. The mirror PRT of the transfer standard was measured using an ASL model F700 AC Resistance bridge at a current of 1 mA and frequency of 90 Hz.

Measurement traceability to the SI is obtained via by pressure, temperature and electrical standards maintained at KRISS.

5.5 NIST

The NIST Hybrid Humidity Generator (HHG) was used to provide the reference dew-point temperature. This generator produces humidified air with water amount fractions (water mole fractions) ranging from 1.0×10^{-7} to 0.57 using calibration gas flows up to 150 standard liters per minute. At ambient pressure these amount fractions correspond to dew/frost points ranging from –90 °C to +85 °C. The HHG may be used to calibrate instruments measuring water amount fraction, such as cavity ring-down hygrometers. It may also be used to calibrate chilled-mirror hygrometers measuring dew/frost-point temperature when an additional pressure measurement is made at the inlet of the hygrometer.

The HHG combines the two-pressure and divided-flow humidity generation methods (hence the name “hybrid”). The centerpiece of the HHG is a heat exchanger/saturator that is immersed in a temperature-controlled bath stable to within 1 mK. For dew/frost-point temperatures that are above –10.3 °C, the two-pressure method is employed. For frost points at or below –10.3 °C, the water-vapor/air mixture is produced by mixing metered streams of moist air produced by the two-pressure method with purified, dry air.

The generator and its use in the calibration of hygrometers is documented extensively in [Mey21]. The dewpoint standards generated by the HHG are traceable to the International System of Units (SI) through NIST pressure and temperature standards.

5.6 NMC, A*STAR

Measurements were made using two systems. A Thunder Scientific Model 2500 two-pressure humidity generator was used for dew-point temperature in the range from 30 °C to 65 °C. Saturation pressure, chamber pressure, and pressure drop from the generator to the transfer standard dew-point meter were measured using pressure standards traceable to the SI via NMC's national standards. The saturation temperature was measured with a Standard Platinum Resistance Thermometer traceable to ITS-90 via NMC's national standards. Air was the carrying gas. The transfer dew point meter sampled the air from a small chamber made of stainless tube, connected to the generator´s chamber inlet.

A Weiss climatic chamber model WK340 was used as humidity source for dew-point temperatures from 80 °C to 90 °, using an RH Systems dew-point meter model 373LHX calibrated by NPL as the reference standard. Air was the carrying gas and was sampled directly from the chamber.

In both systems, the provided stainless steel heat hose was used for the connection between the transfer hygrometer and the generator/chamber. The transfer standard PRT resistance was measured with a Fluke Model 1529 DC bridge, using a sensing current of 1 mA.

5.7 NMIJ

The primary humidity standard for the high-humidity range at the NMIJ is realized with a two-pressure (2-P) generator developed by the NMIJ. The main components of the NMIJ 2-P generator are a pressure regulator, a pre-saturator, a heat-exchanger, a main saturator, an expansion valve (EV) and a manifold. Pressurized gas (air) at a pressure of Pu is introduced into the pre-saturator and is humidified by bubbling it through water. After passing through a heat-exchanger, final saturation of the gas is achieved by flowing it over the surface of water in the main saturator kept at a temperature of Ts and a pressure of Ps. After this, the gas flows into the manifold through the EV and its pressure is reduced from Ps to Pt. The manifold has multiple outlet ports to connect hygrometers to the 2-P generator. The dew point of the gas at the outlet, Td, is given by:

$$\frac{e_s(T_d)f(P_t,T_d)}{P_t}=\frac{e_s(T_s)f(P_s,T_s)}{P_s} \qquad \text{Eq. 5.7.a}$$

where $e_s(T)$ is the saturation vapor pressure of water at temperature T; $f(P,T)$ is the water vapor enhancement factor at pressure P and temperature T, which corrects for the non-ideal behavior of the humid gas. By measuring T_s, P_s, and *Pt*, we can accurately determine T_d by using Eq. 5.7.a with an iterative method, and by controlling *Ts* and P_u, we can achieve stable generation of humid gas with a target dew point T_d. T_s and *Ps* can be controlled in the ranges of 5 °C to 98 °C and 100 kPa to 600 kPa, respectively. The range of T_d that can be generated is -10 °C to 95 °C. The measurement results of T_s, P_s, and P_t are traceable to the International System of Units (SI) through the NMIJ primary measurement standards.

5.8 NPL

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 dewpoint temperature. Traceability of measurement was provided by calibration of this thermometer to the International Temperature Scale of 1990 (ITS90) through NPL Temperature Standards.

Air of a known dewpoint 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.

5.9 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 Tinsley SPRT PT-25. Each of the two relevant pressure values (saturator and point-of-use) is measured using an MKS Baratron® pressure transmitter. Both, temperature and pressure measurements, are directly traceable to the national standards of Germany. The generated moist air stream is directed to the transfer standard via a heated line and 6 mm

Swagelok® tubing. The resistance value of the second PRT of the mirror of the transfer standard is read using an ASL F17 resistance bridge.

The vapor pressures and enhancement factors used in the calculation of the reference dew-point temperature are given in [Gre76, Son90, Har98].

6 MEASUREMENT RESULTS

Dew-point temperatures reported, and used along all this report were calculated values from the measured resistance output, by means of the international standard IEC 60751:2008 [IEC08], described in Section 12.8 and previously selected by all participants.

The evaluation is based on that of EURAMET.T-K6 [Hei08] and CCT-K6 [Bel15]. Measurement results reported by all participating laboratories were annexed in Section 12.6, as well as the uncertainty budget in Section 12.7.

6.1 ANALYSIS OF RESULTS

Each participating laboratory reported both dew-point temperature generated (laboratory reference), $t_{d,i}^{ref}$, and dew-point temperature measured by the transfer standard, $t_{d,i}^{hyg}$, for each nominal dew-point temperature, t_d. This was repeated four times for each nominal dew point generated. Thus, difference between them for each point *i*, $\Delta t_{d,i}^{lab}$ is given by:

$$\Delta t_{d,i}^{lab} = t_{d,i}^{hyg} - t_{d,i}^{ref} \qquad \text{Eq. 6.1.a}$$

This way, four values for each nominal dew point temperature, together with a single value obtained from the mean of these, was reported by the participants using the approved template (Section 12.6).

The method of analysis used comprises three main steps:

1. Determination of the linking path between loops
    a. Function $B_{i,j}$ (Section 12.1.1)
    b. Consistency test of $B_{i,j}$ (Section 12.1.2)
2. Bilateral equivalence, *DoE* (Section 7.1)
3. Key Comparison Reference Values, KCRV (Section 12.2)
    a. Consistency test inter-laboratory (Section 8.2)

Details on the analysis is given in the section indicated for each step.

In the following two figures, the differences reported from every participant with their corresponding measurement uncertainty are depicted:

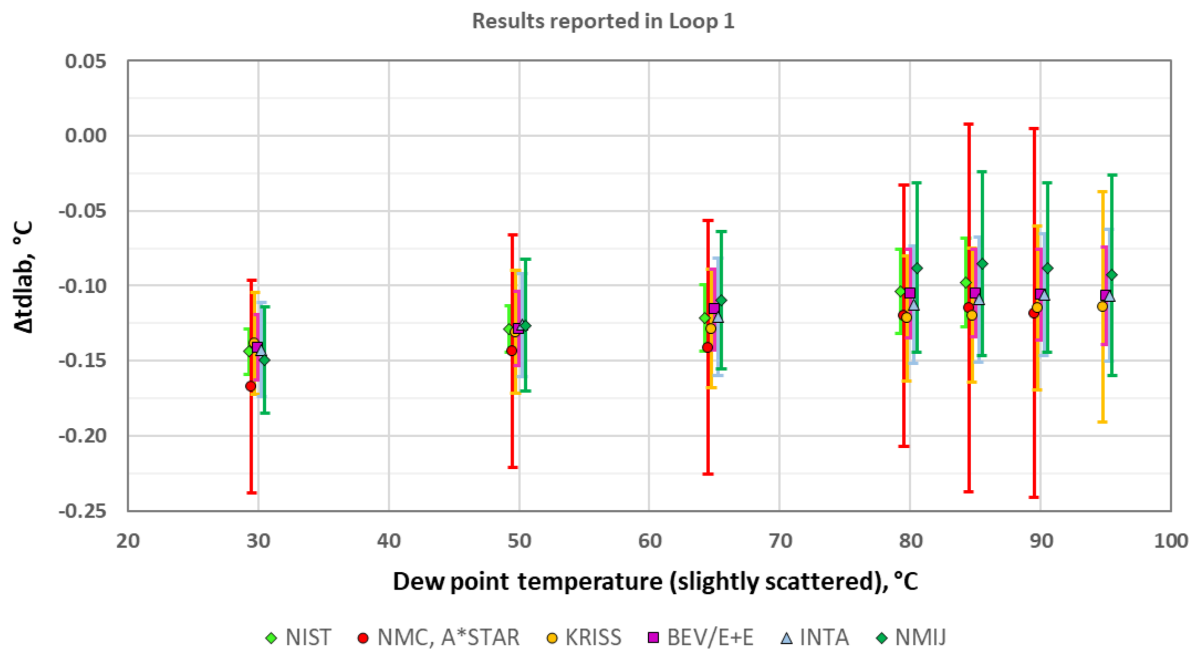


Fig. 6.1.a Results reported for each participant in Loop 1, together with their expanded uncertainty for a coverage factor *k* = 2. At every nominal dew point data set from each participant has been scattered in 0.25 °C for easy viewing.

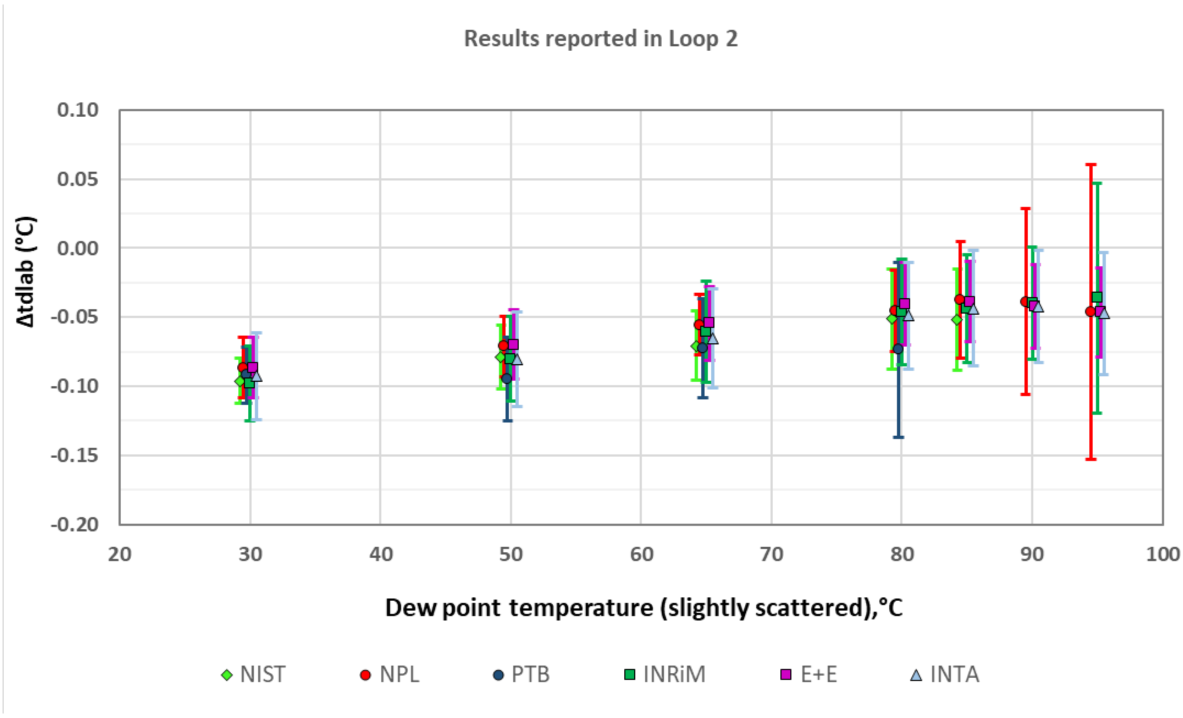


Fig. 6.1.b Results reported for each participant in Loop 2, together with their expanded uncertainty for a coverage factor *k* = 2. At every nominal dew point data set from each participant has been scattered in 0.25 °C for easy viewing.

7 BILATERAL EQUIVALENCE

7.1 ANALYSIS METHOD

The bilateral equivalence, D_{ij}, of laboratory *i* and *j*, also known as Degrees of Equivalence (*DoE*) were initially obtained from:

$$D_{ij} = \Delta t_d^i - \Delta t_d^j + \delta_{stab} = \Delta t_{d,loop(i)}^i + B_{i,j} - \Delta t_{d,loop(j)}^j + \delta_{stab} \quad \text{Eq. 7.1.a}$$

The subscripts *loop(i)* and *loop(j)* mark the loop of laboratory *i* and *j*, respectively. The stability term, δ_{stab}, was considered zero because drift effects of both travelling standards were neglected (see section 4.3), but their contribution due to stability of the transfer standards, as summarized in Table 4.3.2, were considered in the uncertainty budget.

The discrete function B_{ij} was used to calculate the linkage between both loops and was obtained from each link-laboratory given that they could measure simultaneously both standards in parallel four times, so for each link-laboratory and each artefact there were four single measurements at all nominal dew points. Calculation of function *B* is detailed in annexes in Section 12.1.1. according to the following definition of the function *B:*

$$B_{i,j} = result.loop.j - result.loop.i \quad \text{Eq. 7.1.b}$$

This means that a positive $B_{i,j}$ gives larger results in loop 2 than in loop 1 at a given nominal dew point temperature. On the other hand, it is meet that $B_{i,j} = -B_{j,i}$, which means that the way to calculate the difference between a participant of loop 1 and another from loop 2 is just the opposite than calculating the difference between the same participant of loop 2 regarding to the other same participant from loop 1. In addition, as can be seen in Eq. 12.1.a, according to the parameter's own definition B_{ij}, when laboratory *i* and *j* participated in the same loop $B_{i,j}$ is equal to zero.

However, as will be explained in Section 8, the key comparison reference value (KCRV) calculation method used, had to simplify the intercomparison scheme to a single loop, denominated virtual loop, in which a supposed virtual transfer standard was measured by all participants.

The way to create this virtual loop was from the function *B* to generate a virtual transfer standard with an intermediate behaviour between both hygrometers that circulated in loop 1 and 2. In this sense, the correction factor C_{loop} was used and defined according to the following equations:

$$C_{loop.1} = C_1 = \frac{B_{i,j}}{2} \quad \text{Eq. 7.1.c}$$

$$C_{loop.2} = C_2 = \frac{B_{j,i}}{2} = -\frac{B_{i,j}}{2} \quad \text{Eq. 7.1.d}$$

The uncertainty of this factor is determined by the following general expression:

$$u\left(\frac{x}{2}\right) = \frac{\partial\left(\frac{x}{2}\right)}{\partial x} \cdot u(x) = \frac{1}{2}u(x)$$ Eq. 7.1.e

Thus, being consistent with such model, the uncertainty of the correction factor $C_{loop(i)}$ was given as follows:

$$u\left(C_{loop}\right) = \frac{1}{2}u(B_{i,j}) = \frac{1}{2}u\left(B_{j,i}\right)$$ Eq. 7.1.f

Finally, the bilateral equivalence of different participants can be directly calculated using the harmonized laboratory results, $\Delta t_d^{(i)\prime}$, according to next equation:

$$D_{ij} = \Delta t_d^{(i)\prime} - \Delta t_d^{(j)\prime} + \delta_{stab.loop.v}$$ Eq. 7.1.g

where: $\Delta t_d^{(i)\prime}$ is the harmonized result of laboratory *i* in the virtual loop with only one virtual transfer standard and is calculated as follows:

$$\Delta t_d^{(i)\prime} = \Delta t_d^{(i)} + C_{loop(i)}$$ Eq. 7.1.h

$\delta_{stab.loop.v}$ is the stability of the virtual loop calculated as the average of the stability of the two real loops, both considered negligible (see section 4.3):

$$\delta_{stab.loop.v} = \frac{1}{2} \cdot \left(\delta_{stab.loop.1} + \delta_{stab.loop.2}\right) = 0$$ Eq. 7.1.i

The uncertainty associated to the bilateral equivalence considering this virtual loop is fully explained in Section 12.1.3 of the annexes.

7.2 RESULTS

As was previously mentioned, an essential condition to be met by linking laboratories in the loop difference calculation is that both artefacts should be measured in parallel and simultaneously with a symmetrical setup. All measurements that fulfil this condition are considered statistically independent. In other words, loop difference and related uncertainty are not a property of the applied reference but a property of the travelling standards.

Therefore, it was considered the most appropriate to include the three INTA measurements, not only as a broad data pool as possible and reasonable, but INTA had data from the beginning until the end of the comparison, which confers an extra added value to this study.

The calculated values of function $B_{i,j}$ and the corresponding uncertainties are shown in the table below:

Table 7.2.1 Calculated values of $\boldsymbol{B_{i,j}}$ and the related uncertainties (k = 1) used when loop(i) ≠ loop(j) and for each nominal dew-point temperatures.

	Nominal Dew Point in °C						
	30	**50**	**65**	**80**	**85**	**90**	**95**
$\boldsymbol{B_{i,j}}$	0.0517	0.0574	0.0601	0.0643	0.0658	0.0627	0.0598
$\boldsymbol{u(B_{i,j})}$ **(*k* = 1)**	0.0020	0.0023	0.0016	0.0024	0.0024	0.0029	0.0012

The bilateral degrees of equivalence (DoE) for each nominal dew point temperature are shown in Table 7.2.2 to Table 7.2.8, together with related expanded uncertainties, $U(D_{ij})$, given by multiplying by two the $u(D_{ij})$.

Table 7.2.2 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 30 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 30 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	-0.006	0.032	0.000	0.045	-0.011	0.044	0.018	0.077	-0.005	0.042	-0.008	0.035	-0.011	0.035	-0.006	0.034
NIST	0.006	0.032	-	-	0.006	0.039	-0.005	0.038	0.024	0.073	0.001	0.036	-0.003	0.028	-0.006	0.028	0.000	0.027
NMIJ	0.000	0.045	-0.006	0.039	-	-	-0.011	0.049	0.018	0.080	-0.005	0.047	-0.008	0.042	-0.011	0.042	-0.006	0.041
KRISS	0.011	0.044	0.005	0.038	0.011	0.049	-	-	0.029	0.079	0.006	0.046	0.003	0.041	0.000	0.041	0.005	0.040
NMC, A*STAR	-0.018	0.077	-0.024	0.073	-0.018	0.080	-0.029	0.079	-	-	-0.023	0.078	-0.026	0.075	-0.029	0.075	-0.024	0.074
INTA	0.005	0.042	-0.001	0.036	0.005	0.047	-0.006	0.046	0.023	0.078	-	-	-0.003	0.038	-0.006	0.038	-0.001	0.038
BEV/E+E	0.008	0.035	0.003	0.028	0.008	0.042	-0.003	0.041	0.026	0.075	0.003	0.038	-	-	-0.003	0.031	0.002	0.030
NPL	0.011	0.035	0.006	0.028	0.011	0.042	0.000	0.041	0.029	0.075	0.006	0.038	0.003	0.031	-	-	0.005	0.030
PTB	0.006	0.034	0.000	0.027	0.006	0.041	-0.005	0.040	0.024	0.074	0.001	0.038	-0.002	0.030	-0.005	0.030	-	-

Table 7.2.3 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 50 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 50 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	-0.009	0.039	-0.011	0.054	-0.007	0.052	0.006	0.084	0.000	0.047	-0.009	0.042	-0.009	0.039	0.015	0.044
NIST	0.009	0.039	-	-	-0.002	0.050	0.002	0.047	0.015	0.081	0.009	0.041	0.000	0.035	0.000	0.031	0.024	0.038
NMIJ	0.011	0.054	0.002	0.050	-	-	0.004	0.060	0.017	0.090	0.012	0.056	0.002	0.052	0.002	0.049	0.026	0.054
KRISS	0.007	0.052	-0.002	0.047	-0.004	0.060	-	-	0.013	0.088	0.007	0.054	-0.002	0.049	-0.002	0.047	0.022	0.051
NMC, A*STAR	-0.006	0.084	-0.015	0.081	-0.017	0.090	-0.013	0.088	-	-	-0.006	0.085	-0.015	0.083	-0.015	0.081	0.009	0.084
INTA	0.000	0.047	-0.009	0.041	-0.012	0.056	-0.007	0.054	0.006	0.085	-	-	-0.009	0.044	-0.009	0.041	0.014	0.046
BEV/E+E	0.009	0.042	0.000	0.035	-0.002	0.052	0.002	0.049	0.015	0.083	0.009	0.044	-	-	0.000	0.035	0.024	0.041
NPL	0.009	0.039	0.000	0.031	-0.002	0.049	0.002	0.047	0.015	0.081	0.009	0.041	0.000	0.035	-	-	0.024	0.038
PTB	-0.015	0.044	-0.024	0.038	-0.026	0.054	-0.022	0.051	-0.009	0.084	-0.014	0.046	-0.024	0.041	-0.024	0.038	-	-

Table 7.2.4 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 65 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 65 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	0.001	0.046	-0.011	0.061	0.008	0.054	0.021	0.094	0.005	0.052	-0.005	0.046	-0.005	0.043	0.012	0.052
NIST	-0.001	0.046	-	-	-0.012	0.054	0.007	0.047	0.020	0.090	0.004	0.045	-0.006	0.038	-0.006	0.035	0.011	0.045
NMIJ	0.011	0.061	0.012	0.054	-	-	0.019	0.062	0.031	0.098	0.016	0.060	0.006	0.055	0.006	0.053	0.023	0.060
KRISS	-0.008	0.054	-0.007	0.047	-0.019	0.062	-	-	0.013	0.094	-0.003	0.054	-0.013	0.048	-0.013	0.045	0.004	0.053
NMC, A*STAR	-0.021	0.094	-0.020	0.090	-0.031	0.098	-0.013	0.094	-	-	-0.016	0.093	-0.025	0.090	-0.026	0.089	-0.008	0.093
INTA	-0.005	0.052	-0.004	0.045	-0.016	0.060	0.003	0.054	0.016	0.093	-	-	-0.010	0.046	-0.010	0.043	0.007	0.051
BEV/E+E	0.005	0.046	0.006	0.038	-0.006	0.055	0.013	0.048	0.025	0.090	0.010	0.046	-	-	0.000	0.035	0.017	0.045
NPL	0.005	0.043	0.006	0.035	-0.006	0.053	0.013	0.045	0.026	0.089	0.010	0.043	0.000	0.035	-	-	0.017	0.042
PTB	-0.012	0.052	-0.011	0.045	-0.023	0.060	-0.004	0.053	0.008	0.093	-0.007	0.051	-0.017	0.045	-0.017	0.042	-	-

Table 7.2.5 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 80 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 80 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	-0.007	0.058	-0.022	0.070	0.011	0.058	0.009	0.096	0.003	0.055	-0.005	0.051	-0.001	0.050	0.028	0.075
NIST	0.007	0.058	-	-	-0.016	0.071	0.018	0.059	0.016	0.097	0.010	0.057	0.002	0.053	0.006	0.052	0.034	0.076
NMIJ	0.022	0.070	0.016	0.071	-	-	0.034	0.071	0.032	0.105	0.025	0.069	0.017	0.066	0.022	0.065	0.050	0.085
KRISS	-0.011	0.058	-0.018	0.059	-0.034	0.071	-	-	-0.002	0.097	-0.008	0.057	-0.016	0.053	-0.012	0.052	0.016	0.076
NMC, A*STAR	-0.009	0.096	-0.016	0.097	-0.032	0.105	0.002	0.097	-	-	-0.006	0.096	-0.014	0.093	-0.010	0.093	0.018	0.108
INTA	-0.003	0.055	-0.010	0.057	-0.025	0.069	0.008	0.057	0.006	0.096	-	-	-0.008	0.050	-0.004	0.049	0.025	0.074
BEV/E+E	0.005	0.051	-0.002	0.053	-0.017	0.066	0.016	0.053	0.014	0.093	0.008	0.050	-	-	0.004	0.044	0.033	0.071
NPL	0.001	0.050	-0.006	0.052	-0.022	0.065	0.012	0.052	0.010	0.093	0.004	0.049	-0.004	0.044	-	-	0.028	0.070
PTB	-0.028	0.075	-0.034	0.076	-0.050	0.085	-0.016	0.076	-0.018	0.108	-0.025	0.074	-0.033	0.071	-0.028	0.070	-	-

Table 7.2.6 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 85 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 85 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	-0.012	0.058	-0.024	0.074	0.010	0.060	0.005	0.130	0.000	0.058	-0.004	0.050	-0.006	0.059	-	-
NIST	0.012	0.058	-	-	-0.013	0.074	0.022	0.060	0.017	0.130	0.012	0.058	0.007	0.050	0.006	0.059	-	-
NMIJ	0.024	0.074	0.013	0.074	-	-	0.034	0.076	0.030	0.138	0.024	0.075	0.020	0.068	0.018	0.075	-	-
KRISS	-0.010	0.060	-0.022	0.060	-0.034	0.076	-	-	-0.005	0.131	-0.010	0.061	-0.014	0.053	-0.016	0.061	-	-
NMC, A*STAR	-0.005	0.130	-0.017	0.130	-0.030	0.138	0.005	0.131	-	-	-0.005	0.131	-0.010	0.127	-0.011	0.131	-	-
INTA	0.000	0.058	-0.012	0.058	-0.024	0.075	0.010	0.061	0.005	0.131	-	-	-0.004	0.051	-0.006	0.060	-	-
BEV/E+E	0.004	0.050	-0.007	0.050	-0.020	0.068	0.014	0.053	0.010	0.127	0.004	0.051	-	-	-0.002	0.051	-	-
NPL	0.006	0.059	-0.006	0.059	-0.018	0.075	0.016	0.061	0.011	0.131	0.006	0.060	0.002	0.051	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7.2.7 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 90 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 90 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C	D_{ij} in °C	U_{ij} (k = 2) in °C
INRiM	-	-	-	-	-0.015	0.070	0.012	0.069	0.015	0.130	0.003	0.059	0.003	0.052	-0.001	0.079	-	-
NIST	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMIJ	0.015	0.070	-	-	-	-	0.027	0.079	0.030	0.136	0.017	0.070	0.018	0.064	0.013	0.088	-	-
KRISS	-0.012	0.069	-	-	-0.027	0.079	-	-	0.003	0.135	-0.010	0.069	-0.009	0.063	-0.013	0.087	-	-
NMC, A*STAR	-0.015	0.130	-	-	-0.030	0.136	-0.003	0.135	-	-	-0.013	0.130	-0.012	0.127	-0.017	0.141	-	-
INTA	-0.003	0.059	-	-	-0.017	0.070	0.010	0.069	0.013	0.130	-	-	0.001	0.052	-0.004	0.079	-	-
BEV/E+E	-0.003	0.052	-	-	-0.018	0.064	0.009	0.063	0.012	0.127	-0.001	0.052	-	-	-0.004	0.074	-	-
NPL	0.001	0.079	-	-	-0.013	0.088	0.013	0.087	0.017	0.141	0.004	0.079	0.004	0.074	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7.2.8 Degree of equivalence (DoE) between the participants of CCT-K8 at dew-point temperature 95 °C. DoE is expressed as (D_{ij}, U_{ij}), where *i* is the row and *j* the column laboratory.

DoE DP = 95 °C	INRiM		NIST		NMIJ		KRISS		NMC, A*STAR		INTA		BEV/E+E		NPL		PTB	
	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (k = 2)	D_{ij}	U_{ij} (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
INRiM	-	-	-	-	-0.003	0.099	0.018	0.106	-	-	0.011	0.086	0.011	0.081	0.010	0.129	-	-
NIST	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NMIJ	0.003	0.099	-	-	-	-	0.021	0.102	-	-	0.014	0.081	0.014	0.075	0.013	0.126	-	-
KRISS	-0.018	0.106	-	-	-0.021	0.102	-	-	-	-	-0.007	0.089	-0.007	0.084	-0.008	0.132	-	-
NMC, A*STAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INTA	-0.011	0.086	-	-	-0.014	0.081	0.007	0.089	-	-	-	-	0.000	0.056	-0.001	0.116	-	-
BEV/E+E	-0.011	0.081	-	-	-0.014	0.075	0.007	0.084	-	-	0.000	0.056	-	-	0.000	0.112	-	-
NPL	-0.010	0.129	-	-	-0.013	0.126	0.008	0.132	-	-	0.001	0.116	0.000	0.112	-	-	-	-
PTB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Finally, in view of the results obtained in all DoE data tables (Table 7.2.2 to Table 7.2.8), which represent the entire data group analysed, it can be concluded that all participants exhibited very strong cross-correlation among themselves in all cases studied. This assessment is founded on which the resulting DoE were lower than the related uncertainties by a factor of at least of 2 times in the worst case, except between NMIJ and PTB at 80 °C nominal dew point temperature.

8 KEY COMPARISON REFERENCE VALUE

In this comparison, as well as in its equivalents RMOs, a reference value is calculated for each nominal dew point temperature. The availability of reference values is essential to the use of comparison results for review of CMC claims by NMIs and DIs worldwide.

The key comparison reference value reported is the reference value resulting from the measurements taken in this CIPM key comparison, accompanied by its measurement uncertainty.

Only primary realizations were considered to obtain the final KCRV. For this reason, the data set of NMC, A*STAR laboratory at 80 °C, 85 °C and 90 °C dew point temperatures were excluded from the KCRV calculation, because its standard has metrological traceability to SI via NPL humidity standards.

On the other hand, the KCRV calculation method only considered one data set of INTA, specifically the second, or intermediate measurement, in such way that first and third measurement set of INTA are only used to carry out the travelling standards drift study and the different paths between loops for setting robust bilateral equivalences among all participants. And finally, the three link laboratories were treated as normal participants, considering only one measurement set in one loop, i.e., NIST and BEV/E+E in loop 1, and INTA in loop 2; in this way, the contribution of these three laboratories to the KCRVs was not enhanced.

8.1 CALCULATION METHOD

Calculation of the KCRV was based on the procedure developed by M. Cox [Cox02], specially applied according to H. Mitter's comments and recommendations [Mit21] during detailed discussions with the pilot, assistant pilot and coordinator of EURAMET-T.K8 [Des23].

The CCT-K8 was performed with two transfer standards circulating in two loops, with one artefact per loop and, as already mentioned before, this would lead to a set of data for each loop and finally in two loop reference values (not KCRVs). However, a single KCRV must be obtained, for each nominal dew point for the key comparison [CIPM21]. For this matter, the results of all participants had to be harmonized to one single result of KCRV. Such harmonization of two loops was carried out through a virtual artefact equidistant of the two loop-results by normalizing the results of both loops by half the loop difference $B_{i,j}$, applying the correction factor C_{loop}.

