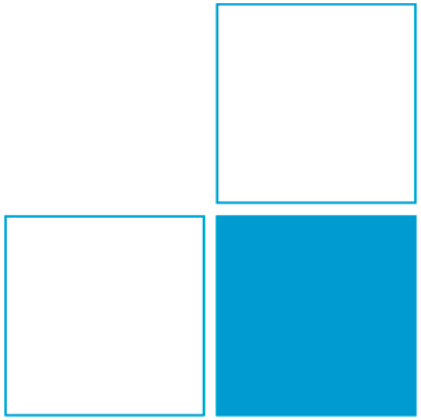
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

Report of the CCM WG Force

15th CCM Meeting at BIPM in February 2015

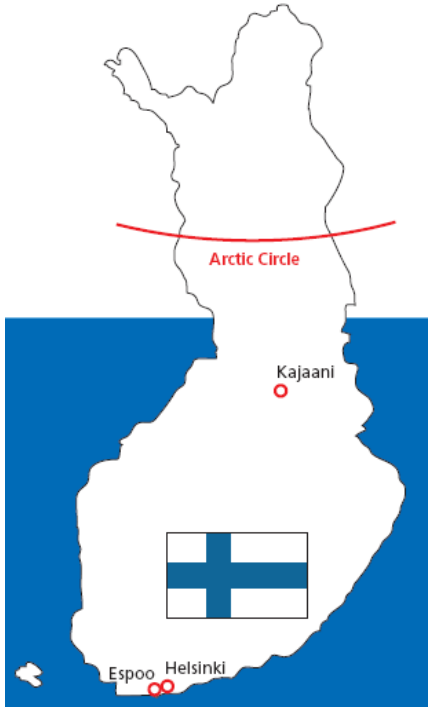
Rolf Kumme, PTB

CCM Meeting
26 – 27 February, 2015



Meetings of the CCM WG Force

Last CCM WG Force Meeting at MIKES in Kajaani, Finland 10th to 12th November 2014



The CCM WG Force meeting take place once in three years.
To make the work more effective it was decided to have a small group which will meet more often for a short time on the occasion of other meetings like EURAMET TC Mass, IMEKO TC3 or ISO TC164.

Terms of reference of CCM WG Force

- **To study issues related to force and torque metrology, including dissemination, and to advise the CCM on these topics as well as on anticipated developments in this field;**
- **To define, organize and approve the necessary key comparisons;**
- **To provide guidance to accept CMCs on force and torque;**
- **To provide liais on at the technical level with ISO TC164/SC 1 and SC 5 and to maintain good links with IMEKO TC3.**

