Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison on humidity (rev 2)

The bag carrying the humidity sensor for calibration.

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Content

Abstract

This report documents an Inter Laboratory Comparison (ILC) on Humidity calibration involving multiple laboratories. The comparison aimed to evaluate the calibration processes, assess measurement consistency, and determine uncertainties. It includes an overview of participating laboratories, calibration schemes, and conditions during the measurement period. Detailed calibration results are presented across a range of humidity points.

Analysis methods, intercomparison reference values, and associated uncertainties are discussed. The report also highlights calibration principles, administrative details, and final conclusions, supported by annexes and appendices detailing the methodology, reporting formats, and references.

Specific observations:

This report covers all together 56 calibrations of the humidity sensors made by 12 laboratories in 8 countries. Their calibration certificates were mostly in their local language but sometimes in English.

The summarized results from 56 calibrations have 0 results got En values above 1.

Purpose and implementation of the comparison

This interlaboratory comparison serves as a tool to verify results reported by calibration laboratories.

It is an effective method to demonstrate technical capacity of the participant and serves as a technical base for accreditation as required by ISO/IEC 17025:2017 (SS-EN ISO/IEC 17025:2018) as specified in point 7.7.2.

Advisory group

The organiser decided about which sensor to use based on general advise from the advisory group about the humidity sensors that should be included in the ILC humidity 2024:1.

The advisory group consisted of Reidun Anita Bergerud and Peter Rothmund Justervesenet Norge, National Metrology Laboratory (NMI) in humidity and Håkan Källgren Swedish Metrology and Quality (SMQ).

Information about the intercomparison

The information about the intercomparison was given in 3 different media:

- LinkedIn
- The data base https://www.eptis.org
- On the web https://smquality.se/interlaboratory-comparisons-ilc

The information on the web was done in 2 steps. General information as ILC humidity 2024:1published on smquality.se and enclosed to this report in annex 1.

Detailed information as a description of the intercomparison/ILC is published on smquality.se
and enclosed with this report the reporting forms as annex 2.

Participating laboratories and measuring scheme for the comparison

Laboratory	**Country**
Justervesenet, Norwegian Metrology Service	Norway
Metroqualibeiras Lda	Portugal
Sartorom Impex SRL	Romania
Caliz B.V.	Netherlands
Siemens Energi AB	Sweden
LHM Instrumentation	Belgien
TPF Control BV	Netherlands
LaboTest AB	Sweden
Element Metech AB	Sweden
EUROPE QUALITE ROMANIA	Romania
Jormita Oy	Finland
Rise AB	Sweden
Justervesenet, Norwegian Metrology Service	Norway

The circulation started in week 33 in 2024 and ended in week 5 2025.

Several of the participants are accredited by FINAS, RVA, RENAR, BELAC, SWEDAC and IPAC.

The reference laboratory Justervesenet, Norway has the status as National Metrology Institute (NMI) and performed the reference calibrations.

Principles concerning the calibration in general.

The reference laboratory calibrated the humidity sensors at the beginning and in the end of the circulation.

During the whole exercise the preliminary reported results were used for checking unexpected drift behaviour of the sensors. The purpose was to maintain equal conditions for all participants over the total measurement period. In doubt the sensors were planned to be called back for a new reference calibration, which however was not necessary.

The description was missing a clear description about the position to calibrate the sensor or if possible hysteresses should be checked and reported.

Equipment for calibration

Manufacturer: Testo Model 440 Serial number 84981451 and read out unit 84644010

Summary of results

Calibration point humidity % RH	CMC values reference laboratory % RH	Possible reference uncertainty (U) in the ILC* % RH	Resulted reference uncertainty (U) % RH
10,0	0,4	2	0,56
15,0	0,4	2	0,58
30,0	0,5	2	0,70
50,0	0,5	2	0,72
80,0	0,8	2	1,05

* Including possible drift during circulation.

The resulting uncertainty is well within the estimated values.

Calibration instructions

The laboratories were allowed maximum 5 days for their calibration. In the call they were advised to use their own calibration and reporting procedures.

Planning and administrative details

Address to send the required documents:
Swedish Metrology and Quality AB Håkan Källgren Dragspelsgatan 21 SE-504 72 Borås, Sweden e-mail: hakan.kallgren@smquality.se Phone: +46 705 774 931

Summary of the timeline planning in the call:

- The preliminary results (excel-protocol) should be sent to the organiser when the parcel was sent to next participant.
- One week after the calibration/measurement the calibration certificate should be sent to the evaluator of the intercomparison.
- A draft report should be dispatched to the participants 2 weeks after receiving the last calibration certificates.
- Comments or feed-back on the draft report to the organiser are expected within 1 week.
- Final report should be finalized within 2 weeks after receiving all comments or feed-back from the participants.

