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Highlights from the CCT Working Group on Digitalization (CCT-WG-Dig)

Dr. Patrick Rourke (CCT-WG-Dig chair)

CCT plenary meeting, BIPM, 21-22 May 2026

Who are we?

NMI/DI	RMO	Person	Participation in other CCT WGs/TGs
NRC (CCT-WG-Dig chair)	SIM	Dr Patrick Rourke	CCT-WG-CTh, CCT-WG-SP
MIRS/UL-FE/LMK	EURAMET	Prof Dr Jovan Bojkovski	CCT-WG-CMC (chair), CCT-WG-SP
CEM	EURAMET	Mr Raúl Caballero Santos	
NIM	APMP	Dr Xiaojuan Feng	CCT-WG-CMC, CCT-WG-CTh, CCT-WG-KC, CCT-WG-SP
PTB	EURAMET	Dr Christof Gaiser	CCT-WG-CTh (chair), CCT-TG-CTh-TTT, CCT-WG-SP
INRIM	EURAMET	Dr Roberto Gavioso	CCT-WG-CTh
NMIJ/AIST	APMP	Dr Yasuki Kawamura	CCT-TG-CTh-TTT
PTB	EURAMET	Dr Ingmar Müller	CCT-WG-NCTh
SMU	EURAMET	Dr Peter Pavlasek	CCT-WG-Env, CCT-WG-ThQ
LNE-LCM/Cnam	EURAMET	Dr Mohamed Sadli	CCT-WG-CMC, CCT-WG-CTh, CCT-WG-KC, CCT-WG-NCTh, CCT-WG-SP
MSL	APMP	Dr Peter Saunders	CCT-WG-NCTh
VTT MIKES	EURAMET	Dr Shahin Tabandeh	CCT-WG-Env, CCT-WG-Hu
NPL	EURAMET	Dr Radka Veltcheva	
NIST	SIM	Dr Richmond Wang	
KRISS	APMP	Dr Inseok Yang	CCT-WG-CTh, CCT-WG-KC

What do we do?

The terms of reference of the CCT-WG-Dig are to advise and support the CCT, and its Working Groups and Task Groups, on digitalization, and to advise and support the BIPM on thermometry-related aspects of the SI Digital Framework.

- Provide thermometry-related digitalization guidance to the BIPM, CCT and other CCT Working Groups and Task Groups
- Liaise with other bodies active in thermometry digitalization, to encourage global digital harmonization and avoid unnecessary parallel work
- Monitor recent developments of Digital Calibration Certificates (DCCs) in the CCT subject areas and connect them in a harmonized approach
- Identify digital functions, data and guidance that would benefit the CCT and broader thermometry community
- Advise BIPM staff during the development and testing of digital functions and documents relevant to the CCT

Highlights from CCT-WG-Dig

OUTLINE

- Public open beta test of CCT Application Programming Interfaces (APIs)
- Strategy 2025-2030+
- Proposal for new Task Group on Distributed Thermal Measurement Systems

PUBLIC OPEN BETA TEST OF CCT APPLICATION PROGRAMMING INTERFACES (APIS)

Public open beta test of CCT APIs:
Origins

CCT-WG-Dig created as TG during 30th plenary meeting of the CCT (2022)

- Request by CCT President, BIPM Director and BIPM staff
- Primary goal: examine what information in CCT documents could usefully be made available in digital machine-readable form
- TG to review documents and recommend what information to digitalize, but not carry out the technical realization
- BIPM to help with implementation

Results!

First set of CCT APIs now ready for public open beta test!

Thanks to the BIPM ILC Department & Jean-Laurent Hippolyte of NPL

Public open beta test of CCT APIs:
Data situation up to now

TABLE IV

Platinum resistance thermometer

The constants A_0, A_i; B_0, B_i; C_0, C_i; D_0 and D_1 in the reference function of equations (9 a); (9 b); (10 a); and (10 b) respectively

