20IND06 PROMETH2O

PROMETH$_2$O

EURAMET

Newsletter n°3

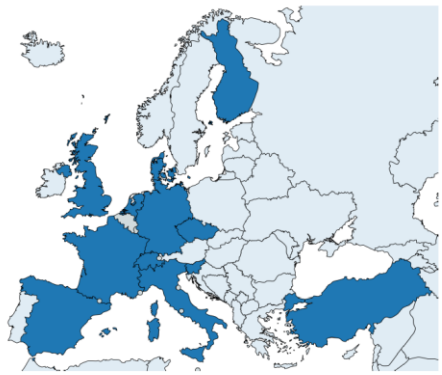
PROMETH$_2$O

Metrology for trace water in ultra-pure process gases

may 2024

Duration	Coordinator	Budget	Amount of work
36 months Start date: 01 June 2021 End date 31 May 2024	Vito Fernicola INRiM	1 798 649,10 €	242 person- months

Consortium partners



19 partners from 12 countries – 242 person-months

PROMETH2O is supported by world leading manufacturers, international organisations and metrology leaders

Commenté [RC1]: Should we change the logo of MBW with that one of Process Insights?

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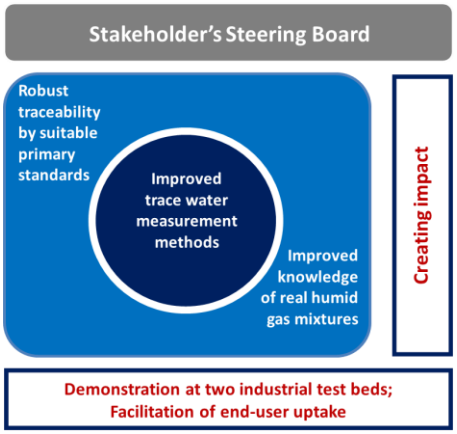
Organization of the consortium



Steering Board members

Chair: Stephanie Bell - NPL

International Organisations	Instrument Manufacturers	Gas Providers
CIPM CCT WG-Hu	Ball Wave	Air Liquide
IAPWS	Meeco	BOC
JCS	Li-Cor	SOL
KRISS	Baker Hughes	SIAD
NMIJ	PST/Rotronic	SAPIO
ISO/TC 158 WG3	EffecTech Ltd.	FHa
CIPM CCQM GAWG		
UNI CIG		
ACCREDIA		

Overview

Trace water is the single largest matrix contaminant in ultra-high purity (UHP) process gases (e.g. argon Ar, nitrogen N_2 and hydrogen H_2), and its presence affects the process yield in UHP gas applications. Even though the manufacturing of UHP gases serves many key technology areas, such as high-value semiconductor manufacturing, the trace water measurements are still lacking metrological traceability in the relevant ranges and matrix gases. The project will fill the knowledge gap regarding metrological traceability - by developing traceable and improved measurement methods at challenging amount fractions between 5 ppm and 5 ppb for use in the production of pure process gases - and will demonstrate its applicability in the gas industry.

You can access to publishable summary **here**.

Need

Due to its ubiquity and chemical properties, water vapour is a critical contaminant and one of the most difficult impurities to eliminate. Water contamination effects become relevant when taking into consideration the worldwide production of gases. The global market for industrial gas is expected to reach US$ 149 billion by 2027, with Europe sharing about 16%, owing to rising demand from the electronics, healthcare and pharmaceutical sectors. The semiconductor market alone is expected to reach $ 5.2 billion by 2026. Bulk process gases with ultra-high purity grade (N6.0 or better) need to be manufactured with total impurities below 1 ppm in volume. According to the International Technology Roadmap for Devices and Systems, water vapour measurement techniques need to measure amounts as low as a few parts per billion at the point of use. From 2015 to 2020 these requirements have tightened for some gases (N_2 and Ar) by more than a factor of five. This presents great challenges to both gas producers and analytical instrument makers which aim to improve trace water measurement methods at the part per billion. This would require a metrological infrastructure and measurement technology to provide robust traceability to trace water measurements with a provision of suitable primary standards, improved optically-based methods and improved knowledge of the thermophysical properties of moist gases.