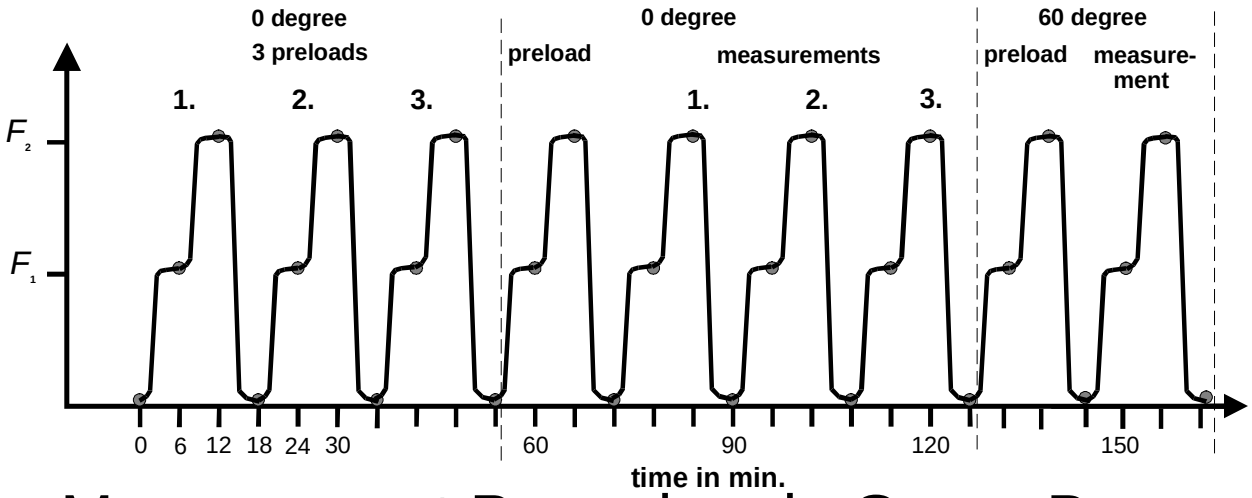
Overview of CCM Force Key Comparisons

- CCM.F-K1.a (load cell up to 10 kN) and .b (up to 5 kN), Results available
- CCM.F-K2.a (load cell up to 100 kN) and .b (up to 50 kN), Results available
- CCM.F-K3.a (force transducer up to 1 MN) and .b (up to 500 kN), Report in progress, Draft A
  Updated report considering the comments obtained from participants after last CCM WG Force Meeting in preparation, next step: Draft B