A_0	− 2,135 347 29	B_0	0,183 324 722
A_1	3,183 247 20	B_1	0,240 975 303
A_2	− 1,801 435 97	B_2	0,209 108 771
A_3	0,717 272 04	B_3	0,190 439 972
A_4	0,503 440 27	B_4	0,142 648 498
A_5	− 0,618 993 95	B_5	0,077 993 465
A_6	− 0,053 323 22	B_6	0,012 475 611
A_7	0,280 213 62	B_7	− 0,032 267 127
A_8	0,107 152 24	B_8	− 0,075 291 522
A_9	− 0,293 028 65	B_9	− 0,056 470 670
A_{10}	0,044 598 72	B_{10}	0,076 201 285
A_{11}	0,118 686 32	B_{11}	0,123 893 204
A_{12}	− 0,052 481 34	B_{12}	− 0,029 201 193
		B_{13}	− 0,091 173 542
		B_{14}	0,001 317 696
		B_{15}	0,026 025 526
C_0	2,781 572 54	D_0	439,932 854
C_1	1,646 509 16	D_1	472,418 020
C_2	− 0,137 143 90	D_2	37,684 494
C_3	− 0,006 497 67	D_3	7,472 018
C_4	− 0,002 344 44	D_4	2,920 828
C_5	0,005 118 68	D_5	0,005 184
C_6	0,001 879 82	D_6	− 0,963 864
C_7	− 0,002 044 72	D_7	− 0,188 732
C_8	− 0,000 461 22	D_8	0,191 203
C_9	0,000 457 24	D_9	0,049 025

Unfriendly to humans
Unfriendly to machines

CCT APIs: make important CCT reference data available to both humans & machines in easily usable form

Public open beta test of CCT APIs:
Where are the APIs?

BIPM SI Digital Framework https://si-digital-framework.org

Consultative Committee for Thermometry (CCT)

The digital services from the Consultative Committee for Thermometry (CCT) provide internationally-agreed reference data for temperature scales and measurements. The reference data sets here are sourced from documents related to the *Mise en pratique* for the definition of the kelvin in the SI and support the realization of scale temperatures via the International Temperature Scale of 1990 (ITS-90) and Provisional Low Temperature Scale of 2000 (PLTS-2000), and the realization of thermodynamic temperature via primary radiometric measurements and acoustic gas thermometry.

- **Consultative Committee for Thermometry (CCT)**
  - ITS-90 International Temperature Scale of 1990 (ITS-90)
  - PLTS-2000 Provisional Low Temperature Scale of 2000
  - Primary radiometric temperature measurement
  - Acoustic gas thermometry

Public open beta test of CCT APIs:

Home | ITS-90 Scale | PLTS-2000 Scale | Primary radiometric temperature measurement | Acoustic gas thermometry

About this service

The Consultative Committee for Thermometry (CCT) is one of the Consultative Committees of the International Committee for Weights and Measures (CIPM). It coordinates thermometry research and provides internationally-agreed reference data for temperature scales and measurements. The reference data sets included in this service are sourced from documents related to the Mise en pratique for the definition of the kelvin in the SI, to support the realization of scale temperatures via the International Temperature Scale of 1990 (ITS-90) and Provisional Low Temperature Scale of 2000 (PLTS-2000), and the realization of thermodynamic temperature via primary radiometric measurements and acoustic gas thermometry.

Available data

- **ITS-90 Scale**:
  - SPRT acceptance criteria at the Ag, Ga and Hg points
  - fixed-point temperature values, and variation with depth and pressure
  - ^{3}He and ^{4}He vapour pressure temperature values and equation coefficients
  - fixed-point isotopic corrections for deuterium in *e*-H_2, ^{22}Ne and ^{21}Ne in Ne, and ^{17}O and ^{18}O in H_2O
  - *e*-H_2 vapour pressure temperature values near 17 K and 20.3 K
  - SPRT reference function and inverse function coefficients, reference function W_r values and first derivative, and inverse function temperatures
- **PLTS-2000 Scale**:
  - ^{3}He melting pressure equation coefficients and reference arrays (Arrays 1–4)
  - melting pressure of ^{3}He
  - derivative of melting pressure of ^{3}He
- **Primary radiometric temperature measurement**:
  - blackbody spectral radiance
  - geometric factor equations and uncertainty
  - integrated transmittance and mean wavelength
  - high-temperature fixed point thermodynamic temperatures
  - radiation constants c_1 and c_2
  - uncertainty budget components and examples
- **Acoustic gas thermometry**:
  - sensitivity of squared speed of sound to specific impurities
  - second acoustic virial coefficient of Ar

Public open beta test of CCT APIs:
How to access the data?