Participation of every NMI was usually expressed as the difference between the measurement results for each participant and the KCRV, once the harmonization results previously explained in Section 7.1, were applied for each nominal dew point temperature evaluated according to the following expression:

$$\Delta t_{KCRV}^{(i)'} = \Delta t_d^{(i)'} - \Delta t_d^{KCRV} \qquad \text{Eq. 8.1.a}$$

The calculation method of the KCRV for the harmonized virtual loop, the linking uncertainties, and the difference between the participants and the KCRV together with the associated uncertainty, is given in detail in Section 12.2 of the annexes.

8.2 CONSISTENCY TEST AND DISCUSSION

The inter-laboratory consistency results were evaluated according to the chi-squared test to the difference of participant with the KCRV. The same criterion defined in CCT-K6 [Bel15] was used, making differentiation between those laboratories which contribute or not to the KCRV and similarly to the uncertainty of the laboratory difference to the KCRV.

The following inequations give the discrepancy criterion, where special attention to the signs of the different terms must be paid, according to H. Mitter's proposal [Mit21].

- If laboratory contributes to KCRV, there is a correlation between $\Delta t_d^{lab'}$ and Δt_d^{KCRV}:

$$\left|\Delta t_d^{lab'} - \Delta t_d^{KCRV}\right| > 2 \cdot \sqrt{u^2\left(\Delta t_d^{lab'}\right) - u^2\left(\Delta t_d^{KCRV}\right) + u^2{}_{stab.loop.v(lab)}} \quad \text{Eq. 8.2.a}$$

- If laboratory does not contribute to KCRV which means that there is no correlation between $\Delta t_d^{lab'}$ and Δt_d^{KCRV}:

$$\left|\Delta t_d^{lab'} - \Delta t_d^{KCRV}\right| > 2 \cdot \sqrt{u^2\left(\Delta t_d^{lab'}\right) + u^2\left(\Delta t_d^{KCRV}\right) + u^2{}_{stab.loop.v(lab)}} \quad \text{Eq. 8.2.b}$$

The following figure shows the results of all participants for each nominal dew-point temperature in relation to the criterion used to identify possible outliers.

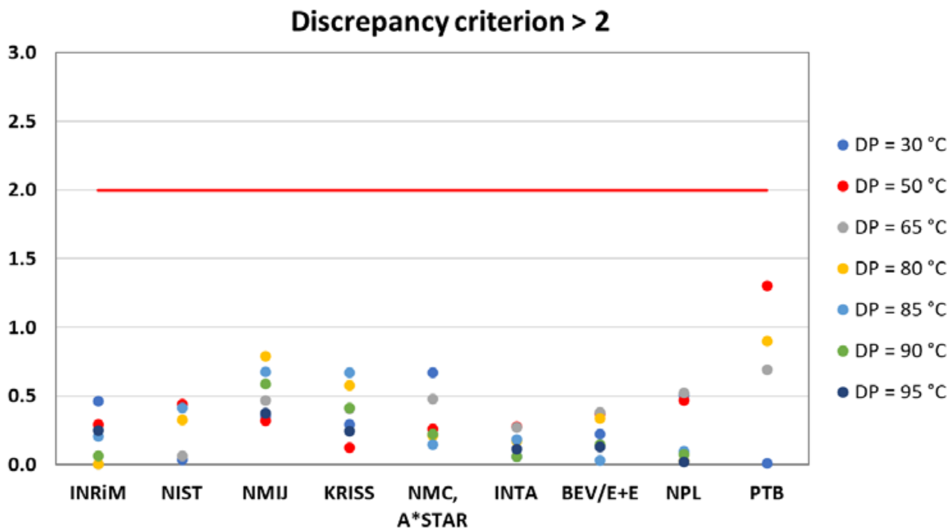


Fig. 8.2.a Results of evaluation of outliers criterion for the calculation of the KCRV taking into account only independent measurements.

As can be seen in the above figure, absolutely all participants and for every nominal dew point temperature which they measured, meet with the inter-laboratory consistency test applied. This is the most graphic example not only for the excellent results shown by all participants, but also about the great performance of both travelling standards which were previously chosen according to a thorough characterization of standards before launching this intercomparison.

8.3 RESULTS

The KCRV results of all laboratories together with their associated uncertainties are given in Table 8.3.2 and depicted in the following figures.

Table 8.3.1 Summary table of the KCRV obtained with their corresponding expanded uncertainty using a coverage factor (k = 2) for a probability higher that 95 %.

	Nominal DP in °C						
	30	**50**	**65**	**80**	**85**	**90**	**95**
KCRV	-0.118	-0.104	-0.091	-0.078	-0.073	-0.073	-0.075
***U* (KCRV) (*k* = 2)**	0.009	0.011	0.012	0.014	0.016	0.018	0.022

Table 8.3.2 Summary table of the difference between the harmonized participant result, $\Delta t_d^{lab'}$, minus the calculated KCRVs for each nominal dew point temperature, Δt_d^{KCRV}, in Celsius degrees. Every difference value comes together with its expanded uncertainty of the partly correlated weighted mean at a coverage probability of 95 %.

KCRV	DP = 30 °C		DP = 50 °C		DP = 65 °C		DP = 80 °C		DP = 85 °C		DP = 90 °C		DP = 95 °C	
	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *k* = 2	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$ *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
	-0.118	**0.009**	**-0.104**	**0.011**	**-0.091**	**0.012**	**-0.078**	**0.014**	**-0.073**	**0.016**	**-0.073**	**0.018**	**-0.075**	**0.022**
INRiM	-0.006	0.026	-0.004	0.030	0.000	0.036	0.000	0.037	-0.004	0.038	0.001	0.038	0.009	0.070
NIST	0.000	0.015	0.005	0.020	-0.001	0.024	0.007	0.040	0.008	0.038	-	-	-	-
NMIJ	-0.006	0.035	0.007	0.043	0.011	0.046	0.022	0.056	0.020	0.060	0.016	0.054	0.012	0.064
KRISS	0.005	0.033	0.002	0.040	-0.008	0.038	-0.011	0.040	-0.014	0.042	-0.011	0.052	-0.009	0.074
NMC, A*STAR	-0.024	0.071	-0.010	0.077	-0.020	0.085	-0.010	0.089	-0.009	0.12	-0.014	0.12	-	-
INTA	-0.001	0.030	-0.005	0.033	-0.005	0.035	-0.003	0.036	-0.004	0.039	-0.001	0.038	-0.002	0.039
BEV/E+E	0.002	0.021	0.005	0.025	0.005	0.025	0.005	0.029	0.000	0.025	-0.002	0.025	-0.002	0.026
NPL	0.005	0.021	0.005	0.020	0.005	0.020	0.000	0.027	0.002	0.040	0.002	0.065	-0.001	0.10
PTB	0.000	0.019	-0.019	0.029	-0.012	0.035	-0.028	0.062	-	-	-	-	-	-

Blue data are those values traceable to another NMI participant in the CCT-K8, that to say not independent, and therefore not taken into account to calculate the KCRV at those nominal dew-point temperatures**.**

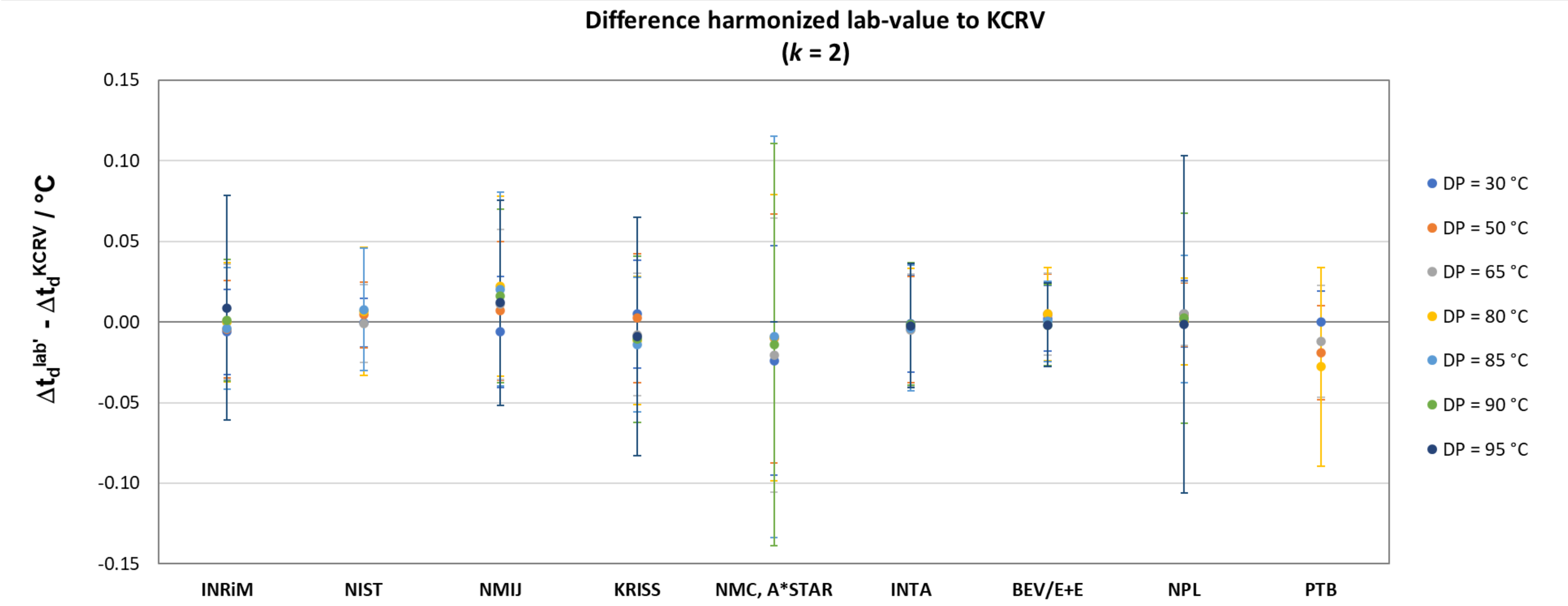


Fig. 8.3.a The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRV for each nominal dew point temperature, in degrees Celsius. Error bars show the expanded uncertainty for a coverage probability of 95 %.

The figure above is divided into different graphs for each nominal dew point evaluated:

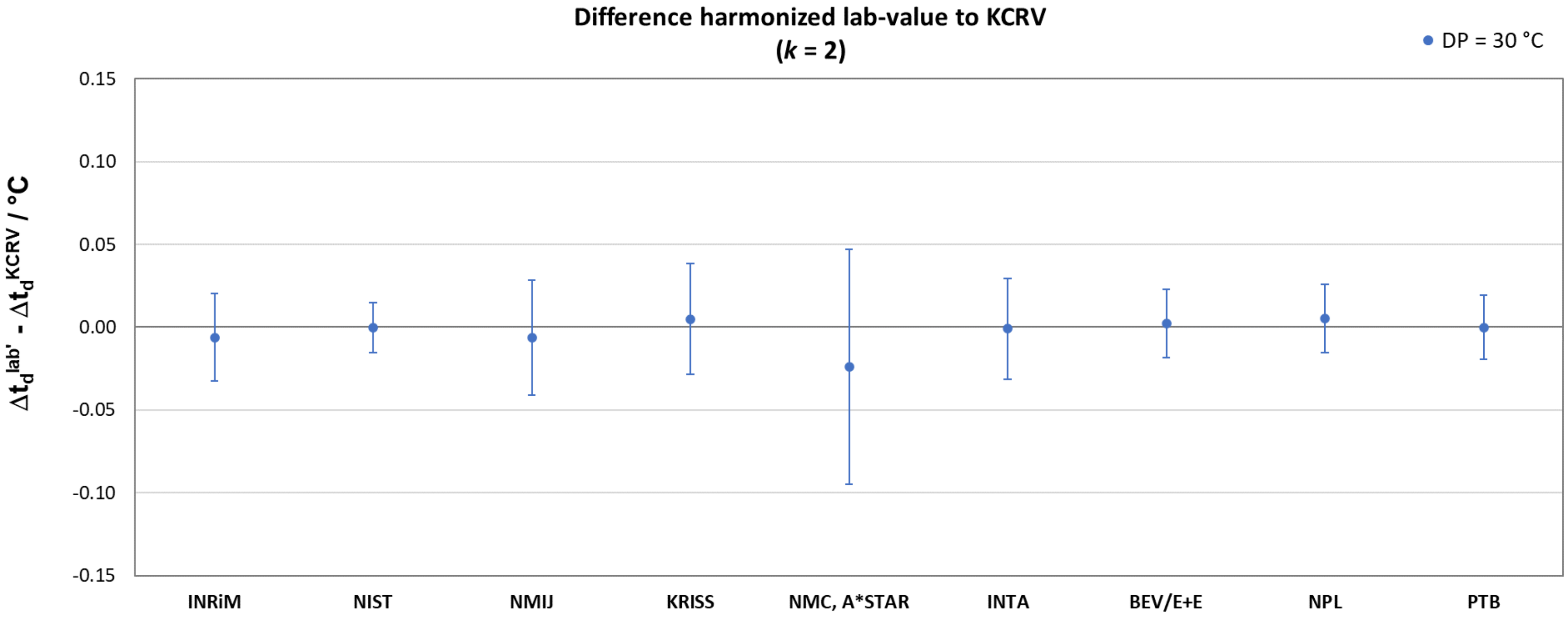


Fig. 8.3.b The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **30 ºC**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

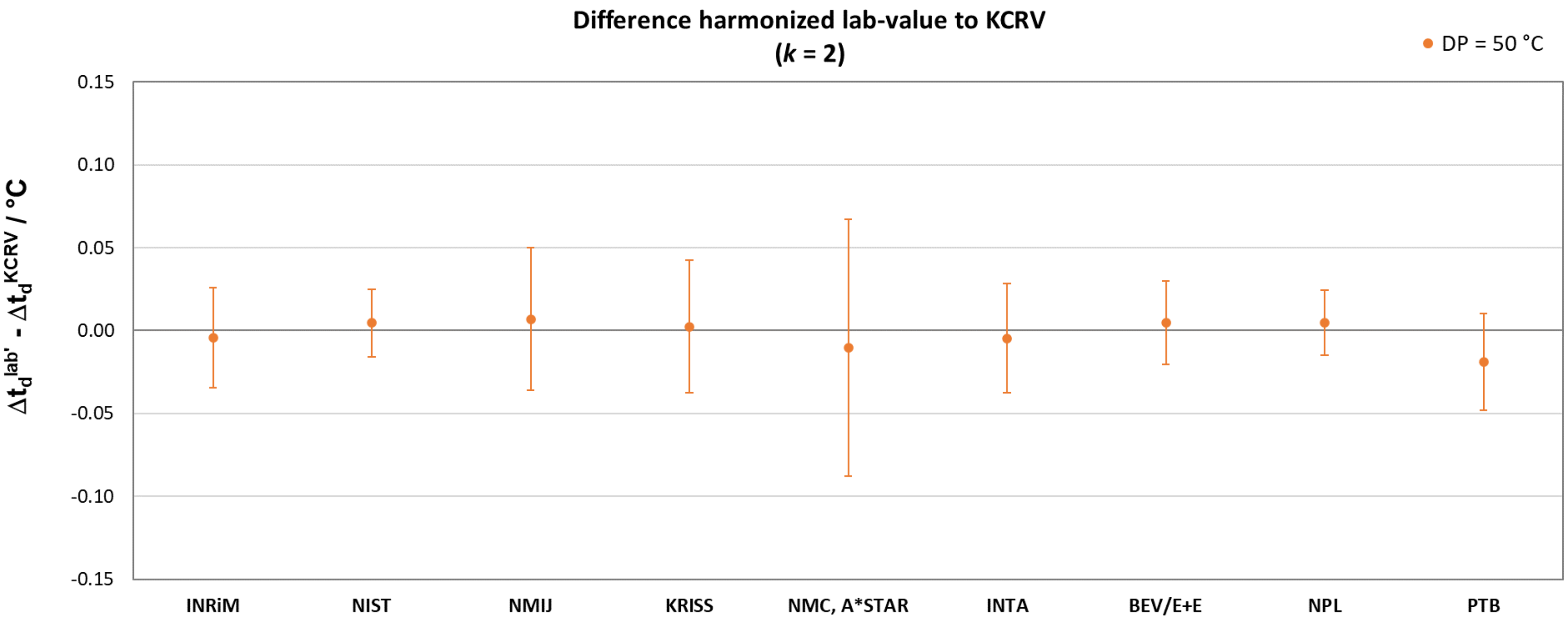


Fig. 8.3.c The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **50 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

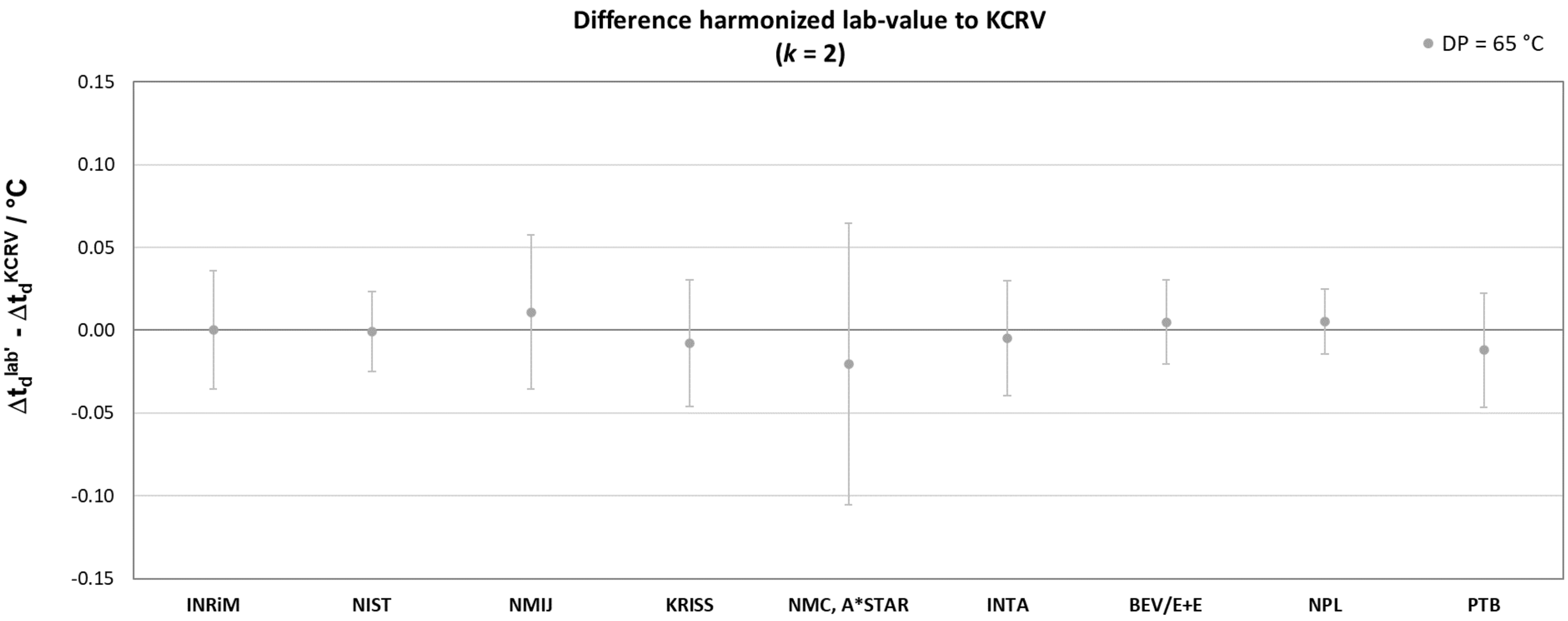


Fig. 8.3.d The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **65 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

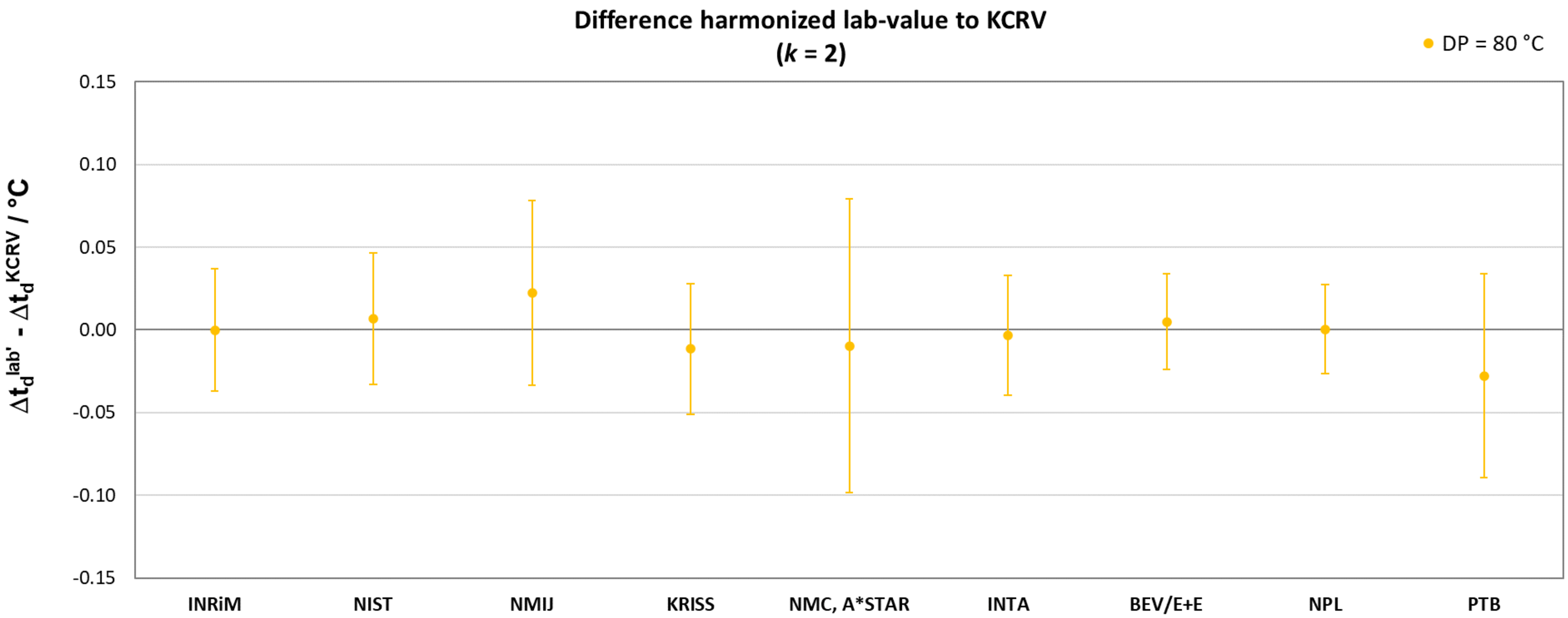


Fig. 8.3.e The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **80 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

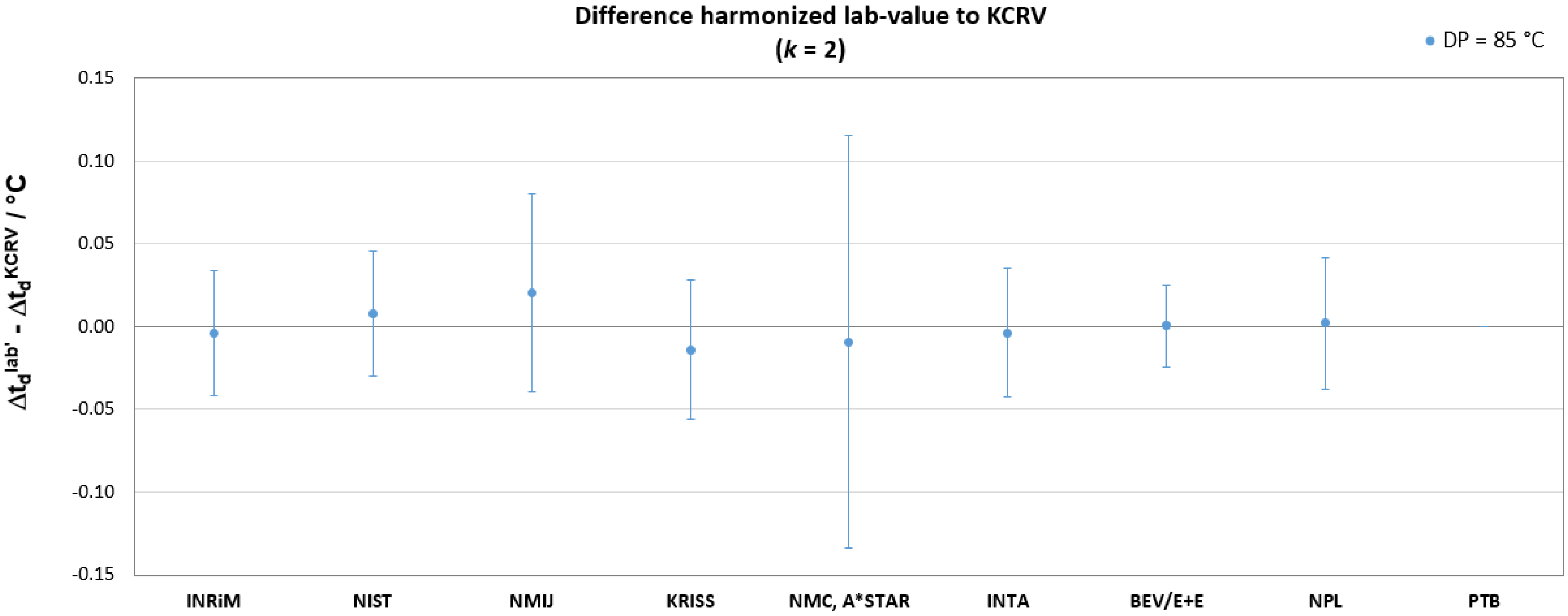


Fig. 8.3.f The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **85 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

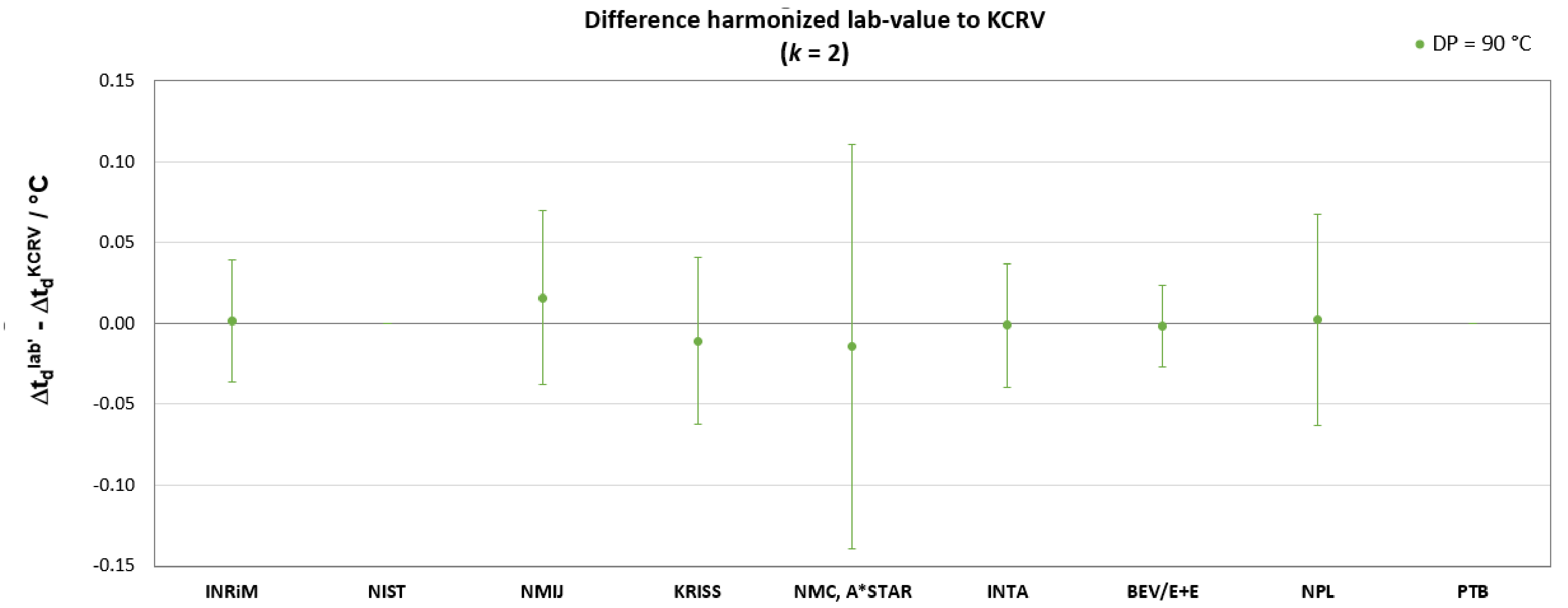


Fig. 8.3.g The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **90 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

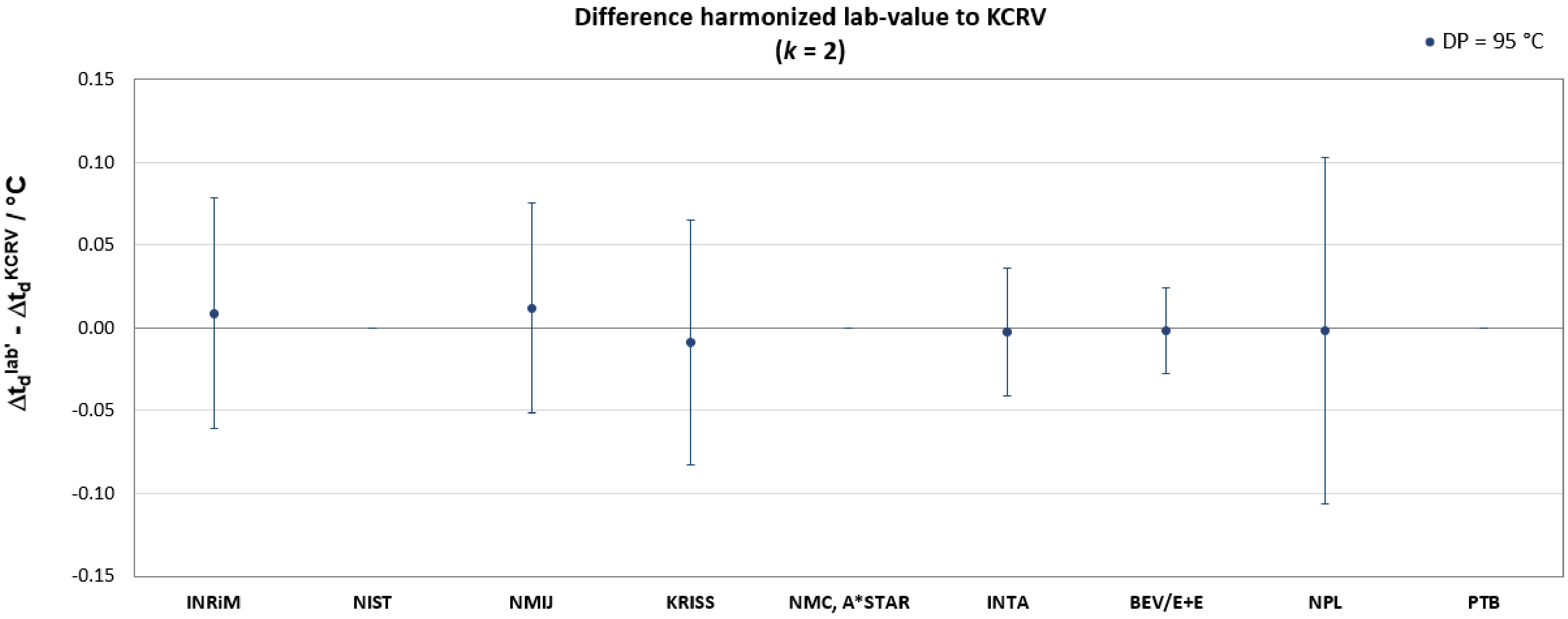


Fig. 8.3.h The harmonized laboratory result, $\Delta t_d^{lab'}$, minus the calculated KCRVs at the nominal dew point temperature **95 °C**, in Celsius degrees. Error bars show the expanded uncertainty for a coverage probability of 95 %.

