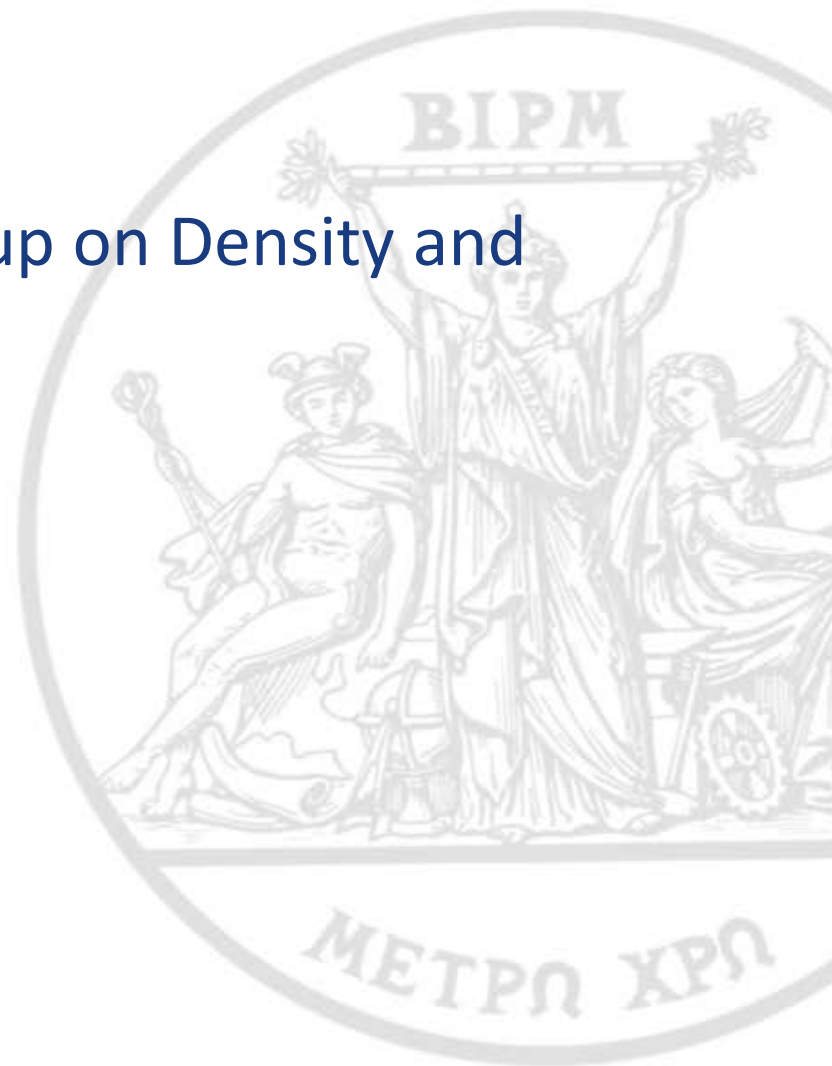


Report of the CCM Working Group on Density and Viscosity

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18th CCM meeting, 20-21 May 2021

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WG Meetings held since last CCM

- ◆ Held since last CCM

April 19, 2021, held online on ZOOM

27 member institutes (NMIs and BIPM) and 3 guest institutes

WG Meetings planned

- ◆ WGDV meeting in 2023 held prior to next CCM meeting

Main actions taken and main achievements

- ◆ Establishment of formulas for density of water and air
 - Recommended table for density of water (2001)
 - Revised formula for density of moist air (CIPM-2007)
 - Guidelines for use of CIPM and IAPWS formulations on density of water (2009)
- ◆ Implementing KCs to cover possible CMCs for a variety of density measurements based on a silicone density standard and also for broad range of viscosity under wide range of temperature
- ◆ Necessary revision of CCM service category
 - 2016 : Standard volume vessel: Density \Rightarrow Fluid Flow
 - Refractive index of liquid: new category for Density

Progressing the state of the art

- ◆ For the determination of the Planck constant to redefine the kilogram, the uncertainty of the density measurement of silicon spheres were significantly reduced by improving optical interferometers for the sphere volume measurement. It is expected that this would be reflected in the results of planned repetition KC of CCM.D-K1.
- ◆ Development for standards of refractive index of liquids based on optical interferometry
- ◆ Development of absolute measurements of viscosity at intermediate viscosity range for realization of more reliable metrological base

Liaison & stakeholders

- ◆ Silicon density standards, covered by CCM.D-K1, are now used by most of the NMIs as density standards for calibrating the density of solids, liquids, and even gases. ⇒ repetition of CCM.D-K1 is planned
- ◆ Traditional users of density standards are the oil, liquor and alcohol industries, where there is still high demand for calibrating hydrometers in legal metrology and taxation (CCM-D-K4).
- ◆ However, for automatization, there is also increasing demand for using oscillation-type density meter covered by CCM.D-K2 and CCM-D-K5.
- ◆ In the 200 CMCs for density, about a half of them are for the density and volume of stainless-steel weights. This is the reason why CCM.D-K3 is necessary.
- ◆ In food industry and agriculture, traceable standard for the refractive index of liquids is needed for sugar content measurements.
- ◆ Supplying the refractive index standard liquids, which is similar to the density standard liquids, is needed (CCM.D-K6). ⇒ Liaison with CCPR
- ◆ Traceable gas density measurement is needed for energy saving and energy transportation. Such a CMC will be covered by a new KC for p - ρ - T properties of fluids.

