DFM
Danish National Metrology Institute

DFM activities relevant to CCM

Lars Nielsen

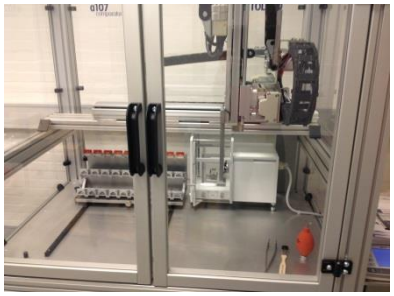
About DFM

- DFM was founded in 1985
- Total number of staffs: >30
- DFM is the Danish national metrology institute in a limited number of fields, including measurement of mass, but excluding the other fields covered by CCM

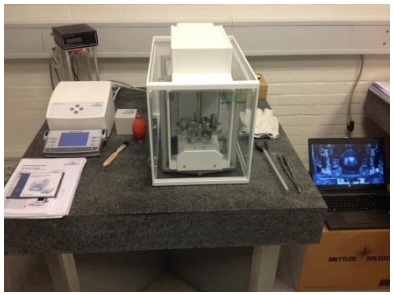
DFM mass laboratory

- Number of staffs: < 2
- National prototype: No. 48
- Number of mass comparators: 4

XP6U



a107



AX1006

AX32004

- Mass range: 1 mg - 20 kg
- Expanded measurement uncertainties: 1/10 to 1/3 of OIML E_1 tolerance
- Procedure: Subdivision/multiplication

DFM mass laboratory

Research activities

- How to evaluate mass values and associated uncertainties of weights from measurements obtained during subdivision/multiplication[1][2]?

1. Nielsen L 1998 Least squares estimation using Lagrange multipliers *Metrologia* **35** 115-18
   Nielsen L 2000 *Metrologia* **47** 183 (erratum)
2. Nielsen L 2002 Evaluation of measurements by the method of least squares *Algorithms for Approximation* IV ed J Levesley *et al* (University of Huddersfield) pp 170-86

Research activities

- How to assign a current mass value to a weight based on its calibration history[3][4]?
  3. Nielsen L 2001 Evaluation of the calibration history of a measurement standard, DFM-01-R25
  4. Nielsen L 2014 Evaluation of mass measurements in accordance with the GUM Metrologia 51 S183-90

- How to carry out a calibration most efficiently using appropriate software?
  - Software: DFM Calibration of weights

Research activities

- CCM WGM TG2: Are the mass values assigned to BIPM Pt/Ir prototypes traceable to the international kilogram prototype ℜ within the claimed uncertainties[5]?

5. Nielsen L *et al* 2015 Improving traceability to the international prototype of the kilogram *Metrologia* **52** 538-51

- EMRP SIB05 NewKILO: How to model the change in masses of sorption standards when transferred from air to vacuum and back[6][7]?

6. Nielsen L 2015 Transferring the unit of mass between weights kept in air and in vacuum, DFM-2015-R03
7. Davidson S *et al* 2016 Air–vacuum transfer; establishing traceability to the new kilogram *Metrologia* **53** A95-113

Research activities

- EMRP SIB05 NewKILO: What is the uncertainty by which the unit of mass could be disseminated from multiple primary realisations to a 1 kg mass standard kept in air [8]?

8. Nielsen L 2016 Disseminating the unit of mass from multiple primary realisations *Metrologia* **53** 1306-1

Key comparisons

Key comparison ID	Period	Measurement standards	Status
EUROMET.M.M-K1	1992-1999	1 kg	Approved for equivalence
EUROMET.M.M-K4	2001-2003	1 kg	Approved for equivalence
EUROMET.M.M-K2	2002-2003	100 mg, 2 g, 20 g, 500 g, 10 kg	Approved for equivalence
EUROMET.M.M-K4.1	2007	1 kg	Approved for equivalence
EURAMET.M.M-K2.4	2013-?	100 mg, 2 g, 20 g, 500 g, 10 kg	Waiting for results from LCAE, Tunisia
EURAMET.M.M-K4.2015	2015-2018	1 kg	Planned

Key comparisons

- How to evaluate the results of key comparisons[9][10]?

9. Nielsen L 1999 Evaluation of measurement intercomparisons by the method of least squares, DFM-99-R39
10. Nielsen L 2003, Identification and handling of discrepant measurements in key comparisons, *Measurement Techniques*, Vol. 46, No. 5, 513-522