9 CONCLUSIONS

A successful key comparison of local realizations of dew-point temperature of humid gas in the range 30 °C to 95 °C of 9 participating NMIs in four RMOs has been performed.

The results show excellent agreement between the realized scales with no detected outliers. The performance of the travelling standards was excellent and can be attributed to the intensive preconditioning and selection of the platinum resistance thermometers, prior to their integration into the measuring head assembly, that led to insignificant drift.

The resulting expanded uncertainty assigned to the KCRV values ranges from 9 mK to 22 mK for dew-point temperatures from 30 °C to 95 °C. This can be considered state of the art and is adequate for comparing the primary realizations of the participant NMIs with reported expanded uncertainties from 17 mK to 110 mK for dew-point temperatures from 30 °C to 95 °C.

Despite the excellent results, the delay in completing the analysis and presenting the different versions of the Draft A of the final report, was exceptionally long compared with the excellent measurement phase, carried out in record time. The delay in the preparation step of Draft A was mainly due to the selection and development of the most suitable method for analyzing DoEs and KCRV, which could also serve as a reference for future key comparisons of humidity measurement. In close collaboration with PTB and BEV/E+E, the framework of the development of the analysis method covering 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 simpler approaches. Based on the study for the given data set it could be stated that the differences between arithmetic and weighted mean are negligible, whereas neglecting the influence of correlation without using an approximation for the repeatability, in some cases, can lead to unrealistic small uncertainties and a significant number of potential outliers. The importance of consideration of correlation is discussed extensively in Draft B of EURAMET.T-K8 [Des23]. In the CCT-K8 comparison reported, the quality of the results with no outliers, whatever the consistency test applied, did not justify, in the opinion of some participants, the applicability of intralaboratory consistency tests on the supplied data set (four measurements) and it was agreed to use the aggregate result of the four measurements supplied by the participants as reported in the approved template, without further treatment. For the interlaboratory consistency tests, in determining the DoE and KCRV, the same methodology used in EURAMET.T-K8 was applied, based on the modified Birge Ratio [Bod14] and weighted mean. It is emphasized that no correction due to Birge ratio >1 had to be applied in this comparison, due to the excellent results of the participants.

A lot of discussions were held by participants which led to five versions and inevitably increasing the delay in obtaining the final report. During the discussion the conclusion was drawn that a simpler approach compared to the evaluation of EURAMET.T-K8 is sufficient since the data quality in CCT-K8 is much more homogenous than in EURAMET.T-K8. Therefore, NMIs should not be discouraged to pilot future comparisons, since methods are available for a lot of kinds of data quality.

As a result, the following lessons were learned, that could be beneficial for future humidity key comparisons:

1. The careful selection and annealing of the PRTs integrated into the chilled mirror transfer standards can lead to an excellent long-term stability during the comparison.
2. Having two loops, although requiring a slightly more complex analysis, ensures that the measurement phase of the comparison can be completed within one year with a suitable number of participants representing all RMOs.
3. In this and previous dew-point key comparisons, the definition of the four repeated or reproduced reference conditions and measurements has been ambiguous, and the uniformity of execution of this by participants has been unclear. In future comparisons, it would be advisable to ensure greater clarity and consistent action for multiple repeated or reproduced values.
4. The methodology of analysis and treatment of supplied data should be included in the protocol approved by the participants prior to any data processing. This involves an adequate mathematical and statistical knowledge from the pilot and co-pilot that, in the case of INTA, had to be acquired during the development of the comparison itself. Changes and modifications may always be required later depending on the particular needs of the intercomparison, but having adequate foresight helps to avoid possible tedious discussions that greatly increase the intercomparisons closure.
5. The linking method designed to establish a single KCRV using a virtual transfer standard defined on the simultaneous measurements of both transfer standards by the pilot, co-pilot and one other laboratory, mitigated the envisaged complexity of the analysis of two loops, as the comparison is analyzed as a single loop.

10 ACKNOWLEDGEMENTS

This comparison would not have been possible without the generous collaboration of MBW Calibration of Switzerland, and in particular, of Mr. Daniel Mutter. Support was provided in record time, even on site. He arranged for up to three batches of PRTs to be supplied, specially assembled for calibration and then finally integrating the selected probes in the measurement heads and provided information and technical assistance during measurements at the most inconvenient hours.

Equally important has been the support of Dr. Helmut Mitter, of BEV/E+E whose excellent knowledge of statistics enabled the different analysis scenarios to be performed, establishing the DoE and KCRV, with robust statistical methods. We also wish to thank Dr. Volker Ebert for hosting at PTB our colleague Dr. Jaime Garcia Gallegos during his period as a research student at INTA, and Dr. Regina Deschermeier who liaised in the analysis of the EURAMET.T-K8, providing useful knowledge [Des23] for the analysis of this comparison.

Special thanks to Sarah Beardmore from the NPL for her invaluable assistance in conducting the measurements for the aforementioned laboratory.

11 REFERENCES

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12 ANNEXES

12.1 ANALYSIS METHOD

12.1.1 FUNCTION $B_{i,j}$ AND UNCERTAINTY

Function *B*, used in the linkage between loops, was calculated as follows:

$$B_{ij} = \begin{cases} \dfrac{\sum_{k=1}^{n} \left({P_k(i,j)}/{u^2[P_k(i,j)]} \right)}{\sum_{k=1}^{n} \left({1}/{u^2 P_k(i,j)} \right)} & for\ loop(i) \neq loop(j) \\ 0 & for\ loop(i) = loop(j) \end{cases} \qquad \text{Eq. 12.1.a}$$

where: P_k is an aggregated loop difference for each potential link laboratory, *k*, calculated by weighted mean:

$$P_k(i,j) = \mu_{wm}(P_{s,i,k}) = \frac{\sum_i \frac{P_{s,i,k}}{u^2(P_{s,i,k})}}{\sum_i \frac{1}{u^2(P_{s,i,k})}} \qquad \text{Eq. 12.1.b}$$

$$u\left(P_k(i,j)\right) = \left(\sum_i \frac{1}{u^2(P_{s,i,k})} \right)^{-1/2} \qquad \text{Eq. 12.1.c}$$

where: $P_{s,i,k}$ is the loop difference for each single measurement i of $n = 4$ for each link laboratory *k*:

$$P_{s,i,k} = \Delta t_{d,L2,i}^{lab} - \Delta t_{d,L1,i}^{lab} \qquad \text{Eq. 12.1.d}$$

$\Delta t_{d,L1,i}^{lab}$ and $\Delta t_{d,L2,i}^{lab}$ are the single *i* measurements of dew point difference at each nominal dew point temperature and calculated according to Eq.6.1.a for loop 1 and 2, respectively.

It can be said that P_k describes the potential routes of linking, and the function B_{ij} is the weighted mean of all these possible routes of linking.

One of the main advantages of this intercomparison was that all link-laboratories could measure both hygrometers simultaneously, making it possible to calculate the differences between loops for each single measurement together with the corresponding uncertainty. This scenario allowed correlation effects to be quantified, and not having to be simplified and thus, usually overestimated without a statistical basis, so the uncertainty reached for the linkages will be the minimum possible.

The uncertainty calculation of $\Delta t_{d,Li,i}^{lab}$ is given by:

$$u^2\left(\Delta t_{d,L1,i}^{lab}\right) = u^2\left(\Delta t_{d,L1,i}^{ref}\right) + u^2\left(\Delta t_{d,L1,i}^{instab}\right) + u^2\left(\Delta t_{d,L1,i}^{res}\right) = \left(u_{corr,L1,i}\right)^2 + \left(u_{stat,L1.i}\right)^2 \qquad \text{Eq. 12.1.e}$$

As it has been explained above, the correlated uncertainty because of the refence of nominal dew point temperatures was the same in both loops as measurements were taking simultaneously. For this reason, following simplification was assumed:

$$u_{corr,i} = u_{corr,L1,i} = u_{corr,L2,i} \qquad \text{Eq. 12.1.f}$$

On the other hand, the uncertainty of $P_{s,i,k}$ is given as follows:

$$u^2(P_{s,i,k}) = u^2\left(\Delta t_{d,L1,i}^{lab}\right) + u^2\left(\Delta t_{d,L2,i}^{lab}\right) - 2 \cdot u\left(\Delta t_{d,L1,i}^{lab}\right) \cdot u\left(\Delta t_{d,L2,i}^{lab}\right) \cdot corr_{L1,L2} \qquad \text{Eq. 12.1.g}$$

where the correlation coefficient, $corr_{L1,L2}$, was calculated as follows:

$$corr_{L1,L2,i} = \frac{u_{corr,L1,i} \cdot u_{corr,L2,i}}{u\left(\Delta t_{d,L1,i}^{lab}\right) \cdot u\left(\Delta t_{d,L2,j}^{lab}\right)} = \frac{u_{corr,i}^2}{u\left(\Delta t_{d,L1,i}^{lab}\right) \cdot u\left(\Delta t_{d,L2,j}^{lab}\right)} \qquad \text{Eq. 12.1.h}$$

The final expression used to obtain the uncertainty of $P_{s,i,k}$ is the result of combining the last two equations:

$$u^2(P_{s,i,k}) = u^2\left(\Delta t_{d,L1,i}^{lab}\right) + u^2\left(\Delta t_{d,L2,i}^{lab}\right) - 2 \cdot u_{corr,i}^2 \qquad \text{Eq. 12.1.i}$$

For CCT-K8, there were a total of five possible paths for the linkage, namely: three sets of four measurements of INTA and one set of four measurements coming from NIST and BEV/E+E. Every set of linkages provides four differences between loops, $P_{s,i,k}$, which were statistical independent. The weighted mean for the four single loop differences, P_k, was calculated using Eq.12.1.b and the corresponding uncertainty $u(P_k)$ using the Eq.12.1.d which was corrected according the following equation, triggered by the modified Birge ratio exceeding one:

$$u_{BM}\left(P_k(i,j)\right) = \sigma_{BM,P_k} \cdot u\left(P_k(i,j)\right) \qquad \text{Eq. 12.1.j}$$

Coming up next the five aggregated loop differences at each nominal dew point, P_k, were used to calculate the initial discrete function *B* by means of a weighted mean value without correlation:

$$B(i,j) = \frac{\sum_k \left({P_k(i,j)}/{u_{BM}{}^2[P_k(i,j)]} \right)}{\sum_k (u_{BM}{}^{-2}[P_k(i,j)])} \qquad \text{Eq. 12.1.k}$$

where, u_{BM}, is the uncertainty associated to the function $B_{i,j}$, calculated as is shown as follows and corrected by the modified Birge ration in those cases in which exceeded one:

$$u(B_{i,j}) = \left(\sum_k \frac{1}{u_{BM}^2[P_k(i,j)]} \right)^{-1/2} \qquad \text{Eq. 12.1.l}$$

$$u_{BM}(B_{i,j}) = \sigma_{BM,B} \cdot u(B_{i,j}) \qquad \text{Eq. 12.1.m}$$

12.1.2 CONSISTENCY TESTS FOR LINKAGE

In this section, auxiliary results for the diverse consistency tests performed are shown and evaluated. Firstly, the consistency survey on the aggregated loop difference for each link laboratory, P_k, calculated from every single loop difference, $P_{s,i,k}$, was summarized for both methods evaluated.

Table 12.1.1 Consistency test of the aggregated loop difference for each link laboratory, P_k, calculated by weighted mean of all loop differences, $P_{s,I,k}$, for each single measurement *i* of *n* = 4.

	Nominal Dew Point Temperature						
	30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
	Chi-squared test, χ^2						
INTA1	0.76	0.20	0.18	0.56	0.07	0.10	0.31
NIST	0.37	0.17	0.58	0.51	0.16		
BEV/E+E	2.86	0.80	0.83	0.05	0.57	0.92	1.39
INTA2	0.74	0.23	3.11	0.65	1.73	1.74	0.28
INTA3	0.46	0.53	1.72	0.13	0.08	0.88	0.07
	Modified Birge Ratio, σ_{BM,P_k}						
INTA1	0.87	0.44	0.43	0.75	0.27	0.32	0.56
NIST	0.61	0.41	0.76	0.71	0.40		
BEV/E+E	**1.69**	0.89	0.91	0.22	0.76	0.96	**1.18**
INTA2	0.86	0.48	**1.76**	0.81	**1.32**	**1.32**	0.53
INTA3	0.68	0.73	**1.31**	0.36	0.28	0.94	0.26

On the other hand, it can be seen that uncertainties of function $B_{i,j}$, shown in Table 7.2.1, are reached after performing a second calculation of modified Birge ratios, $\sigma_{BM,B}$, by applying again Eq. 12.1.m. This decision was taken after checking that in the first step not all values of σ_{BM,P_k}, were less than one and, therefore did not meet the criteria of modified Birge ratio in this point of the analysis. Applying that second step was decided because this would only derive in an increase of the related uncertainties of $B_{i,j}$, but never the $B_{i,j}$ values themselves, acting only on the final assigned uncertainties of the bilateral equivalences, $u(B_{i,j})$, but did not change the degrees of equivalences (*DoE*).

Table 12.1.2 Consistency test results for the first step of function $B_{i,j}$ in every nominal dew point temperature and using both methods: Chi-squared test and modified Birge ratio.

		Nominal Dew Point Temperature in °C						
		30 °C	**50 °C**	**65 °C**	**80 °C**	**85 °C**	**90 °C**	**95 °C**
		First step consistency test						
χ^2		38.12	102.69	36.96	50.99	36.376	26.73	1.86
		failed	**failed**	**failed**	**failed**	**failed**	**failed**	pass
σ_{BM}		4.37	7.17	4.30	5.05	4.26	5.17	1.36
		failed	**failed**	**failed**	**failed**	**failed**	**failed**	**failed**

As can be seen at a glance, a second calculation of modified Birge ratio for function $B_{i,j}$ was necessary because in all nominal dew points exceeded the limit. As curiosity, because its use is not recommended either in this case, here it can be checked again that chi-squared criterion is less restrictive than Birge ratio method, since in 95 °C Chi-squared criterion was fulfilled. In the following table is showed the increasing uncertainty of function $B_{i,j}$ for applying this second modified Birge ratio step.

Table 12.1.3 Calculated values of $u(B_{i,j})$ for k = 1 applying only one or two modified Birge ratio steps.

	Nominal Dew Point in °C						
	30	**50**	**65**	**80**	**85**	**90**	**95**
1st step	0.0005	0.0003	0.0004	0.0005	0.0006	0.0006	0.0009
2nd step	0.0020	0.0023	0.0016	0.0024	0.0024	0.0029	0.0012

12.1.3 UNCERTAINTY OF D_{ij}

From the equation to describe the bilateral equivalence of different participants in the virtual loop (Eq. 7.1.g), the corresponding uncertainties are as follows:

$$u^2(D_{ij}) = u^2\left(\Delta t_d^{(i)'} - \Delta t_d^{(j)'}\right) = u^2\left(\Delta t_d^{(i)'}\right) + u^2\left(\Delta t_d^{(j)'}\right) - 2 \cdot corr_{i,j} \cdot u\left(\Delta t_d^{(i)'}\right) \cdot u\left(\Delta t_d^{(j)'}\right) \quad \text{Eq. 12.1.n}$$

Considering the method of harmonization of results of laboratory expressed by the Eq. 7.1.h and the general expression above, the following expression is obtained:

$$u^2(D_{ij}) = u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right) + u^2\left(\Delta t_d^{(j)}\right) + u^2\left(C_{loop(j)}\right) - 2 \cdot corr_{i,j} \cdot u\left(\Delta t_d^{(i)'}\right) \cdot u\left(\Delta t_d^{(j)'}\right) \quad \text{Eq. 12.1.o}$$

At a nominal dew point temperature, $u\left(C_{loop(i)}\right)$ is equal for all harmonized lab values which also means that $u\left(C_{loop(i)}\right) = u\left(C_{loop(j)}\right)$ which also leads to correlations between $u\left(\Delta t_d^{(i)'}\right)$ and $u(\Delta t_d^{(j)'})$ that were taken into account here below.

$$u^2(D_{ij}) = u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right) + u^2\left(\Delta t_d^{(j)}\right) + u^2\left(C_{loop(j)}\right) - 2 \cdot corr_{i,j} \cdot u\left(\Delta t_d^{(i)'}\right) \cdot u\left(\Delta t_d^{(j)'}\right) \quad \text{Eq. 12.1.p}$$

where the correlation coefficient, $corr_{i,j}$, is calculated according to the same which also leads to correlations between methods developed in Eq. 12.1.h:

$$corr_{i,j} = \frac{u^2\left(C_{loop(i)}\right)}{u\left(\Delta t_d^{(i)'}\right) \cdot u\left(\Delta t_d^{(j)'}\right)} \quad \text{Eq. 12.1.q}$$

Correlation factors applied to each participant were summarized in the following table:

Table 12.1.4 Correlation factors, $\boldsymbol{corr_{i,j}}$, obtained for each participant at every nominal dew point temperature.

	Nominal Dew Point in °C						
	30	**50**	**65**	**80**	**85**	**90**	**95**
INRiM	7.38E-05	7.38E-05	3.41E-05	7.34E-05	7.00E-05	9.91E-05	1.02E-05
NIST	1.20E-04	1.20E-04	4.84E-05	6.89E-05	7.00E-05	-	-
NMIJ	5.71E-05	5.71E-05	2.66E-05	5.04E-05	4.60E-05	7.28E-05	1.11E-05
KRISS	5.91E-05	5.91E-05	3.22E-05	6.92E-05	6.40E-05	7.55E-05	9.69E-06
NMC, A*STAR	2.83E-05	2.83E-05	1.48E-05	3.30E-05	2.30E-05	3.34E-05	-
INTA	6.48E-05	6.48E-05	3.50E-05	7.49E-05	6.80E-05	9.86E-05	1.68E-05
BEV/E+E	9.27E-05	9.27E-05	4.63E-05	9.09E-05	9.79E-05	1.35E-04	2.19E-05
NPL	9.27E-05	9.27E-05	5.71E-05	9.63E-05	6.73E-05	6.12E-05	6.98E-06
PTB	9.80E-05	9.80E-05	3.52E-05	4.58E-05	-	-	-

Combining the two previous equations it also meets that:

$$u^2(D_{ij}) = u^2\left(\Delta t_d^{(i)'} - \Delta t_d^{(j)'}\right) = u^2\left(\Delta t_d^{(i)'}\right) + u^2\left(\Delta t_d^{(j)'}\right) - 2 \cdot u^2(C_{loop(i)}) \qquad \text{Eq. 12.1.r}$$

The term $2 \cdot u^2(C_{loop(i)})$ also can be simplified as:

$$2 \cdot u^2(C_{loop(i)}) = 2 \cdot \left(\frac{u(B_{j,i})}{2}\right)^2 = \frac{u^2(B_{j,i})}{2} \qquad \text{Eq. 12.1.s}$$

Thus, the final equation that gives the uncertainty of D_{ij} considering correlation is:

$$u^2(D_{ij}) = u^2\left(\Delta t_d^{(i)'}\right) + u^2\left(\Delta t_d^{(j)'}\right) - \frac{u^2(B_{j,i})}{2} + u^2{}_{stab.loop} \qquad \text{Eq. 12.1.t}$$

12.2 ANALYSIS METHOD OF KCRV

The KCRV was calculated from the harmonized laboratory results of the single virtual loop as weighted mean of all labs, considering only one set of measurements for each participant. Thus, the expression which gives the KCRV is:

$$\Delta t_d^{KCRV} = \frac{\sum_i \frac{\Delta t_d^{(i)'}}{u^2(\Delta t_d^{(i)'})}}{\sum_i \frac{1}{u^2(\Delta t_d^{(i)'})}} + \delta_{stab.loop} = \frac{\sum_i \frac{\Delta t_d^{(i)} + C_{loop(i)}}{u^2(\Delta t_d^{(i)}) + u^2(C_{loop(i)})}}{\sum_i \frac{1}{u^2(\Delta t_d^{(i)}) + u^2(C_{loop(i)})}} + \delta_{stab.loop} \qquad \text{Eq. 12.2.a}$$

where for the particular case of this intercomparison, $\delta_{stab.loop}$ was neglected as has already been justified.

On the other hand, the uncertainty of the KCRV is calculated as:

$$u^2(\Delta t_d^{KCRV}) = \left[\sum_i \frac{1}{u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right)}\right]^{-1} + u^2{}_{stab.loop} \qquad \text{Eq. 12.2.b}$$

According to the Eq. 8.1.a, the difference between harmonized laboratory result, $\Delta t_d^{lab\prime}$, and KCRV is calculated, including the stability term, as follows:

$$\Delta_{KCRV}^{lab} = \Delta t_d^{lab\prime} - \Delta t_d^{KCRV} \qquad \text{Eq. 12.2.c}$$

$$\Delta_{KCRV}^{lab} = \Delta t_d^{lab\prime} - \frac{\sum_i \frac{\Delta t_d^{(i)\prime}}{u^2\left(\Delta t_d^{(i)\prime}\right)}}{\sum_i \frac{1}{u^2\left(\Delta t_d^{(i)\prime}\right)}} - \delta_{stab.loop} = \Delta t_d^{lab\prime} - \frac{\sum_i \frac{\Delta t_d^{(i)} + C_{loop(i)}}{u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right)}}{\sum_i \frac{1}{u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right)}} - \delta_{stab.loop} \qquad \text{Eq. 12.2.d}$$

And the uncertainty the difference between the harmonized laboratory results, $u(\Delta t_d^{lab\prime})$, and KCRV is given by:

$$u\left(\Delta_{KCRV}^{lab}\right) = u\left(\Delta t_d^{lab\prime} - \Delta t_d^{KCRV}\right) \qquad \text{Eq. 12.2.e}$$

- If laboratory contributes to KCRV, there is a correlation between $\Delta t_d^{lab\prime}$ and Δt_d^{KCRV}:

$$u^2(\Delta_{KCRV}^{lab}) = u^2\left(\Delta t_d^{lab}\right) - u^2(\Delta t_d^{KCRV}) + u^2{}_{stab.loop} \qquad \text{Eq. 12.2.f}$$

$$u^2(\Delta_{KCRV}^{lab}) = u^2\left(\Delta t_d^{lab\prime}\right) - \left[\sum_i \frac{1}{u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right)}\right]^{-1} + u^2{}_{stab.loop} \qquad \text{Eq. 12.2.g}$$

- If laboratory does not contribute to KCRV which means that there is no correlation between $\Delta t_d^{lab\prime}$ and Δt_d^{KCRV}:

$$u^2(\Delta_{KCRV}^{lab}) = u^2\left(\Delta t_d^{lab}\right) + u^2(\Delta t_d^{KCRV}) + u^2{}_{stab.loop} \qquad \text{Eq. 12.2.h}$$

$$u^2(\Delta_{KCRV}^{lab}) = u^2\left(\Delta t_d^{lab\prime}\right) + \left[\sum_i \frac{1}{u^2\left(\Delta t_d^{(i)}\right) + u^2\left(C_{loop(i)}\right)}\right]^{-1} + u^2{}_{stab.loop} \qquad \text{Eq. 12.2.i}$$

where the uncertainty of the stability of the virtual loop, $u_{stab.loop}$, is obtained by:

$$u_{stab.loop} = \frac{1}{2} \cdot \left[u^2{}_{stab.loop.1} + u^2{}_{stab.loop.2}\right]^{1/2} \qquad \text{Eq. 12.2.j}$$

12.3 SUMMARY TABLE OF ALL PARTICIPANTS

The following tables summarize the individual results of each participant. The header reproduced below shows the symbols used in the Humidity CMC Review Protocol [CCT24] between brackets.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab.}$ [$V_{NMI, RC}$]	$u(\Delta t_d^{lab.})$ [$u_{NMI, RC}$]	$u_{stab.loop}$ [u_{RC}]	Δt_d^{KCRV} [V_{RCRV}]	$u(\Delta t_d^{KCRV})$ [u_{RCRV}]	$\Delta t_d^{lab.} - \Delta t_d^{KCRV}$ [$V_{NMI, RC} - V_{RCRV}$]	$U(\Delta t_d^{lab.} - \Delta t_d^{KCRV})$

Table 12.3.1 Summary of the most important value obtained by **INRiM** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (*k* = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.098	0.014	-0.124	0.014	0.0018	-0.118	0.009	-0.006	0.026
50	-0.080	0.016	-0.109	0.016	0.0018	-0.104	0.011	-0.004	0.030
65	-0.061	0.019	-0.091	0.019	0.0018	-0.091	0.012	0.000	0.036
80	-0.046	0.020	-0.078	0.020	0.0018	-0.078	0.014	0.000	0.037
85	-0.044	0.020	-0.077	0.020	0.0018	-0.073	0.016	-0.004	0.038
90	-0.040	0.021	-0.071	0.021	0.0018	-0.073	0.018	0.001	0.038
95	-0.036	0.037	-0.066	0.037	0.0018	-0.075	0.022	0.009	0.070

Table 12.3.2 Summary of the most important value obtained by **NIST** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (*k* = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.144	0.008	-0.118	0.008	0.0018	-0.118	0.009	0.000	0.015
50	-0.129	0.011	-0.100	0.011	0.0018	-0.104	0.011	0.005	0.020
65	-0.121	0.013	-0.091	0.013	0.0018	-0.091	0.012	-0.001	0.024
80	-0.104	0.021	-0.071	0.021	0.0018	-0.078	0.014	0.007	0.040
85	-0.098	0.020	-0.065	0.020	0.0018	-0.073	0.016	0.008	0.038

Table 12.3.3 Summary of the most important value obtained by **NMIJ** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (*k* = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.150	0.018	-0.124	0.018	0.0018	-0.118	0.009	-0.006	0.035
50	-0.126	0.022	-0.098	0.022	0.0018	-0.104	0.011	0.007	0.043
65	-0.110	0.024	-0.080	0.024	0.0018	-0.091	0.012	0.011	0.046
80	-0.088	0.029	-0.056	0.029	0.0018	-0.078	0.014	0.022	0.056
85	-0.085	0.031	-0.052	0.031	0.0018	-0.073	0.016	0.020	0.060
90	-0.088	0.028	-0.057	0.028	0.0018	-0.073	0.018	0.016	0.054
95	-0.093	0.034	-0.063	0.034	0.0018	-0.075	0.022	0.012	0.064

Table 12.3.4 Summary of the most important value obtained by **KRISS** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (*k* = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.139	0.017	-0.113	0.017	0.0018	-0.118	0.009	0.005	0.033
50	-0.131	0.021	-0.102	0.021	0.0018	-0.104	0.011	0.002	0.040
65	-0.128	0.020	-0.098	0.020	0.0018	-0.091	0.012	-0.008	0.038
80	-0.122	0.021	-0.089	0.021	0.0018	-0.078	0.014	-0.011	0.040
85	-0.120	0.022	-0.087	0.022	0.0018	-0.073	0.016	-0.014	0.042
90	-0.115	0.027	-0.083	0.027	0.0018	-0.073	0.018	-0.011	0.052
95	-0.114	0.039	-0.084	0.039	0.0018	-0.075	0.022	-0.009	0.074

Table 12.3.5 Summary of the most important value obtained by **NMC, A*STAR** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (*k* = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.167	0.036	-0.142	0.036	0.0018	-0.118	0.009	-0.024	0.071
50	-0.143	0.039	-0.115	0.039	0.0018	-0.104	0.011	-0.010	0.077
65	-0.141	0.043	-0.111	0.043	0.0018	-0.091	0.012	-0.020	0.085
80	-0.120	0.044	-0.088	0.044	0.0018	-0.078	0.014	-0.010	0.089
85	-0.115	0.062	-0.082	0.062	0.0018	-0.073	0.016	-0.009	0.12
90	-0.118	0.062	-0.087	0.062	0.0018	-0.073	0.018	-0.014	0.12

Table 12.3.6 Summary of the most important value obtained by **INTA** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (k = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.093	0.016	-0.119	0.016	0.0018	-0.118	0.009	-0.001	0.030
50	-0.080	0.017	-0.109	0.017	0.0018	-0.104	0.011	-0.005	0.033
65	-0.065	0.018	-0.095	0.018	0.0018	-0.091	0.012	-0.005	0.035
80	-0.049	0.019	-0.081	0.019	0.0018	-0.078	0.014	-0.003	0.036
85	-0.043	0.021	-0.076	0.021	0.0018	-0.073	0.016	-0.004	0.039
90	-0.043	0.021	-0.074	0.021	0.0018	-0.073	0.018	-0.001	0.038
95	-0.047	0.022	-0.077	0.022	0.0018	-0.075	0.022	-0.002	0.039

Table 12.3.7 Summary of the most important value obtained by **BEV/E+E** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (k = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.141	0.011	-0.115	0.011	0.0018	-0.118	0.009	0.002	0.021
50	-0.129	0.013	-0.100	0.013	0.0018	-0.104	0.011	0.005	0.025
65	-0.116	0.014	-0.086	0.014	0.0018	-0.091	0.012	0.005	0.025
80	-0.105	0.016	-0.073	0.016	0.0018	-0.078	0.014	0.005	0.029
85	-0.105	0.015	-0.072	0.015	0.0018	-0.073	0.016	0.000	0.025
90	-0.106	0.015	-0.075	0.015	0.0018	-0.073	0.018	-0.002	0.025
95	-0.107	0.017	-0.077	0.017	0.0018	-0.075	0.022	-0.002	0.026

Table 12.3.8 Summary of the most important value obtained by **NPL** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (k = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.087	0.011	-0.112	0.011	0.0018	-0.118	0.009	0.005	0.021
50	-0.071	0.011	-0.100	0.011	0.0018	-0.104	0.011	0.005	0.020
65	-0.055	0.011	-0.085	0.011	0.0018	-0.091	0.012	0.005	0.020
80	-0.045	0.015	-0.078	0.015	0.0018	-0.078	0.014	0.000	0.027
85	-0.038	0.021	-0.071	0.021	0.0018	-0.073	0.016	0.002	0.040
90	-0.039	0.034	-0.070	0.034	0.0018	-0.073	0.018	0.002	0.065
95	-0.046	0.053	-0.076	0.053	0.0018	-0.075	0.022	-0.001	0.10

Table 12.3.9 Summary of the most important value obtained by **PTB** in the CCT-K8 including: the weighted mean values and their corresponding mean in the virtual loop together with their standard uncertainties; the uncertainty of the stability of the virtual loop; the KCRVs and theirs uncertainties; and the differences with the KCRV and the corresponding expanded uncertainty using a coverage factor (k = 2) for a probability higher that 95 %.