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Objectives

The overall objective of PROMETH2O is to provide new and improved trace water measurements relevant to the production of pure gases and to demonstrate their impact in improving selected industrial processes and applications.
The specific objectives of this project are:
1. To improve trace water measurement methods in the amount fraction range between 5 parts in 10^6 (5 ppm) and 5 parts in 10^9 (5 ppb) or, equivalently, between -65 °C and -105 °C frost point temperature at 0.1 MPa with a relative standard uncertainty between 3 % and 8 %, from the upper to lower range, respectively.
2. To provide robust traceability to trace water measurements by developing suitable primary standards for the amount fraction range from 5 ppm to 5 ppb (or -65 °C to -105 °C frost point temperature at 0.1 MPa) with a relative standard uncertainty less than 3 % to 8 %, in selected gas matrices of air, N_2, Ar and H_2 at pressures up to 1 MPa.
3. To improve the present knowledge of thermophysical data of real humid gas mixtures, in particular the water vapour enhancement in N_2 and Ar in the temperature range from -30 °C to -90 °C and at pressures from 0.1 MPa to above 1 MPa.
4. To demonstrate improved trace water measurement methods between 5 ppm and 5 ppb or, equivalently, between -65 °C and -105 °C frost point temperature at 0.1 MPa, in two industrially relevant facilities (test beds).
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (CIPM, IAPWS, JCS) and end users (instrument manufacturers, gas providers).

Contact us

Project Leader:

Vito FERNICOLA – INRiM

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Project's website:

https://www.prometh2o.eu/

WP leaders

WP1 leader: Alexander FATEEV – DTU (alfa@kt.dtu.dk)

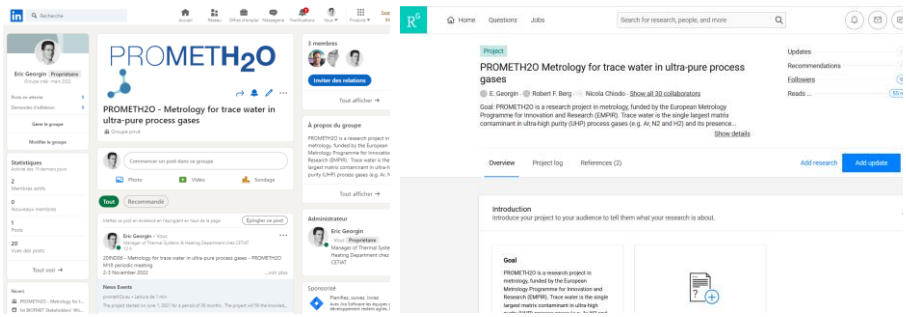
WP2 leader: Rugiada CUCCARO – INRiM (r.cuccaro@inrim.it)

WP3 leader: Stefan PERSIJN – VSL (SPersijn@vsl.nl

WP4 leader: Eric GEORGIN – LNE-CETIAT (eric.georgin@cetiat.fr)

Follow us

Interested by following project and related special events? Follow us on LinkedIn and Research Gate !



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Key achievements at a glance

One of the major events for the project at the beginning of 2024 was the organization of a project meeting and a workshop on the same day within the framework of the Gas Analysis 2024 symposium, which was held in Paris, France, from January 30th to February 1st.

A productive project meeting in the home stretch

The meeting held on this occasion was the last in-person meeting before the project concludes in the next five months. The latest discussions related to the timeline, data handling, and deliverables were conducted.

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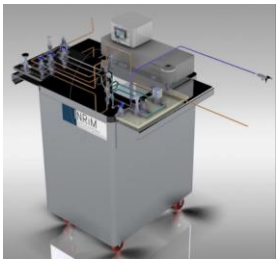
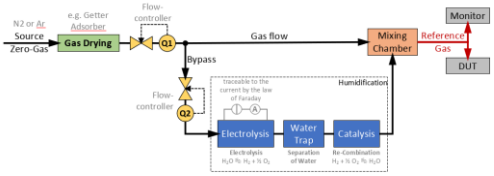
WP2: Provision of robust traceability to trace water measurements in real humid gas mixtures

Special attention should be given to the work completed in Work Package 2, particularly within Tasks 2.2 and 2.3. The JRP partner has made significant advancements in measuring the water vapor enhancement factor in Ar, N_2, andH_2 . These improvements were achieved at selected temperatures and pressures within the frost-point temperature range of -90 °C to -30 °C and a pressure range from 0.1 MPa to over 1 MPa. Furthermore, a web application was developed to refine the correlation equations for humid gas mixtures. This tool operates within the temperature range of -30 °C to -90 °C and a pressure range from 0.1 MPa to over 1 MPa, covering N_2, Ar and H_2 . It provides end users with a resource to enhance the comparability of trace humidity measurements across different principles and gas matrices. These efforts were also discussed in greater detail during the afternoon session of the workshop.

