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20IND06 PROMETH2O

# Metrology for trace water in ultra-pure process gases

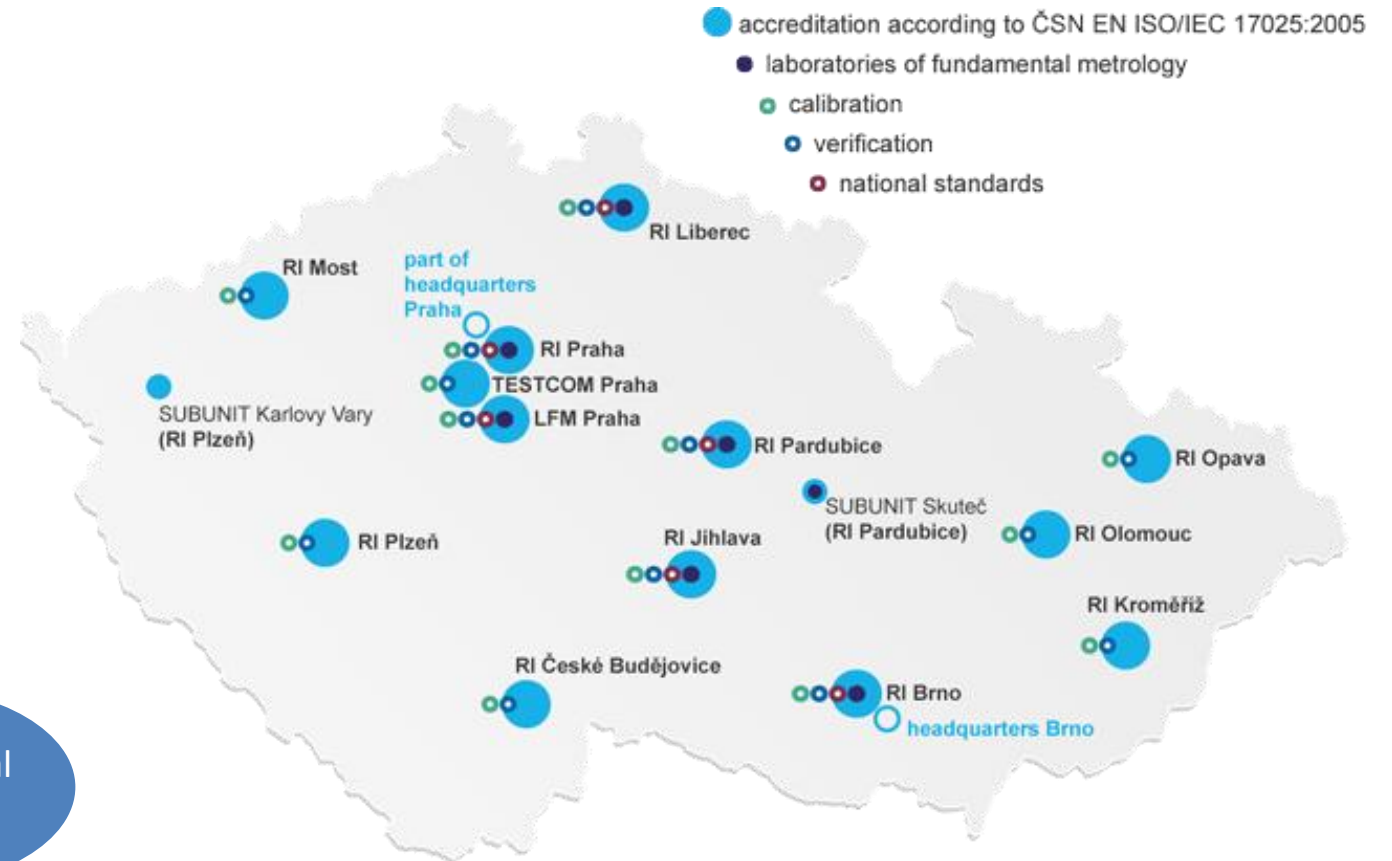
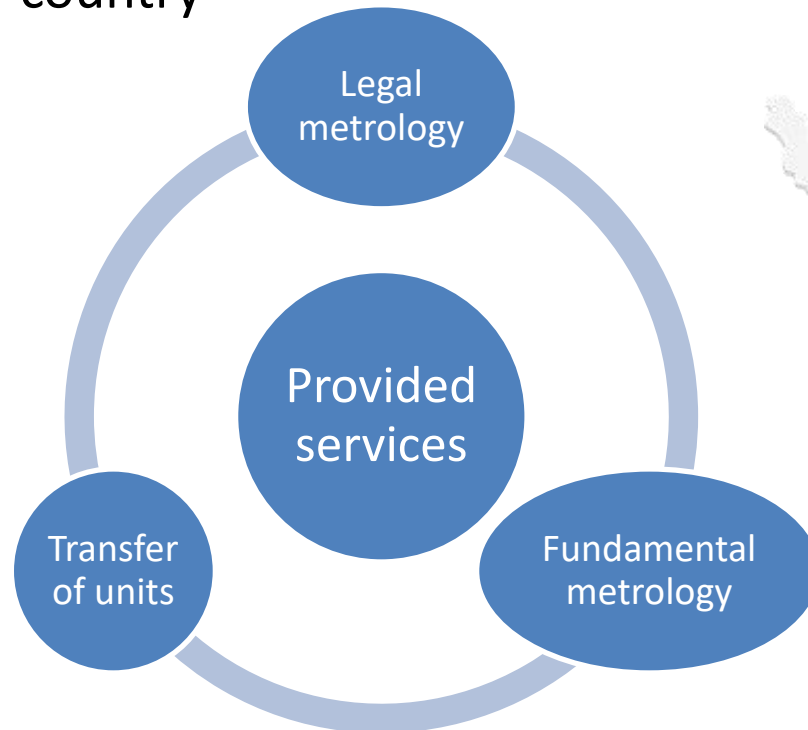
Introduction of CMI