Nominal Dew Point, °C	Reported Results		Lab. Results in virtual loop		Drift virtual transfer standard	KCRV		Difference with KCRV	
	Δt_d	$u(\Delta t_d)$	$\Delta t_d^{lab'}$	$u(\Delta t_d^{lab'})$	$u_{stab.loop}$	Δt_d^{KCRV}	$u(\Delta t_d^{KCRV})$	$\Delta t_d^{lab'} - \Delta t_d^{KCRV}$	$U(\Delta t_d^{lab'} - \Delta t_d^{KCRV})$
30	-0.092	0.010	-0.118	0.010	0.0018	-0.118	0.009	0.000	0.019
50	-0.095	0.015	-0.124	0.015	0.0018	-0.104	0.011	-0.019	0.029
65	-0.073	0.018	-0.103	0.018	0.0018	-0.091	0.012	-0.012	0.035
80	-0.074	0.032	-0.106	0.032	0.0018	-0.078	0.014	-0.028	0.062

12.4 ABBREVIATIONS

BEV	Bundesamt für Eich- und Vermessungswesen (Federal Office of Metrology and Surveying)
CCT	Consultative Committee on Thermometry
CEM	Centro Español de Metrología
CIPM	Comité International des Poids et Mesures
DI	Designated Institutes
DoE	Degree of Equivalence
E+E	E + E Elektronik Ges.mbH
INRiM	Istituto Nazionale di Ricerca Metrologica
INTA	Instituto Nacional de Técnica Aeroespacial
ITS-90	International Temperature Scale
KRISS	Korea Research Institute of Standards and Science
LRV	Loop Reference Value
MBW	MBW Calibration Ltd.
NIST	National Institute of Standards and Technology
NMC, A*STAR	National Metrology Centre
NMI	National Metrology Institute
NMIJ	National Metrology Institute of Japan
NPL	National Physical Laboratory
PTB	Physikalisch-Technische Bundesanstalt
PRT	Platinum Resistance Thermometer
KCRV	Key Comparison Reference Value

12.5 DETAILS OF PARTICIPATING INSTITUTES

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12.6 RESULTS REPORTED BY ALL PARTICIPANTS

Following are showed the results reported by participants pasted from the Excel template used in this comparison.

Fig. 12.6.a Results reported by **BEV/E+E** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name: BEV/E+E Elektronik

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

Put cursor here for notes

ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	29.957	111.6012	29.815	-0.142	29.815	-0.142
Meas 2	29.956	111.6015	29.816	-0.141	29.816	-0.141
Meas 3	29.957	111.6016	29.816	-0.141	29.816	-0.141
Meas 4	29.957	111.6016	29.816	-0.141	29.816	-0.141

Uncertainties (in °C)

Hygrometer		08-1215		
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0109	0.0110	0.0110	0.0109
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0005	0.0007	0.0005	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.010906	0.010989	0.01099	0.010923

Effective degrees of freedom of uncertainty estimates: 351

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.141
Type A standard uncertainty due to reproducibility of difference results	0.0006
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0109**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **50** °C Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	49.954	119.3301	49.826	-0.129	49.826	-0.129
Meas 2	49.954	119.3298	49.825	-0.129	49.825	-0.129
Meas 3	49.954	119.3302	49.826	-0.128	49.826	-0.128
Meas 4	49.954	119.3300	49.826	-0.128	49.826	-0.128

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0134	0.0121	0.0122	0.0123
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0005	0.0005	0.0004	0.0005
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.013417	0.012068	0.012177	0.012277

Effective degrees of freedom of uncertainty estimates: 324

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.129
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0005
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0134**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **65** °C Lab name BEV/E+E Elektronik

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

Put cursor here for notes

ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	64.950	125.0967	64.835	-0.115	64.835	-0.115
Meas 2	64.949	125.0959	64.833	-0.116	64.833	-0.116
Meas 3	64.948	125.0957	64.832	-0.116	64.832	-0.116
Meas 4	64.947	125.0952	64.831	-0.116	64.831	-0.116

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0136	0.0131	0.0138	0.0130
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0007	0.0005	0.0007	0.0006
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.013658	0.013107	0.013775	0.013054

Effective degrees of freedom of uncertainty estimates: 305

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.116
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0005
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0137**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 80 °C — Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer 08-1215					
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	79.954	130.8389	79.848	-0.106	79.848	-0.106
Meas 2	79.954	130.8390	79.848	-0.105	79.848	-0.105
Meas 3	79.953	130.8386	79.847	-0.105	79.847	-0.105
Meas 4	79.952	130.8386	79.847	-0.105	79.847	-0.105

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0158	0.0144	0.0147	0.0143
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0006	0.0008	0.0010	0.0014
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015859	0.014416	0.014748	0.014344

Effective degrees of freedom of uncertainty estimates: 306

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.105
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0003
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0159**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 85 °C — Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer 08-1215					
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	84.956	132.7467	84.851	-0.105	84.851	-0.105
Meas 2	84.956	132.7464	84.851	-0.105	84.851	-0.105
Meas 3	84.956	132.7466	84.851	-0.105	84.851	-0.105
Meas 4	84.955	132.7457	84.849	-0.106	84.849	-0.106

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0144	0.0148	0.0143	0.0146
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0013	0.0012	0.0013	0.0007
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.014464	0.014806	0.014348	0.014606

Effective degrees of freedom of uncertainty estimates: 270

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.105
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0005
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0145**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **90** °C Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	89.964	134.6529	89.858	-0.106	89.858	-0.106
Meas 2	89.964	134.6529	89.858	-0.106	89.858	-0.106
Meas 3	89.963	134.6523	89.856	-0.106	89.856	-0.106
Meas 4	89.963	134.6525	89.857	-0.106	89.857	-0.106

Uncertainties (in °C)

Hygrometer			08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0152	0.0150	0.0148	0.0155
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0008	0.0008	0.0008	0.0015
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015252	0.015031	0.014841	0.015529

Effective degrees of freedom of uncertainty estimates: 278

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.106
Type A standard uncertainty due to reproducibility of difference results	0.0004
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0153**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **95** °C Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	94.960	136.5518	94.853	-0.107	94.853	-0.107
Meas 2	94.959	136.5517	94.853	-0.107	94.853	-0.107
Meas 3	94.960	136.5519	94.853	-0.107	94.853	-0.107
Meas 4	94.960	136.5517	94.853	-0.107	94.853	-0.107

Uncertainties (in °C)

Hygrometer			08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0158	0.0160	0.0156
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0015	0.0010	0.0013	0.0013
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.016978	0.015873	0.016076	0.015612

Effective degrees of freedom of uncertainty estimates: 314

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.107
Type A standard uncertainty due to reproducibility of difference results	0.0001
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0170**

Fig. 12.6.b Results reported by **BEV/E+E** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 30 °C Lab name: BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	29.957	111.6219	29.868	-0.089	29.868	-0.089
Meas 2	29.956	111.6227	29.870	-0.086	29.870	-0.086
Meas 3	29.957	111.6229	29.871	-0.086	29.871	-0.086
Meas 4	29.957	111.6231	29.871	-0.086	29.871	-0.086

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0109	0.0110	0.0110	0.0109
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0006	0.0006	0.0007	0.0007
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.01091	0.01098	0.010997	0.010901

Effective degrees of freedom of uncertainty estimates: 351

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.087
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0014
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0110**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 50 °C | Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer 08-1216	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	49.954	119.3527	49.885	-0.070	49.885	-0.070
Meas 2	49.954	119.3525	49.884	-0.070	49.884	-0.070
Meas 3	49.954	119.3528	49.885	-0.069	49.885	-0.069
Meas 4	49.954	119.3524	49.884	-0.070	49.884	-0.070

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0134	0.0121	0.0122	0.0123
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0006	0.0004	0.0005	0.0005
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.013421	0.012068	0.012179	0.012277

Effective degrees of freedom of uncertainty estimates: 324

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.070
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0003
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0134**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 65 °C | Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer 08-1216	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	64.950	125.1199	64.896	-0.055	64.896	-0.055
Meas 2	64.949	125.1194	64.894	-0.055	64.894	-0.055
Meas 3	64.948	125.1193	64.894	-0.054	64.894	-0.054
Meas 4	64.947	125.1189	64.893	-0.055	64.893	-0.055

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0136	0.0131	0.0138	0.0130
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0008	0.0006	0.0008	0.0006
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.013662	0.013113	0.013779	0.013051

Effective degrees of freedom of uncertainty estimates: 305

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.054
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0002
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0137**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 80 °C | Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	79.954	130.8637	79.913	-0.041	79.913	-0.041
Meas 2	79.954	130.8638	79.914	-0.040	79.914	-0.040
Meas 3	79.953	130.8634	79.912	-0.040	79.912	-0.040
Meas 4	79.952	130.8633	79.912	-0.040	79.912	-0.040

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1216				
Standard uncertainty of applied condition	0.0158	0.0144	0.0147	0.0143
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0007	0.0009	0.0010	0.0013
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015862	0.014422	0.014746	0.014336

Effective degrees of freedom of uncertainty estimates: 306

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.040
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0003
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0159**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 85 °C | Lab name BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216				
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C	Check	
Meas 1	84.956	132.7721	84.918	-0.038	84.918	-0.038
Meas 2	84.956	132.7719	84.918	-0.038	84.918	-0.038
Meas 3	84.956	132.7717	84.917	-0.039	84.917	-0.039
Meas 4	84.955	132.7708	84.915	-0.040	84.915	-0.040

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1216				
Standard uncertainty of applied condition	0.0144	0.0148	0.0143	0.0146
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0010	0.0010	0.0010	0.0008
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.014442	0.014794	0.014324	0.014613

Effective degrees of freedom of uncertainty estimates: 270

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.039
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0008
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0145**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 90 °C — Lab name: BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer	08-1216				Check	
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C		
Meas 1	89.964	134.6769	89.921	-0.042	89.921	-0.042
Meas 2	89.964	134.6771	89.922	-0.042	89.922	-0.042
Meas 3	89.963	134.6768	89.921	-0.042	89.921	-0.042
Meas 4	89.963	134.6765	89.920	-0.043	89.920	-0.043

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0152	0.0150	0.0148	0.0155
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0009	0.0010	0.0008	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015255	0.01504	0.014839	0.015486

Effective degrees of freedom of uncertainty estimates: 278

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.042
Type A standard uncertainty due to reproducibility of difference results	0.0004
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0153**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 95 °C — Lab name: BEV/E+E Elektronik

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer	08-1215				Check	
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C		
Meas 1	94.960	136.5741	94.912	-0.048	94.912	-0.048
Meas 2	94.959	136.5748	94.913	-0.046	94.913	-0.046
Meas 3	94.960	136.5752	94.915	-0.045	94.915	-0.045
Meas 4	94.960	136.5749	94.914	-0.046	94.914	-0.046

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0158	0.0160	0.0156
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0011	0.0015	0.0011	0.0015
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.016948	0.015913	0.016065	0.015628

Effective degrees of freedom of uncertainty estimates: 314

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.046
Type A standard uncertainty due to reproducibility of difference results	0.0012
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0170**

Fig. 12.6.c Results reported by **INRiM** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 30 °C Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.287	111.7455	30.187	-0.100
Meas 2	30.288	111.7465	30.190	-0.098
Meas 3	30.287	111.7463	30.189	-0.098
Meas 4	30.286	111.7464	30.190	-0.096

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0136	0.0136	0.0136	0.0136
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0010	0.0010	0.0020	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.001	0.001	0.001	0.001
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.014	0.014	0.014	0.014

Effective degrees of freedom of uncertainty estimates: 147

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.098
Type A standard uncertainty due to reproducibility of difference results	0.0017
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0137**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 50 °C Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	50.242	119.4587	50.160	-0.082
Meas 2	50.244	119.4599	50.163	-0.081
Meas 3	50.245	119.4615	50.167	-0.078
Meas 4	50.272	119.4712	50.192	-0.080

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0152	0.0152	0.0152	0.0152
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0010	0.0020	0.0020	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.004	0.004	0.004	0.004
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.016	0.016	0.016	0.016

Effective degrees of freedom of uncertainty estimates: 206

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.080
Type A standard uncertainty due to reproducibility of difference results	0.0017
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0158**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 65 °C Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	65.242	125.2304	65.184	-0.058
Meas 2	65.242	125.2292	65.181	-0.061
Meas 3	65.240	125.2280	65.178	-0.062
Meas 4	65.241	125.2288	65.180	-0.061

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0180	0.0180	0.0180	0.0180
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0030	0.0020	0.0020	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.003	0.003	0.003	0.003
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.018	0.018	0.018	0.018

Effective degrees of freedom of uncertainty estimates: 98

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.061
Type A standard uncertainty due to reproducibility of difference results	0.0017
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0186**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 80 °C | Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.207	130.9565	80.157	-0.050
Meas 2	80.207	130.9583	80.161	-0.046
Meas 3	80.209	130.9597	80.165	-0.044
Meas 4	80.208	130.9593	80.164	-0.044

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0188	0.0188	0.0188	0.0188
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0030	0.0020	0.0020	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.004	0.004	0.004	0.004
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.019	0.019	0.019	0.019

Effective degrees of freedom of uncertainty estimates: 125

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.046
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0028
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0197**

Any correction and uncertainty due to long term drift (if required) will be estimated, based on repeat measurements by pilots

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 85 °C Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	85.187	132.8577	85.143	-0.044
Meas 2	85.197	132.8621	85.154	-0.043
Meas 3	85.193	132.8599	85.149	-0.044
Meas 4	85.193	132.8603	85.149	-0.044

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0193	0.0193	0.0193	0.0193
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0040	0.0030	0.0040	0.0030
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.005	0.005	0.005	0.005
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020	0.020	0.020	0.020

Effective degrees of freedom of uncertainty estimates: 121

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.044
Type A standard uncertainty due to reproducibility of difference results	0.0005
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0203**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 90 °C Lab name INRIM

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	90.173	134.7569	90.131	-0.042
Meas 2	90.175	134.7573	90.132	-0.043
Meas 3	90.173	134.7579	90.134	-0.039
Meas 4	90.175	134.7599	90.139	-0.036

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0199	0.0199	0.0199	0.0199
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0020	0.0030	0.0020	0.0050
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.005	0.005	0.005	0.005
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.021	0.021	0.021	0.021

Effective degrees of freedom of uncertainty estimates: 172

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.040
Type A standard uncertainty due to reproducibility of difference results	0.0032
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0208**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 95 °C Lab name INRIM

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

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ROBERT: Type serial number: 08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	95.164	136.6567	95.129	-0.035
Meas 2	95.161	136.6551	95.125	-0.036
Meas 3	95.167	136.6575	95.131	-0.036
Meas 4	95.145	136.6481	95.107	-0.038

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0345	0.0345	0.0345	0.0345
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0110	0.0130	0.0330	0.0280
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.0003	0.0003	0.0003	0.0003
Std uncert due to non-linearity of travelling standard [if needed] / Self-heating Effect	0.005	0.005	0.005	0.005
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.037	0.037	0.048	0.045

Effective degrees of freedom of uncertainty estimates: 61

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.036
Type A standard uncertainty due to reproducibility of difference results	0.0013
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0365**

Fig. 12.6.d Results reported by **INTA2** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.033	111.6294	29.888	-0.145
Meas 2	29.978	111.6093	29.836	-0.142
Meas 3	30.040	111.6336	29.898	-0.142
Meas 4	30.032	111.6304	29.890	-0.142

Uncertainties (in °C)

	Hygrometer		08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0155	0.0155	0.0155	0.0155
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0016	0.0025	0.0040	0.0016
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015564	0.015682	0.015987	0.015572

Effective degrees of freedom of uncertainty estimates: 85

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.143
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0015
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0156**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **50** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	49.983	119.3422	49.857	-0.126
Meas 2	49.979	119.3405	49.853	-0.126
Meas 3	49.981	119.3417	49.856	-0.125
Meas 4	49.986	119.3425	49.858	-0.127

Uncertainties (in °C)

	Hygrometer		08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0169	0.0169	0.0169
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0018	0.0034	0.0025	0.0027
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.017041	0.017288	0.017126	0.017157

Effective degrees of freedom of uncertainty estimates: 92

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.126
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0011
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0171**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **65** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	64.992	125.1125	64.876	-0.116
Meas 2	65.020	125.1212	64.899	-0.121
Meas 3	64.999	125.1129	64.877	-0.122
Meas 4	65.007	125.1152	64.883	-0.124

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0180	0.0180	0.0180	0.0180
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0142	0.0008	0.0006	0.0007
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.022963	0.018026	0.018019	0.018023

Effective degrees of freedom of uncertainty estimates: 90

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.121
Type A standard uncertainty due to reproducibility of difference results	0.0032
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0232**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **80** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.007	130.8558	79.892	-0.114
Meas 2	79.997	130.8529	79.885	-0.112
Meas 3	79.993	130.8511	79.880	-0.112
Meas 4	79.975	130.8441	79.862	-0.113

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0193	0.0193	0.0193	0.0193
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0017	0.0062	0.0015	0.0016
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.019368	0.020271	0.019357	0.019362

Effective degrees of freedom of uncertainty estimates: 87

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.113
Type A standard uncertainty due to reproducibility of difference results	0.0010
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0194**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 85 °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	84.951	132.7431	84.842	-0.109
Meas 2	84.913	132.7282	84.803	-0.110
Meas 3	84.928	132.7344	84.819	-0.109
Meas 4	84.934	132.7367	84.825	-0.109

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0207	0.0207	0.0207	0.0207
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0018	0.0032	0.0026	0.0017
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.02078	0.020954	0.020872	0.020776

Effective degrees of freedom of uncertainty estimates: 99

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.109
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0004
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0208**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 90 °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	89.966	134.6534	89.859	-0.106
Meas 2	89.951	134.6478	89.845	-0.106
Meas 3	89.967	134.6539	89.861	-0.106
Meas 4	89.973	134.6568	89.868	-0.105

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0200	0.0200	0.0200	0.0200
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0050	0.0022	0.0021	0.0032
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020577	0.020082	0.020069	0.02021

Effective degrees of freedom of uncertainty estimates: 105

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.106
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0005
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0206**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **95** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	95.080	136.5979	94.974	-0.106
Meas 2	95.063	136.5919	94.959	-0.105
Meas 3	95.054	136.5869	94.945	-0.109
Meas 4	95.020	136.5747	94.913	-0.106

Uncertainties (in °C)

Hygrometer	08-1215			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0216	0.0216	0.0216	0.0216
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0031	0.0037	0.0027	0.0040
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.021805	0.021905	0.021752	0.021943

Effective degrees of freedom of uncertainty estimates: 94

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.106
Type A standard uncertainty due to reproducibility of difference results	0.0017
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0219**

Fig. 12.6.e Results reported by **INTA2** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.033	111.6495	29.940	-0.093
Meas 2	29.978	111.6283	29.885	-0.093
Meas 3	30.040	111.6526	29.948	-0.092
Meas 4	30.032	111.6496	29.940	-0.092

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0155	0.0155	0.0155	0.0155
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0018	0.0021	0.0038	0.0016
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.015585	0.015623	0.015948	0.01557

Effective degrees of freedom of uncertainty estimates: 85

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.093
Type A standard uncertainty due to reproducibility of difference results	0.0004
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0156**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **50** °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	49.983	119.3595	49.902	-0.081
Meas 2	49.979	119.3580	49.898	-0.081
Meas 3	49.981	119.3592	49.902	-0.079
Meas 4	49.986	119.3606	49.905	-0.081

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0169	0.0169	0.0169
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0024	0.0033	0.0030	0.0025
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.017118	0.017261	0.017211	0.017123

Effective degrees of freedom of uncertainty estimates: 92

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.080
Type A standard uncertainty due to reproducibility of difference results	0.0007
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0171**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 65 °C | Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	64.992	125.1310	64.924	-0.068
Meas 2	65.020	125.1430	64.956	-0.064
Meas 3	64.999	125.1348	64.934	-0.065
Meas 4	65.007	125.1380	64.943	-0.064

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1216				
Standard uncertainty of applied condition	0.0180	0.0180	0.0180	0.0180
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0011	0.0007	0.0008	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.018041	0.018023	0.018026	0.018035

Effective degrees of freedom of uncertainty estimates: 90

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.065
Type A standard uncertainty due to reproducibility of difference results	0.0018
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0181**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 80 °C | Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.007	130.8807	79.958	-0.049
Meas 2	79.997	130.8772	79.949	-0.048
Meas 3	79.993	130.8752	79.943	-0.049
Meas 4	79.975	130.8682	79.925	-0.049

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1216				
Standard uncertainty of applied condition	0.0193	0.0193	0.0193	0.0193
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0011	0.0014	0.0015	0.0021
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.01933	0.019351	0.019357	0.019409

Effective degrees of freedom of uncertainty estimates: 87

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.049
Type A standard uncertainty due to reproducibility of difference results	0.0006
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0193**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 85 °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	84.951	132.7687	84.909	-0.042
Meas 2	84.913	132.7542	84.871	-0.041
Meas 3	84.928	132.7588	84.883	-0.045
Meas 4	84.934	132.7609	84.889	-0.045

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0207	0.0207	0.0207	0.0207
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0018	0.0024	0.0037	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020783	0.020839	0.021029	0.020799

Effective degrees of freedom of uncertainty estimates: 99

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.043
Type A standard uncertainty due to reproducibility of difference results	0.0022
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0209**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 90 °C Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	89.966	134.6762	89.919	-0.047
Meas 2	89.946	134.6713	89.906	-0.040
Meas 3	89.962	134.6774	89.922	-0.040
Meas 4	89.973	134.6800	89.929	-0.044

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0200	0.0200	0.0200	0.0200
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0052	0.0026	0.0019	0.0031
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020615	0.02013	0.020048	0.020196

Effective degrees of freedom of uncertainty estimates: 105

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.043
Type A standard uncertainty due to reproducibility of difference results	0.0034
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0209**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 95 °C | Lab name INTA2

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	95.080	136.6207	95.034	-0.046
Meas 2	95.063	136.6138	95.016	-0.047
Meas 3	95.054	136.6099	95.006	-0.048
Meas 4	95.019	136.5967	94.971	-0.048

Uncertainties (in °C)

Hygrometer	08-1216			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0216	0.0216	0.0216	0.0216
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0048	0.0034	0.0037	0.0038
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.022123	0.021856	0.021904	0.021914

Effective degrees of freedom of uncertainty estimates: 94

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.047
Type A standard uncertainty due to reproducibility of difference results	0.0012
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0222**

Fig. 12.6.f Results reported by **KRISS** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: 30 °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.111	111.6605	29.968	-0.143
Meas 2	30.129	111.6685	29.989	-0.140
Meas 3	30.128	111.6696	29.992	-0.136
Meas 4	30.128	111.6703	29.993	-0.134

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0166	0.0166	0.0166	0.0166
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0007	0.0004	0.0012	0.0006
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.016614	0.016606	0.01664	0.016611

Effective degrees of freedom of uncertainty estimates: 468

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.139
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0040
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0171**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: 50 °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	50.119	119.3878	49.976	-0.143
Meas 2	50.139	119.4028	50.015	-0.125
Meas 3	50.144	119.4017	50.012	-0.132
Meas 4	50.164	119.4130	50.041	-0.123

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0174	0.0174	0.0174	0.0174
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0059	0.0027	0.0021	0.0029
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.018374	0.017608	0.017521	0.01764

Effective degrees of freedom of uncertainty estimates: 394

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.131
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0091
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0205**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **65** °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	65.180	125.1793	65.050	-0.130
Meas 2	65.160	125.1714	65.030	-0.130
Meas 3	65.141	125.1639	65.010	-0.130
Meas 4	65.217	125.1958	65.093	-0.124

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0182	0.0182	0.0182	0.0182
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0042	0.0028	0.0036	0.0058
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.018677	0.018409	0.018557	0.019114

Effective degrees of freedom of uncertainty estimates: 346

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.128	
Type A standard uncertainty due to reproducibility of difference results	0.0063	** STDEV x 2
(Derived from standard deviation of 4 values on same instrument)		
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0197**	

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **80** °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.171	130.9162	80.051	-0.120
Meas 2	80.152	130.9069	80.026	-0.125
Meas 3	80.153	130.9073	80.028	-0.125
Meas 4	80.162	130.9142	80.046	-0.116

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0200	0.0200	0.0200	0.0200
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0041	0.0036	0.0043	0.0028
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020422	0.020319	0.020463	0.020194

Effective degrees of freedom of uncertainty estimates: 322

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.122
Type A standard uncertainty due to reproducibility of difference results	0.0044
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0209**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **85** °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	85.115	132.8023	84.997	-0.117
Meas 2	85.126	132.8051	85.005	-0.121
Meas 3	85.106	132.7988	84.988	-0.118
Meas 4	85.107	132.7974	84.984	-0.122

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0211	0.0211	0.0211	0.0211
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0049	0.0050	0.0047	0.0049
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.021655	0.021675	0.021625	0.021663

Effective degrees of freedom of uncertainty estimates: 310

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.120	
Type A standard uncertainty due to reproducibility of difference results	0.0048	** STDEV x 2
(Derived from standard deviation of 4 values on same instrument)		
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0222**	

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **90** °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	90.125	134.7106	90.010	-0.115
Meas 2	90.124	134.7131	90.016	-0.108
Meas 3	90.132	134.7138	90.018	-0.114
Meas 4	90.128	134.7094	90.006	-0.122

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0214	0.0214	0.0214	0.0214
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0021	0.0020	0.0033	0.0022
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.021499	0.021494	0.021646	0.021513

Effective degrees of freedom of uncertainty estimates: 300

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.115	
Type A standard uncertainty due to reproducibility of difference results	0.0168	** STDEV x 3
(Derived from standard deviation of 4 values on same instrument)		
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0273**	

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **95** °C Lab name KRISS

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	95.113	136.6100	95.006	-0.107
Meas 2	95.113	136.6044	94.991	-0.122
Meas 3	95.114	136.6102	95.007	-0.107
Meas 4	95.141	136.6156	95.021	-0.120

Uncertainties (in °C)

Hygrometer		08-1215		
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0244	0.0244	0.0244	0.0244
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0170	0.0174	0.0170	0.0170
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.029738	0.029958	0.029738	0.029738

Effective degrees of freedom of uncertainty estimates: 246

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.114	
Type A standard uncertainty due to reproducibility of difference results	0.0245	** STDEV x 3
(Derived from standard deviation of 4 values on same instrument)		
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0385**	

Fig. 12.6.g Results reported by **NIST** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name NIST

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	29.998	111.6162	29.853	-0.144
Meas 2	29.994	111.6153	29.851	-0.143
Meas 3	29.988	111.6123	29.844	-0.145
Meas 4	29.976	111.6079	29.832	-0.144

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0082	0.0082	0.0082	0.0082
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0019	0.0007	0.0007	0.0021
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.008407	0.008228	0.008231	0.008472

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.144
Type A standard uncertainty due to reproducibility of difference results	0.0007
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0084**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **50** °C Lab name NIST

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

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Results

ROBERT:
Type serial number:
08-1215 or 08-1216

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	49.975	119.3381	49.847	-0.129
Meas 2	49.981	119.3403	49.852	-0.128
Meas 3	49.987	119.3422	49.857	-0.130
Meas 4	49.969	119.3358	49.841	-0.128

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1215				
Standard uncertainty of applied condition	0.0110	0.0110	0.0110	0.0110
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0019	0.0007	0.0007	0.0021
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.011155	0.011021	0.011023	0.011205

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.129
Type A standard uncertainty due to reproducibility of difference results	0.0006
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0112**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **65** °C Lab name NIST

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

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Results

ROBERT:
Type serial number:
08-1215 or 08-1216

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	65.014	125.1176	64.889	-0.124
Meas 2	65.032	125.1254	64.910	-0.122
Meas 3	65.026	125.1244	64.907	-0.119
Meas 4	65.009	125.1171	64.888	-0.121

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1215				
Standard uncertainty of applied condition	0.0114	0.0114	0.0114	0.0114
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0060	0.0056	0.0045	0.0050
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.012893	0.012717	0.012262	0.012429

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.121
Type A standard uncertainty due to reproducibility of difference results	0.0021
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0131**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **80** °C Lab name NIST

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

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Results

ROBERT: Type serial number: 08-1215 or 08-1216

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	79.985	130.8527	79.885	-0.100
Meas 2	80.064	130.8815	79.960	-0.104
Meas 3	80.048	130.8746	79.942	-0.106
Meas 4	80.036	130.8713	79.933	-0.103

Uncertainties (in °C)

	Hygrometer 08-1215 Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0166	0.0166	0.0166	0.0166
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0126	0.0025	0.0054	0.0069
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.02081	0.016783	0.017454	0.017991

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.104
Type A standard uncertainty due to reproducibility of difference results	0.0025
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0210**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **85** °C Lab name NIST

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

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Results

ROBERT: Type serial number: 08-1215 or 08-1216

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	84.501	132.5757	84.403	-0.098
Meas 2	84.548	132.5942	84.451	-0.097
Meas 3	84.555	132.5953	84.454	-0.101
Meas 4	84.492	132.5738	84.398	-0.095

Uncertainties (in °C)

	Hygrometer 08-1215 Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0169	0.0169	0.0169
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0109	0.0082	0.0098	0.0034
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.020125	0.01878	0.019516	0.017244

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.098
Type A standard uncertainty due to reproducibility of difference results	0.0027
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0203**

Fig. 12.6.h Results reported by **NIST** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name NIST

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	29.998	111.6351	29.902	-0.095
Meas 2	29.994	111.6337	29.899	-0.095
Meas 3	29.988	111.6309	29.892	-0.097
Meas 4	29.976	111.6261	29.879	-0.097

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0082	0.0082	0.0082	0.0082
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0014	0.0014	0.0010	0.0018
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.008319	0.008326	0.008264	0.008391