Analysis of the calibration results

The evaluator used the principles of the ISO/IEC 17043:2023 in the reporting.

As an easy-to-understand measure to judge each participant result its distance to the assigned reference value is used, normalized with respect to the uncertainty in this difference. This measure the En-value is calculated for every calibrated sensor according to equation 1).

$$En_{i,j} = \frac{x_{i,j} - x_{ref,j}}{\sqrt{U_{i,j}^2 + U_{ref,j}^2}} \qquad \text{(eq. 1)}$$

$x_{i,j}$: Single measurement result (deviation from reference value); index *i* and *j* count the various participants respectively.

$x_{ref,j}$: Assigned inter-comparison reference value.

$U_{i,j}$: The estimated expanded uncertainty (k=2) stated by each laboratory.

$U_{ref,j}$: The estimated expanded uncertainty (k=2) of the assigned reference.

$En_{i,j}$: The calculated En-value for each participant.

Inter-comparison reference value and its uncertainty

The reference values $x_{ref,j}$ are calculated as the average from the first and last calibration provided by the reference laboratory.

$$x_{ref} = \frac{R_1 + R_2}{2} \qquad \text{(eq. 2)}$$

For each instrument

$x_{ref,j}$: The calculated inter-comparison reference value.
R_1 & R_2: The assigned comparison reference values provided by the reference laboratory at start and end. In the result tables and the diagrams only the symbol REF is used for identifying the assigned reference result.

The measurement uncertainty for the sensors was calculated as the uncertainty of their mean (equation 3).

The calibration points reported uncertainties that were the same at the beginning and the end. Thus, the measurement uncertainty fused was:

U_j: The combined uncertainty from two calibrations by the reference laboratory

Given the same uncertainty for a level at start and at the end the uncertainty of the reference value is identical with that stated by the laboratory in one of the calibrations. Otherwise, the reference uncertainty lies close to the middle of both.

The data supplied by the reference laboratory indicated a small drift that was considered. The uncertainty of the inter-comparison reference value was then composed by adding half of the detected drift over the time for the total exercise, see equation 4.

$$U_{ref,j} = U_j + \frac{1}{2} abs\left(R_{2,j} - R_{1,j}\right) \qquad \text{(eq. 4)}$$

The change in the humidity results between first and final calibration half of this difference is added to the combined uncertainty to catch this possible drift. However, the differences found are far below the stated calibration uncertainties and do not contribute much to the uncertainty of the reference values.

The principle of the intercomparison

An absolute value of E_n of less than |1| is often used as a criterion for an acceptable measurement quality, according to ISO/IEC 17043:2023, formula B6. It means a reported deviation x_i from the nominal mass value by a participant does not deviate more from the assigned reference comparison value x_{ref} than what can be expected from the calculated uncertainty in this difference.

$$E_n < 1: \quad \left|x_i - x_{ref}\right| < \sqrt{U_i^2 + U_{ref}^2} \qquad \text{(eq. 5)}$$

However, to make this measure a reliable one for an inter-comparison the reference U_{ref} must be small enough not to contribute significantly to the right side of equation 4. Due to the quadratic combination ideally U_{ref} should be in the range of 1/3 of U_i. That was not the fact in this ILC. This is not always easy to achieve in relation to all laboratories, which means that relatively high En-values although between -1 and +1 must not be regarded totally reliable if U_{ref} and U_i are of the same size or if $U_{ref} > U_i$.

Measuring results on calibration in the ILC

The following tables present the found deviations from the reference value along with the stated measurement uncertainty for each sensor.

The “error” and “uncertainty” are reported in the following tables. This presentation is chosen to allow the participants to compare the tabled data in this report with their own documentation.

Together with the estimated uncertainty U_{ref} these two values are used for calculating each participants E_n-value displayed in the last column.

It was the ambition of the organizer to incorporate directly the excel-protocols from participants into the evaluation calculations for reporting the outcome of the comparison measurements after first having checked all data against those in the calibration certificates delivered in a separate calibration certificate. This worked quite well.

The following tables are built with increasing participant identity numbers and list at the bottom the belonging reference value based on the average of two calibrations denoted as REF. The identity numbers are not following the logistic scheme. The participants are informed in separate emails about their number.