KCs completed (Density)

- ◆ **CCM.D-K1 Density measurement of a silicon sphere by hydrostatic weighing (2001-2003)**
Pilot : NMIJ (JP), Pilot group: METAS (CH), NRC (CA)
Participants: NMIJ (JP), PTB (DE), INRIM (IT), KRISS (KR), METAS (CH), NRC (CA), CEM (ES),
CENAM (MX)
- ◆ **CCM.D-K2 Comparison of liquid density standards (2004-2005)**
Pilot: PTB (DE), Pilot group: NMIJ (JP), NRC (CA)
Participants: BEV (AT), NRC (CA), PTB (DE), OMH (HU), NMIJ (JP), KRISS (KR), CENAM (MX),
VNIIM (RU)
- ◆ **CCM.D-K4 Hydrometers (2011-2012)**
Pilot: INRIM (IT), Pilot group: CENAM (MX), PTB (DE)
Participants: INRIM (IT), CENAM (MX), PTB (DE), LATU (UY), NMIJ (JP), LNE (FR), NMIA (AU), NIST
(US), KRISS (KR)

KCs underway (Density)

- ◆ **CCM.D-K3 Density measurements of stainless-steel weights (2021-)**

Status: Technical Protocol in progress, Participants identified

Pilot: NMIJ (JP), Pilot group: BEV (AT), CENAM (MX)

Participants: BIPM, NIM (CN), NIMT (TH), NMIJ (JP), A*STAR (SG), BEV (AT), INRIM (IT), METAS (CH), PTB (DE), UME (TR), NMISA (ZA), NIS (EG), CENAM (MX), INMETRO (BR), NRC (CA)

- ◆ **CCM.D-K5 Density measurements by oscillation-type density meters (2019-)**

Status: Liquid samples in preparation, Participants identified

Pilot: BEV (AT)

Participants: BEV (AT), A*STAR (SG), NPL (UK), CENAM (MX), NMIA (AU), PTB (DE), IPQ (PT), NRC (CA), UME (TR), NMIJ (JP), SMU (SK), GUM (PL), INMETRO (BR), METAS (CH), HMI (HR), INM (RO), FORCE (DK)

KCs planned (density)

- ◆ CCM.D-K6 Refractive index of liquids

Status : Questionnaire on methods, conditions and standard liquids in preparation

Pilot : NMIJ(JP)

Comment: This KC is closely related to the samples prepared for the density standard liquids. It is being organized as a joint KC with CCPR because CMCs and KCs on other optical properties are in CCPR. About 4 - 6 NMIs in CCM and CCPR are interested in this KC.

KCs planned (Repetition KCs on density)

- ◆ **CCM.D-K1 Density of a silicon sphere (after 2022?-)**

Pilot : offered by PTB just after last meeting

- ◆ **CCM.D-K2 Liquid density (2023-)**

- ◆ **CCM.D-K4 Hydrometer calibrations (2027-)**

KCs completed and underway (Viscosity of standard liquids)

KCs completed

- ◆ **CCM.V-K1 (2002)**

Wide viscosity range (10 mm²/s to 40000 mm²/s) with three liquids, Pilot : PTB, 18 participants

- ◆ **CCM.V-K2 (2006)**

Wide temperature range (- 40 °C to 100 °C) with two liquids, Pilot: Cannon, 14 participants

- ◆ **CCM.V-K3 (2012-13)**

Wide viscosity range (5 mm²/s to 160000 mm²/s) with three liquids, Pilot: NMIJ, 19 participants

KC underway

- ◆ **CCM.V-K4 (2018-)**

Wide temperature range (10 °C to 100 °C) with two liquids, Pilot: CENAM, 12 participants

Status : Draft A ver.2

Program of work for the next 5 years

- ◆ Completion of KCs underway and planned
CCM.D-K3, CCM.D-K5, CCM.D-K6 and CCM.V-K4
- ◆ Linking RMO KCs to the CIPM KCs
- ◆ Liaison with CCPR for the refractive index evaluation (CCM.D-K6)
- ◆ Planning and starting next or repetition KCs
CCM.D-K1, CCM.D-K2, CCM.D-K4 and CCM.V-K5
- ◆ Consideration of new scope for new KCs
Density measurements under high pressures and high temperatures ($p\rho T$ properties)
Surface tension

Proposed changes (membership, chairmanship)

- ◆ No change in the WGDV membership since last CCM
27 member institutes (NMIs and BIPM)

- ◆ New vice-chair of WGDV

Vice-chair (former chair for 17 years), Dr. Kenichi Fujii, retired NMIJ in 2020

Proposal of new vice-chair in the field of density:

Luis Omar Becerra (CENAM):

He already served as chair in density part of this WGDV meeting

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