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.096
Type A standard uncertainty due to reproducibility of difference results	0.0007
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0084**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8	Nominal value:	50	°C	Lab name	NIST

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

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Results

ROBERT:
Type serial number:
08-1215 or 08-1216

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	49.975	119.3570	49.896	-0.079
Meas 2	49.981	119.3598	49.903	-0.077
Meas 3	49.987	119.3612	49.907	-0.080
Meas 4	49.969	119.3549	49.890	-0.079

Uncertainties (in °C)

Hygrometer			08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0110	0.0110	0.0110	0.0110
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0033	0.0022	0.0042	0.0016
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.011484	0.011225	0.011778	0.011118

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green backgro

Aggregation of results

Mean of 4 dew-point temperature differences	-0.079
Type A standard uncertainty due to reproducibility of difference results	0.0012
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0115**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **65** °C Lab name NIST

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

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Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	65.014	125.1376	64.942	-0.072
Meas 2	65.032	125.1461	64.964	-0.068
Meas 3	65.026	125.1431	64.956	-0.070
Meas 4	65.009	125.1353	64.936	-0.073

ROBERT:
Type serial number:
08-1215 or 08-1216

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0114	0.0114	0.0114	0.0114
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0041	0.0037	0.0074	0.0038
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.012099	0.011983	0.013591	0.012028

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.071
Type A standard uncertainty due to reproducibility of difference results	0.0022
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0123**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8

Nominal value: **80** °C Lab name NIST

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

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Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	79.985	130.8717	79.934	-0.051
Meas 2	80.064	130.9023	80.014	-0.050
Meas 3	80.048	130.8961	79.998	-0.050
Meas 4	80.036	130.8897	79.982	-0.055

ROBERT:
Type serial number:
08-1215 or 08-1216

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0166	0.0166	0.0166	0.0166
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0110	0.0025	0.0032	0.0076
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.019887	0.016783	0.016907	0.018255

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.051
Type A standard uncertainty due to reproducibility of difference results	0.0022
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0200**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8	Nominal value:	85	°C	Lab name	NIST

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	84.501	132.5938	84.450	-0.050
Meas 2	84.548	132.6121	84.498	-0.050
Meas 3	84.555	132.6129	84.500	-0.055
Meas 4	84.492	132.5902	84.441	-0.052

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0169	0.0169	0.0169	0.0169
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0056	0.0102	0.0067	0.0057
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.017795	0.01972	0.018195	0.017829

Effective degrees of freedom of uncertainty estimates: >50

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.052
Type A standard uncertainty due to reproducibility of difference results	0.0023
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0179**

Fig. 12.6.i Results reported by **NMC, A*STAR** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name NMC, A*STAR

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.000	111.6083	29.833	-0.166
Meas 2	30.002	111.6077	29.832	-0.170
Meas 3	30.028	111.6206	29.865	-0.163
Meas 4	30.003	111.6080	29.832	-0.170

Uncertainties (in °C)

Hygrometer		08-1215		
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0352	0.0355	0.0348	0.0353
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0052	0.0030	0.0021	0.0017
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.0355	0.0356	0.0349	0.0354

Effective degrees of freedom of uncertainty estimates: 2319 k=2

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.167
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0035
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0357**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **50** °C Lab name NMC, A*STAR

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

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Results

ROBERT:
Type serial number:
08-1215 or 08-1216

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	(meas dp - applied dp) in °C
Meas 1	50.064	119.3657	49.918	-0.145
Meas 2	50.061	119.3657	49.919	-0.142
Meas 3	50.065	119.3677	49.924	-0.141
Meas 4	50.035	119.3548	49.890	-0.145

Uncertainties (in °C)

Hygrometer		08-1215		
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0388	0.0385	0.0385	0.0386
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0027	0.0023	0.0022	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.038931	0.03854	0.038513	0.038678

Effective degrees of freedom of uncertainty estimates: 2298

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.143
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0021
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0390**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **65** °C Lab name NMC, A*STAR

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	65.070	125.1369	64.940	-0.130
Meas 2	64.966	125.0944	64.829	-0.137
Meas 3	64.940	125.0796	64.790	-0.149
Meas 4	64.938	125.0793	64.790	-0.148

Uncertainties (in °C)

	Hygrometer		08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0417	0.0420	0.0421	0.0419
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0025	0.0027	0.0024	0.0019
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.041808	0.042101	0.042207	0.041898

Effective degrees of freedom of uncertainty estimates: 905
In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.141
Type A standard uncertainty due to reproducibility of difference results	0.0093
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0429**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **80** °C Lab name NMC, A*STAR

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.167	130.9140	80.045	-0.122
Meas 2	80.240	130.9439	80.124	-0.116
Meas 3	80.246	130.9445	80.125	-0.121
Meas 4	80.232	130.9393	80.111	-0.121

Uncertainties (in °C)

	Hygrometer		08-1215	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0429	0.0429	0.0429	0.0429
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0084	0.0070	0.0043	0.0070
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.043766	0.043517	0.043167	0.04352

Effective degrees of freedom of uncertainty estimates:
In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation. 3003

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.120
Type A standard uncertainty due to reproducibility of difference results	0.0026
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0438**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 85 °C | Lab name NMC, A*STAR

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	85.001	132.7619	84.891	-0.110
Meas 2	85.230	132.8467	85.114	-0.117
Meas 3	85.026	132.7686	84.909	-0.117
Meas 4	85.021	132.7673	84.905	-0.115

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0608	0.0608	0.0608	0.0608
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0087	0.0056	0.0041	0.0105
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.061436	0.061077	0.060959	0.061723

Effective degrees of freedom of uncertainty estimates:
In most cases the effective number of degrees of freedom will be large. 2046
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.115
Type A standard uncertainty due to reproducibility of difference results	0.0033
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0618**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 | Nominal value: 90 °C | Lab name NMC, A*STAR

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	90.257	134.7603	90.140	-0.117
Meas 2	90.181	134.7309	90.063	-0.118
Meas 3	90.205	134.7410	90.089	-0.116
Meas 4	90.257	134.7580	90.134	-0.123

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3 (08-1215)	Meas 4
Standard uncertainty of applied condition	0.0610	0.0610	0.0610	0.0610
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0040	0.0066	0.0069	0.0086
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.061148	0.061368	0.061401	0.061617

Effective degrees of freedom of uncertainty estimates:
In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation. 2037

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.118
Type A standard uncertainty due to reproducibility of difference results	0.0032
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0617**

Fig. 12.6.j Results reported by **NMIJ** in Loop 1

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: **30** °C — Lab name: NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	29.989	111.6103	29.838	-0.151
Meas 2	29.997	111.6143	29.849	-0.148
Meas 3	30.006	111.6173	29.856	-0.150
Meas 4	29.993	111.6121	29.843	-0.150

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0176	0.0176	0.0176	0.0176
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0002	0.0001	0.0002	0.0002
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.017648	0.017647	0.017648	0.017648

Effective degrees of freedom of uncertainty estimates: 1069601

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.150
Type A standard uncertainty due to reproducibility of difference results	0.0013
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0177**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: **50** °C — Lab name: NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	50.011	119.3534	49.886	-0.124
Meas 2	49.985	119.3422	49.857	-0.127
Meas 3	49.999	119.3478	49.872	-0.127
Meas 4	49.982	119.3414	49.855	-0.127

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0219	0.0219	0.0219	0.0219
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0004	0.0002	0.0003	0.0004
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.021944	0.021942	0.021943	0.021944

Effective degrees of freedom of uncertainty estimates: 1403893

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.126
Type A standard uncertainty due to reproducibility of difference results	0.0013
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0220**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 65 °C — Lab name NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer	08-1215			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	65.004	125.1174	64.889	-0.115
Meas 2	64.990	125.1113	64.873	-0.116
Meas 3	65.006	125.1237	64.906	-0.101
Meas 4	65.015	125.1251	64.909	-0.106

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0226	0.0226	0.0226	0.0226
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0002	0.0002	0.0005	0.0003
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.022592	0.022592	0.022596	0.022593

Effective degrees of freedom of uncertainty estimates: 1510

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.110
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0075
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0238**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 80 °C — Lab name NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

Hygrometer	08-1215			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.004	130.8631	79.912	-0.092
Meas 2	79.990	130.8571	79.896	-0.094
Meas 3	79.997	130.8643	79.915	-0.082
Meas 4	80.004	130.8664	79.920	-0.084

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0281	0.0281	0.0281	0.0281
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0004	0.0007	0.0005	0.0006
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.028103	0.028109	0.028104	0.028105

Effective degrees of freedom of uncertainty estimates: 1587

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.088
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0060
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0287**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 85 °C Lab name NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	85.004	132.7711	84.915	-0.088
Meas 2	84.986	132.7641	84.897	-0.089
Meas 3	84.982	132.7667	84.904	-0.078
Meas 4	84.995	132.7690	84.910	-0.086

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1215				
Standard uncertainty of applied condition	0.0305	0.0305	0.0305	0.0305
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0009	0.0013	0.0014	0.0012
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.030542	0.030556	0.030563	0.030554

Effective degrees of freedom of uncertainty estimates: 1776

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.085
Type A standard uncertainty due to reproducibility of difference results	0.0049
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0309**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 90 °C Lab name NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	89.991	134.6702	89.904	-0.087
Meas 2	89.977	134.6654	89.891	-0.086
Meas 3	89.980	134.6654	89.891	-0.089
Meas 4	89.982	134.6657	89.892	-0.090

Uncertainties (in °C)

Hygrometer	Meas 1	Meas 2	Meas 3	Meas 4
08-1215				
Standard uncertainty of applied condition	0.0282	0.0282	0.0282	0.0282
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0014	0.0013	0.0012	0.0011
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.028191	0.028189	0.028182	0.028181

Effective degrees of freedom of uncertainty estimates: 1446

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.088
Type A standard uncertainty due to reproducibility of difference results	0.0019
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0283**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **95** °C Lab name NMIJ

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

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ROBERT:
Type serial number:
08-1215 or 08-1216

Results

	Hygrometer	08-1215		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	94.989	136.5698	94.900	-0.089
Meas 2	94.996	136.5716	94.905	-0.091
Meas 3	94.982	136.5644	94.886	-0.096
Meas 4	94.993	136.5687	94.897	-0.096

Uncertainties (in °C)

Hygrometer 08-1215	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0334	0.0334	0.0334	0.0334
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0014	0.0015	0.0011	0.0017
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.033395	0.0334	0.033384	0.033406

Effective degrees of freedom of uncertainty estimates: 803

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.093
Type A standard uncertainty due to reproducibility of difference results	0.0035
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0336**

Fig. 12.6.k Results reported by **NPL** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **30** °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.027	111.6499	29.941	-0.086
Meas 2	30.029	111.6508	29.943	-0.086
Meas 3	30.030	111.6512	29.944	-0.086
Meas 4	30.029	111.6501	29.941	-0.088

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0104	0.0104	0.0104	0.0104
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0014	0.0013	0.0013	0.0015
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.011	0.011	0.011	0.011

Effective degrees of freedom of uncertainty estimates: 197.934794

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.087
Type A standard uncertainty due to reproducibility of difference results	0.0007
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0109**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: **50** °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	50.035	119.3837	49.965	-0.070
Meas 2	50.033	119.3826	49.962	-0.071
Meas 3	50.034	119.3826	49.962	-0.072
Meas 4	50.039	119.3845	49.967	-0.072

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0104	0.0104	0.0104	0.0104
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0010	0.0009	0.0007	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.011	0.011	0.011	0.011

Effective degrees of freedom of uncertainty estimates: 200.023063

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.071
Type A standard uncertainty due to reproducibility of difference results	0.0006
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0109**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 65 °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	64.999	125.1387	64.944	-0.055
Meas 2	65.000	125.1389	64.945	-0.055
Meas 3	65.006	125.1410	64.950	-0.055
Meas 4	65.008	125.1415	64.952	-0.056

$$t=-\frac{A}{2B}-\sqrt{\frac{A^2}{4B^2}-\frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0107	0.0107	0.0107	0.0107
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0009	0.0004	0.0006	0.0009
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.011	0.011	0.011	0.011

Effective degrees of freedom of uncertainty estimates: 219.501234

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.055
Type A standard uncertainty due to reproducibility of difference results	0.0006
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0111**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 80 °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	80.008	130.8836	79.965	-0.042
Meas 2	80.037	130.8936	79.992	-0.045
Meas 3	80.051	130.8993	80.007	-0.045
Meas 4	80.063	130.9021	80.014	-0.049

$$t=-\frac{A}{2B}-\sqrt{\frac{A^2}{4B^2}-\frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0144	0.0144	0.0144	0.0144
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0016	0.0008	0.0010	0.0008
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.015	0.015	0.015	0.015

Effective degrees of freedom of uncertainty estimates: 672.908508

In most cases the effective number of degrees of freedom will be large.

If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.045
Type A standard uncertainty due to reproducibility of difference results	0.0029
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0150**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 85 °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	84.925	132.7612	84.889	-0.035
Meas 2	84.933	132.7632	84.895	-0.038
Meas 3	84.938	132.7647	84.899	-0.039
Meas 4	84.942	132.7665	84.903	-0.039

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0208	0.0208	0.0208	0.0208
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0013	0.0013	0.0012	0.0010
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.021	0.021	0.021	0.021

Effective degrees of freedom of uncertainty estimates: 2824.50638

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.038
Type A standard uncertainty due to reproducibility of difference results	0.0016
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0211**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 90 °C Lab name NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	89.962	134.6789	89.926	-0.036
Meas 2	89.984	134.6856	89.944	-0.040
Meas 3	89.992	134.6888	89.952	-0.040
Meas 4	89.981	134.6844	89.941	-0.040

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0335	0.0335	0.0335	0.0335
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0018	0.0012	0.0013	0.0011
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.034	0.034	0.034	0.034

Effective degrees of freedom of uncertainty estimates: 18174.6441

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.039
Type A standard uncertainty due to reproducibility of difference results	0.0022
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0337**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 95 °C — Lab name: NPL

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

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Results

	Hygrometer			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	94.853	136.5368	94.814	-0.039
Meas 2	94.988	136.5826	94.934	-0.054
Meas 3	95.058	136.6122	95.012	-0.046
Meas 4	95.064	136.6140	95.017	-0.047

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R}{}}$$

Uncertainties (in °C)

	Hygrometer			
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0530	0.0530	0.0530	0.0530
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0017	0.0030	0.0018	0.0020
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]	0.002887	0.002887	0.002887	0.002887
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature (6 values)	0.053	0.053	0.053	0.053

Effective degrees of freedom of uncertainty estimates: 100446.002

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

Aggregation of results

Mean of 4 dew-point temperature differences	-0.046
Type A standard uncertainty due to reproducibility of difference results	0.0061
two values (each derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument (2 values)	**0.0534**

Fig. 12.6.l Results reported by **PTB** in Loop 2

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 30 °C — Lab name: PTB

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

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ROBERT: Type serial number: 08-1215 or 08-1216

Results

	Hygrometer: 08-1216			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	30.001	111.6391	29.913	-0.088
Meas 2	30.003	111.6387	29.912	-0.091
Meas 3	29.999	111.6367	29.907	-0.093
Meas 4	29.999	111.6352	29.902	-0.096

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0098	0.0098	0.0098	0.0098
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0002	0.0002	0.0002	0.0002
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.009755	0.009755	0.009757	0.009758

Effective degrees of freedom of uncertainty estimates: 137

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.092
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0034
Standard uncertainty of mean dew-point temperature difference for the instrument	0.0103

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 — Nominal value: 50 °C — Lab name: PTB

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

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ROBERT: Type serial number: 08-1215 or 08-1216

Results

	Hygrometer: 08-1216			
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	49.997	119.3592	49.901	-0.096
Meas 2	50.003	119.3627	49.911	-0.093
Meas 3	50.005	119.3610	49.906	-0.098
Meas 4	49.963	119.3473	49.871	-0.092

Uncertainties (in °C)

Hygrometer 08-1216	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0150	0.0150	0.0150	0.0150
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0001	0.0001	0.0002	0.0002
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.014995	0.015012	0.014991	0.014962

Effective degrees of freedom of uncertainty estimates: 119

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.095
Type A standard uncertainty due to reproducibility of difference results (Derived from standard deviation of 4 values on same instrument)	0.0029
Standard uncertainty of mean dew-point temperature difference for the instrument	0.0153

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 65 °C Lab name PTB

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

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ROBERT: Type serial number: 08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	64.995	125.1307	64.924	-0.071
Meas 2	65.009	125.1359	64.937	-0.071
Meas 3	65.000	125.1316	64.926	-0.074
Meas 4	65.001	125.1320	64.927	-0.074

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0179	0.0179	0.0179	0.0179
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0004	0.0004	0.0004	0.0002
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.017931	0.017928	0.017897	0.017896

Effective degrees of freedom of uncertainty estimates: 131

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.073
Type A standard uncertainty due to reproducibility of difference results	0.0016
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0180**

REPORTING TEMPLATE FOR DEW-POINT IN CCTG-K8 Nominal value: 80 °C Lab name PTB

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

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ROBERT: Type serial number: 08-1215 or 08-1216

Results

	Hygrometer	08-1216		
	Applied dew-point in °C	Resistance output in ohm	Output in °C	Difference (meas dp - applied dp) in °C
Meas 1	79.993	130.8689	79.927	-0.067
Meas 2	80.004	130.8694	79.928	-0.075
Meas 3	80.012	130.8716	79.934	-0.078
Meas 4	80.003	130.8695	79.928	-0.074

Uncertainties (in °C)

	Hygrometer		08-1216	
	Meas 1	Meas 2	Meas 3	Meas 4
Standard uncertainty of applied condition	0.0312	0.0312	0.0315	0.0314
Std uncert due to short-term stability (from standard deviation) of measurements of travelling standard (type A)	0.0005	0.0007	0.0006	0.0007
Std uncert due to long-term drift of travelling standard [if needed]				
Std uncert due to resolution of travelling standard [if needed]				
Std uncert due to non-linearity of travelling standard [if needed]				
Covariance between applied and measured values of dew/frost-point temperature [if needed]				
Combination of these standard uncertainties in quadrature	0.031197	0.03122	0.031474	0.031445

Effective degrees of freedom of uncertainty estimates: 77

In most cases the effective number of degrees of freedom will be large.
If significantly small, need to be taken into account throughout the calculation.

NOTE: only fill in fields with green background

Aggregation of results

Mean of 4 dew-point temperature differences	-0.074
Type A standard uncertainty due to reproducibility of difference results	0.0050
(Derived from standard deviation of 4 values on same instrument)	
Standard uncertainty of mean dew-point temperature difference for the instrument	**0.0316**

12.7 UNCERTAINTY BUDGET REPORTED BY ALL PARTICIPANTS

Fig. 12.7.a Uncertainty budget reported by **BEV/E+E** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature Nominal value: 30 °C Lab name BEV/E+E

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) 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)	0.0040	°C	50	-	1.000	K/K	0.0040	°C	5.11688E-12
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99878E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99878E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59341E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19805E-13
	Temperature stability	0.0002	°C	>50	-	1.000	K/K	0.0002	°C	1.27054E-17
Saturation pressure										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.017	K/hPa	0.0008	°C	7.53008E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.017	K/hPa	0.0048	°C	1.05283E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.017	K/hPa	0.0017	°C	1.48857E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.017	K/hPa	0.0050	°C	1.20574E-11
	Stability of the pressure	0.07	hPa	>50	-	0.017	K/hPa	0.0011	°C	3.46697E-14
	Effect of the tubing between the saturator and the pressure gauge	0.00	hPa	50	-	0.017	K/hPa	0.0000	°C	0
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.017	K/hPa	0.0008	°C	7.53008E-15
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.017	K/hPa	0.0048	°C	1.05788E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.017	K/hPa	0.0017	°C	1.49569E-13
	Stability of the pressure	0.07	hPa	>50	-	0.017	K/hPa	0.0012	°C	3.672E-14
	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									
	Stability of the flow	0.02	l/min	50	-	0.007	K/(l/min)	0.0001	°C	8.66138E-18
	Reproducibility	0.01	l/min	50	-	0.007	K/(l/min)	0.0001	°C	5.41336E-19
Saturation efficiency										
	Saturation efficiency	0.0021	hPa	50	-	0.409	K/hPa	0.0009	°C	1.14652E-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	7.93078E-15
	Water vapour enhancement formula(e)	0.0041	hPa	50	-	0.409	K/hPa	0.0017	°C	1.52733E-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					-			0.0110	°C	
Effective degrees of freedom				350	-				°C	4.13775E-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	-	0.017	K/hPa	0.0004	°C	5.84256E-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					-			0.0110	°C	
Effective degrees of freedom				351	-				°C	4.13781E-11
Expanded uncertainty					-			0.0220	°C	

Fig. 12.7.b Uncertainty budget reported by **BEV/E+E** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	95	°C		Lab name	BEV/E+E			
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)	0.0040	°C	50	-	1.000	K/K	0.0040	°C	5.11674E-12
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99873E-14
	Self-heating and residual heat fluxes (sensor)	0.0010	°C	50	-	1.000	K/K	0.0010	°C	1.99873E-14
	Resolution and accuracy or linearity (indicator unit)	0.0023	°C	50	-	1.000	K/K	0.0023	°C	5.59325E-13
	Saturator:									
	Temperature homogeneity	0.0020	°C	50	-	1.000	K/K	0.0020	°C	3.19796E-13
	Temperature stability	0.0001	°C	>50	-	1.000	K/K	0.0001	°C	7.15351E-18
Saturation pressure										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.05	hPa	50	-	0.025	K/hPa	0.0012	°C	4.15681E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0074	°C	5.84926E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	8.27007E-13
	Pressure differences in the saturator cell	0.30	hPa	50	-	0.025	K/hPa	0.0076	°C	6.69876E-11
	Stability of the pressure	0.14	hPa	>50	-	0.025	K/hPa	0.0036	°C	3.4552E-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	4.15681E-14
	Long-term stability (sensor and indicator)	0.29	hPa	50	-	0.025	K/hPa	0.0074	°C	5.87293E-11
	Resolution and accuracy or linearity (indicator unit)	0.10	hPa	50	-	0.025	K/hPa	0.0025	°C	8.30353E-13
	Stability of the pressure	0.14	hPa	>50	-	0.025	K/hPa	0.0036	°C	3.4921E-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									
	Stability of the flow	0.02	l/min	50	-	0.065	K/(l/min)	0.0013	°C	5.72846E-14
	Reproducibility	0.01	l/min	50	-	0.065	K/(l/min)	0.0007	°C	3.58029E-15
Saturation efficiency										
	Saturation efficiency	0.0424	hPa	50	-	0.032	K/hPa	0.0014	°C	7.08916E-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)	0.0152	hPa	50	-	0.032	K/hPa	0.0005	°C	1.18833E-15
	Water vapour enhancement formula(e)	0.0420	hPa	50	-	0.032	K/hPa	0.0014	°C	6.83448E-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					-			0.0158	°C	
Effective degrees of freedom				313	-				°C	2.00754E-10
Expanded uncertainty					-			0.0317	°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	3.24357E-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					-			0.0158	°C	
Effective degrees of freedom				314	-				°C	2.00758E-10
Expanded uncertainty					-			0.0317	°C	

Fig. 12.7.c Uncertainty budget reported by **INTA** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature — Nominal value: 30 °C — Lab name: INTA2

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) 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)	0.0025	°C	50	-	0.963		0.0024	°C		6.7274E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.963		0.0018	°C		1.56847E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.963		0.0017	°C		1.54997E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.963		0.0004	°C		4.60675E-16
	Saturator:										
	Temperature homogeneity	0.0058	°C	50	-	0.963		0.0056	°C		1.91355E-11
	Temperature stability	0.0100	°C	19	-	0.963		0.0096	°C		4.53209E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-1.29E-04		-0.0009	°C		1.32514E-14
	Long-term stability (sensor and indicator)	18	Pa	50	-	-1.29E-04		-0.0023	°C		5.66334E-13
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-1.29E-04		-0.0001	°C		6.13234E-19
	Pressure differences in the saturator cell	29	Pa	50	-	-1.29E-04		-0.0037	°C		3.83271E-12
	Stability of the pressure	60	Pa	19	-	-1.29E-04		-0.0077	°C		1.88231E-10
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-1.29E-04		-0.0007	°C		6.13234E-15
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	1.71E-04		0.0010	°C		2.24013E-14
	Long-term stability (sensor and indicator)	15	Pa	50	-	1.71E-04		0.0026	°C		9.04964E-13
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	1.71E-04		0.0010	°C		1.92055E-14
	Stability of the pressure	20	Pa	19	-	1.71E-04		0.0034	°C		7.27788E-12
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	1.71E-04		0.0010	°C		1.92055E-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	-	17.34		0.0005	°C		1.25651E-15
	Water vapour enhancement formula(e)	0.00007	%	50	-	17.41		0.0012	°C		4.8066E-14
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-17.41		-0.0005	°C		1.27471E-15
	Water vapour enhancement formula(f) at tc, pc	0.00003	%	50	-	-17.41		-0.0005	°C		1.71322E-15
					-				°C		
Combined uncertainty					-			0.015	°C		
Effective degrees of freedom					-	85			°C	sum	6.74274E-10
Expanded uncertainty					-	2.030		**0.031**	°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		1.83069E-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						85			°C	sum	6.74274E-10
Expanded uncertainty						2.030		**0.031**	°C		

Fig. 12.7.d Uncertainty budget reported by **INTA** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature — Nominal value: 95 °C — Lab name: INTA2

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) 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)	0.0026	°C	55	-	0.969		0.0024	°C		6.37038E-13
	Long-term stability (sensor and indicator)	0.0018	°C	62	-	0.969		0.0017	°C		1.48253E-13
	Self-heating and residual heat fluxes (sensor)	0.0017	°C	50	-	0.969		0.0016	°C		1.464E-13
	Resolution and accuracy or linearity (indicator unit)	0.0004	Ohm/Ohm	50	-	0.969		0.0004	°C		4.70088E-16
	Saturator:										
	Temperature homogeneity	0.0087	°C	50		0.969		0.0082	°C		9.14997E-11
	Temperature stability	0.0100	°C	19	-	0.969		0.0095	°C		4.28069E-10
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7	Pa	50	-	-2.24E-04		-0.0016	°C		1.20238E-13
	Long-term stability (sensor and indicator)	18	Pa	50	-	-2.24E-04		-0.0040	°C		5.13869E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	50	-	-2.24E-04		-0.0001	°C		5.56424E-18
	Pressure differences in the saturator cell	29	Pa	50	-	-2.24E-04		-0.0065	°C		3.47765E-11
	Stability of the pressure	60	Pa	19	-	-2.24E-04		-0.0134	°C		1.70793E-09
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	-2.24E-04		-0.0013	°C		5.56424E-14
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	6	Pa	50	-	2.67E-04		0.0016	°C		1.32519E-13
	Long-term stability (sensor and indicator)	15	Pa	50	-	2.67E-04		0.0040	°C		5.35349E-12
	Resolution and accuracy or linearity (indicator unit)	6	Pa	50	-	2.67E-04		0.0015	°C		1.13614E-13
	Stability of the pressure	20	Pa	19	-	2.67E-04		0.0053	°C		4.30537E-11
	Effect of the tubing between the saturator and the pressure gauge	6	Pa	50	-	2.67E-04		0.0015	°C		1.13614E-13
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	-	27.09		0.0008	°C		7.48099E-15
	Water vapour enhancement formula(e)	0.00002	%	50	-	27.48		0.0006	°C		3.29726E-15
Other uncertainties											
	Saturation vapour pressure formula(e) at tc	0.00003	%	50	-	-27.48		-0.0008	°C		7.92145E-15
	Water vapour enhancement formula(f) at tc, pc	0.00002	%	50	-	-27.48		-0.0005	°C		1.74021E-15
					-				°C		
Combined uncertainty					-			0.022	°C		
Effective degrees of freedom					-	94			°C	sum	2.31731E-09
Expanded uncertainty					-	2.027		**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		1.08298E-15
	Other								°C		
Combined uncertainty								0.022	°C		
Effective degrees of freedom						94			°C	sum	2.31731E-09
Expanded uncertainty						2.027		**0.044**	°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)

Fig. 12.7.e Uncertainty budget reported by **INRiM** at 30 °C dew-point temperature.