- CCM.F-K4.a (load cell up to 4 MN) and .b (up to 2 MN) , Results available

Measurement Procedure of CCM Force Key Comparisons

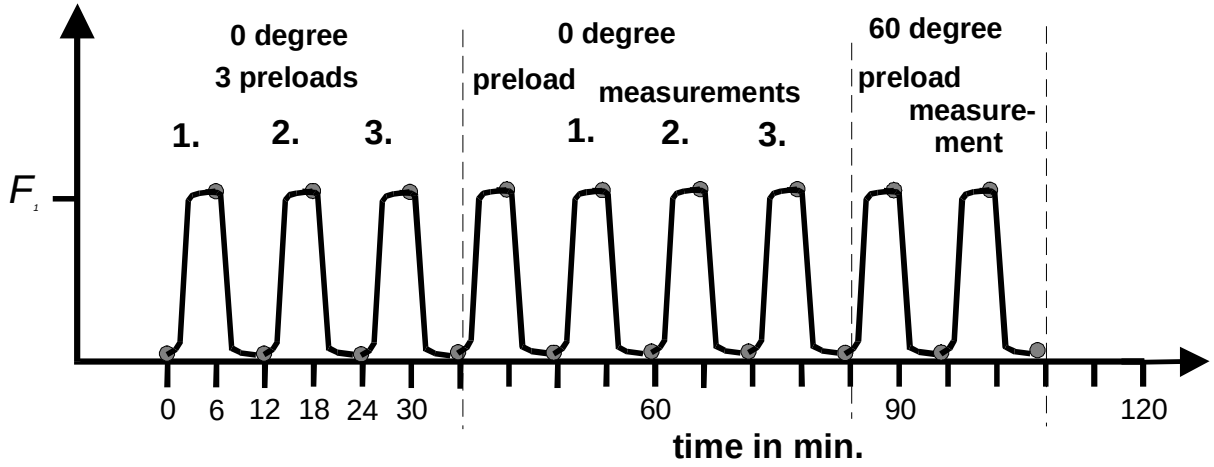
- Measurement Procedure in Group A



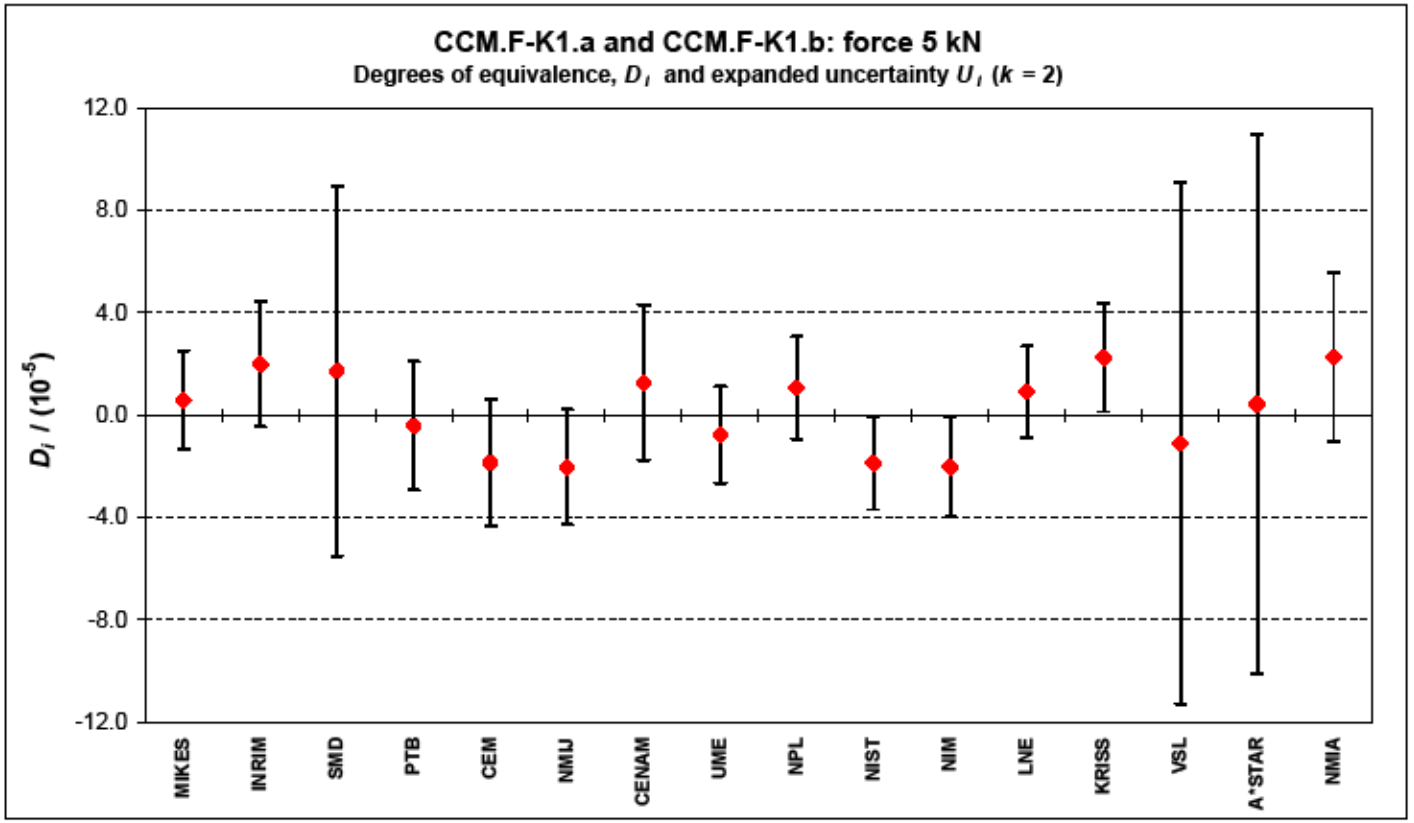
1 preload +
1 measurement
cycle in position

60°	60°
120°	120°
180°	180°
240°	240°
300°	300°
360°/0°	360°
1.rotation	2.rotation