**Lukáš Kolík**

Project kick-off meeting – Online, hosted by INRIM, 14<sup>th</sup> of June 2021

- Established in 1993
- Approx. 350 employees all over country



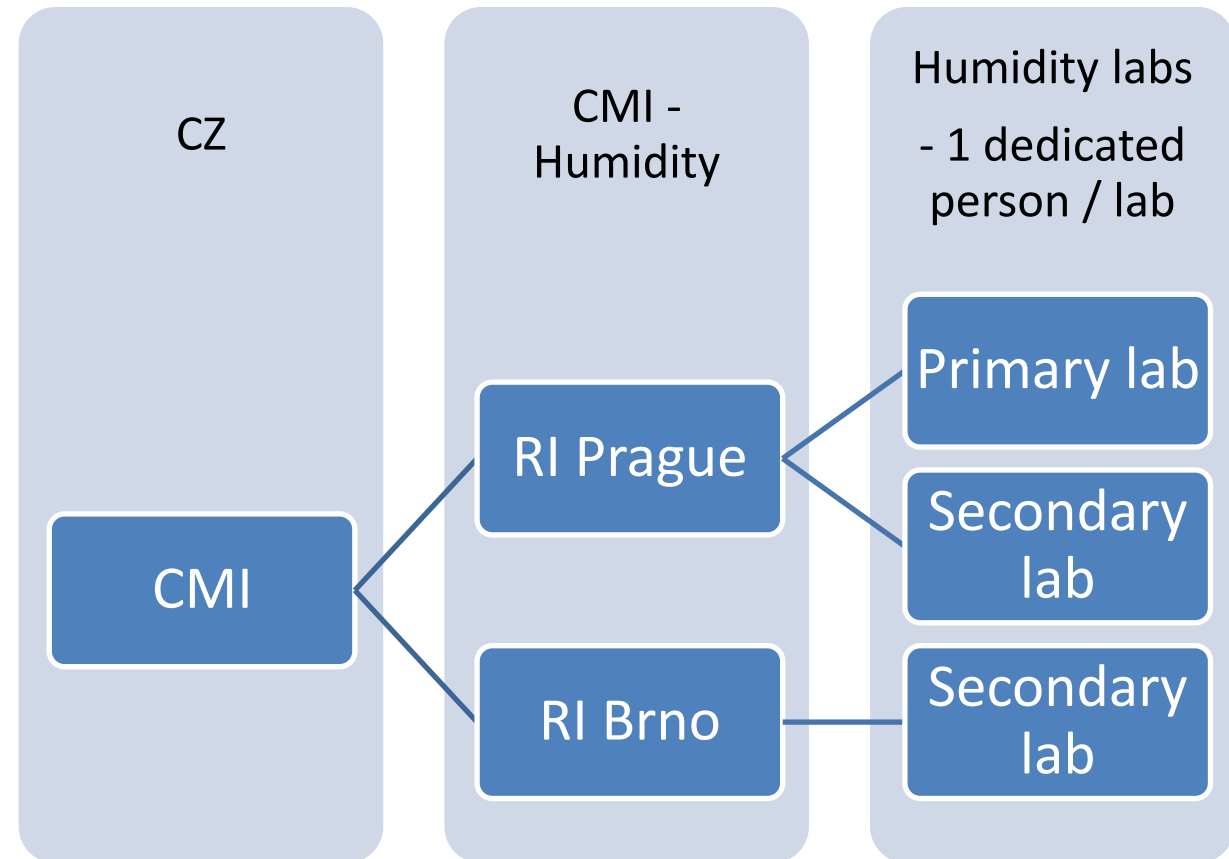
- Measuring site for humidity (g-H<sub>2</sub>O):

- **RI Prague:**

- ✓ National standard at pressure above 100 kPa
- ✓ Air, N<sub>2</sub>, Ar, CH<sub>4</sub>, natural gas

- **RI Brno:**

- ✓ National standard at atmospheric pressure
- ✓ Air only

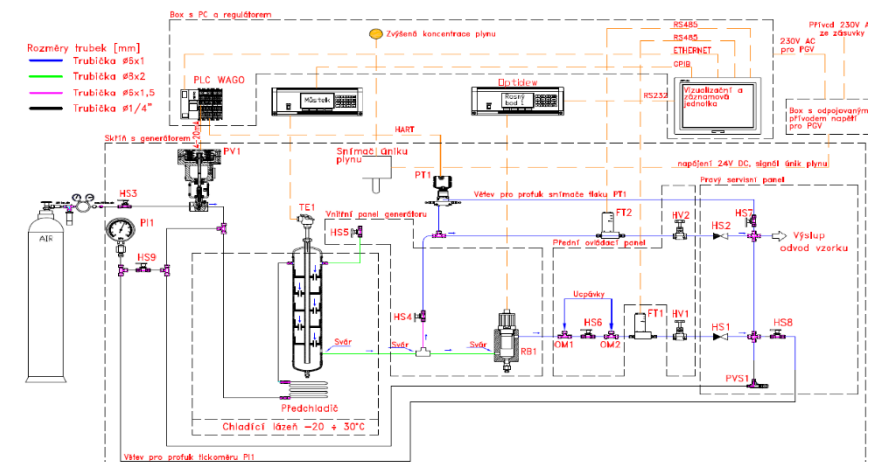
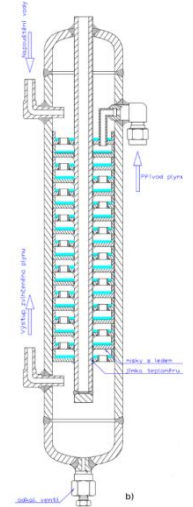


- Humidity related projects:
  - (19ENG09 BIOFMET, 2020-2023 – more of moisture)
  - 15RPT03 HUMEA, 2016-2019
  - ENV07 MeteoMet
  - ENV58 MeteoMet 2
  - SIB64 METefnet