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

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) 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	50	-	1.00	°C/°C	0.010	°C		2E-10
	Long-term stability (sensor and indicator)	0.0029	°C	50	-	1.00	°C/°C	0.003	°C		1.39549E-12
	Self-heating and residual heat fluxes (sensor)	0.0000	°C	50	-	1.00	°C/°C	0.000	°C		0
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.00	°C/°C	0.000	°C		1.39549E-16
	Saturator:										
	Temperature homogeneity	0.0010	°C	50	-	1.00	°C/°C	0.001	°C		2E-14
	Temperature stability	0.0020	°C	20	-	1.00	°C/°C	0.002	°C		8E-13
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	17.5000	Pa	50	-	-1.7E-04	°C/Pa	-0.003	°C		1.42082E-12
	Long-term stability (sensor and indicator)	15.0000	Pa	50	-	-1.7E-04	°C/Pa	-0.002	°C		7.66922E-13
	Resolution and accuracy or linearity (indicator unit)	0.1000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		1.51491E-21
	Pressure differences in the saturator cell	15.0000	Pa	50	-	-1.7E-04	°C/Pa	-0.002	°C		7.66922E-13
	Stability of the pressure	13.0000	Pa	20	-	-1.7E-04	°C/Pa	-0.002	°C		1.08168E-12
	Effect of the tubing between the saturator and the pressure gauge	0.1000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		1.51491E-21
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	2.0000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		2.42385E-16
	Long-term stability (sensor and indicator)	2.5000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		5.91761E-16
	Resolution and accuracy or linearity (indicator unit)	0.0010	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		1.51491E-29
	Stability of the pressure	0.5400	Pa	20	-	-1.7E-04	°C/Pa	0.000	°C		3.22034E-18
	Effect of the tubing between the saturator and the pressure gauge	0.1000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		1.51491E-21
Flow measurement:											
	Flow meter										
	Stability of the flow	0.001	l/min	60	-	0.013	°C/l/min	0.000	°C		1.94976E-22
	Reproducibility	0.0087	l/min	50	-	0.013	°C/l/min	0.000	°C		3.22838E-18
Saturation efficiency											
	Saturation efficiency	0.003	°C	50	-	1.00	°C/°C	0.003	°C		1.39549E-12
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	0.0000	Pa	50	-	-1.7E-04	°C/Pa	0.000	°C		0
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
	Bath homogeneity	0.006	°C	50	-	1.00	°C/°C	0.006	°C		2.23278E-11
	Flow meter - Resolution	0.001	l/min	50	-	0.013	°C/l/min	0.000	°C		5.7122E-22
Combined uncertainty					-			0.013	°C		
Effective degrees of freedom				142	-				°C	sum	2.29976E-10
Expanded uncertainty					-			0.0269	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	10.0000	Pa	50	-	-1.7E-04	°C/Pa	-0.002	°C		1.51491E-13
	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								0.014	°C		
Effective degrees of freedom				147					°C	sum	2.30128E-10
Expanded uncertainty								0.027	°C		

Fig. 12.7.f Uncertainty budget reported by **INRiM** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature Nominal value: 95 °C Lab name: INRIM

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)	0.0100	°C	50	-	1.00	°C/°C	0.010	°C		2E-10
	Long-term stability (sensor and indicator)	0.0029	°C	50	-	1.00	°C/°C	0.003	°C		1.39549E-12
	Self-heating and residual heat fluxes (sensor)	0.0000	°C	50	-	1.00	°C/°C	0.000	°C		0
	Resolution and accuracy or linearity (indicator unit)	0.0003	°C	50	-	1.00	°C/°C	0.000	°C		1.39549E-16
	Saturator:										
	Temperature homogeneity	0.0058	°C	50	-	1.00	°C/°C	0.006	°C		2.23278E-11
	Temperature stability	0.0200	°C	20	-	1.00	°C/°C	0.020	°C		0.000000008
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	17.5000	Pa	50	-	-2.6E-04	°C/Pa	-0.005	°C		8.40739E-12
	Long-term stability (sensor and indicator)	15.0000	Pa	50	-	-2.6E-04	°C/Pa	-0.004	°C		4.5381E-12
	Resolution and accuracy or linearity (indicator unit)	0.1000	Pa	50	-	-2.6E-04	°C/Pa	0.000	°C		8.96414E-21
	Pressure differences in the saturator cell	15.0000	Pa	50	-	-2.6E-04	°C/Pa	-0.004	°C		4.5381E-12
	Stability of the pressure	90.0000	Pa	20	-	-2.6E-04	°C/Pa	-0.023	°C		1.47034E-08
	Effect of the tubing between the saturator and the pressure gauge	0.1000	Pa	50	-	-2.6E-04	°C/Pa	0.000	°C		8.96414E-21
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	2.0000	Pa	50	-	-2.6E-04	°C/Pa	-0.001	°C		1.43426E-15
	Long-term stability (sensor and indicator)	2.5000	Pa	50	-	-2.6E-04	°C/Pa	-0.001	°C		3.50162E-15
	Resolution and accuracy or linearity (indicator unit)	0.0010	Pa	50	-	-2.6E-04	°C/Pa	0.000	°C		8.96414E-29
	Stability of the pressure	7.0000	Pa	20	-	-2.6E-04	°C/Pa	-0.002	°C		5.38073E-13
	Effect of the tubing between the saturator and the pressure gauge	0.1000	Pa	50	-	-2.6E-04	°C/Pa	0.000	°C		8.96414E-21
Flow measurement:											
	Flow meter										
	Stability of the flow	0.040	l/min	60	-	0.020	°C/l/min	0.001	°C		6.82667E-15
	Reproducibility	0.0087	l/min	50	-	0.020	°C/l/min	0.000	°C		1.80855E-17
Saturation efficiency											
	Saturation efficiency	0.003	°C	50	-	1.00	°C/°C	0.003	°C		1.39549E-12
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	0.0000	Pa	50	-	-2.6E-04	°C/Pa	0.000	°C		0
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
	Bath homogeneity	0.006	°C	50	-	1.00	°C/°C	0.006	°C		2.23278E-11
	Flow meter - Resolution	0.010	l/min	50	-	0.020	°C/l/min	0.000	°C		3.2E-17
Combined uncertainty					-			0.034	°C		
Effective degrees of freedom				61	-				°C	sum	2.29689E-08
Expanded uncertainty					-			0.0687	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	10.0000	Pa	50	-	-2.6E-04	°C/Pa	-0.003	°C		8.96414E-13
	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								0.034	°C		
Effective degrees of freedom				61					°C	sum	2.29698E-08
Expanded uncertainty								0.069	°C		

Fig. 12.7.g Uncertainty budget reported by **KRISS** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	KRISS				
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)	0.0020	°C	60	-	1.000	°C	0.0020	°C		2.66667E-13
	Long-term stability (sensor and indicator)	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Self-heating and residual heat fluxes (sensor)	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Resolution and accuracy or linearity (indicator unit)	0.0010	°C	60	-	1.000	°C	0.0010	°C		1.66667E-14
	Saturator:										
	Temperature homogeneity	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Temperature stability	0.0020	°C	99	-	1.000	°C	0.0020	°C		1.61616E-13
Saturation pressure										0.009	
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7.15	Pa	60	-	1.713E-04	°C/Pa	0.0012	°C		3.753E-14
	Long-term stability (sensor and indicator)	5.77	Pa	60	-	1.713E-04	°C/Pa	0.0010	°C		1.59555E-14
	Resolution and accuracy or linearity (indicator unit)	1.30	Pa	60	-	1.713E-04	°C/Pa	0.0002	°C		4.10135E-17
	Pressure differences in the saturator cell	50.00	Pa	60	-	1.713E-04	°C/Pa	0.0086	°C		8.97499E-11
	Stability of the pressure	5.00	Pa	20	-	1.713E-04	°C/Pa	0.0009	°C		2.6925E-14
	Effect of the tubing between the saturator and the pressure gauge	10.00	Pa	60	-	1.713E-04	°C/Pa	0.0017	°C		1.436E-13
Gas pressure at the generator outlet:										0.009	
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.30	Pa	60	-	1.713E-04	°C/Pa	0.0006	°C		1.70298E-15
	Long-term stability (sensor and indicator)	5.80	Pa	60	-	1.713E-04	°C/Pa	0.0010	°C		1.62505E-14
	Resolution and accuracy or linearity (indicator unit)	1.30	Pa	60	-	1.713E-04	°C/Pa	0.0002	°C		4.10135E-17
	Stability of the pressure	3.00	Pa	20	-	1.713E-04	°C/Pa	0.0005	°C		3.48948E-15
	Effect of the tubing between the saturator and the pressure gauge	10.00	Pa	60	-	1.713E-04	°C/Pa	0.0017	°C		1.436E-13
Flow measurement:										0.002	
	Flow meter										
	Stability of the flow			60	-			0.0050	°C		1.04167E-11
	Reproducibility			60	-			0.0050	°C		1.04167E-11
Saturation efficiency											
	Saturation efficiency			60	-			0.0050	°C		1.04167E-11
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant			60	-			0.0000	°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0160	%	100	-	0.175	°C	0.0028	°C		6.14656E-13
	Water vapour enhancement formula(e)	0.0050	%	100	-	-0.175	°C	-0.0009	°C		5.86182E-15
Other uncertainties										0.003	
				100	-			0.0000	°C		0
				100	-			0.0000	°C		0
				100	-			0.0000	°C		0
Combined uncertainty					-			**0.0159**	°C		
Effective degrees of freedom				**412.31**	-					sum	1.53704E-10
Expanded uncertainty					-			**0.0317**	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	10.0000	Pa	60		1.713E-04	°C/Pa	0.0005	°C		1.16316E-15
	Other (moisture ad/desorpsion in tubing from saturator to hygrometer)			60				0.0050	°C		1.04167E-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								**0.0166**	°C		
Effective degrees of freedom				**467.53**					°C	sum	1.64122E-10
Expanded uncertainty								**0.0333**	°C		

Fig. 12.7.h Uncertainty budget reported by **KRISS** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	95	°C		Lab name	KRISS				
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)	0.0020	°C	60	-	1.000	°C	0.0020	°C		2.66667E-13
	Long-term stability (sensor and indicator)	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Self-heating and residual heat fluxes (sensor)	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Resolution and accuracy or linearity (indicator unit)	0.0010	°C	60	-	1.000	°C	0.0010	°C		1.66667E-14
	Saturator:										
	Temperature homogeneity	0.0050	°C	60	-	1.000	°C	0.0050	°C		1.04167E-11
	Temperature stability	0.0020	°C	99	-	1.000	°C	0.0020	°C		1.61616E-13
Saturation pressure										0.009	
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	7.15	Pa	60	-	2.676E-04	°C/Pa	0.0019	°C		2.23487E-13
	Long-term stability (sensor and indicator)	5.77	Pa	60	-	2.676E-04	°C/Pa	0.0015	°C		9.50135E-14
	Resolution and accuracy or linearity (indicator unit)	1.30	Pa	60	-	2.676E-04	°C/Pa	0.0003	°C		2.44231E-16
	Pressure differences in the saturator cell	50.00	Pa	60	-	2.676E-04	°C/Pa	0.0134	°C		5.34451E-10
	Stability of the pressure	5.00	Pa	20	-	2.676E-04	°C/Pa	0.0013	°C		1.60335E-13
	Effect of the tubing between the saturator and the pressure gauge	10.00	Pa	60	-	2.676E-04	°C/Pa	0.0027	°C		8.55121E-13
Gas pressure at the generator outlet:										0.014	
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	3.30	Pa	60	-	2.676E-04	°C/Pa	0.0009	°C		1.01411E-14
	Long-term stability (sensor and indicator)	5.80	Pa	60	-	2.676E-04	°C/Pa	0.0016	°C		9.67698E-14
	Resolution and accuracy or linearity (indicator unit)	1.30	Pa	60	-	2.676E-04	°C/Pa	0.0003	°C		2.44231E-16
	Stability of the pressure	3.00	Pa	20	-	2.676E-04	°C/Pa	0.0008	°C		2.07794E-14
	Effect of the tubing between the saturator and the pressure gauge	10.00	Pa	60	-	2.676E-04	°C/Pa	0.0027	°C		8.55121E-13
Flow measurement:										0.003	
	Flow meter										
	Stability of the flow			60	-			0.0050	°C		1.04167E-11
	Reproducibility			60	-			0.0050	°C		1.04167E-11
Saturation efficiency											
	Saturation efficiency			60	-			0.0050	°C		1.04167E-11
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant			60	-			0.0000	°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.0090	%	100	-	0.270	°C	0.0024	°C		3.48678E-13
	Water vapour enhancement formula(e)	0.0030	%	100	-	-0.270	°C	-0.0008	°C		4.30467E-15
Other uncertainties										0.003	
				100	-			0.0000	°C		0
				100	-			0.0000	°C		0
				100	-			0.0000	°C		0
Combined uncertainty					-			0.0193	°C		
Effective degrees of freedom				229.22	-					sum	6.00066E-10
Expanded uncertainty					-			0.0385	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	10.0000	Pa	60		2.676E-04	°C/Pa	0.0005	°C		1.16316E-15
	Other (moisture ad/desorpsion in tubing from saturator to hygrometer)			60				0.0150	°C		8.4375E-10
* 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								0.0244	°C		
Effective degrees of freedom				246.14					°C	sum	1.44382E-09
Expanded uncertainty								0.0488	°C		

Fig. 12.7.i Uncertainty budget reported by **NIST** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	30	°C		Lab name	NIST				
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)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	--	0.0010	°C		2E-14
	Self-heating and residual heat fluxes (sensor)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Resolution and accuracy or linearity (indicator unit)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Saturator:										
	Temperature homogeneity	0.0010	°C	50	-	1.000	--	0.0010	°C		2E-14
	Temperature stability	0.0012	°C	10	-	1.000	--	0.0012	°C		2.0736E-13
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	31.0000	Pa	50	-	0.000	°C/Pa	0.0050	°C		1.27215E-11
	Long-term stability (sensor and indicator)	7.0000	Pa	50	-	0.000	°C/Pa	0.0011	°C		3.30737E-14
	Resolution and accuracy or linearity (indicator unit)	7.0000	Pa	50	-	0.000	°C/Pa	0.0011	°C		3.30737E-14
	Pressure differences in the saturator cell	7.0000	Pa	50	-	0.000	°C/Pa	0.0011	°C		3.30737E-14
	Stability of the pressure	8.0000	Pa	10	-	0.000	°C/Pa	0.0013	°C		2.82111E-13
	Effect of the tubing between the saturator and the pressure gauge	0.0000	Pa	50	-	0.000	°C/Pa	0.0000	°C		0
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	18.0000	Pa	50	-	0.000	°C/Pa	0.0031	°C		1.79517E-12
	Long-term stability (sensor and indicator)	7.0000	Pa	50	-	0.000	°C/Pa	0.0012	°C		4.10588E-14
	Resolution and accuracy or linearity (indicator unit)	1.0000	Pa	50	-	0.000	°C/Pa	0.0002	°C		1.71007E-17
	Stability of the pressure	13.0000	Pa	10	-	0.000	°C/Pa	0.0022	°C		2.44207E-12
	Effect of the tubing between the saturator and the pressure gauge	0.0000	Pa	50	-	0.000	°C/Pa	0.0000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0100	L/min	50	-	0.000	°C·min/L	0.0000	°C		0
	Reproducibility	0.0100	L/min	50	-	0.000	°C·min/L	0.0000	°C		0
Saturation efficiency											
	Saturation efficiency	0.0020	°C	50	-	1.000	--	0.0020	°C		3.2E-13
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	0.0000		50	-			0.0000	°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	0.2714	Pa	50	-	0.004	°C/Pa	0.0011	°C		2.72098E-14
	Water vapour enhancement formula(e)	0.0002		50	-	17.300	--	0.0034	°C		2.70425E-12
Other uncertainties											
		0.0000		50	-				°C		0
		0.0000		50	-				°C		0
		0.0000		50	-				°C		0
Combined uncertainty					-			0.0082	°C		
Effective degrees of freedom					-				°C	sum	2.06837E-11
Expanded uncertainty					-			0.0160	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	3.0000	Pa	50		0.000	°C/Pa	0.0005	°C		1.38516E-15
	Other			50					°C		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								0.0082	°C		
Effective degrees of freedom									°C	sum	2.06851E-11
Expanded uncertainty								0.0165	°C		

Fig. 12.7.j Uncertainty budget reported by **NIST** at 85 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	85	°C		Lab name	NIST				
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)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Long-term stability (sensor and indicator)	0.0010	°C	50	-	1.000	--	0.0010	°C		2E-14
	Self-heating and residual heat fluxes (sensor)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Resolution and accuracy or linearity (indicator unit)	0.0005	°C	50	-	1.000	--	0.0005	°C		1.25E-15
	Saturator:										
	Temperature homogeneity	0.0082	°C	50	-	1.000	--	0.0082	°C		9.04244E-11
	Temperature stability	0.0025	°C	15	-	1.000	--	0.0025	°C		2.60417E-12
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	31.0000	Pa	50	-	0.000	°C/Pa	0.0076	°C		6.67244E-11
	Long-term stability (sensor and indicator)	7.0000	Pa	50	-	0.000	°C/Pa	0.0017	°C		1.73472E-13
	Resolution and accuracy or linearity (indicator unit)	7.0000	Pa	50	-	0.000	°C/Pa	0.0017	°C		1.73472E-13
	Pressure differences in the saturator cell	7.0000	Pa	50	-	0.000	°C/Pa	0.0017	°C		1.73472E-13
	Stability of the pressure	27.0000	Pa	15	-	0.000	°C/Pa	0.0066	°C		1.27989E-10
	Effect of the tubing between the saturator and the pressure gauge	0.0000	Pa	50	-	0.000	°C/Pa	0.0000	°C		0
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	18.0000	Pa	50	-	0.000	°C/Pa	0.0045	°C		8.20125E-12
	Long-term stability (sensor and indicator)	7.0000	Pa	50	-	0.000	°C/Pa	0.0018	°C		1.87578E-13
	Resolution and accuracy or linearity (indicator unit)	1.0000	Pa	50	-	0.000	°C/Pa	0.0003	°C		7.8125E-17
	Stability of the pressure	33.0000	Pa	15	-	0.000	°C/Pa	0.0083	°C		3.08834E-10
	Effect of the tubing between the saturator and the pressure gauge	0.0000	Pa	50	-	0.000	°C/Pa	0.0000	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0100	L/min	50	-	0.000	°C·min/L	0.0000	°C		0
	Reproducibility	0.0100	L/min	50	-	0.000	°C·min/L	0.0000	°C		0
Saturation efficiency											
	Saturation efficiency	0.0020	°C	50	-	1.000	--	0.0020	°C		3.2E-13
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant	0.0000		50	-			0.0000	°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(e)	3.6073	Pa	50	-	0.000	°C/Pa	0.0016	°C		1.2464E-13
	Water vapour enhancement formula(e)	0.0001		50	-	25.465	--	0.0015	°C		1.09596E-13
Other uncertainties											
		0.0000		50	-				°C		0
		0.0000		50	-				°C		0
		0.0000		50	-				°C		0
Combined uncertainty					-			0.0169	°C		
Effective degrees of freedom					-				°C	sum	6.06062E-10
Expanded uncertainty					-			0.0338	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	3.0000	Pa	50		0.000	°C/Pa	0.0008	°C		6.32813E-15
	Other			50					°C		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								0.0169	°C		
Effective degrees of freedom									°C	sum	6.06069E-10
Expanded uncertainty								0.0339	°C		

Fig. 12.7.k Uncertainty budget reported by **NMC, A*STAR** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature — Nominal value: 30 °C — Lab name: NMC, A*STAR

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) 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)	0.005	°C	1000	-	1	°C	0.005	°C		6.25E-13
	Long-term stability (sensor and indicator)	0.000	°C		-	1	°C	0.000	°C		#¡DIV/0!
	Self-heating and residual heat fluxes (sensor)	0.000	°C		-	1	°C	0.000	°C		#¡DIV/0!
	Resolution and accuracy or linearity (indicator unit)	0.000	°C		-	1	°C	0.000	°C		#¡DIV/0!
	Saturator:										
	Temperature homogeneity	0.020	°C	1000	-	1	°C	0.020	°C		1.6E-10
	Temperature stability (std of 110 readings)	0.0014	°C	109	-	1	°C	0.0014	°C		3.65231E-14
Note 1: A SPRT was used to measure the stauration temperature during the measurement. The standard uncertainty of the SPRT, including cal un, drift, selfheating, resolution, linearity, etc, is 5 mK											
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	42	Pa	1000	-	-0.0001792	°C/Pa	-0.0075	°C		3.20816E-12
	Long-term stability (sensor and indicator)	45	Pa	1000	-	-0.0001792	°C/Pa	-0.0081	°C		4.22775E-12
	Resolution and accuracy or linearity (indicator unit)	1	Pa	1000	-	-0.0001792	°C/Pa	-0.0002	°C		1.031E-18
	Pressure differences in the saturator cell	10	Pa	1000	-	-0.0001792	°C/Pa	-0.0018	°C		1.031E-14
	Stability of the pressure	14.7	Pa	109	-	-0.0001792	°C/Pa	-0.0026	°C		4.39973E-13
	Effect of the tubing between the saturator and the pressure gauge	10	Pa	1000	-	-0.0001792	°C/Pa	-0.0018	°C		1.031E-14
Note 2 The saturation pressure is measured by a precison pressure reference. The reference sensor is palced at the same level of the saturator.											
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	12	Pa	1000	-	0.0001778	°C/Pa	0.0021	°C		2.07021E-14
	Long-term stability (sensor and indicator)	15	Pa	1000	-	0.0001778	°C/Pa	0.0000	°C		0
	Resolution and accuracy or linearity (indicator unit)	1	Pa	1000	-	0.0001778	°C/Pa	0.0002	°C		9.98365E-19
	Stability of the pressure	3.4	Pa	109	-	0.0001778	°C/Pa	0.0006	°C		1.17018E-15
	Effect of the tubing between the saturator and the pressure gauge	10	Pa	1000	-	0.0001778	°C/Pa	0.0018	°C		9.98365E-15
Note 3: The pressure at the transfer standard side is measured by a precision pressure reference. The reference sensor is palced at the same level of the saturator.											
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0012	l/min	1000	-	-		0.000	°C		0
	Reproducibility	0.0114	l/min	1000	-	-		0.000	°C		0
Saturation efficiency											
	Saturation efficiency	0.025	°C	1000	-	1	°C	0.025	°C		3.90625E-10
Note 4: The saturation efficiency is taken from Thunder Scientific's estimation which is 0.143 % of saturation pressure											
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)	0.002	°C	1000	-	1	°C	0.002	°C		1.6E-14
	Water vapour enhancement formula(e)	0.002	°C	1000	-	1	°C	0.002	°C		1.6E-14
Note 6: The water saturation vapor pressure is calculated based on Bob Hardy ITS-90 formulation											
Note 7: Assume un uncertainty on the water saturation vapor pressure formulation of 0.005%											
Note 8: The enhancement factor is calculated based on Greenspan formulation											
Note 9: The uncertainty of the enhancement factor is calculated based on Jeremy Lovell-Smith's fit to the original uncertainty of the Greenspan formulation											
Other uncertainties											
					-				°C		#¡DIV/0!
					-				°C		#¡DIV/0!
					-				°C		#¡DIV/0!
Combined uncertainty					-			0.0347	°C		
Effective degrees of freedom					-			2588.3604		**sum**	5.59247E-10
Expanded uncertainty					-			0.0694	°C	k=	2
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument	0.001	°C	1000	-	1.000	°C	0.0010	°C		1E-15
	bridge calibration (correction, cal uncertainty, long term drift resolution)	0.002	°C	1000	-	1.000	°C	0.0020	°C		1.6E-14
Note 10. For type B method the number of degrees of freedom is taken as infiitive, a large number is inserted for calculation.											
Combined uncertainty								0.0348	°C		
Effective degrees of freedom								2609.8393		**sum**	5.59264E-10
Expanded uncertainty								0.0695	°C	k=	2
	Reproducibility			3				0.003459332			4.77362E-11
	generator stability			9				0.0053			8.7672E-11
	Transfer artefact stability			109				0.0052			6.7079E-12
	Combined							0.035710383			
	Effective degrees of freedom							2318.593704		Sum	7.0138E-10
										k=2	

Fig. 12.7.l Uncertainty budget reported by **NMC, A*STAR** at 90 °C dew-point temperature.

Uncertainty analysis of dewpoint temperature — Nominal value: 90 °C — Lab name: NMC, A*STAR

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_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	0.10	°C	1000	-	0.500		0.0500	°C		6.25E-09
	Long-term stability	0.050	°C	1000	-	0.577		0.0289	°C		6.9453E-10
	Linearity	0.003	°C	1000	-	0.577		0.0017	°C		9.0011E-15
	Resolution	0.0005	°C	1000	-	0.577		0.0003	°C		6.9453E-18
	Effect of non-ideal condensed layer	0.010	°C	1000	-	0.577		0.0058	°C		1.1112E-12
	Short-term stability (103 readings)	0.0033	ohm	102	-	2.630		0.0086	°C		5.3546E-11
Uncertainty originated from the climatic chamber											
	Chamber uniformity	0.016	°C	1000	-	0.577		0.0092	°C		7.2826E-12
	Pressure effect	0.020	°C	1000	-	0.577		0.0115	°C		1.778E-11
	Difference between Thunder 2500 and Weiss chamber at 65 °C	0.013	°C	1000	-	0.577		0.0075	°C		3.1738E-12
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0184	l/min	1000	-	-		0.0000	°C		0
	Reproducibility	0.0009	l/min	1000	-	-		0.0000	°C		0
Other uncertainties											
					-				°C		#¡DIV/0!
					-				°C		#¡DIV/0!
					-				°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											
	bridge calibration (correction, cal uncertainty, long term drift resolution)	0.002	°C	1000	-	1.000	°C	0.0020	°C		1.6E-14
Note 1. For type B method the number of degrees of freedom is taken as infiitive, a large number is inserted for calculation.											
Combined uncertainty					-			0.0610	°C		
Effective degrees of freedom					-			1972.0750	°C	**sum**	7.0274E-09
Expanded uncertainty					-			0.1220	°C	k=	2
	Reproducibility			3				0.00321558			3.5638E-11
	Transfer artefact stability			102				0.00859747			5.3565E-11
	Combined							0.0617007			
	Effective degrees of freedom							2036.50281		Sum	7.1166E-09
										k=2	

Fig. 12.7.m Uncertainty budget reported by **NMIJ** at 30 °C dew-point temperature.

Uncertainty analysis of dew point temperature Nominal value: 30 °C Lab name **NMIJ**

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) 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, Freezing Point of Indium	0.0030	°C			0.852		0.0026	°C		0
	Calibration, Triple point of H2O	0.0030	°C			0.852		0.0026	°C		0
	Interpolation	0.0010	°C			0.852		0.0009	°C		0
	ice point check	0.0055	°C			0.852		0.0047	°C		0
	Long-term stability (sensor and indicator)	0.0005	ohm			2.131	°C/ohm	0.0011	°C		0
	Self-heating and residual heat fluxes (sensor)	0.0005	ohm			2.131	°C/ohm	0.0011	°C		0
	Resistance bridge:										0
	accuracy	0.0005	°C			0.852		0.0004	°C		0
	resolution	0.0000	ohm			2.131	°C/ohm	0.0001	°C		0
	linearity	0.0001	ohm			2.131	°C/ohm	0.0002	°C		0
	Standard resistance:								°C		0
	calibration	0.0001	ohm			2.131	°C/ohm	0.0003	°C		0
	temp dep	0.0018	ohm			2.131	°C/ohm	0.0038	°C		0
	drift	0.0010	ohm			2.131	°C/ohm	0.0021	°C		0
	Saturator:										0
	Temperature homogeneity	0.0010	°C	99		0.852		0.0009	°C		5.32946E-15
	Temperature stability	0.0020	°C	99		0.852		0.0017	°C		8.52714E-14
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	15.5800	Pa			5.590E-05	°C/Pa	0.0009	°C		0
	interpolation (calibration curve)	2.8700	Pa			5.590E-05	°C/Pa	0.0002	°C		0
	Long-term stability (sensor and indicator)	13.8564	Pa			5.590E-05	°C/Pa	0.0008	°C		0
	Resolution and accuracy or linearity (indicator unit)	2.8868	Pa			5.590E-05	°C/Pa	0.0002	°C		0
	temperature dependence	17.1473	Pa			5.590E-05	°C/Pa	0.0010	°C		0
	lean of the pressure gauge	26.9430	Pa			5.590E-05	°C/Pa	0.0015	°C		0
	repeatability	2.8000	Pa			5.590E-05	°C/Pa	0.0002	°C		0
	reproducibility	117.7706	Pa			5.590E-05	°C/Pa	0.0066	°C		0
	Pressure differences in the saturator cell										0
	Stability of the pressure	2.8000	Pa	29		5.590E-05	°C/Pa	0.0002	°C		2.06994E-17
	Effect of the tubing between the saturator and the pressure gauge	3.3948	Pa			5.590E-05	°C/Pa	0.0002	°C		0
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	5.0000	Pa			1.720E-04	°C/Pa	0.0009	°C		0
	interpolation (calibration curve)	0.0000	Pa			1.720E-04	°C/Pa	0.0000	°C		0
	Long-term stability (sensor and indicator)	13.8564	Pa			1.720E-04	°C/Pa	0.0024	°C		0
	Resolution and accuracy or linearity (indicator unit)	0.2887	Pa			1.720E-04	°C/Pa	0.0000	°C		0
	temperature dependence	3.1835	Pa			1.720E-04	°C/Pa	0.0005	°C		0
	lean of the pressure gauge	5.0037	Pa			1.720E-04	°C/Pa	0.0009	°C		0
	repeatability	1.1000	Pa			1.720E-04	°C/Pa	0.0002	°C		0
	reproducibility	18.2739	Pa			1.720E-04	°C/Pa	0.0031	°C		0
	Stability of the pressure	1.1000	Pa	29		1.720E-04	°C/Pa	0.0002	°C		4.41417E-17
	Effect of the tubing between the generator and the hygrometer										0
	altitude	3.3948	Pa			1.720E-04	°C/Pa	0.0006	°C		0
	pressure drop (sample line)	24.1385	Pa			1.720E-04	°C/Pa	0.0042	°C		0
	pressure drop (td port)	16.0000	Pa			1.720E-04	°C/Pa	0.0028	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		0
	Reproducibility				-				°C		0
Saturation efficiency											
	Saturation efficiency	0.0092	°C			1.000		0.0092	°C		0
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant								°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(t1)	5.00E-05				17.419	°C	0.0009	°C		0
	Saturation vapour pressure formula(td)	5.00E-05				17.419	°C	0.0009	°C		0
	Water vapour enhancement formula(p1t1)	4.70E-04				17.419	°C	0.0082	°C		0
	Water vapour enhancement formula(p2td)	1.37E-04				17.419	°C	0.0024	°C		0
Other uncertainties											
					-				°C		0
					-				°C		0
					-				°C		0
Combined uncertainty					-			0.0176	°C		
Effective degrees of freedom					-			1069601		sum	9.06657E-14
Expanded uncertainty					-			0.0353	°C		

Additional uncertainty in applied condition at point of use

	Components	Standard uncertainty	unit	Degrees of freedom	unit	Sensitivity coefficient	unit	Uncertainty contribution	unit		Calculation of degrees of freedom
	Pressure drop between point of realisation and measuring instrument								°C		0
	Other								°C		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	9.06657E-14
Expanded uncertainty							°C		

Fig. 12.7.n Uncertainty budget reported by **NMIJ** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature — Nominal value: 95 °C — Lab name: NMIJ

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) 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, Freezing Point of Indium	0.0030	°C			0.988		0.0030	°C		0
	Calibration, Triple point of H2O	0.0030	°C			0.988		0.0030	°C		0
	Interpolation	0.0010	°C			0.988		0.0010	°C		0
	ice point check	0.0055	°C			0.988		0.0054	°C		0
	Long-term stability (sensor and indicator)	0.0005	ohm			2.469	°C/ohm	0.0012	°C		0
	Self-heating and residual heat fluxes (sensor)	0.0005	ohm			2.469	°C/ohm	0.0012	°C		0
	Resistance bridge:										0
	accuracy	0.0005	°C			0.988		0.0005	°C		0
	resolution	0.0000	ohm			2.469	°C/ohm	0.0001	°C		0
	linearity	0.0001	ohm			2.469	°C/ohm	0.0002	°C		0
	Standard resistance:								°C		0
	calibration	0.0001	ohm			2.469	°C/ohm	0.0003	°C		0
	temp dep	0.0018	ohm			2.469	°C/ohm	0.0044	°C		0
	drift	0.0010	ohm			2.469	°C/ohm	0.0025	°C		0
	Saturator:										0
	Temperature homogeneity	0.0200	°C	99		0.988		0.0198	°C		1.53796E-09
	Temperature stability	0.0050	°C	99		0.988		0.0049	°C		6.00766E-12
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	10.0000	Pa			2.492E-04	°C/Pa	0.0025	°C		0
	interpolation (calibration curve)	2.8700	Pa			2.492E-04	°C/Pa	0.0007	°C		0
	Long-term stability (sensor and indicator)	13.8564	Pa			2.492E-04	°C/Pa	0.0035	°C		0
	Resolution and accuracy or linearity (indicator unit)	2.8868	Pa			2.492E-04	°C/Pa	0.0007	°C		0
	temperature dependence	17.1473	Pa			2.492E-04	°C/Pa	0.0043	°C		0
	lean of the pressure gauge	26.9430	Pa			2.492E-04	°C/Pa	0.0067	°C		0
	repeatability	2.8000	Pa			2.492E-04	°C/Pa	0.0007	°C		0
	reproducibility	74.4535	Pa			2.492E-04	°C/Pa	0.0186	°C		0
	Pressure differences in the saturator cell										0
	Stability of the pressure	2.8000	Pa	29		2.492E-04	°C/Pa	0.0007	°C		8.18021E-15
	Effect of the tubing between the saturator and the pressure gauge	3.3948	Pa			2.492E-04	°C/Pa	0.0008	°C		0
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	5.0000	Pa			2.682E-04	°C/Pa	0.0013	°C		0
	interpolation (calibration curve)	0.0000	Pa			2.682E-04	°C/Pa	0.0000	°C		0
	Long-term stability (sensor and indicator)	13.8564	Pa			2.682E-04	°C/Pa	0.0037	°C		0
	Resolution and accuracy or linearity (indicator unit)	0.2887	Pa			2.682E-04	°C/Pa	0.0001	°C		0
	temperature dependence	3.1835	Pa			2.682E-04	°C/Pa	0.0009	°C		0
	lean of the pressure gauge	5.0037	Pa			2.682E-04	°C/Pa	0.0013	°C		0
	repeatability	1.1000	Pa			2.682E-04	°C/Pa	0.0003	°C		0
	reproducibility	18.2739	Pa			2.682E-04	°C/Pa	0.0049	°C		0
	Stability of the pressure	1.1000	Pa	29		2.682E-04	°C/Pa	0.0003	°C		2.61199E-16
	Effect of the tubing between the generator and the hygrometer										0
	altitude	3.3948	Pa			2.682E-04	°C/Pa	0.0009	°C		0
	pressure drop (sample line)	24.1385	Pa			2.682E-04	°C/Pa	0.0065	°C		0
	pressure drop (td port)	16.0000	Pa			2.682E-04	°C/Pa	0.0043	°C		0
Flow measurement:											
	Flow meter										
	Stability of the flow				-				°C		0
	Reproducibility				-				°C		0
Saturation efficiency											
	Saturation efficiency	0.0092	°C			1.000		0.0092	°C		0
Correlation between pressure and temperature measurement (if relevant)											
	Correlation between pressure and temperature measurement if relevant								°C		0
Uncertainty due to formulae/calculations											
	Saturation vapour pressure formula(t1)	5.00E-05				27.168	°C	0.0014	°C		0
	Saturation vapour pressure formula(td)	5.00E-05				27.168	°C	0.0014	°C		0
	Water vapour enhancement formula(p1t1)	0.00E+00				27.168	°C	0.0000	°C		0
	Water vapour enhancement formula(p2td)	0.00E+00				27.168	°C	0.0000	°C		0
Other uncertainties											
					-				°C		0
					-				°C		0
					-				°C		0
Combined uncertainty					-			0.0334	°C		
Effective degrees of freedom					-			803		sum	1.54398E-09
Expanded uncertainty					-			0.0667	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument								°C		0
	Other								°C		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	1.54398E-09
Expanded uncertainty									°C		

Fig. 12.7.o Uncertainty budget reported by **NPL** at 30 °C dew-point temperature.