- Measurement Procedure in Group B



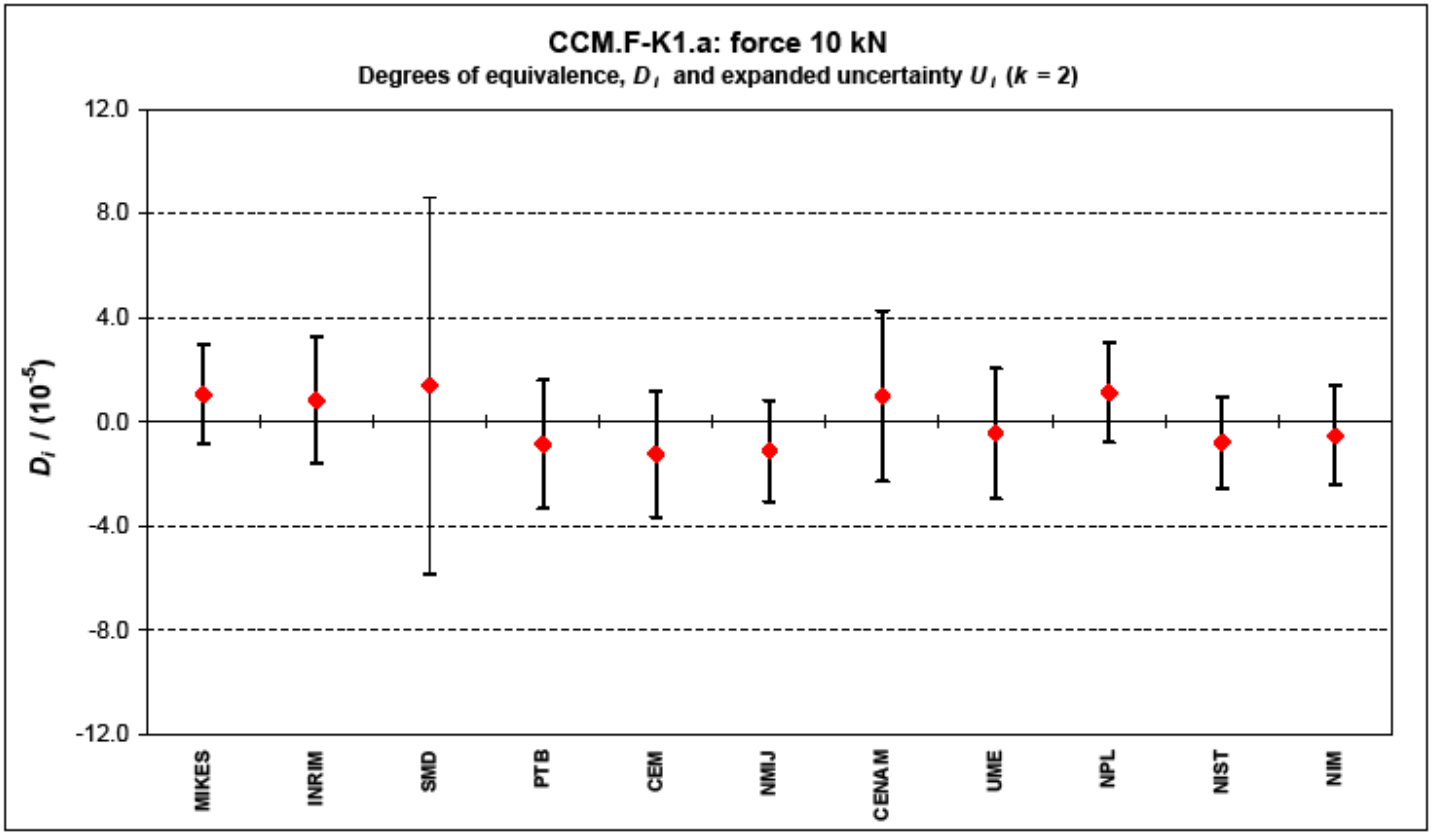
CCM.F-K1.a (load cell up to 10 kN) and .b (up to 5 kN)