Additionally, within Task 2.1: "Development of Primary Humidity Standards for Trace Water Vapor in an Increased Range of Gas Matrices," several National Metrology Institutes have developed their primary humidity standards for ultra-trace water vapor across a broader range of gas matrices, includingN_2, air Ar, and H_2. These standards are based on various principles, and provide traceability through different routes.



INRiM LFP generator



PTB Coulometric Trace Water Generator

VTT Permeation system based on a passivated magnetic suspension balance

LNE-CETIAT mixed flow generator

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PROMETH2O project meeting

JRP partners organized an in-person workshop on January 30th. In order to have a higher impact while promoting this event the opportunity has been taken to organize this event during the Gas Analysis conference.

The workshop was aimed at technicians, engineers, and researchers from National Metrology Institutes (NMIs), as well as gas and instrument manufacturers, accredited laboratories, and industry professionals. The workshop began with an opening presentation of the project, followed by a keynote lecture that discussed the measurement challenges associated with trace water in pure gases. Additionally, perspectives from a gas manufacturer were shared, along with the introduction of an innovative device by an instrument manufacturer that enables traceability to the SI units, even on-site. The workshop concluded with a presentation of the project's achievements, including the development of instruments, trace water standards, and software tools.

The organization of this workshop was very successful; all available seats were filled!

The presentations are available on the project website for broader dissemination.

Workshop

PROMETH2O - Metrology for trace water in ultra-pure process gases

30th of January 2024 (14:00-17:45)

In the framework of the EURAMET-EMPIR project PROMETH2O (https://www.prometh2o.eu), we are pleased to invite you to the PROMETH2O workshop, which will take place on 30 January 2024 as a satellite event of the symposium GAS Analysis 2024

VENUE: Gas Analysis 2024 Symposium / Hyvolution Paris

Paris Expo, Hall 4, Porte de Versailles, France

30^{stht} of January 2023 – OCEANIE ROOM	
14:00 - 14:15	*Outline of PROMETH2O* *V. FERNICOLA - INRIM not*
14:15 – 14:50	Measurement challenges for trace water in pure gases *S. BELL - NPL*
Industrial challenges in producing and assessing ultra-pure process gases	
14:50 - 15:10	Water measurement and control in pure gas manufacturing *S. BOGGIO - NIPPON GASES*
15:10 – 15:30	Calibration and measurement: ensuring traceability to industry *N. HAWES - QROMETRIC*
15:30 - 16:15	Coffee Break
Meeting the stakeholders needs	
16:15 – 16:35	Novel reference standards to provide measurement traceability in the part-per-billion regime *D. HUDOKLIN - UNIVERSITY OF LJUBLJANA*
16:35 – 16:55	Virial coefficients of mixtures of water vapor and simple gases from first-principles calculations K. MEIER - HELMUT-SCHMIDT-UNIVERSITÄT INSTITUT FÜR THERMODYNAMIK
16:55 - 17:15	Next-generation trace water sensors and analysers for the industry *L. GIANFRANI - UNIVERSITA DEGLI STUDI DELLA CAMPANIA "LUIGI VANVITELLI"*
17:15 - 17:35	Validated software applications for moist real gases *S. TABANDEH - VTT-MIKES*
17:35 – 17:45	Wrap-up and conclusions

Few words about our speakers

Vito Fernicola is a prominent researcher at the Istituto Nazionale di Ricerca Metrologica (INRiM) in Italy. He specializes in physical thermodynamics and plays a key role in developing and maintaining primary standards of humidity. These standards are crucial for disseminating frost- and dew-point temperature scales across a broad range of pressures. His efforts also ensure measurement traceability for trace humidity in both pure and energetic gases, and for various industrial and scientific applications. Additionally, Dr. Fernicola is a member of Accredia, the Italian accreditation body, where he tackles challenges in the calibration and measurement fields, emphasizing the importance of metrological traceability for product and service quality across Europe.

Stephanie Bell is a principal scientist at the National Physical Laboratory (NPL) in the UK, leading research on humidity in gases and moisture in materials. With over 25 years of experience, she is internationally recognized for her expertise in humidity measurement and calibration. Dr. Bell's work contributes significantly to the development and maintenance of standards for measuring temperature and humidity, which are vital for various industrial and scientific applications. She is also actively involved in the World Meteorological Organization, representing the UK and contributing to global metrology standards.

Stefano Boggio works at Nippon Gases Industrial S.r.l. in Chivasso, Italy, part of the European group of Nippon Sanso Holdings Corporation. His role focuses on quality assurance in the production of pure process gases, highlighting his expertise during a presentation at a metrology symposium on the production of these gases at Nippon Gases.

