Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

DOI: 10.7795/810.20200430
https://doi.org/ 10.7795/810.20200430

This work was presented at:

The final Workshop "Improved measurement standards for humidity at high temperatures: impact on the industry"

12th July 2018, INRIM Torino-Italy

Workshop Website

https://www.empir-hit.eu/en/documents?facet_theme=Workshop

Acknowledgement

This work was supported by HIT within EMPIR.

https://www.empir-hit.eu/

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

The authors are with the PTB working group

https://www.ptb.de/cms/en/ptb/fachabteilungen/abt3/fb-34/ag-342.html

https://www.ptb.de/cms/en/ptb/fachabteilungen/abt3/fb-34/ag-341.html

Contact:

Henning Bohlius
E-Mail: henning.bohlius@ptb.de
Olav Werhahn
E-mail: olav.werhahn@ptb.de

Physikalisch-Technische
BundesanstaltBundesallee 100
D-38116 Braunschweig

Metrological validation of a new dTDLAS-Hygrometer

PTB:

Henning Bohlius, Florian Bubser, Olav Werhahn, Regina Deschermeier and Volker Ebert

TU-Darmstadt

Luigi Biondo and Steven Wagner

Abstract

Results of the collaborative study of TU-Darmstadt and PTB in the HIT project were presented at the final workshop at INRIM, Torino, Italy.

PTB has set up a system for the validation of dTDLAS-hygrometers which were developed by TU-Darmstadt within the framework of HIT. The calibration facility is designed to calibrate humidity in air measurement devices at temperatures up to 100 °C. The system was designed to perform validations and/or calibrations of a device under test like the dTDLAS-hygrometer from TU DA. Traceability was achieved by comparison to a primary humidity standard via a reference chilled mirror hygrometer.

The developed dTDLAS hygrometer was shown to yield relative deviations of less than 5 % as compared to the reference value. This is nicely confirming its capability to be used as a transfer standard. Based on PTB's validation result and on further validation performed at INRIM for temperatures above 100°C the dTDLAS hygrometer could subsequently be applied successfully at an industrial site within the project thus demonstrating the valuable capabilities of such dTDLAS systems for industrial applications.

The measurement approach of dTDLAS-hygrometers complying with the TILSAM method[1] like the one from TU-Darmstadt in HIT is promoted by PTB 3.42.

[1]TILSAM, Traceable Infrared Laser-Spectrometric Amount fraction Measurement; URL: https://www.euramet.org/Media/docs/projects/934_METCHEM_Interim_Report.pdf

Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

EURAMET

TECHNISCHE UNIVERSITÄT DARMSTADT

Metrological validation of a new dTDLAS-Hygrometer

Henning Bohlius, Florian Bubser, Olav Werhahn, Regina Deschermeier and Volker Ebert – PTB,

Luigi Biondo and Steven Wagner – TU-DA

HIT – Final Project Meeting Torino, Italy July 2018

Motivation

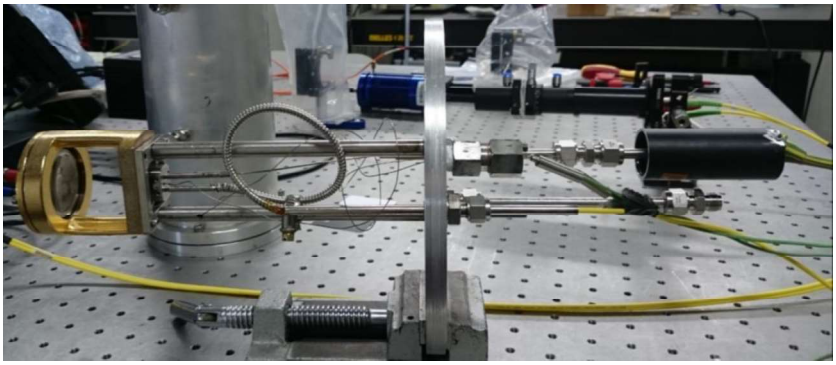
- Quality control during production and process control in the industry
- Humidity measurements inside industrial process plants
  - High temperatures and/or pressures
  - Harsh conditions (tar, dust, corrosive environment)
- Avoid sampling effects (condensation)
- dTDLAS as an optical gas transfer standard (calibration free)