The BIPM key comparison database, May 2009

7/8

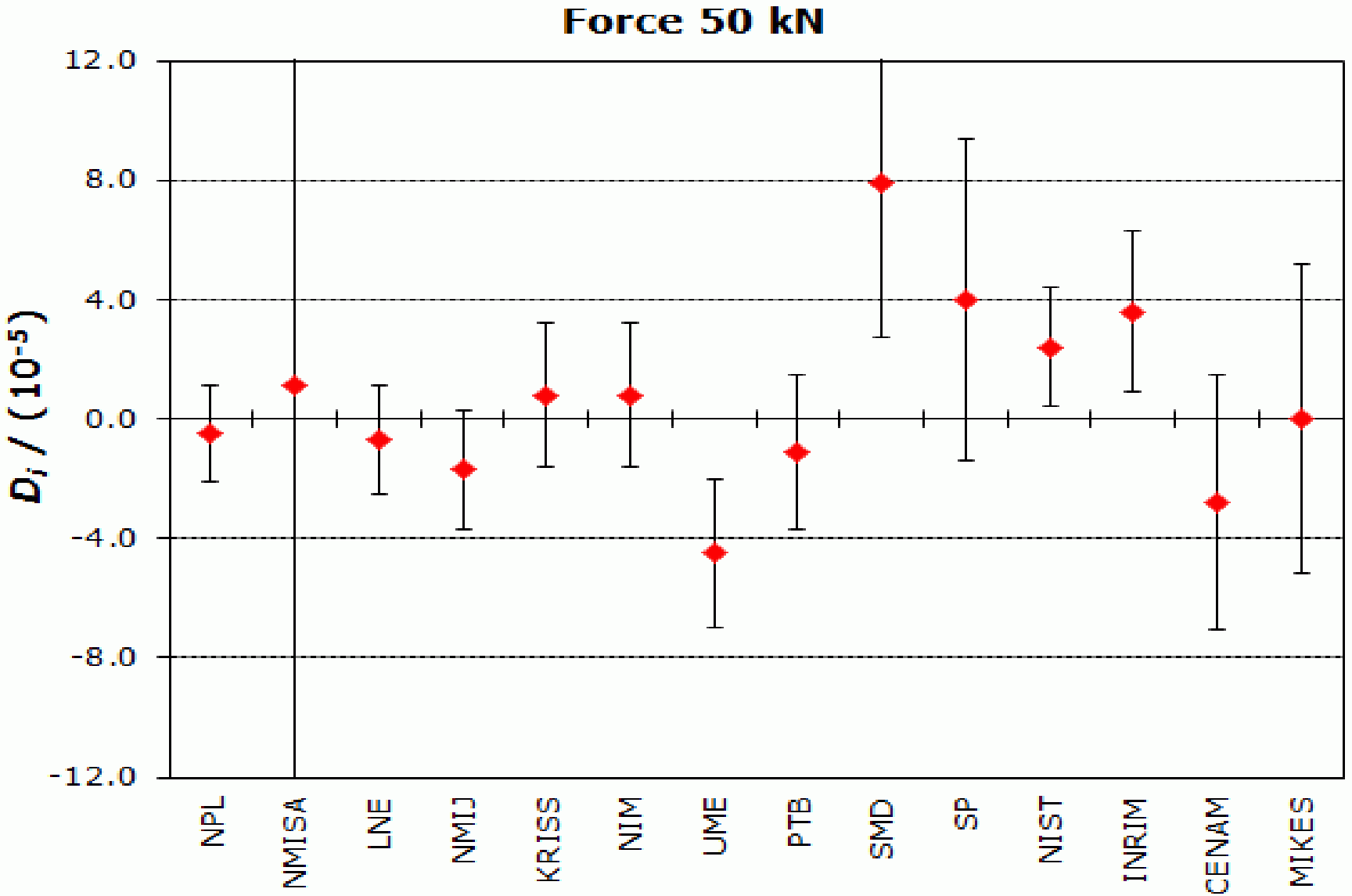
CCM.F-K1.a (load cell up to 10 kN)