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

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)			Infinite	-			0.0025	°C		0
	Long-term stability (sensor and indicator)			Infinite	-			0.0030	°C		0
	Self-heating and residual heat fluxes (sensor)			Infinite	-			0.0030	°C		0
	Resolution and accuracy or linearity (indicator unit)			Infinite	-			0.0016	°C		0
	Saturator:										
	Temperature homogeneity			Infinite	-			0.0050	°C		0
	Temperature stability			9.00E+00	-			0.0050	°C		6.94E-11
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		
	Long-term stability (sensor and indicator)				-				°C		
	Resolution and accuracy or linearity (indicator unit)				-				°C		
	Pressure differences in the saturator cell			Infinite	-			0.0018	°C		0
	Stability of the pressure				-				°C		
	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)				-				°C		
	Long-term stability (sensor and indicator)				-				°C		
	Resolution and accuracy or linearity (indicator unit)				-				°C		
	Stability of the pressure				-				°C		
	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			Infinite	-			0.0030	°C		0
	Draw off rate			Infinite	-			0.0030	°C		0
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											
	Contamination			Infinite	-			0.0010	°C		0
	Desorption and leaks			Infinite	-			0.0000	°C		0
	Temperature conditioning of gas			Infinite	-			0.0000	°C		0
Combined uncertainty					-			0.0100	°C		
Effective degrees of freedom					-				°C	sum	6.94444E-11
Expanded uncertainty					-			0.0199	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument			Infinite				0.0029	°C		0
	Other								°C		
Combined uncertainty								0.0104	°C		
Effective degrees of freedom								166.0490	°C	sum	6.94444E-11
Expanded uncertainty								0.0207	°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)

Fig. 12.7.p Uncertainty budget reported by **NPL** at 95 °C dew-point temperature.

Uncertainty analysis of dew point temperature		Nominal value:	95	°C		Lab name	NPL				
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)			Infinite	-			0.0025	°C		0
	Long-term stability (sensor and indicator)			Infinite	-			0.0030	°C		0
	Self-heating and residual heat fluxes (sensor)			Infinite	-			0.0030	°C		0
	Resolution and accuracy or linearity (indicator unit)			Infinite	-			0.0016	°C		0
	Saturator:										
	Temperature homogeneity			Infinite	-			0.0150	°C		0
	Temperature stability			9.00E+00	-			0.0050	°C		6.94E-11
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)				-				°C		
	Long-term stability (sensor and indicator)				-				°C		
	Resolution and accuracy or linearity (indicator unit)				-				°C		
	Pressure differences in the saturator cell			Infinite	-			0.0030	°C		0
	Stability of the pressure				-				°C		
	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)				-				°C		
	Long-term stability (sensor and indicator)				-				°C		
	Resolution and accuracy or linearity (indicator unit)				-				°C		
	Stability of the pressure				-				°C		
	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			Infinite	-			0.0500	°C		0
	Draw off rate			Infinite	-			0.0030	°C		0
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											
	Contamination			Infinite	-			0.0010	°C		0
	Desorption and leaks			Infinite	-			0.0000	°C		0
	Temperature conditioning of gas			Infinite	-			0.0000	°C		0
Combined uncertainty					-			0.0529	°C		
Effective degrees of freedom					-				°C	sum	6.94444E-11
Expanded uncertainty					-			0.1058	°C		
Additional uncertainty in applied condition at point of use											
	Pressure drop between point of realisation and measuring instrument			Infinite				0.0029	°C		0
	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								0.0530	°C		
Effective degrees of freedom								113230.3656	°C	sum	6.94444E-11
Expanded uncertainty								0.1059	°C		

Fig. 12.7.q Uncertainty budget reported by **PTB** at 30 °C 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
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											
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		9.3845E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C		5.62648E-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	0.0041	°C	50	-	1.000	K/K	0.0041	°C		5.64704E-12
	Temperature stability	0.0000	°C	109	-	1.000	K/K	0.0000	°C		1.76208E-20
Saturation pressure											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.3795	hPa	50	-	-0.002	K/hPa	-0.0007	°C		4.73022E-15
	Long-term stability (sensor and indicator)	1.8764	hPa	50	-	-0.002	K/hPa	-0.0034	°C		2.82838E-12
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.002	K/hPa	-0.0001	°C		1.58447E-19
	Pressure differences in the saturator cell	-	-		-	-	-	-	°C		
	Stability of the pressure	0.0415	hPa	109	-	-0.002	K/hPa	-0.0001	°C		3.09672E-19
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.002	K/hPa	-0.0002	°C		2.3777E-17
Gas pressure at the generator outlet:											
	Pressure gauge:										
	Calibration uncertainty (sensor and indicator unit)	0.0423	hPa	50	-	0.017	K/hPa	0.0007	°C		5.45562E-15
	Long-term stability (sensor and indicator)	0.1155	hPa	50	-	0.017	K/hPa	0.0020	°C		3.02335E-13
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.017	K/hPa	0.0000	°C		1.181E-19
	Stability of the pressure	0.0021	hPa	109	-	0.017	K/hPa	0.0000	°C		1.55774E-20
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.017	K/hPa	0.0003	°C		2.52513E-16
Flow measurement:											
	Flow meter										
	Stability of the flow	0.0000	l/min	109	-	-0.010	K/(l/min)	0.0000	°C		3.85544E-28
	Reproducibility	0.0058	l/min	50	-	-0.010	K/(l/min)	-0.0001	°C		2.57908E-19
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		4.28177E-17
	Water vapour enhancement formula(e)	0.0006	-	50	-	0.072	K/hPa	0.0000	°C		5.54058E-20
Other uncertainties											
	Pressure drop between point of realisation and measuring instrument	0.0006	K	50		1.000	K/K	0.0006	°C		2.58686E-15
					-				°C		
					-				°C		
Combined uncertainty					-			0.010	°C		
Effective degrees of freedom				137	-				°C	sum	6.58449E-11
Expanded uncertainty					-			0.020	°C		

Fig. 12.7.r Uncertainty budget reported by **PTB** at 80 °C 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) 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)	0.0008	°C	50	-	1.000	K/K	0.0008	°C	9.3845E-15
	Long-term stability (sensor and indicator)	0.0073	°C	50	-	1.000	K/K	0.0073	°C	5.62648E-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	0.0083	°C	50	-	1.000	K/K	0.0083	°C	9.29248E-11
	Temperature stability	0.0001	°C	109	-	1.000	K/K	0.0001	°C	1.15587E-18
Saturation pressure										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.3795	hPa	50	-	-0.015	K/hPa	-0.0056	°C	2.03579E-11
	Long-term stability (sensor and indicator)	1.8764	hPa	50	-	-0.015	K/hPa	-0.0279	°C	1.21728E-08
	Resolution and accuracy or linearity (indicator unit)	0.0289	hPa	50	-	-0.015	K/hPa	-0.0004	°C	6.81925E-16
	Pressure differences in the saturator cell				-				°C	
	Stability of the pressure	0.0199	hPa	109	-	-0.015	K/hPa	-0.0003	°C	7.04669E-17
	Effect of the tubing between the saturator and the pressure gauge	0.1010	hPa	50	-	-0.015	K/hPa	-0.0015	°C	1.02331E-13
Gas pressure at the generator outlet:										
	Pressure gauge:									
	Calibration uncertainty (sensor and indicator unit)	0.0423	hPa	50	-	0.024	K/hPa	0.0010	°C	2.07157E-14
	Long-term stability (sensor and indicator)	0.1155	hPa	50	-	0.024	K/hPa	0.0028	°C	1.14801E-12
	Resolution and accuracy or linearity (indicator unit)	0.0029	hPa	50	-	0.024	K/hPa	0.0001	°C	4.48441E-19
	Stability of the pressure	0.0062	hPa	109	-	0.024	K/hPa	0.0001	°C	4.36473E-18
	Effect of the tubing between the saturator and the pressure gauge	0.0196	hPa	50	-	0.024	K/hPa	0.0005	°C	9.58828E-16
Flow measurement:										
	Flow meter									
	Stability of the flow	0.0005	l/min	109	-	-0.009	K/(l/min)	0.0000	°C	4.39316E-24
	Reproducibility	0.0058	l/min	50	-	-0.009	K/(l/min)	-0.0001	°C	1.73651E-19
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	2.54944E-12
	Water vapour enhancement formula(e)	0.0001	-	50	-	0.100	K/hPa	0.0000	°C	1.46026E-22
Other uncertainties										
	Pressure drop between point of realisation and measuring instrument	0.0030	K	50		1.000	K/K	0.0030	°C	1.68775E-12
					-				°C	
					-				°C	
Combined uncertainty					-			0.0312	°C	
Effective degrees of freedom				77	-				°C	sum 1.23486E-08
Expanded uncertainty					-			0.0624	°C	

12.8 IEC 60751 RELATIONSHIP

Based on the international standard IEC 60751:2008 [IEC08], a nominal resistance-temperature characteristic of the PRT in the travelling standard can be defined as follows:

$$\mathrm{R_t} = R_0(1 + A\mathrm{t} + Bt^2)^2 \qquad \text{Eq. 12.8.a}$$

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 = $3.9083 \cdot 10^{-3}$ °C^{-1}
B = $-5.775 \cdot 10^{-7}$ °C^{-2}

Solving the quadratic equation, the temperature can be calculated with:

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R_0 - R_T}{BR_0}} \qquad \text{Eq. 12.8.b}$$

12.9 TECHNICAL PROTOCOL

CCT-K8 Comparison of realizations of local scales of dew-point temperature of humid gas

Dew-point Temperature: 30 °C to 95 °C

Technical protocol (Approved CCT WG.KC)

Contents

1. INTRODUCTION

1.1 Under the Mutual Recognition Arrangement (MRA)[1] the metrological equivalence of national measurement standards will be determined by a set of key comparisons chosen and organized by the Consultative Committees of the CIPM working closely with the Regional Metrology Organizations (RMOs).

1.2 At the 24th Meeting of the CCT in May 2008, it was agreed to organise a CCT Comparison in dew-point temperature (high range) as a follow-up of the existing CCT-K6 dew-point temperature comparison, as proposed by CCT-WG6 (Now WG-Hu).

1.3 The completed registration form for the proposed CCT-Kx high range dew-point key comparison was submitted on 26/09/2008 and registered in the KCDB database on 29/09/2008

[1] *MRA, Mutual Recognition Arrangement, BIPM, 1999.*

1.4 This technical protocol has been drawn up by the Coordinator in consultation with the nominated participants listed in Section 2. It is based on the protocol developed by CCT/WG6 and designed to encourage coherence between CCT-K8 and the corresponding RMO-K8s.

1.5 The procedure outlined in this document cover the technical operations to be followed during measurement of the travelling standards. The procedure, which follows the guidelines established by the BIPM[2,3] is based on current best practice in the use of dew/frost-point hygrometers and takes account of the experience gained from the CCT-K6, EURAMET.T-K6, EURAMET.T-K8 and APMP.T-K8.

1.6 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 (NMI)[4].

[2] *T.J. Quinn, "Guidelines for key comparisons carried out by Consultative Committees", Appendix F to the MRA, BIPM, Paris.*
[3] *CIPM MRA-D-05. "Measurement comparisons in the CIPM MRA"*
[4] *The term national metrology institute and acronym (NMI) also encompasses the designated institutes (DI) throughout the document.*

2. ORGANIZATION

2.1 Participants

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

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 INTA is the Coordinator of the comparison and the Pilot for both loops, taking main responsibility for running the comparison. NIST is Assistant Pilot. The third, common participant is BEV/E+E who also covers the full range of the comparison, complementing the capability of NIST.

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.

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 submit an uncertainty budget of their humidity standards.

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

RMO	NMI	Country	Role	Loop
APMP	Korea Research Institute of Standards and Science (KRISS)	KR		1
	National Metrology Centre (NMC, A*STAR)	SG		1
	National Metrology Institute of Japan (NMIJ), AIST	JP		1
COOMET				
EURAMET	Instituto Nacional de Técnica Aeroespacial (INTA)	ES	***C, P***	1, 2
	Istituto Nazionale di Ricerca Metrologica (INRiM)	IT		2
	National Physical Laboratory (NPL)	GB		2
	Physikalisch-Technische Bundesanstalt (PTB)	DE		2
	E+E Elektronik Ges.m.b.H. (BEV/E+E)	AT	***L***	1, 2
SIM	National Institute for Standards and Technology (NIST)	US	***P***	1, 2

4. 2.2 Method of comparison

2.2.1 The comparison is of the realization of local scales of dew-point temperature at the participating NMIs.

2.2.2 The comparison will be made by calibration of travelling standards purchased by *Centro Español de Metrología* (CEM) and deposited at INTA as part of the Spanish humidity national metrology infrastructure. The travelling standards 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 (See Fig. 2.2.1). Measurements will start in the Pilot and Assistant Pilot laboratories. 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 to carry out final measurements to monitor drift. The draft of a time schedule for this comparison can be found in **Appendix B**. Allowing between 4 and 6 weeks per set of measurements (including shipping), this comparison will have a duration of approximately 10 months.

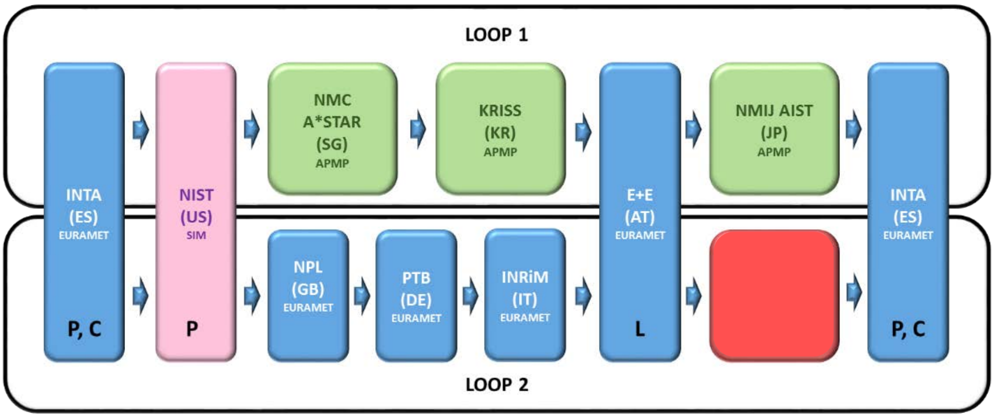

Fig. 2.2.1 Circulation scheme

2.2.4 All results are to be communicated directly to the Pilot (INTA) within three 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. Exclusion of a participant's results from the report may occur if the results are not available in time to prepare the draft report.

2.2.5 Each participant must inform the Pilot within 24 hours of the arrival and despatch of the travelling standards, with copy to the Coordinator. 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 immediately.

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 (INTA) or to the Assistant Pilot laboratory (NIST), or the sequence of participation may be changed to the most practical arrangement.

2.2.7 The Coordinator (INTA) must be informed about any delays in the schedule.

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, detailed instructions have been provided in **Appendix C** of this protocol. 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, large oscillations, etc. 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 could 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 shock indicators 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 current shipping address. If possible, have it shipped directly to the laboratory. Note that the addresses in **Appendix A** 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 D.**

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 and insurance.

2.5.2 Each laboratory pays its share of the services[5] provided by MBW Calibration AG. The participants will be invoiced by MBW Calibration AG after completion of the comparison.

3. DESCRIPTION OF THE TRAVELLING STANDARDS

3.1. Artefacts

3.1.1 Centro Español de Metrología (CEM) lends one travelling standard per loop for the key comparison. The instruments are state-of-the-art, commercially available chilled-mirror 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 55 x 58 cm
Weight (in packing case):	40 kg
Manufacturer:	MBW Calibration AG
Owner:	Centro Español de Metrología (CEM)
Electrical supply:	230 V / 50 Hz
Electrical connection:	Instrument socket IEC/EN 60320-2-2 (socket C14/plug C13) The instrument is 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, pressure measurement insert, condensation trap, flowmeter, operating manual
Approximate value for insurance and customs declaration:	40 000 EUR

Serial numbers of the instruments are:
<u>Loop 1</u>   <u>Loop2</u>

[5] *MBW Calibration AG, will provide technical support on site with the transfer standards or at the factory premises in Switzerland, as applicable.*

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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-point temperatures, 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-point temperatures.

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-point temperatures). These values are chosen in accordance with the maximum 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 The measurements are to be performed at a system absolute pressure not to exceed 108 kPa. Participants should take into account that the flow which has to be adjusted for a constant volumetric at the conditions of the mirror depends strongly on the system pressure and the ambient pressure. Please note that the supplied rotameters are calibrated for use at 1013.25 hPa and 20 ºC. it is recommended that all measurements are performed at the same nominal system pressure that is applicable to the laboratory conditions. For laboratories at a suitable altitude above sea level, it is recommended that the nominal system pressure be set to 101.3 kPa and for other laboratories at the most convenient value up to 105.0 kPa.

4.1.8 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 accurately as possible. A possible value for this pressure drop found during the initial tests in the Pilot laboratories is approximately 18 Pa at a flow rate of the wet gas of 0.5 l/min. This should be verified with own measurements by each participant. For this purpose, a special adaptor has been provided to be inserted instead of the endoscope to act as a pressure measurement port.

Attention: Great care should be placed when inserting or removing this so as not to damage the internal o-ring seal in the endoscope port. It should be inserted or removed slowly whilst turning slightly to avoid pinching the O-ring.

A 6 mm connector is also available at the top of the 12 mm tee at the instrument outlet (see Fig. 1) in order to connect for measurement of pressure drop between head and exit.

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.

4.1.9 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-point temperatures will help prevent this fault.

4.1.10 Due to dew-point temperatures above ambient temperature the condensing water from the outlet of the hygrometer must be separated before entering the variable area flowmeter (rotameter) e.g. by a condensation trap (use hoses or tubes with large 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 variable-area flow meter and the laboratory's flow measurement [6]. Further examples are given in **Appendix G**. Participants should contact the pilot in advance of receiving the instruments if they require assistance in determining the values for their exact laboratory conditions. The following table shows this correction assuming saturation condition at 20 °C (room temperature), volume expansion, according to the system pressure of 101.3 kPa and temperature of the heated head and tube and is calculated for a wet gas flow of 0.5 l/min.

[6] Mitter H, Böse N, Benyon R and T. Vicente, "Pressure drop considerations in the characterization of dew-point transfer standards at high temperatures". Int. Journal of Thermophysics (2012), Vol. 33, Issue 8-9, pp 1726-1740

Dew-point temperature °C	Head temperature °C	Volume of water %	Indicated flow rate after the condensation trap l/min
30	60	4.2	0.44
50	80	12.3	0.38
65	95	24.9	0.31
80	110	47.1	0.21
85	115	57.4	0.17
90	115	69.5	0.12
95	115	83.7	0.06

Table 2: Example of indicated flow rate after the condensation trap for the selected dew-point for a system pressure of 101.3 kPa, room temperature 20 ºC.

4.1.11 A suitable condensation trap and variable-area flowmeter (rotameter) has been provided[7]. This should be connected to the instrument outlet directly (see Fig. 1).

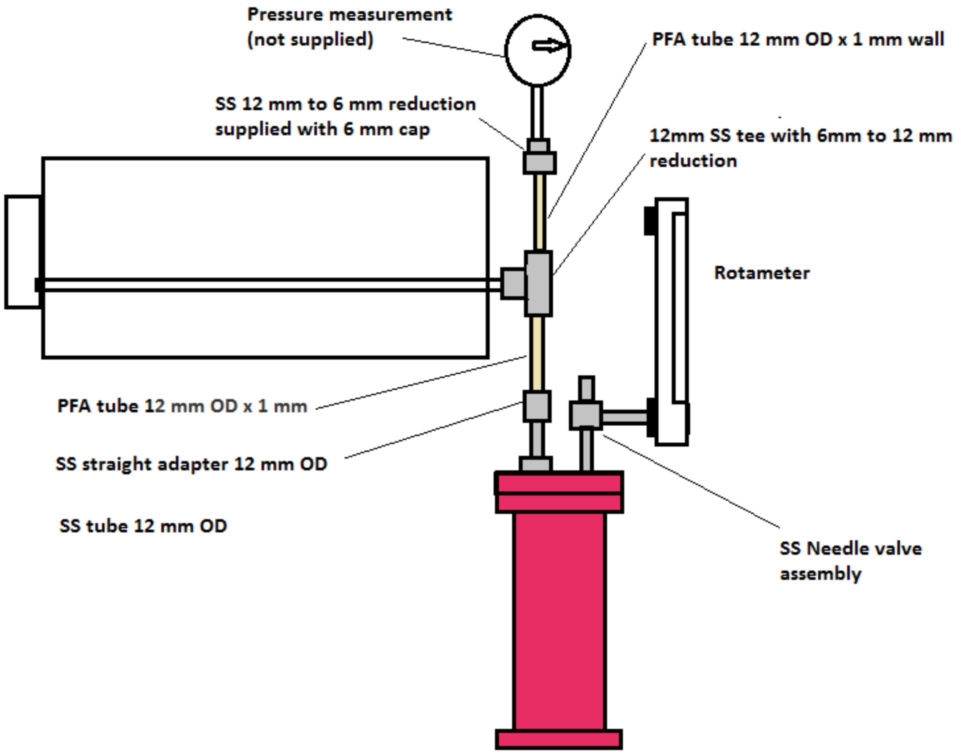

Fig. 1: Schematic of connection of condensation trap with pressure measurement port

4.1.12 Once the flow has been set, the flowmeter should be removed[8] and purged with dry gas. Care must be taken not to touch the needle valve setting whilst removing the flowmeter.

[7] *NOTE: Participants may use their own condensation trap if this is more convenient with their generation system.*

[8] *NOTE: This is to avoid condensation in the flow meter at higher dew-point temperatures after accumulating water in the condensation trap that could lead to wetting of the flow*

4.1.13 Four sets of measurements are carried out at each generated nominal dew-point temperature. The condensate should be cleared and the mirror cleaned if necessary. The flow after the condensation trap should be readjusted. Where relevant (e.g. significant contribution due to lack of reproducibility of the reference value), values should be taken after returning from another value). This is to reduce the effect of any irreproducibility of the travelling standards [9].

4.1.14 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”).

4.1.15 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 volumetric flow rate of 0.5 l/min, the flow-rate indications of the hygrometer, the rotameter and the laboratory flow meter are compared to each other (at a pressure corresponding to the sample gas pressure during dew-point temperature 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 temperature 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, measured with an external bridge or multimeter, and mirror temperature reading from the RS-232 port are recorded during ten minutes (at least ten measurements). This result should be sent to the Pilot, together with the results of the measurement indicated in section **5.2**, as soon as possible, in order to check the condition of the transfer standard**.**

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.

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meter and consequent change the flow through the instrument. Also, sometimes flowmeters tend to oscillate with a back-effect on the instrument.

[9] *NOTE: It is assumed that the reproducibility of the reference generator is already known. The characterization of the transfer standards has shown that the principal contribution due to lack of reproducibility is the flow setting after the condensation trap and the existence of contamination on the mirror.*

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 maximum selectable head temperature is 115 °C. This applies also for dew-point temperatures of 90 °C and above.

3) Wait until the head temperature has stabilized to the pre-set 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[10] according to an indication by the supplied variable-area 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-point temperatures, a new cleaning process may be necessary.

[10] *NOTE: Volumetric flow-rate at the measurement head conditions (temperature and pressure).*

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)

4.1.16 Participants should avoid lengthy additional measurements, except those necessary to give confidence in the results of this comparison.

4.1.17 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.

4.1.18 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.

4.1.19 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 E.**

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 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 according to their normal calibration procedures.

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 temperature measurements should be reported.

4.2.5 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 reproduced measurements, within three weeks of completing their measurements to the Pilot (refer to section 2.2.4).

5.2 The participants shall report to the Pilot the first measurement at a nominal dew-point temperature of 30 ºC within 48 h of it being measured, together with the initial tests performed in **4.1.14**, to check the correct performance of the transfer standard(s).

5.3 The Pilot shall 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.

5.4 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, because of the use of the generalised IEC 60751 relationship. The travelling standards are used simply as comparators.

5.5 Participants should report results to the Pilot in terms of dew-point temperature. The main measurement results comprise:

- values of dew-point temperature 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 temperature.

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.

5.6 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 values.

5.7 In addition, the difference between the hygrometer reading on all occasions will be analysed and will serve as a check of consistency.

5.8 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**.

5.9 Participants should provide a description of the operation of their dew-point facilities used in the comparison.

5.10 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.

5.11 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. 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. Draft B is the first public version.

5.12 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.

6. UNCERTAINTY OF MEASUREMENT

6.1 The uncertainty of the key comparison results will be derived from:

- o the quoted uncertainty of the dew-point temperature realisation (applied dew-point temperature)
- o the estimated uncertainty relating to the short-term stability of the travelling standard at the time of measurement
- o the estimated uncertainty due to any drift of the travelling standard over the period of the comparison (estimated by the Pilots)
- o the estimated uncertainty in mean values due to dispersion of repeated results (reflecting the combined reproducibility of laboratory standard and travelling standards)
- o the estimated uncertainty due to non-linearity of the travelling standards in any case where measurements are significantly away from the agreed nominal value
- o the estimated covariance between applied (laboratory standard) and measured (travelling standard) values of dew-point temperature (if found significant)
- o 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 JCGM100 (2008): *Evaluation of measurement data - Guide to the expression of uncertainty in measurement*. A list of the all significant components of the uncertainty budget[11] 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 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 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.

6.3 The uncertainty budget stated by the participating laboratory should be referenced to an internal report and/or a published article.

7. BILATERAL EQUIVALENCE

7.1 Bilateral equivalences at each dew point will be calculated from differences D_{ij} between participants *i* and *j*, where

[11] For example, see J. Nielsen, J. Lovell-Smith, M.J. de Groot, S. Bell, Uncertainty in the Generation of Humidity, CCT/03-20 (BIPM, Sèvres Cedex, France, 2003)

$$Dij = R_i - R_j, \quad (1)$$

The bilateral degree of equivalence (DoE) is determined as

$$(D_{ij}, U_{ij}) = (D_{ij}, ku(D_{ij})), \quad (2)$$

where the coverage factor k=2 provides a coverage probability of 95 % for sufficiently large effective number of degrees of freedom of $u(D_{ij})$[12].

In this case, $u(D_{ij})$ is given by

$$u^2(D_{ij}) = u^2(x_i) + u^2(x_j) + u^2_{drift}, \quad (3)$$

where u^2_{drift} is the uncertainty in the comparison due to drift of the hygrometer at a given dew point value. For simplicity, u^2_{drift}, is assigned a single generalised value at each dew point, irrespective of whether participants measured in immediate succession or separated in time. If drift is observed then then clause 8.4 will be applied.

The DoE will be calculated for each pair of participants at each nominal measurement point.

8. THE KEY COMPARISON REFERENCE VALUE (KCRV)

8.1 The outputs of the key comparison are expected to be:

- Results of individual participants for comparison of the hygrometers against their dew-point temperature 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 key comparison reference value (KCRV) for each nominal value of dew-point temperature in the comparison. The KCRV will be calculated as a weighted mean of all valid results.
- Estimates of equivalence of each participant to the KCRV. This might be expressed in terms of the Degree of Equivalence (DOE) given as a difference and its uncertainty (Δ ±U), in °C.

8.2 In the field of dew-point standards, the KCRV does not have any absolute significance with respect to an SI unit. It is calculated only for purposes such as the presentation and inter-relation of key comparison data for the MRA.