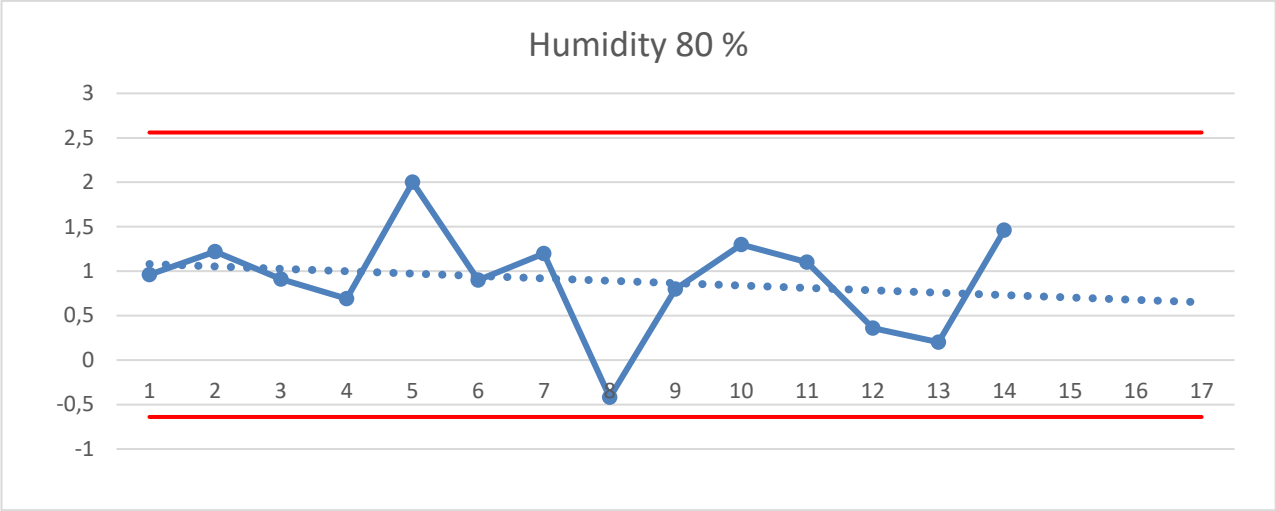
Calibration certificates Justervesenet

Before calibration 301758-1
After calibration 306624-1

Stability checks on the sensor

The stability of the sensor was checked after each reported result from laboratories and the intention was to call back the sensor for an intermediate reference calibration if the stability was not within established criteria.

The stability was checked by using the trend line and that results were within the red lines that represents ± 2 times the uncertainty by the reference laboratory.



Result of the humidity sensors

Observe that the results for the laboratories are not in chronological order.

REF indicates the error of the instrument at the reference laboratory and U the expanded uncertainty during the 2 reference calibrations inclusive drift.

The dots and vertical lines in the diagrams represent the error in the calibration and the uncertainty by the different laboratories.

Table 1 Calibration results at 10 % RH

Identification	Error % RH	Uncertainty % RH	En value
1	0,20	1,40	0,24
2	0,7	1,4	0,10
3	0,65	1,70	0,05
4	0,52	1,0	0,03
6	0,61	0,18	0,09
8	0,65	0,50	0,13
9	1,0	1,7	0,25
10	0,6	1,5	0,03
11	0,97	0,26	0,68
12	0,20	1,30	0,25
	Ref	**U**	
	0,56	**0,56**	

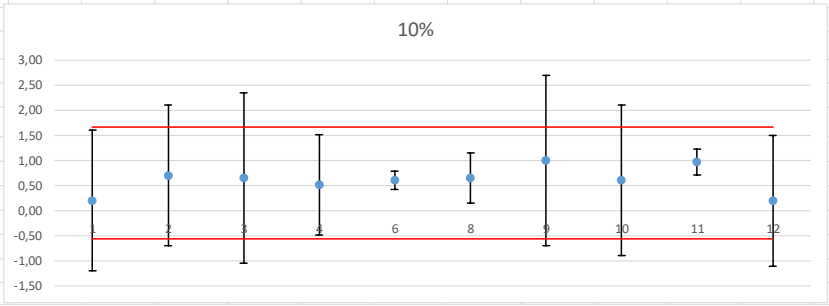


Table 2 Calibration results at 15 % RH

Identification	Error % RH	Uncertainty % RH	En value
1	0,20	1,40	0,32
2	0,8	1,4	0,08
3	0,84	1,70	0,09
4	0,67	1,0	0,01
5	1,28	1,70	0,33
6	0,64	0,27	0,06
8	0,71	0,50	0,04
10	0,6	1,5	0,05
11	0,76	0,26	0,13
12	0,30	1,30	0,27
	Ref	**U**	
	0,68	**0,58**	