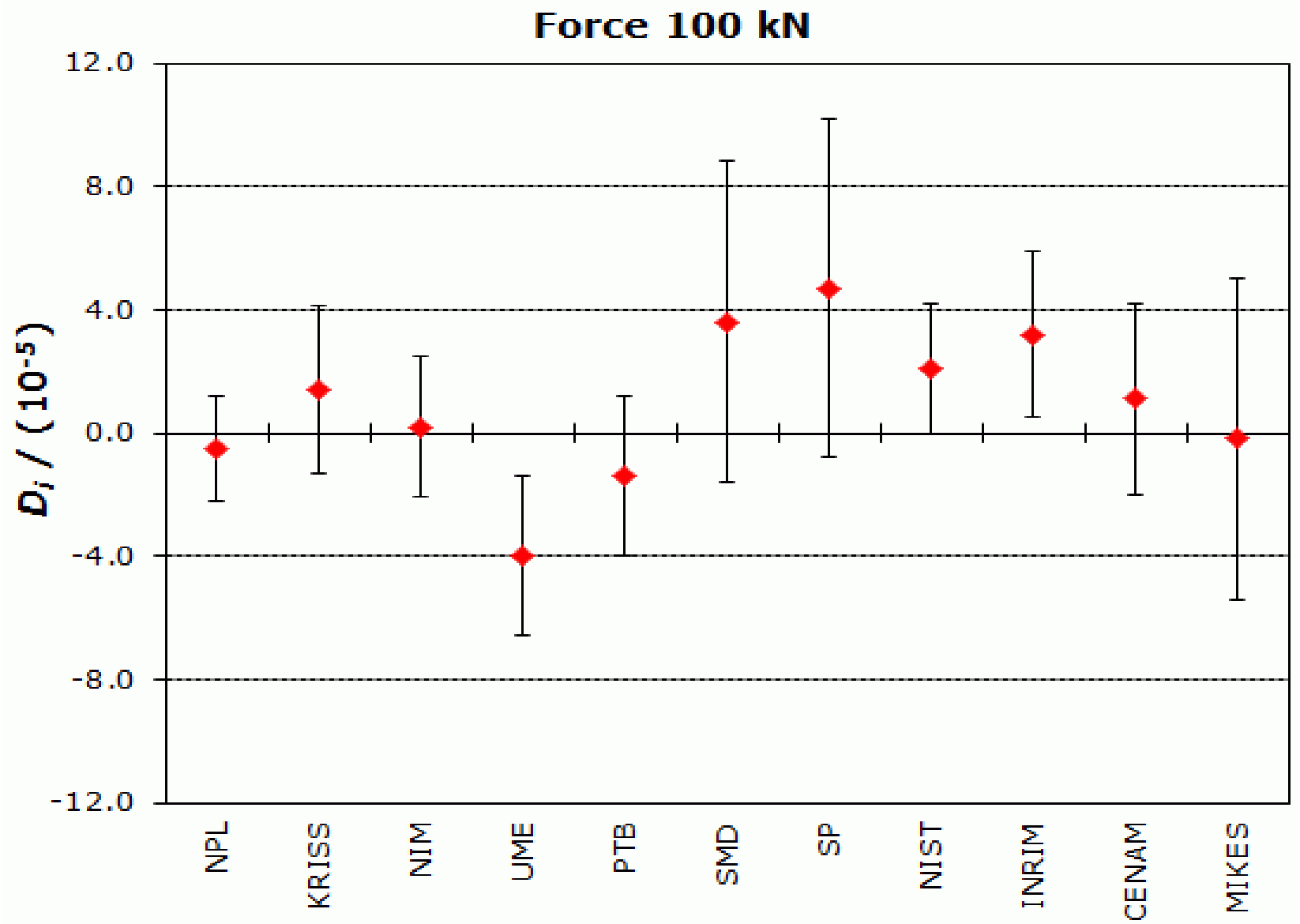
The BIPM key comparison database, May 2009