The reference data can be accessed in different ways:

Swagger UI

All available reference data may be explored and tested via the Swagger UI.

Open Swagger UI →

JSON API

The data may be directly accessed in JSON format via GET commands, for example

```
GET /cct/its-90/sprt-ref-function/calculate-wr
```

All endpoints are described in the **Swagger UI**.

HTML and TSV

A selected sub-set of the reference data sets are embedded as HTML tables within the ITS-90 Scale, PLTS-2000 Scale, Primary radiometric temperature measurement and Acoustic gas thermometry tabs, and can be downloaded in TSV (tab-separated values) format via the *Download TSV* buttons. The TSV files can be opened directly in spreadsheet software or consumed by processing scripts. The first line of each file is a comment (starting with `#`) identifying the dataset.

Human-friendly user interface:
Interactive web apps allow people to navigate and retrieve the data

Machine-friendly application programming interface:
Computers can directly request the data from the BIPM SIDF server

GET `/its-90/sprt-ref-function/coefficients` Returns a list of coefficients for the ITS-90 reference function or the inverse function.

Returns a list of coefficients for the ITS-90 reference function or the inverse function, for a given constant with possible values (A, B, C, D).

Provenance of this data and further information can be found here:

- H Preston-Thomas "The International Temperature Scale of 1990 (ITS-90)" 1990 Metrologia 27 3
- H Preston-Thomas "Erratum: The International Temperature Scale of 1990 (ITS-90)" 1990 Metrologia 27 107

Parameters Try it out

Name	Description
constant * required string *(query)*	Enter constant with possible values (A, B, C, D). *Example* : A A

Responses

Code	Description	Links
200	Successful retrieval of coefficients Media type: application/json Examples: A coefficients list Controls Accept header. Example Value | Schema	*No links*


```
{
  "name": "Return: array of the Ai coefficients",
  "data": {
    "A0": -2.13534729,
    "A1": 3.1832472,
    "A2": -1.80143597,
    "A3": 0.71727204,
    "A4": 0.50344027,
    "A5": -0.61899395,
    "A6": -0.05332322,
    "A7": 0.28021362,
    "A8": 0.10715224,
    "A9": -0.29302865,
    "A10": 0.04459872,
    "A11": 0.11868632,
    "A12": -0.05248134
  }
}
```

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Human-friendly user interface:
Interactive web apps allow people to navigate and retrieve the data

Machine-friendly application programming interface:
Computers can directly request the data from the BIPM SIDF server

Human-friendly tables & files:
Selected data sets are embedded in landing pages, for easy manual access

SPRT reference function coefficients

Coefficients for the ITS-90 reference function (A_0–A_{12} for T_{90} below 273.16 K; C_0–C_9 for T_{90} at or above 273.15 K) and inverse function (B_0–B_{15} below 273.16 K; D_0–D_9 at or above 273.15 K).

A — reference function (T_{90} < 273.16 K)

Download TSV

Coefficient	Value
A0	-2.13534729
A1	3.18324720
A2	-1.80143597
A3	0.71727204
A4	0.50344027
A5	-0.61899395
A6	-0.05332322
A7	0.28021362
A8	0.10715224
A9	-0.29302865
A10	0.04459872
A11	0.11868632
A12	-0.05248134

Public open beta test of CCT APIs:
Please join us!

Come try out the CCT APIs at

https://si-digital-framework.org

- Send your feedback via:
  - GitHub: https://github.com/TheBIPM/SIDF-CCT-API-issues (free account required)
  - E-mail: cristhian.paredes@bipm.org & patrick.rourke@nrc-cnrc.gc.ca

- Formal CCT approval will eventually be needed to remove the “beta version” tag

STRATEGY 2025-2030+

Strategy 2025-2030+

Achievements 2021-2025	Future Scan 2025-2030+
Developed and published a restructured machine-readable “2019D” version of the *MeP*-K on the BIPM website. Collaborated with the BIPM to develop Application Programming Interfaces (APIs) for machine and human readable and actionable access to digital functions and reference data related to the *MeP*-K.	Complete open beta test and publication of *MeP*-K-related APIs. Identify needs for additional APIs that would support the global thermal metrology community to build new capabilities more easily and to automate workflows. For example, digital functions and reference data related to humidity, thermophysical quantities, primary thermometry, and CCT guidance documents.

