EURAMET

EURAMET Summer School on temperature and humidity measurements
MIRS/UL-FE/LMK, Ljubljana, 11-15 September 2023

Agenda version 2023-09-04

Outline

Lectures

Day	Session	Session
Monday 8:30 – 18:15	**Thermometry Fundamentals (room P2)** all participants	
Tuesday 9:00 – 13:00	**Humidity Fundamentals (room P2)** all participants	
Tuesday 14:00 – 18:00	**Contact Thermometry (room P2)** **(A1)**	**Humidity (room P1)** **(B1)**
Wednesday 9:00 – 13:00	**Non-Contact Thermometry (room P2)** **(A2)**	**Humidity (room P1)** **(B2)**

Hands-on Training Sessions
(Several experiment setups will be placed in P1, P2, P6, LMK1, LMK2 and Lobby – students will be organised in groups and will rotate among experiment setups)

Day	Session	Session	Session
Wednesday 14:00 – 17:00	**Contact Thermometry** **(A3)**	**Non-contact Thermometry** **(A4)**	**Humidity** **(B3)**
Thursday 9:00 – 17:00	**Contact Thermometry** **(A3)**	**Non-contact Thermometry** **(A4)**	**Humidity** **(B3)**

Friday 9:00 – 13:00	**Open forum for discussing questions of the students** **and presentations on future developments in thermal metrology (room P2)**

City walk will be organised on Wednesday, 13 September

The event dinner will take place on Thursday, 14 September

Rooms:
        P1 – lecture room ground floor
        P2 - lecture room ground floor
        P6 - lecture room ground floor
        Lobby – main hall ground floor
        LMK 1 – 3rd floor
        LMK 2 – 2nd floor

Day 1, Monday, 11 Sep 2023   (P2)

8:00 – 8:30	Registration	
8:30 – 9:00	Course opening and overview	Marko Topič, Tanasko Tasić, Jovan Bojkovski, Steffen Rudtsch
9:00 – 9:15	Greeting from the host	Janko Drnovšek
9:15 – 10:00	Ice break session – the most difficult thermal measurement I have made – a number of speakers	Lecturers
10:00 – 11:15	Overview of the SI and international metrology, CGPM, CIPM, BIPM, CCT, RMOs, EURAMET, TCs, EURAMET Technical Committee for Thermometry	Dolores del Campo, Tanasko Tasić and Steffen Rudtsch
11:15 – 11:45	Discussion and coffee –break	
11:45 – 12:30	The new definition of kelvin and its impact to industry	Jonathan Pearce
12:30 – 13:30	Introduction to uncertainty of measurement	Stephanie Bell
13:30 – 14:30	Lunch	
14:30 – 15:15	The nature of temperature, thermal physics, temperature scales, ITS-90	Andrea Peruzzi
15:15 – 16:30	Traceability and uncertainty in temperature measurement	Steffen Rudtsch
16:30 – 16:45	Coffee	
16:45 – 17:15	Overview of contact thermometry	Jonathan Pearce
17:15 – 18:15	Humidity fundamentals (basic definitions in hygrometry)[i]	Stephanie Bell

Day 2 Tuesday, 12 Sep 2023 (P2)

Humidity fundamentals		
9:00 – 10:00	Overview of non-contact thermometry[i]	Mohamed Sadli
10:00 – 10:30	Traceability routes to accurate humidity measurements	Domen Hudoklin
10:30 – 11:00	Coffee break	
11:00 – 12:00	Humidity generation principles	Vito Fernicola
12:00 – 13:00	Relative humidity and dew-point sensors types	Eric Georgin
13:00 – 14:00	Lunch	

