

## Annual report of DFM to CCM 2021

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### 1. Introduction

This report describes the activities carried out by DFM in the field of mass in the period from May 2019 to April 2021.

### 2. Scientific research and development

DFM has developed and implemented a measurement design that eliminates weighing position errors detected on an automatic 32 kg mass comparator during calibration of mass standards in the range 2 kg – 20 kg.

DFM has participated in CCM Task Group on the Phases for the Dissemination of the kilogram following redefinition (CCM-TGPfD-kg).

### 3. Key comparisons

DFM participated in the comparison EURAMET.M.M-K4.2015 and was member of the support group set up for this comparison. The Final report was published in March 2020 [11].

DFM was a member of the support group for the key comparison CCM.M-K8.2019 [12].

Key comparison ID	Period	Measurement standards	Status
EURAMET.M.M-K4.2015	2015-2020	1 kg	Final report

**Table 1.** Key comparisons on calibration of mass standards in which DFM has actively participated in the period May 2019 to April 2021.

### 4. Relevant publications

- [1] Nielsen L 1998 Least squares estimation using Lagrange multipliers *Metrologia* **35** 115-18  
Nielsen L 2000 *Metrologia* **47** 183 (erratum)
- [2] Nielsen L 1999 Evaluation of measurement intercomparisons by the method of least squares, DFM-99-R39
- [3] Nielsen L 2001 Evaluation of the calibration history of a measurement standard, DFM-01-R25
- [4] 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
- [5] Nielsen L 2003, Identification and handling of discrepant measurements in key comparisons, *Measurement Techniques*, Vol. 46, No. 5, 513-522
- [6] Nielsen L 2014 Evaluation of mass measurements in accordance with the GUM *Metrologia* **51** S183-90
- [7] Nielsen L *et al* 2015 Improving traceability to the international prototype of the kilogram *Metrologia* **52** 538-51

- [8] Nielsen L 2015 Transferring the unit of mass between weights kept in air and in vacuum, DFM-2015-R03
- [9] Davidson S *et al* 2016 Air–vacuum transfer; establishing traceability to the new kilogram *Metrologia* **53** A95-113
- [10] Nielsen L 2016 Disseminating the unit of mass from multiple primary realisations *Metrologia* **53** 1306-16
- [11] Alisic S *et al* 2020 Final report on EURAMET comparison on 1 kg stainless steel mass standards *Metrologia* **57** 07011
- [12] Stock M *et al* 2020 Report on the CCM key comparison of kilogram realizations CCM.M-K8.2019 *Metrologia* **57** 07030