New dTDLAS-Hygrometer of TU-Darmstadt

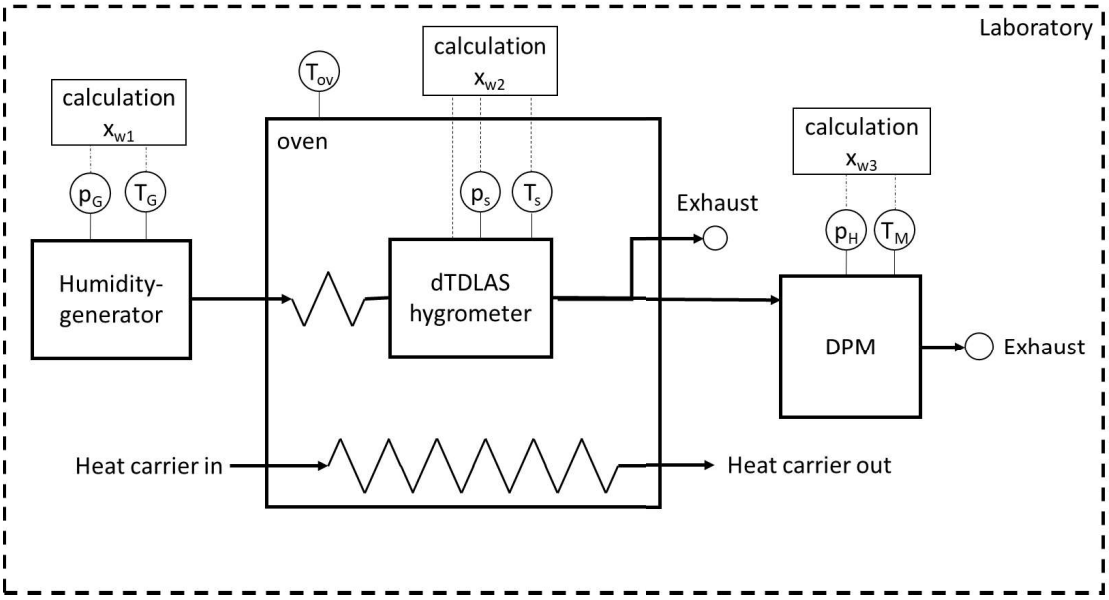
- Advantages:
- In situ measurement
- High accuracy and precision
- High selectivity
- Robustness: Temperature stability > 200 °C New
- Robustness: Pressure resistant > 10 bar New
- Particle loaded or condensing atmosphere
- High temporal resolution – up to kHz
- Less process disturbance
- Flexible and simple system integration New

New dTDLAS-Hygrometer of TU-Darmstadt

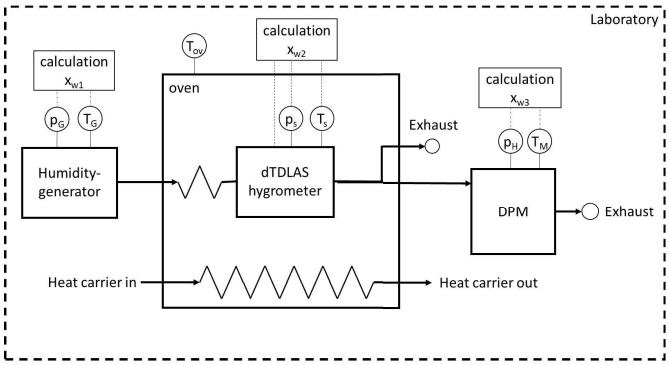
- Single ended configuration
- 3D printed chassis and optics (Additive Manufacturing)
- Completely fiber-coupled

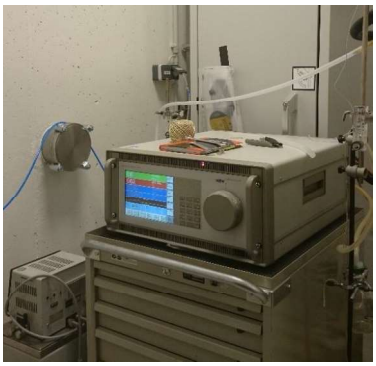


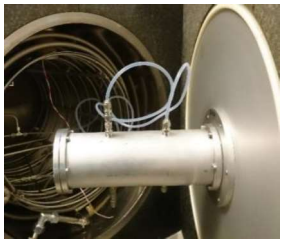
Validation Procedure and Set-up at the PTB