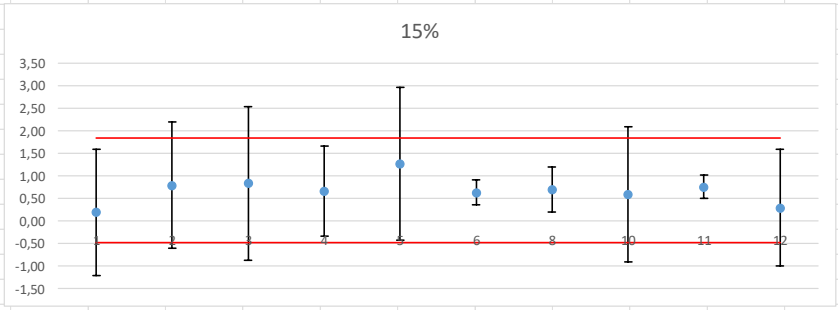


Table 3 Calibration results at 30 % RH

Identification	Error % RH	Uncertainty % RH	En value
1	0,40	1,60	0,37
2	0,9	1,4	0,10
3	1,05	1,80	0,00
4	0,99	1,0	0,05
5	1,60	1,70	0,30
6	0,91	0,44	0,17
7	1,19	1,3	0,09
8	0,82	0,60	0,25
9	1,1	1,8	0,03
10	0,7	1,5	0,21
11	1,18	0,44	0,16
12	0,80	1,40	0,16
	Ref	**U**	
	1,05	**0,70**	

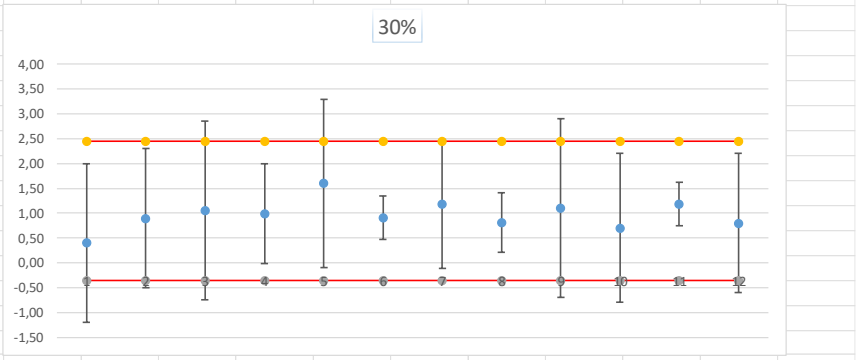


Table 4 Calibration results at 50 % RH

Identification	Error % RH	Uncertainty % RH	En value
1	0,90	2,00	0,25
2	1,0	1,4	0,28
3	1,75	1,80	0,16
4	1,13	1,0	0,25
5	1,72	1,70	0,15
6	1,18	0,68	0,26
7	0,79	1,3	0,44
8	1,09	0,70	0,35
9	1,3	2,00	0,07
10	1,1	1,5	0,20
11	1,23	0,72	0,21
12	0,90	1,70	0,29
	Ref	**U**	
	1,44	**0,72**	

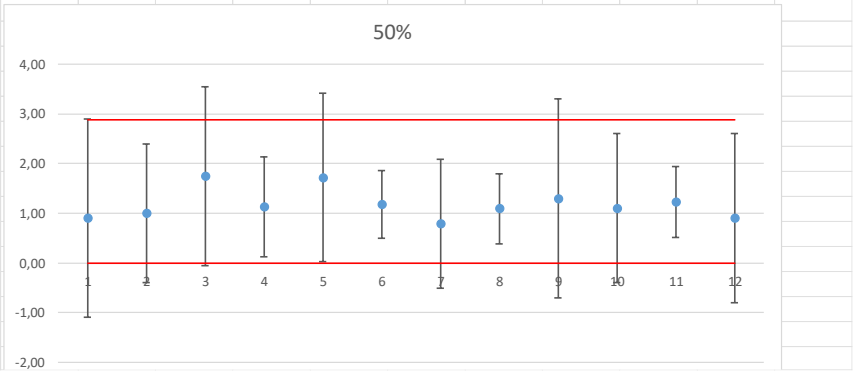
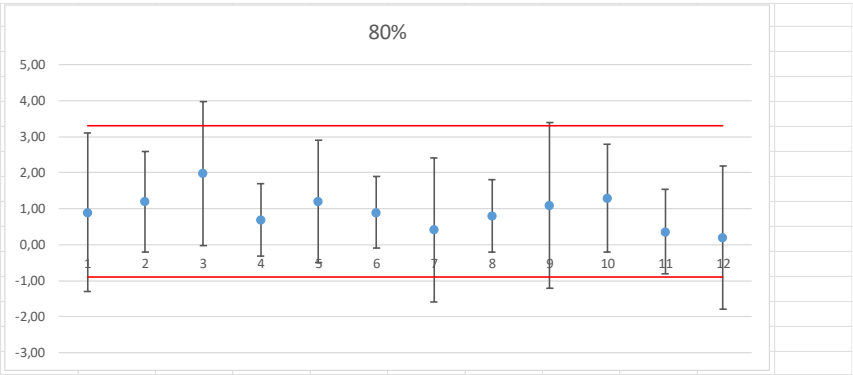