8/8

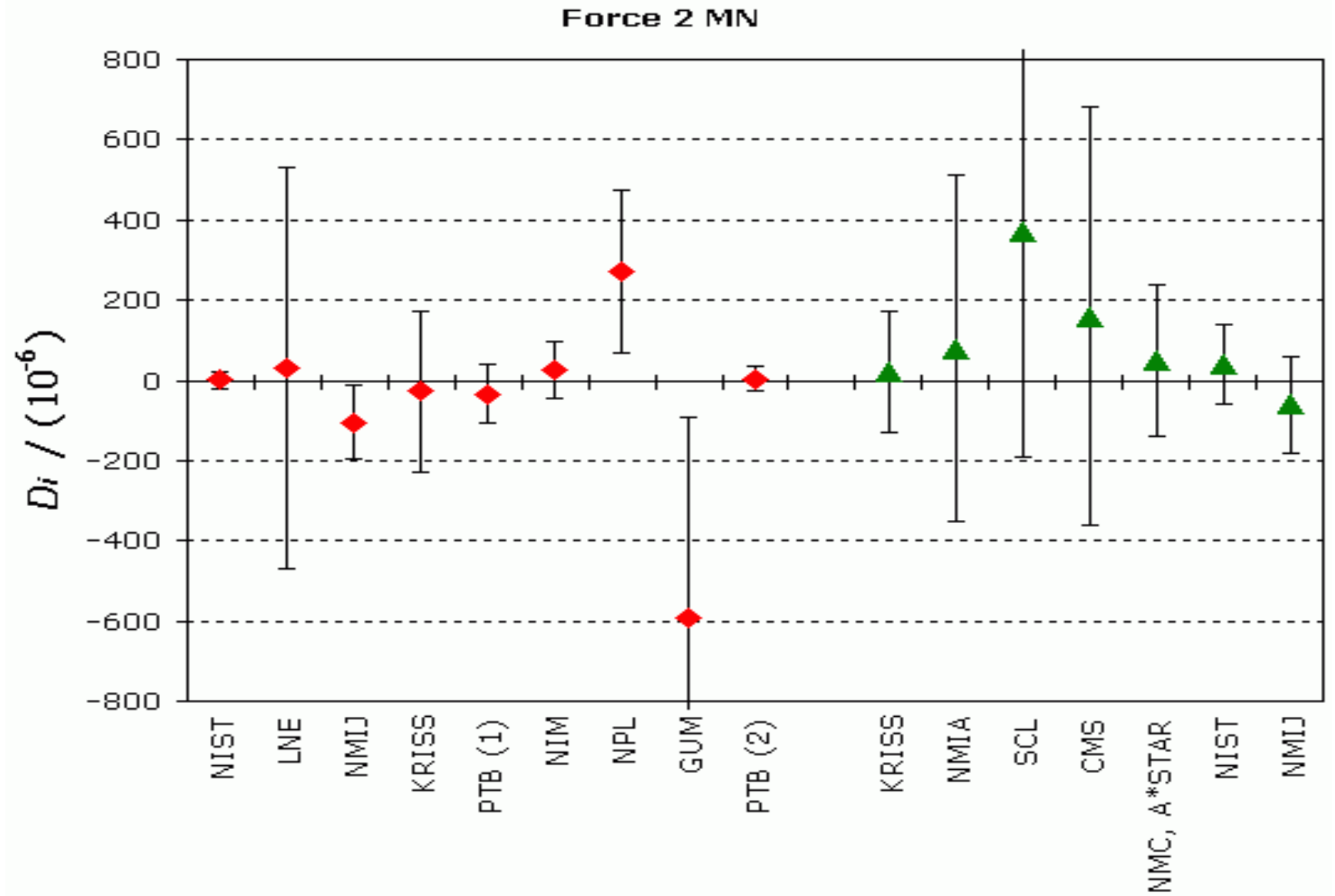
CCM.F-K2.a (load cell up to 100 kN) and .b (up to 50 kN)