Validation Procedure and Set-up at the PTB



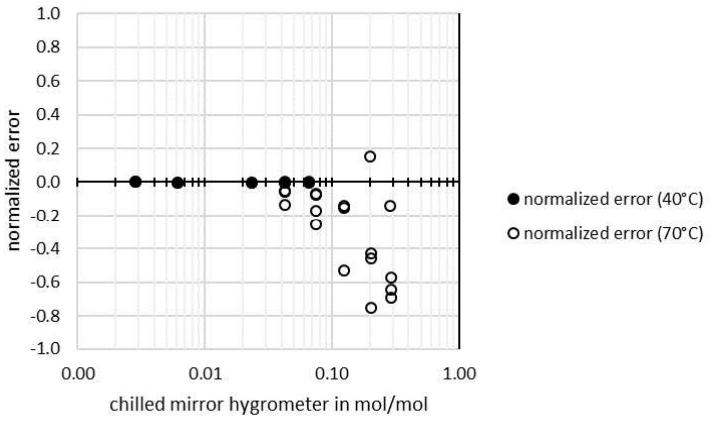




Validation of Set-up

- Set-up piping length of 16 m from the generator to the dTDLAS
  - Is any water vapor lost?
- Therefore the generated molar water content at the inlet (humidity generator) and at the outlet (chilled mirror hygrometer) are compared.
- Direct comparison of the chilled mirror hygrometer with the two pressure humidity generator (connected by a short heated piping < 2m) for evaluation.

Validation of Set-up



$$\text{normalized error} = \frac{\Delta x_w}{\sqrt{U_{HG}^2 + U_{CMH}^2}}$$

- All values are found in the range of ± 1 the normalized error
- This is in agreement with the residual found in direct comparison of CMH and HG

No significant influence of the set-up

dTDLAS vs. Chilled Mirror Hygrometer

Linearity and relative deviations tested

- At 40°C and 70°C with a dry gas flow of 4 l/min
- In the relative humidity range of ~0 to 98 %RH
  - 3000 ppm to 28 vol.% water vapor

First results:

- No relative deviations found larger than 5 %
- Detailed results will be published soon

Traceability:
Chilled mirror hygrometer traceable back to a primary standard

OUTLOOK: High-speed in-situ dTDLAS for dynamic calibrations

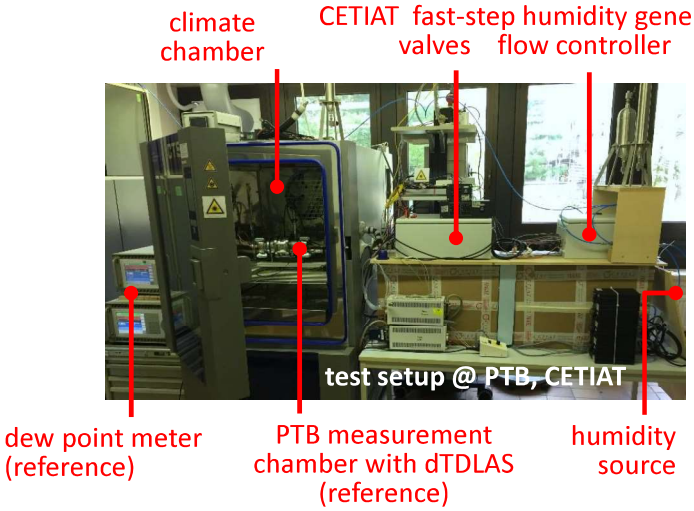
Motivation:

- Difficulties in the metrological evaluation of the temporal behavior of commercial hygrometers under rapid humidity changes
- Metrological characterization of response time?
- Dependence of dynamic behavior on: temperature, step height, flow rate?
- Comparison of different measurement principles?

IDEA:

- Step-Change Humidity generator PLUS
- TDLAS in situ hygrometer as *sampling-free first-principle-based* reference hygrometer with well over 10 Hz temporal resolution

High-Speed dTDLAS-Set-up for dynamic calibrations



WORK IN PROGRESS

Results upcoming
stay tuned

Or contact us
Volker.ebert@ptb.de

(partially based on earlier results from other EMPIR projects and PTB internal studies)

Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
Bundesallee 100
DE-38116 Braunschweig
Volker Ebert + Henning Bohlius
E-Mail: henning.bohlius@ptb.de
www.ptb.de

Stand: 07/18