- **Primary humidity generator, 1P1T type, thermodynamic saturation-based principle, in Prague:**

- **Pressure: 15 MPa max.**
- **Humidity range:  $(-80 \text{ to } 30) ^\circ\text{C}_{\text{dp/fp}}$**
- **Gas matrix: Air,  $\text{N}_2$ , Ar,  $\text{CH}_4$ , natural gas**
- **Flow rate: up to approx.  $2 \text{ L}_\text{N}/\text{min}$**
- **U ( $k=2$ ) from  $-80 ^\circ\text{C}_{\text{fp}}$  to  $-30 ^\circ\text{C}_{\text{fp}}$ :**
  - ✓ at **1 MPa:**  $0.11\text{-}0.23 ^\circ\text{C}$
  - ✓ at **0.1 MPa:**  $0.09\text{-}0.15 ^\circ\text{C}$  or less



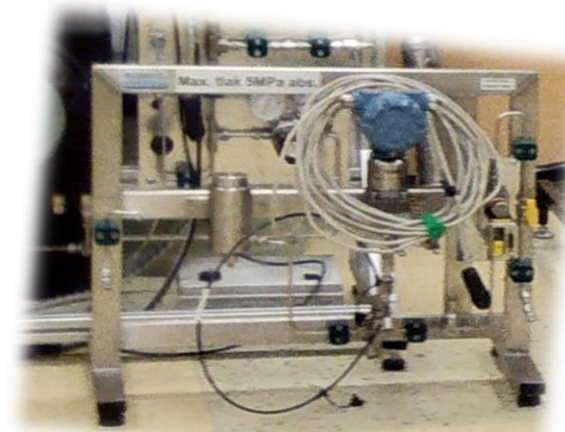
- **Secondary generator** (1P2T, 2P1T, 2P2T):
  - 6 MPa max.
  - Various gases
- **Climatic chamber** – Weiss, type 125 SB:
  - (-70 to 150) °C of temperature range
  - 20-90 %rh
- **Field measurement – SKID Michell:**
  - 5 MPa max.
  - Air, N<sub>2</sub>, Ar, CH<sub>4</sub>, natural gas

Secondary generator (VGV)



SKID Michell

Climatic chamber



- MBW 373LX-HP:**

- $(-95 \text{ to } 20) ^\circ\text{C}_{\text{dp/fp}}$ , accuracy:  $\pm 0.1 ^\circ\text{C}_{\text{dp/fp}}$
- max. 20 MPa
- 0-1  $\text{L}_\text{N}/\text{min}$  flow rate of sample



MBW 373



Michell S8000

+ Michell Optidew (25 MPa max.)

- Michell S8000 Integrale:**

- $(-60 \text{ to } 40) ^\circ\text{C}_{\text{dp/fp}}$  (for  $>20 ^\circ\text{C}_{\text{dp}}$  measurement with some modification)
- res.  $0.001 ^\circ\text{C}$
- $\pm 0.1 ^\circ\text{C}_{\text{dp/fp}}$  accuracy
- 1.7 MPa of pressure max.

from 07/2020 new resistance bridge MI 6242T + Tinsley resistance standard (old ASL F300 in the picture)



WP No	Work Package Title	Active Partners (WP leader in bold)	Months
WP1	Improved trace water measurement methods and techniques	<b>DTU</b> , INRIM, MBW, PTB, Qrometric, SUN, TUBITAK	35.2
WP2	Provision of robust traceability to trace water measurements in real humid gas mixtures	<b>INRIM</b> , CEM, CETIAT, <a href="#">CMI</a> , CNAM, INTA MBW, PTB, UL, UNICAS, UVa, VSL, VTT	138.7
WP3	Demonstration at industrial test beds and facilitation of end-user uptake	<b>VSL</b> , DTU, INRIM, MBW, Nippon Gases, Qrometric, UL, Vaisala	28.8
WP4	Creating impact	<b>CETIAT</b> , all partners	19.8
WP5	Management and coordination	<b>INRIM</b> , all partners	19.1
Total months			241.6