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Ned Hawes is the Operations Director at Qrometric in the UK. He has extensive experience with the Thunder Scientific 2500, a device used for humidity generation and calibration. His responsibilities include servicing this equipment on-site to ensure optimal performance and conducting diagnostics to identify faults and confirm essential upgrades. His contributions are significant in maintaining the operational efficiency of critical calibration equipment at Qrometric.

Domen Hudoklin is an Associate Professor at the University of Ljubljana, specifically in the Faculty of Electrical Engineering, within the Laboratory of Metrology and Quality. Since 1997, he has been involved in the research and development of measurement principles for humidity on both primary and secondary levels. His work includes significant contributions to the field of metrology, focusing on the precision and reliability of humidity measurements.

Karsten Meier holds the position of Professor (Prof. Dr.-Ing.) at Helmut-Schmidt-Universität in Hamburg, where he leads the Institute for Thermodynamics within the Faculty of Mechanical Engineering. His expertise is in fundamental and applied research in thermodynamics, including areas like heat transfer, refrigeration processes, and the thermodynamic properties of mixtures. Professor Meier is deeply involved in various research projects and the development of experimental methodologies related to thermodynamics.

Livio Gianfrani is a Full Professor at the University of Campania "Luigi Vanvitelli," specifically in the Department of Mathematics and Physics. He completed his Laurea and PhD degrees in physics at the University of Naples Federico II. Professor Gianfrani specializes in precision spectroscopy of molecular gases, focusing on the quantitative analysis of molecular interactions and transitions in the near-infrared spectrum. His work has significantly enhanced the understanding and measurement accuracy at the kHz level for various molecular systems.

Shahin Tabandeh is a senior scientist at VTT MIKES, a part of the VTT Technical Research Centre of Finland. With a rich background in metrology and nearly a decade of experience in a diverse range of measurements, including temperature, humidity, pressure, and optical and microwave measurements, he holds PhD degrees in Metrology from Politecnico di Torino, Italy, and in Electrical Engineering from Aalto University, Finland. Dr. Tabandeh has been involved in several significant European research projects in metrology, focusing on advancements in humidity standards and sensor technologies. His work extends to thermal management systems for space telescopes and the development of sensors among other projects.

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Kaleidoscopy of the Workshop






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Thank you all for your participation!!!

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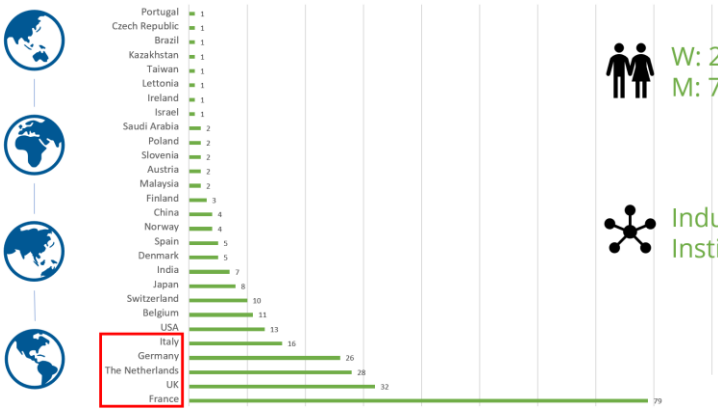
Key figures of Gas Analysis

	vs. 2022
269 participants from 28 countries	+12%
65% from overseas	+3 pts
33 exhibitors on 384 m²	+45 m²
85 speakers including 23 poster presenters	+8 speakers
148 participants in the Gala Dinner	+10 pax.



W: 28%
M: 72%

Industry: 59%
Instituts: 41%

Key figures of the PROMETH2O workshop

62 participants from 28 countries
77% from overseas
8 speakers
Category: 28 attendees, 19 speakers/academics, 1 student

Pays	Nb	%
France	14	22.58%
Italie	10	16.13%
Allemagne	6	9.68%
Espagne	4	6.45%
Pays Bas	4	6.45%
Etats Unis	4	6.45%
Grande Bretagne	3	4.84%
Japon	2	3.23%
Pologne	2	3.23%
Finlande	2	3.23%
Slovenie	2	3.23%
Danemark	1	1.61%
Inde	1	1.61%
Republique Tcheque	1	1.61%
Israel	1	1.61%
Lettonie	1	1.61%
Irlande	1	1.61%
Autriche	1	1.61%
Chine	1	1.61%
Taiwan	1	1.61%
Nb de contacts	62	100.00%

W: 24%
M: 76%

Industry: 52%
Instituts: 48%

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