[12] *Cox, M., The evaluation of key comparison data, Metrologia **39** (2002) 589-595*

8.3 In this comparison and other corresponding RMO comparisons, a reference value is calculated for each nominal value of dew point, treating them as separate data populations for this purpose.

For each nominal dew point value, a key comparison reference value (KCRV)[12] will be calculated as the weighted mean, y, of results

$$y = \frac{x_1/u^2(x_1) + \ldots + x_N/u^2(x_N)}{1/u^2(x_1) + \ldots + 1/u^2(x_N)}, \tag{4}$$

this method of calculation has been agreed by CCT Working Group 6 and applied successfully in CCT-K6. For comparison, values of arithmetic mean and median will also calculated. The uncertainty in weighted mean due to dispersion will be calculated from

$$\frac{1}{u^2(y)} = \frac{1}{u^2(x_1)} + \ldots + \frac{1}{u^2(x_N)}. \tag{5}$$

After collection of participant results, data will be checked for outliers, and calculation of the weighted mean will be made both with and without the outlying results. Values of arithmetic mean and median will also be calculated. As well as the uncertainty in weighted mean due to dispersion, an additional uncertainty in KCRV due to drift of the travelling standard will be include, if necessary, as defined in the next section.

8.4 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 Pilot. 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 KCRV, or by other suitable method so that the estimates of equivalence can be meaningfully calculated between results taken at different times.

8.5 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.

8.6 A chi-squared test will be carried out on the results with and without any identified outliers, as a measure of the consistency of the data and uncertainties.

Discrepant results will be identified using the criterion:

$$\left| R_{lab} - R_{KCRV} \right| > 2\sqrt{u^2(R_{lab}) - u^2(R_{KCRV})} \tag{6}$$

The decision whether to exclude marginally-outlying data will be based on the impact on the KCRV.

6. Appendix A.DETAILS OF PARTICIPATING INSTITUTES

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

Instituto Nacional de Técnica Aeroespacial (INTA) Spain
Address: Centro de Metrología y Calibración, Ctra. a Ajalvir, km. 4
ES-28850 Torrejón de Ardoz
Contact: Dr Robert Benyon
Phone: +34 915 201 711
Fax: +34 915 201 645
E-mail: benyonpr@inta.es

Istituto Nazionale di Ricerca Metrologica (INRiM) Italy
Address: Strada delle Cacce, 73, I-10135 – Torino
Contact: Dr Vito Fernicola
Phone: +39 011 3977 337
Fax: +39 011 3977 347
E-mail: v.fernicola@inrim.it

Korea Research Institute of Standards and Science (KRISS) R. of Korea
Address: 267 Gajeong-Ro Yuseong-Gu Daejeon 305-340
Contact: Dr. Byung Il Choi
Phone: +82 428685275
Fax: +82 428685290
Email: cbi@kriss.re.kr

National Institute for Standards and Technology (NIST) United States of America
Address: Bldg. 221, Rm. B131. 100 Bureau Dr.
Gaithersburg, MD 20899
Contact; Dr. Christopher Meyer
Phone: +1 301 975 4825
Fax: +1 301 548 0206
E-mail: christopher.meyer@nist.gov

National Metrology Centre (NMC, A*STAR) Singapore
Address: 1 Science Park Drive. PSB Building.
Singapore 118221
Contact Dr. Wang Li
Phone: 65 6279 1959
Fax: 65 6279 1996
Email: wang_li@nmc.a-star.edu.sg

National Metrology Institute of Japan (NMIJ), AIST Japan
Address: AIST Tsukuba Central 3,
Tsukuba 305-8563
Contact: Dr Hisashi Abe
Phone +81 29 861 6845
Fax: +81 29 861 4068
Email: abe.h@aist.go.jp

National Physical Laboratory (NPL) United Kingdom
Address: Hampton Road, Teddington, Middlesex, TW11 0LW
Contact: Dr Stephanie Bell
Phone: +44 20 8943 6402
Fax: +44 20 8943 6306
Email: Stephanie.Bell@npl.co.uk

Physikalisch-Technische Bundesanstalt (PTB) Germany
Address: Bundesallee 100, D-38116 Braunschweig
Contact: Dr.-Ing. Regina Deschermeier
Prof. Dr. Volker Ebert
Phone: +49 531 592 3241
+49 531 592 3200
Fax: +49 531 592 69 3241
E-mail: regina.deschermeier@ptb.de
volker.ebert@ptb.de

7. Appendix B.PROVISIONAL TIME SCHEDULE FOR THE COMPARISON

Year		2 0 1 6						2 0 1 7																							
Month		O		N		D		J		F		M		A		M		J		J		A		S		O		N		D	
Spain	ES	■	■	X																											
United States of America	US			■	■	■	X																								
Singapore	SG						■	■	■	■	X																				
Republic of Korea	KR										■	■	■	X																	
Austria	AT													■	■	■	X														
Japan	JP																■	■	■	X											
Spain	ES																			■	■	■									

Figure 1: Comparison scheme of loop 1 (One column corresponds to two weeks; ■ = measurement, X = measurement / transportation).

Year		2 0 1 6						2 0 1 7																							
Month		O		N		D		J		F		M		A		M		J		J		A		S		O		N		D	
Spain	ES	■	■	X																											
United States of America	US			■	■	■	X																								
United Kingdom	GB						■	■	■	X																					
Germany	DE									■	■	X																			
Italy	IT											■	■	X																	
Austria	AT													■	■	■	X														
																	■	■	■	X											
Spain	ES																			■	■	■									

Figure 2: Comparison scheme of loop 2 (One column corresponds to two weeks; ■ = measurement, X = measurement / transportation).

Activity	Start Month	Provisional date
Draft of technical protocol completed by the Coordinator and sent to participants		Nov. 2016
All comments received from participants		Nov. 2016
Submission of a revised protocol to participants for unanimous approval		Nov. 2016
Submission of revised protocol to CCT/WG6 and TC THERM Chairman		Nov. 2016
Travelling standards characterized by the Pilots		Jan. 2009 – Nov 2016
The first set of key comparison measurements according to the protocol at the Pilot laboratories	INTA: Month 1 NIST: Month 2	Oct. 2016 Nov 2016
Travelling standards sent to participant by Co-Pilot	Month 3	Dec. 2016
Completion of measurements	Month 11 approx.	Aug. 2017
Draft A ready	Month 13 approx.	Oct. 2017
Deadline for comments on draft A	Month 14	Nov. 2017
Draft B ready and submitted to CCT/WG.KC	Month 15	Dec. 2017

Appendix C. PACKING / UNPACKING INSTRUCTIONS

CCT-K8

PACKING / UNPACKING INSTRUCTIONS

Table of contents

1. INTRODUCTION

Each instrument is packed in a ZARGES aluminium case that has 10 removable layers of shock-absorbent foam. The layers of foam should be handled with great care to avoid separation of the pre-formed segments.

IMPORTANT:
PACKING & UNPACKING SHOULD ONLY BE PERFORMED BY QUALIFIED LABORATORY PERSONNEL

2. UNPACKING INSTRUCTIONS
2.1 Unpacking

Place transport box in the laboratory at a location close to the point of use and clear an area on a bench/table large enough to take all the contents (hygrometer, condensation trap and accessories). Keep the supplied pallet for despatch. Open the case, releasing the two fastners on one side (it will be necessary to cut the tie wraps blocking the fastners.

Step 1: Remove layer 1 that is the top cover. This exposes layer 2.

Fig.1: Layer 2

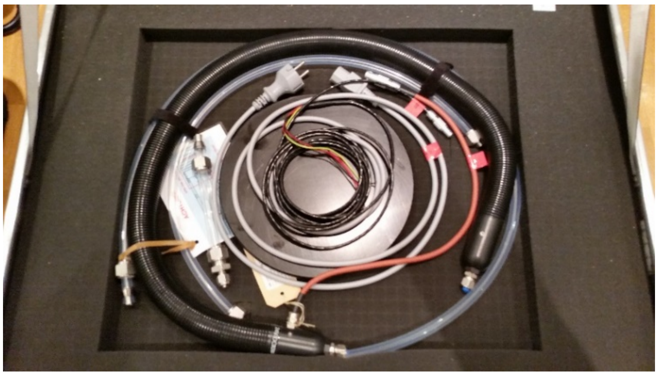

Fig.2: Layer 2 (with instrument operation manual removed)

This has the following contents, that should be removed:

a) Instrument operation manual in an envelope.
b) Shielded cable with LEMO connector for 2nd PRT measurements.
c) Mains cable fitted with European Schuko.
d) 24 V MBW SS heated hose terminated in LEMO connector (for use at inlet if required).
e) 75 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts.
f) 100 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nut one end.
g) Short PFE 12 mm OD tube fitted with 12 mm Swagelok nut on one end and a Swagelok 12 mm to 6 mm connector with a 6 mm cap on the other. (For use with condensation trap).
h) Condensation trap support base.

3

Step 2: Successively remove layers 2 to 6, being careful not to tear the foam and remove the transfer standard. This is best done by two persons, one taking care of the foam. The instrument has two handles that can only be fully opened when the instrument is out of the box, so care has to be taken when removing the instrument. Do not hold by the measuring head.

Fig.3: Layer 5

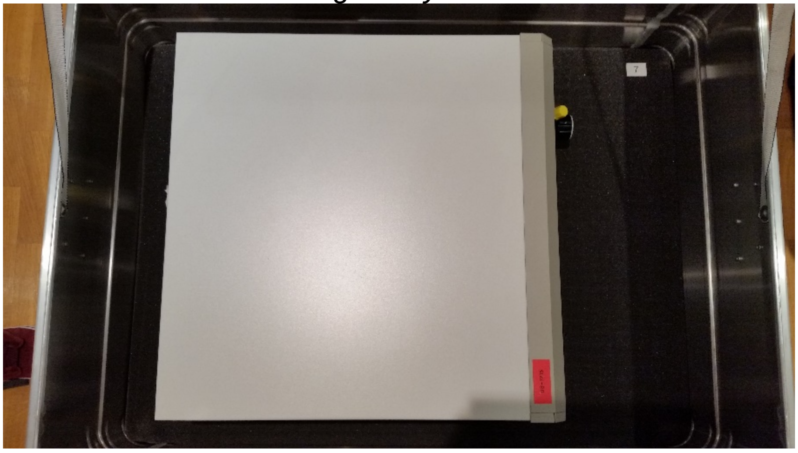

Fig.4: Layer 7

Step 3: Successively remove layers 7 to 10. Once layer 9 has been removed, the condensation trap main body will be visible.

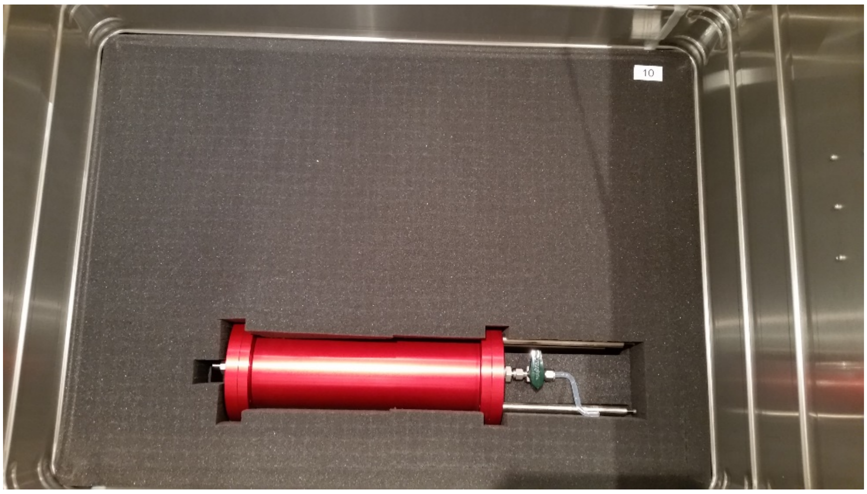

Fig.5: Layer 10

Once layer 10 has been removed, the bottom layer (that should not be removed) is visible:

Fig.6: Bottom layer

It contains:
a) Box of lint-free tissues.
b) Swagelok box that contains [Swagelok SS tee 12 mm with adaptor to 6 mm to connect to instrument outlet, a Swagelok SS 12 mm to 6 mm adaptor to be used as alternative instead of tee if more convenient in instrument set-up, a spare SS 12 mm nut, 12 mm ferrules and insert, a spare LEMO connector for PRT measurement, a SS needle valve assembly with two short lengths of SS tube with 6 mm Swagelok fittings for use with condensation trap] and a ¼" Swagelok connector with o-ring and support ring and a spare o-ring (only to be used if the laboratory needs to have the instrument with ¼" inlet instead of 6 mm). Four SS adaptors from 6 mm to ¼" Swagelok.
c) Spare blank head in red bubble wrap bag.[13]
d) Endoscope case that contains, endoscope, MBW insert for pressure measurement terminated in 6 mm Swagelok fitting, ¼"cap, ¼" nut, set of ¼" nylon ferrules (see Fig. 7).
e) ABB Flowmeter with 6 mm Swagelok at inlet and yellow and red caps (to be removed prior to use).
f) Stainless Steel 12 mm OD insert exit tube for condensation trap.
g) 50 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts.
h) Main body of condensation trap.

Fig.7: Contents of endoscope case

[13] The spare head is provided forr use in case of troubleshooting or failure of endoscope, photodiode or detector in the main measuring head.

2.2 Assembly of condensation trap

Assemble the condensation trap as follows:

a) Attach the base to the four stainless steel legs of the condensation trap using the Allen screws and washers. The base gas a stand-off so that the screw heads do not touch the work bench. Place the condensation trap in the vertical position (see Fig. 8).
b) Insert the stainless-steel exit insert tube into the 12 mm bore-through coupling and hand tighten the 12 mm Swagelok nut and then tighten just under ¼ turn. (the end with the 12 mm straight connector should protrude from the condensation trap
c) Connect the needle valve assembly and hand tighten the 6 mm Swagelok on the condensation trap end and then tighten just under ¼ turn. Check that the needle valve Swagelok couplings are tight (just under ¼ turn from hand tight).
d) Remove the yellow and red plastic protection caps at the inlet and outlet and attach the flowmeter inlet to the needle valve, keeping the flowmeter vertical. Tighten the 6 mm Swagelok nuts to just under ¼ turn from hand tight.

Fig.8: Condensation trap assembled with flowmeter

3. PACKING INSTRUCTIONS

3.1 Preparation of the transfer standard

Once the instrument has been purged with dry gas at the end of the calibration, switch off the instrument and unplug the mains cable from the mains supply and the instrument.
Turn off the generator gas supply to the instrument. Open the condensation trap drain valve and allow the instrument head to depressurize.
Carefully remove the endoscope and place it in its case, together with the pressure measurement insert, the nylon ferrules, the ¼" Swagelok nut, ¼" and Swagelok cap (see Fig. 7). Close the endoscope case.
Place the yellow screw on cap on the endoscope port on the measurement head.
Disconnect the gas lines at the outlet and inlet of the instrument and place the yellow screw on caps on the inlet and outlet Swagelok connectors.
Unplug the heated line LEMO connector.

3.2 Disassembly of the condensation trap

The following instructions are to be followed to prepare the condensation trap for packing:

a) Ensure the condensation trap is empty by opening the drain valve.
b) Remove the flowmeter by loosening the 6 mm Swagelok nut at the flowmeter inlet and place the yellow and red plastic protection caps at the inlet and outlet, respectively.
c) Remove the needle valve assembly by loosening the 6 mm Swagelok on the trap end. (*The needle valve Swagelok nuts should not be loosened and the valve assembly should be the valve and the two short lengths of 6 mm tube with their Swagelok nuts and ferrules*).
d) Disconnect the PFE inlet tube assembly from the condensation trap inlet Swagelok 12 mm adaptor.
e) Remove the stainless steel exit insert tube (that should retain its 12 mm adaptor) by loosening the 12 mm Swagelok nut on the condensation trap end.
f) Remove the condensation trap base by loosening the four stainless steel screws and replacing them afterwards in the four support legs of the condensation trap.
g) Disconnect the two 12 mm nuts on the ends of the 12 mm tee (leave the 12 mm to 6 mm adapter on the short length with its 6 mm cap untouched).

3.3 Packing

Step 1: Open the case and carefully remove layers 1 to 9 of the packaging foam until the bottom unnumbered layer is visible. Place the following in the corresponding cut out sections[14] (refer to figure 6):

a) Box of lint-free tissues.
b) Swagelok box that contains [Swagelok SS tee 12 mm with adaptor to 6 mm to connect to instrument outlet, a Swagelok SS 12 mm to 6 mm adaptor to be used as alternative instead of tee if more convenient in instrument set-up, a spare SS 12 mm nut, 12 mm ferrules and insert, a spare LEMO connector for PRT measurement, a SS needle valve assembly with two short lengths of SS tube with 6 mm Swagelok fittings for use with condensation trap] and a ¼" Swagelok connector with o-ring and support ring and a spare o-ring (only to be used if the laboratory needs to have the instrument with ¼" inlet instead of 6 mm).
c) Spare blank head in red bubble wrap bag.

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[14] *Note: As each element is placed in the box, please tick it off on the despatch form in the measurement protocol*

d) Endoscope case that contains, endoscope, MBW insert for pressure measurement terminated in 6 mm Swagelok fitting, ¼"cap, ¼" nut, set of ¼" nylon ferrules (see Fig. 7).
e) ABB Flowmeter with 6 mm Swagelok at inlet and yellow and red caps (to be removed prior to use).
f) Stainless Steel 12 mm OD insert exit tube for condensation trap (including 12 mm adaptor).
g) 50 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts.
h) Main body of condensation trap.

Step 2: Place layer 10 (see Fig. 5).

Step 3: Place layers 9, 8 and 7 and put the transfer standard in place (check it has the yellow caps on inlet, outlet and endoscope port (see Fig. 4).

Step 4: Place layers 6 and 5 and put the transfer standard in place (see Fig. 3).

Step 5: Place layers 4, 3 and 2 and place the following components in the cut out (see Fig. 1 & 2).

a) 24 V MBW SS heated hose terminated in LEMO connector (for use at inlet if required)
b) 75 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts.
c) 100 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nut one end.
d) Short PFE 12 mm OD tube fitted with 12 mm Swagelok nut on one end and a Swagelok 12 mm to 6 mm connector with a 6 mm cap on the other. (For use with condensation trap).
e) Condensation trap support base
f) Shielded cable with LEMO connector for 2^{nd} PRT measurements.
g) Mains cable fitted with European Schuko plug.
h) Instrument operation manual in an envelope.

Step 6: If you are in an EU member state and the destination is also an EU member State then place the ATA carnet on top of the instrument manual.

Step 7: Place layer 1 and close the case. Place tie-wraps on the two fasteners.

Step 8: If the ATA carnet is to be used then place it in a large envelope marked "ATA CARNET" And fix to the outer top surface of the case.

Step 9: Clearly label the outside of the case in at least two places with the destination[15] and origin address and contact details (be sure to remove the old labels from the previous shipment). Please ensure all the shock indicators are attached and are not in the RED alarm condition. Otherwise replace with new ones.

Step 10: Fix the aluminium transport case to a standard pallet suitable for international shipment. If the laboratory is shipping two instruments in their transport case these should be fitted on one large pallet side by side and never shipped with two separate pallets (See Fig. 9).

Fig.9: Details of cases on pallet

8. Appendix D. FORM FOR REPORTING ON RECEIPT OF TRAVELLING STANDARDS

[15] *Please check current details with next participant as defined in the measurement protocol.*

TO: *(Pilot Laboratory)*

Dr. Robert Benyon

Fax: 00 34 91520 1645 **E-mail**: benyonpr@inta.es

FROM: *(Participating Laboratory)*

Fax: **E-mail:**

We confirm having received the travelling standard of the CCT Comparison of Dew-point Temperature (CCT/K8):

- ☐ Loop 1: S/N: 08-1215;
- ☐ Loop 2: S/N: 08-1216;

on: ____________________ (date)

After visual inspection

- ☐ No damage has been noticed;
- ☐ The following damage must be reported (attach photograph):

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 (attach photograph):

Are there any visible signs of damage to the instruments?

☐ No

☐ Yes: Please give details (attach photograph):

Do you believe the travelling standards are functioning correctly?

☐ Yes

☐ No: Please indicate your concerns:

PACKING LIST

Received	Items	Dispatched
	Instrument operation manual in an envelope	
	Shielded cable with LEMO connector for 2nd PRT measurements	
	Power cord with Standard CEE 7/VII plug	
	24 V MBW SS heated hose terminated in LEMO connector (for use at inlet if required) and terminated in 6 mm Swagelok	
	24 V MBW SS heated hose terminated in LEMO connector (for use at inlet if required) and terminated in ¼” Swagelok	
	75 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts	
	100 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nut one end	
	Short PFE 12 mm OD tube fitted with 12 mm Swagelok nut on one end and a Swagelok 12 mm to 6 mm connector with a 6 mm cap on the other. (For use with condensation trap).	
	Condensation trap support base	
	Dew-point hygrometer MBW 373 HX S/N: _______* with 2 yellow caps on gas inlet and outlet and endoscope port.	
	Box of lint-free tissues	
	Swagelok box that contains: • Swagelok SS tee 12mm with adaptor to 6 mm to connect to instrument outlet, a • Swagelok SS 12mm to 6 mm adaptor • Spare SS 12 mm nut, 12 mm ferrules and insert • Spare LEMO connector for PRT measurement • SS needle valve assembly with two short lengths of SS tube with 6 mm Swagelok fittings for use with condensation trap • SS Swagelok Tube Fitting, Male Connector, 1/4 in. Tube OD x 1/8 in. Male ISO Parallel Thread, Straight Shoulder (SS-400-1-2RS) with o-ring, support ring and spare o-ring. • Two SS Swagelok Tube Fittings, Reducer, 1/4 in. x 6 mm Tube OD SS-400-R-6M with fitted 6mm nut and ferrules. • 6 mm Plug SS-400-P • ¼” Plug SS-6M0-P	
	Spare blank head in red bubble wrap bag	
	Endoscope case that contains: • Endoscope: S/N: _____________* • MBW insert for pressure measurement terminated in 6 mm Swagelok fitting • ¼”cap, ¼” nut, set of ¼” nylon ferrules.	
	ABB Flowmeter with 6 mm Swagelok at inlet and yellow and red caps.	
	Stainless Steel 12 mm OD insert exit tube for condensation trap	
	50 cm PFE 12 mm OD tube fitted with 12 mm Swagelok nuts	
	Main body of condensation trap	
	Zarges K470 IP 65 Aluminium transport case	

*) Please add serial number

Laboratory: ______________________________

Date: ______________ Signature: ______________________

9. Appendix E. IEC 60751 RELATIONSHIP

Based on the international standard IEC 60751:2008, 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

$$t = -\frac{A}{2B} - \sqrt{\frac{A^2}{4B^2} - \frac{R_0 - R_t}{BR_0}}$$

10. 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.

11. Appendix G. EXAMPLES OF FLOW-METER SETTINGS

The following table summarises the flowmeter settings for a laboratory temperature of 22 ºC and ambient pressure of 980 hPa and 1013.25 hPa as a function of system pressure.

Ambient conditions		**System pressure [hPa]**		**1013.25**			**1030**			**1050**		
Temp. [ºC]	**Pressure [hPa]**	**dew-point temp. [°C]**	**head temp. [ºC]**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
22	**1013.25**	**30**	**60**	0.44	0.44	**0.44**	0.44	0.44	**0.45**	0.44	0.45	**0.46**
		50	**80**	0.38	0.38	**0.38**	0.38	0.38	**0.39**	0.38	0.39	**0.40**
		65	**95**	0.31	0.31	**0.31**	0.31	0.32	**0.32**	0.31	0.32	**0.33**
		80	**110**	0.21	0.21	**0.21**	0.21	0.22	**0.22**	0.22	0.22	**0.23**
		85	**115**	0.17	0.17	**0.17**	0.17	0.17	**0.18**	0.17	0.18	**0.18**
		90	**115**	0.12	0.12	**0.12**	0.12	0.13	**0.13**	0.13	0.13	**0.13**
		95	**115**	0.06	0.06	**0.06**	0.07	0.07	**0.07**	0.08	0.08	**0.08**
22	**980**	**30**	**60**	0.44	0.45	**0.46**	0.44	0.46	**0.46**	0.44	0.47	**0.47**
		50	**80**	0.38	0.39	**0.40**	0.38	0.40	**0.40**	0.38	0.41	**0.41**
		65	**95**	0.31	0.32	**0.32**	0.31	0.33	**0.33**	0.31	0.34	**0.34**
		80	**110**	0.21	0.22	**0.22**	0.21	0.22	**0.23**	0.22	0.23	**0.23**
		85	**115**	0.17	0.17	**0.17**	0.17	0.18	**0.18**	0.17	0.19	**0.19**
		90	**115**	0.12	0.12	**0.12**	0.12	0.13	**0.13**	0.13	0.14	**0.14**
		95	**115**	0.06	0.07	**0.07**	0.07	0.07	**0.07**	0.08	0.08	**0.08**

(1) Volume flow after condensation
(2) Volume flow after needle valve (there occurs some expansion from system pressure to ambient which changes the flow)
(3) Volume flow indicated by the flow meter (here the calibration parameters 1013.25 hPa and 20 °C are corrected to the real conditions ambient temperature and pressure.

12. Appendix H.GUIDE ON USE OF SWAGELOK FITTINGS

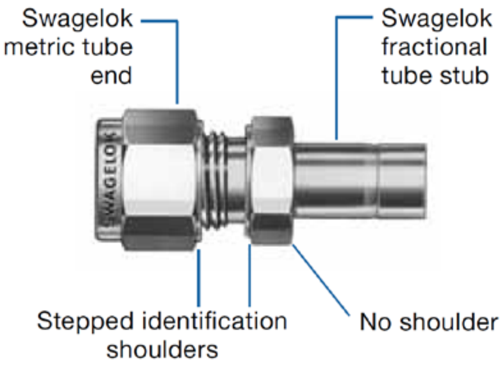
For the correct use of the instruments it is important to distinguish between metric and fractional measurements of connectors and couplings and to correctly tighten them for reproducible, leak-free operation.

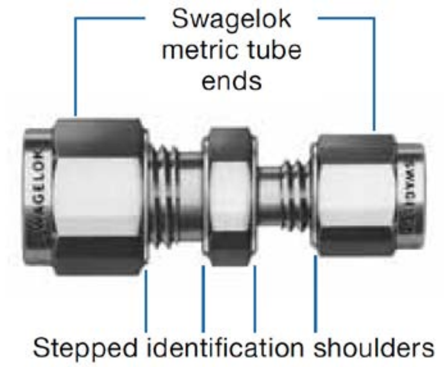
Intermix/Interchange with Other Manufacturers' Components

The critical interaction of precision parts is essential for reliability and safety. Components of other manufacturers should not be intermixed with the Swagelok fittings supplied.

Metric Swagelok Tube Fittings

Metric tube fittings have a stepped shoulder on the body hex.





Shaped fittings, such as elbows, crosses, and tees, are stamped MM for metric tubing and have no step on the forging.

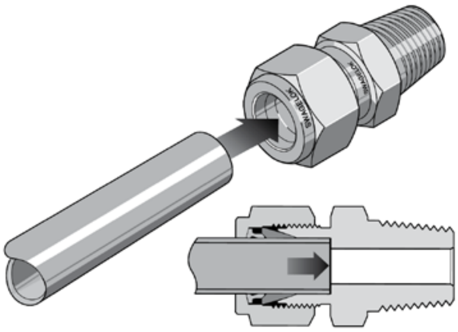
Safety Precautions

- Do not bleed system by loosening fitting nut or fitting plug.
- Do not assemble and tighten fittings when system is pressurized.
- Make sure that the tubing rests firmly on the shoulder of the tube fitting body before tightening the nut.
- Do not mix materials or fitting components from various manufacturers—tubing, ferrules, nuts, and fitting bodies.
- Never turn fitting body. Instead, hold fitting body and turn nut.
- Avoid unnecessary disassembly of unused fittings.

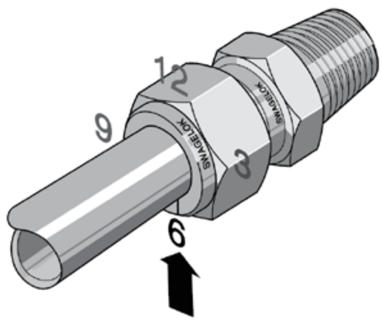
Swagelok Tube Fittings Up to 1 in./25 mm

These instructions apply both to traditional fittings and to fittings with the advanced back-ferrule geometry.

1. Fully insert the tube into the fitting and against the shoulder
rotate the nut finger-tight.

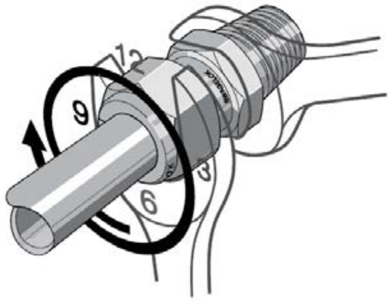


2. Mark the nut at the 6 o'clock position.



3. While holding the fitting body steady, tighten the nut one and one quarter turns to the 9 o'clock position.

For 1/16, 1/8, and 3/16 in.; 2, 3, and 4 mm tube fittings, tighten the nut threequarters turn to the 3 o'clock position.



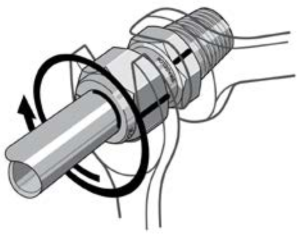
Reassembly—All Sizes

You may disassemble and reassemble Swagelok tube fittings many times.
Always depressurize the system before disassembling a Swagelok tube fitting.

Prior to disassembly, mark the tube at the back of the nut; mark a line along the nut and fitting body flats.
Use these marks to ensure that you return the nut to the previously pulled-up position.

Insert the tube with preswaged ferrules into the fitting until the front ferrule seats against the fitting body.

While holding the fitting body steady, rotate the nut with a wrench to the previously pulled-up position, as indicated by the marks on the tube and flats. At this point, you will feel a significant increase in resistance. Tighten the nut slightly.



13. Appendix I. DOCUMENT REVISION HISTORY

The following table includes the document revision history. Document version is identified by date.

Date	Description	Changes
10/11/2016	First draft sent to participants and CCT-WG/Hu.	
26/11/2016	Second draft sent to participants	Addressing comments of PTB, BEV/E+E and NMIJ.
14/12/2016	Revised version submitted to CCT WG.KC	Addressing comments of CCT. WG-KC Additional section on Swagelok fittings
21/12/2016	Revised version submitted to CCT WG.KC	Addressing comments of CCT. WG-KC Clarification of spare head and section 4.1.13
22/02/2017	Final version approved by CCT WG.KC	Section 4.1.13 reverted to that of 14/12/2016 (including footnote)