WP2	Provision of robust traceability to trace water measurements in real humid gas mixtures	<b>INRIM</b> , CEM, CETIAT, <b>CMI</b> , CNAM, INTA MBW, PTB, UL, UNICAS, UVa, VSL, VTT	138.7
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## Deliverables

Relevant objective (Activity delivering the deliverable)	Deliverable number	Deliverable description	Deliverable type	Partners (Lead in bold)	Delivery date
<b>2</b> (A2.1.6)	D3	Report on the development of primary trace water vapour standards describing the range, the estimated uncertainty and the gas species in which reference values can be generated.	Report	<b>INRIM</b> , VTT, <b>CMI</b> , INTA, UL, PTB, MBW, VSL, CETIAT	M30
<b>3</b> (A2.3.4)	D5	Report on the development and validation of correlation equations for the enhancement of water vapour and provision of a data set.	Report, Data set	<b>VTT</b> , CNAM, CETIAT, <b>CMI</b> , VSL, UL, INTA, CEM, UVa, UNICAS	M32
<b>5</b>	D8	Evidence of contributions to or influence on new or improved international guides, recommendations and standards with a specific focus on the following committees:  CIPM CCT WG-Hu, EURAMET TC-T, CIPM CCQM GAWG, IAPWS WG TPWS.  Examples of early uptake of project outputs by end-users.	Reporting documents	<b>CETIAT</b> , all partners	M36
<b>n/a</b>	D9	Delivery of all technical and financial reporting documents as required by EURAMET	Reporting documents	<b>INRIM</b> , all partners	M36 + 60 days

## a. Task 2.1: Development of primary humidity standards for trace water vapour in an increased range of gas matrices

	Activity number	Activity description	Partners (Lead in bold)
A2.1.2 upgrade $-80\text{ }^{\circ}\text{C}_{\text{fp}}$ -> $-90\text{ }^{\circ}\text{C}_{\text{fp}}$ for air, $\text{N}_2$ and Ar	A2.1.2 M18	CMI, INTA and UL will upgrade their saturation-based generators to extend the lower limit of reference frost-point temperatures to $-90\text{ }^{\circ}\text{C}$ and at pressures up to 1 MPa and above (INTA to 0.5 MPa) with standard uncertainty of $0.25\text{ }^{\circ}\text{C}$ at $-90\text{ }^{\circ}\text{C}$ . Such trace water generators in nitrogen and argon will perform/support the investigation of water vapour enhancement factor in Task 2.2. Participation in the pilot study described in Task 1.3 requires these standards to be available.	CMI, INTA, UL
A2.1.7 publication	A2.1.7 M36	PTB in cooperation with all partners will write peer reviewed journal papers describing the new/improved primary standards developed for trace water vapour. It will be submitted before M36.	<b>PTB</b> , INRIM, VTT, CMI, INTA, UL, MBW, VSL, CETIAT
A2.2.2 measurement of $f$ -factors	A2.2.2 M24	CMI, VSL and UL will perform independent measurements of the enhancement of water vapour in nitrogen and argon in the frost-point temperature range between $-90\text{ }^{\circ}\text{C}$ and $-30\text{ }^{\circ}\text{C}$ (VSL to $-80\text{ }^{\circ}\text{C}$ ) at selected pressures from 0.1 MPa to above 1 MPa using their facilities upgraded in Task 2.1.	<b>CMI</b> , VSL, UL
A2.2.5 g- $\text{H}_2\text{O}$ data to CNAM -> $f$ -factors	A2.2.5 M27	CNAM on behalf of all partners will report the findings and will provide a data set to Task 2.3 for the development of correlation equations.	<b>CNAM</b> , CETIAT, CMI, VSL, UL, INTA, CEM, UVa