Parallel Session A1: Thermometry: Contact thermometry - Tuesday, 12 Sep 2023 afternoon (P2)		
14:00 – 14:45	Fixed points	Jonathan Pearce
14:45 – 15:30	PRTs (resistance measurement, bridge linearity, operating principles, what makes a good thermometer, materials oxidation, handling annealing, common sources of uncertainty	Steffen Rudtsch
15:30 – 15:45	Coffee break	
15:45 – 16.30	Uncertainty analysis SPRTs	Andrea Peruzzi
16:30 – 17:30	Thermocouples	Frank Edler
17:30 – 18:00	Other contact probes and common measurement scenarios (e.g. liquid in glass, PRTs, thermistors, …)	Jovan Bojkovski

Parallel Session B1: Humidity - Tuesday, 12 Sep 2023 afternoon (P1)		
14:00 – 15:00	Design of a secondary RH calibration setup	Eric Georgin
15:00 – 15:30	Design of a dew-point calibration setup (secondary and primary)	Vito Fernicola
15:30 – 16:00	Coffee break	
16:00 – 16:30	Design of a dew-point calibration setup (secondary and primary) - continuation	Vito Fernicola
16:00 – 18:00	Uncertainty analysis – dew-point	Stephanie Bell

Day 3, Wednesday, 13 Sep 2023 – morning (P2)

Parallel Session A2: Thermometry: Non-Contact thermometry - Wednesday, 13 Sep 2023 morning		
9:00 – 10:00	ITS-90 realisation and *mise-en-pratique* in radiation thermometry, sources (fixed point blackbodies, VTBB, HTBBs, HTFPs)	Mohamed Sadli
10:00 – 10:30	ITS-90 realisation - methods and instruments (pyrometers, monochromator-based spectroradiometers, extrapolation methodologies, characterisation of SSE, spectral responsivity, linearity)	Stephan Briaudeau
10:30 – 11:00	Coffee break	
11:00 – 11:30	ITS-90 realisation - methods and instruments (pyrometers, monochromator-based spectroradiometers, extrapolation methodologies, characterisation of SSE, spectral responsivity, linearity) - continuation	Stephan Briaudeau
11:30 – 12:15	Techniques for the calibration of radiation thermometers, blackbody sources and thermal imaging systems and the evaluation of uncertainties	Helen McEvoy
12:15 – 13:00	Thermodynamic temperature	Klaus Anhalt
13:00 – 14:00	Lunch	

Parallel Session B2: Humidity - Wednesday, 13 Sep 2023 morning (P1)		
9:00 – 10:00	Uncertainty analysis – relative humidity	Domen Hudoklin
10:00 – 10:30	Uncertainty contributions from a hygrometer (chilled-mirror hygrometer, RH impedance sensor)	Eric Georgin
10:30 – 11:00	Coffee break	
11:00 – 12:00	Design of a dew-point calibration setup (secondary and primary) - continuation	Vito Fernicola
12:00 – 13:00	Practical considerations: couplings, leakages, heating, tube materials	Domen Hudoklin
13:00 – 14:00	Lunch	

Day 3, Wednesday, 13 Sep 2023 - afternoon

Parallel Session A3: Thermometry: Contact thermometry – Wednesday, 13 Sep 2023 afternoon, hands-on training		
14:00 – 17:00	Realisation of TPW, calibration of SPRT at fixed points (e.g. realisation of fixed points of Hg and Ga), calculation of a,b coefficients, uncertainty components Usage of automatic resistance bridges Calibration of TC at fixed points, uncertainty components Usage of digital voltmeter Secondary contact (calibration by comparison, uncertainties, equations)	Jovan Bojkovski, Andrea Peruzzi, Vincencij Žužek
Experiments will be repeated for several groups, with foreseen coffee break at 15:30 – 16:00		

Parallel Session A4: Thermometry: Non-Contact thermometry - Wednesday, 13 Sep 2023 afternoon, Hands-on training		
14:00 – 17:00	Secondary calibration of non-contact thermometer (traceability, BB, uncertainties, problems (e.g. size of source, pixels at thermal vision cameras)	Igor Pušnik. Vid Mlačnik, Klaus Anhalt, Frédéric Bourson
Experiments will be repeated for several groups, with foreseen coffee break at 15:30 – 16:00		