2nd set of CCT APIs is already in development:
thermodynamic inaccuracy of the ITS-90 (T-T_{90}), humidity, thermophysical quantities

Strategy 2025-2030+

Achievements 2021-2025	Future Scan 2025-2030+
Reviewed NMI progress on implementing thermometry Digital Calibration Certificates (DCCs), and the state of DCC schema, templates and tools.	Evaluate the expansion of DCCs to integrate connections with digital functions and reference data such as CCT APIs (for example, the ITS-90 SPRT reference function), CMCs in the KCDB, and the SI Digital Framework, ensuring version control of the values used in each DCC. In consultation with external stakeholders such as instrument manufacturers and the QI Digital initiative, advance the possibility to leverage the digital workflow enabled by DCCs so that calibration results can be automatically updated into end user measurement devices without requiring them to be manually entered.

Strategy 2025-2030+

Achievements 2021-2025	Future Scan 2025-2030+
Developed and raised a document indexing and archiving suggestion to the CCT and CIPM, for possible implementation by the BIPM and use across all CCs. Advised BIPM during the development and testing of the SI Digital Framework.	Engage with and advise the BIPM on upcoming development of the cross-CC document repository and website redesign, to ensure these meet the needs of the CCT and thermometry community. Collaborate with the BIPM on solutions to the problems of external web searches surfacing old versions of important CCT documents, and poor usability of the BIPM website internal search function.

Strategy 2025-2030+

Achievements 2021-2025	Future Scan 2025-2030+
	In consultation with CCT-WG-KC, explore the use of the PTB Digital Metrology Expert (DME) software for analysis of CCT key comparisons, supplementary comparisons, etc.; and the expansion of DME to incorporate resources such as the NIST Decision Tree and other APIs.

Strategy 2025-2030+

System metrology:

“Here the CIPM strategy identifies the importance to establish trustworthy references for data acquired from sensor systems as well as to understand the propagation of measurement uncertainties in sensor networks. This is linked to the growing use of low-cost uncalibrated and often interconnected sensors. It also highlights the need to develop practical methods for the metrological evaluation of interconnected sensors. Temperature and humidity sensors are essential components in most environmental and industrial sensor networks. The WG on Digitalization will discuss how the CCT could contribute to guarantee trust, reliability, interoperability and traceability of such distributed interconnected measurement systems in the future, including the possible establishment of a dedicated CCT TG to focus on the aspects of sensor networks relevant to the CCT.”

PROPOSAL FOR NEW TASK GROUP ON DISTRIBUTED THERMAL MEASUREMENT SYSTEMS

Thanks to Dr. Shahin Tabandeh (VTT MIKES)

Proposal for new Task Group:
Distributed Thermal Measurement Systems

Thermal measurements are increasingly performed using distributed and digitally enabled measurement systems

- Multiple sensors, sometimes without conventional calibration
- Multiple data-processing layers
- Data-driven models
- “Distributed” = multiple spatially-separated sensing elements
- “Distributed” = multiple co-located redundant sensing elements

Challenges for:

- Traceability
- Uncertainty evaluation
- Validation

Propose creation of new CCT-TG-Dig-DTMS under CCT-WG-Dig

Proposal for new Task Group:
Distributed Thermal Measurement Systems

Draft TG objectives

- **Adaptation of sensor network metrology frameworks to thermometry**
  To review and adapt concepts and approaches developed within Forum-MD on sensor networks to applications involving temperature, humidity, and environmental monitoring.
- **Development of metrological guidance for distributed thermal measurement systems**
  To identify practical approaches for establishing traceability, uncertainty evaluation, and non-conventional system-level validation and calibration methods.
- **Support digital interoperability of thermometry data in sensor networks**
  To identify requirements and recommendations for Digital Calibration Certificates (DCC), machine-readable sensor information, and APIs for reliable machine-to-machine data exchange.
- **Strengthen coordination with digitalisation activities and stakeholders**
  To facilitate interaction between CCT-WG-Dig, RMO digitalisation groups, relevant external organisations and standardisation bodies, ensuring alignment of thermometry practices in sensor networks.

Thoughts? Interest & support from the CCT?