Table 5 Calibration results at 80 % RH

Identification	Error % RH	Uncertainty % RH	En value
1	0,90	2,20	0,13
2	1,2	1,4	0,01
3	1,98	2,00	0,34
4	0,69	1,0	0,36
5	1,21	1,70	0,00
6	0,90	1,00	0,21
7	0,42	2,0	0,35
8	0,80	1,0	0,28
9	1,1	2,3	0,04
10	1,3	1,5	0,05
11	0,36	1,17	0,54
12	0,20	2,00	0,45
	Ref	**U**	
	1,21	**1,05**	



Comments on the calibration certificates

-- not a part of the intercomparison

All laboratories:

- Explain that they report uncertainty values on confidence level 95 % according to EA-4/02M
- Document the temperature during the calibration

Most of the laboratories:

- explain that they calibrate in a climate chamber
- report on the real humidity and indicated humidity and difference
- report measurement error, but others the correction.
- specified their uncertainty with 2 digits in the certificate, but some laboratories gave 1 significant presentation of uncertainty values.
- document the resolution of indication on the humidity sensor

Some laboratories:

- refer to reference standards on compliance accordance to different decision rules
- explain how they mounted the equipment and the cable in the climatic chamber
- that they calibrated during increasing and decreasing humidities
- explain that the equipment is a capacitive sensor
- document the environment temperature, relative humidity and atmospheric pressure
- explain that the results do not include possibly hysteresis on the sensors

Additions and changes to the DRAFT report

One result from one participant has been adjusted, but that change does not change the En value considerably.

Final conclusions

In this inter comparison all the participants could demonstrate a capacity to calibrate and give relevant values in relationship to their uncertainties.

The summarized results from 41 number of calibrations have 0 results got En values above 1.

Evaluation of the results

The participants shall evaluate their results according to ISO/IEC 17025:2017 7.7.3

It is then recommended to evaluate according to descriptions above including the fact where:

- The size of En-values
- En- values in relation to their CMC values

Acknowledgement

We acknowledge the primary calibrations by Justervesenet Norway that supported the ILC with reference calibrations.

We acknowledge Reidun Anita Bergerud and Peter Rothmund at Justervesenet that supported on the setup and evaluation on this ILC

Annex 1 ILC humidity 2024:1

Published on https://smquality.se/

Annex 2 *D*escription of the intercomparison/ILC

Published on https://smquality.se/

Appendix 1 Reporting form

Intercomparison ILC Humidity 2024:1

CODE for pad-lock **504**

Reporting form for preliminary calibration results

Laboratory:	
Name:	
E-mail:	-
Date of reporting:	

Comparison ID

Calibration intercomparison on humidity

Fill the green fields

Date of calibration

Observe ---No adjustments are allowed

Calibration point at the temperature 23 °C

Sensor identification	Nominal value	Measured mean value	Stated error	Measurement uncertainty
	% RH	% RH	% RH	% RH
xxxxxxx	10			
xxxxxxxxx	15			
xxxxxxxxxx	30			
xxxxxxxxxx	50			
xxxxxxxxxx	80			

If the stated uncertainty is the

CMC-value of your laboratory
Please tick the box FALSKT

Comments:	
Reference equipment	
Uncertainty of working standard	
Tracebility	
Temperature in laboratory	
Humidity in laboratory	

References:

- ISO/IEC 17043:2023 Conformity assessment – General requirements for proficiency testing
- ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories
- ISO 13528:2022 Statistical methods for use in proficiency testing by interlaboratory comparison.
- Evaluation of measurement data – Guide to the expression of uncertainty in measurement, GUM (JCGM 100:2008)
- EA-4/02 M:2022 Evaluation of Uncertainty of Measurement in Calibration
- International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)