Parallel Session B3: Humidity - Wednesday, 13 Sep 2023, afternoon, hands-on training		
14:00 – 17:00	RH & dew-point sensors - show different RH and dew-point sensors and discuss their operation Prepare the secondary calibration setup (RH and dew-point) and discuss critical points Run the setup at selected points and discuss the results	Eric Georgin, Vito Fernicola, Domen Hudoklin
Experiments will be repeated for several groups, with foreseen coffee break at 15:30 – 16:00		

19:00   Guided city walk Ljubljana, starting point still to be announced (participants have to register on Monday)

Parallel Session A3: Thermometry: Contact thermometry - Thursday, 14 Sep 2023 ,Hands-on training		
9:00 – 17:00	Realisation of TPW, calibration of SPRT at fixed points (e.g. realisation of fixed points of Hg and Ga), calculation of a,b coefficients, uncertainty components Usage of automatic resistance bridges Calibration of TC at fixed points, uncertainty components Usage of digital voltmeter Secondary contact (calibration by comparison, uncertainties, equations)	Jovan Bojkovski, Andrea Peruzzi, Vincencij Žužek
Experiments will be repeated for several groups, with foreseen breaks: 10:30 – 11:00 Coffee break 13:00 – 14:00 Lunch break 15:30 – 16:00 Coffee break		

Parallel Session A4: Thermometry: Non-Contact thermometry - Thursday, 14 Sep 2023, Hands-on training		
9:00 – 17:00	Secondary calibration of non-contact thermometer (traceability, BB, uncertainties, problems (e.g. size of source, pixels at thermal vision cameras)	Igor Pušnik. Vid Mlačnik, Klaus Anhalt, Frédéric Bourson
Experiments will be repeated for several groups, with foreseen breaks: 10:30 – 11:00 Coffee break 13:00 – 14:00 Lunch break 15:30 – 16:00 Coffee break		

Parallel Session B3: Humidity - Thursday, 14 Sep 2023, Hands-on training		
14:00 – 17:00	RH & dew-point sensors - show different RH and dew-point sensors and discuss their operation Prepare the secondary calibration setup (RH and dew-point) and discuss critical points Run the setup at selected point and discuss the results	Eric Georgin, Vito Fernicola, Domen Hudoklin
Experiments will be repeated for several groups, with foreseen breaks: 10:30 – 11:00 Coffee break 13:00 – 14:00 Lunch break 15:30 – 16:00 Coffee break		

18:00   Transfer to Event dinner, starting point still to be announced (participants have to register on Monday)

Day 5 Friday, 15 Sep 2023

		All participants	
9:00 – 10:30	Presentations of the results of students' experiments Discussion on remaining questions		
10:30 – 11:00	Coffee break		
11:00 – 12:30	Future developments in thermal metrology		Jonathan Pearce, Mohamed Sadli, Andrea Peruzzi, Steffen Rudtsch
12:30 – 13:00	Closing of the event		
13:00 – 14:00	Lunch		

Coffee breaks, lunches and the event dinner will be provided by the host.

A participation fee of 100 EUR + VAT (for students) for the whole course will be charged by the host to partly support logistical costs of the event. The participation fee can be paid only via bank transfer based on a pro-forma invoice issued by the host.

More information about the event is available at the webpage
https://www.euramet.org/publications-media-centre/events/detail/event/euramet-summer-school-on-temperature-and-humidity-measurements

Venue:
University of Ljubljana-Faculty of Electrical Engineering (MIRS/UL-FE/LMK)
Tržaška cesta 25
1000 Ljubljana
Slovenia

WiFi network for Summer School participants at the Faculty of Electrical Engineering.

Network: FE-guest
Username: esummerschool
Password: 5058

Host contact:
jovan.bojkovski@fe.uni-lj.si

EURAMET contact
tanasko.tasic@euramet.org

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[i] The contributions "Humidity fundamentals (basic definitions in hygrometry)" by Stephanie Bell and "Overview of non-contact thermometry" by Mohamed Sadli have been exchanged between their original sections for logistical reasons.