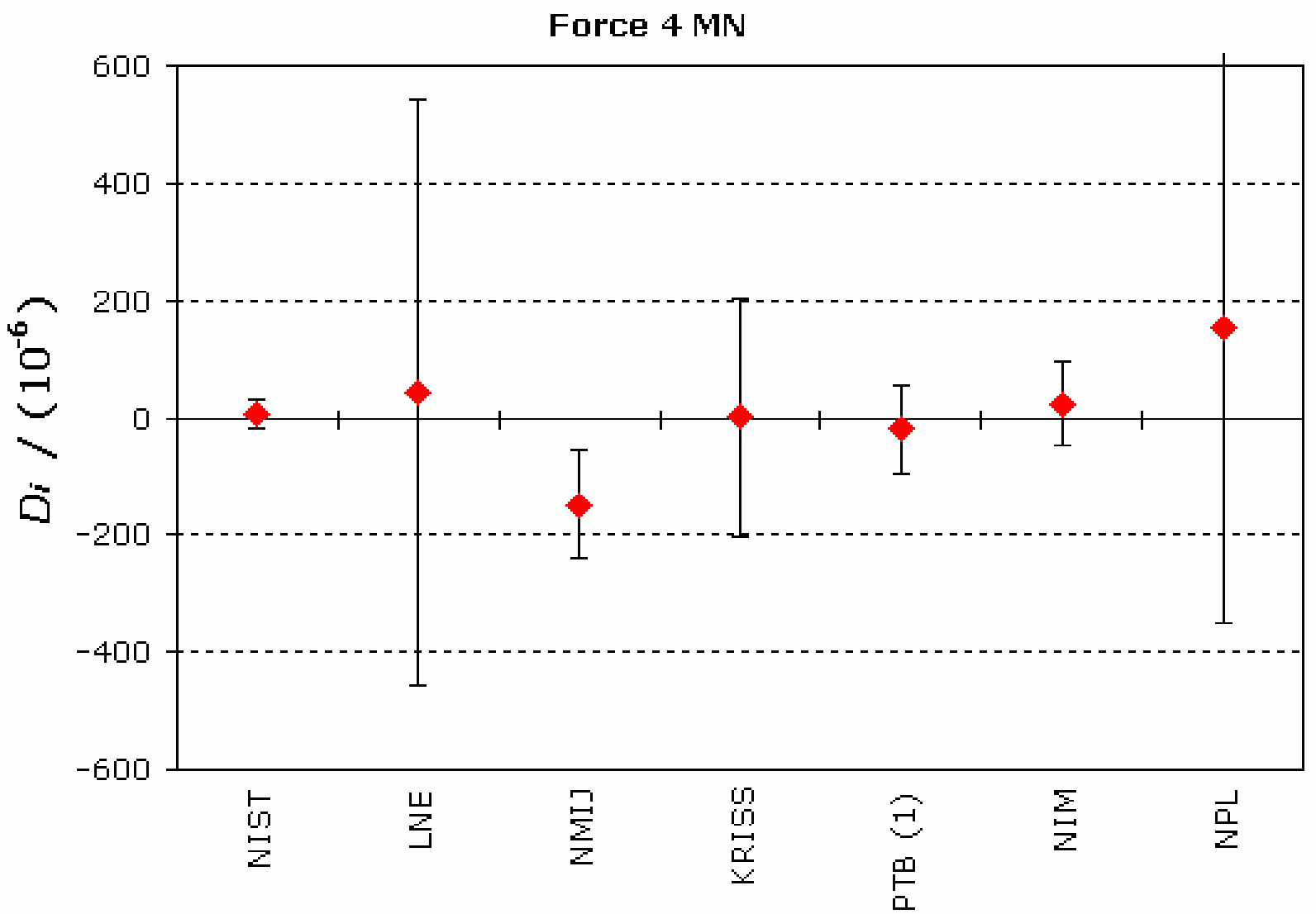
CCM.F-K2.a (load cell up to 100 kN)



CCM.F-K4.b (up to 2 MN) and APMP.M.F-K4.b



CCM.F-K4.a (load cell up to 4 MN)



CCM Force Key Comparisons

- The working group agrees that there is no need to repeat these comparison in the next years, because the stability of dead-weight machines is good enough to extend the period of repeating the comparison to 15 years and more up to 20 years. Only for new machines, linking comparisons to the previous key comparison should be performed.
- If these comparisons are to be repeated, perhaps the tension range should be considered, which will be discussed in future meetings of the CCM WG Force.
- CCM.F-K5 to CCM.F-K22, which had been conducted in the past, were all approved for provisional equivalence as key comparisons

Future CCM Force Key Comparisons

- The CMC table shows that there are many laboratories covering the lower N force range. But there are no comparisons in this range so far.
- The CCM WG Force decided that a key comparison for the force steps of 200 N and 500 N should be performed to cover the lower range.
- MIKES (now VTT) declared the interest to act as a pilot for this range. It was decided that only laboratories with uncertainties of at least 2×10^{-5} should participate.

Discussion of Future Force Key Comparisons

- In the mN force range there are facilities in BEV, PTB and KRISS. In 2015, a facility will also be available at METAS. A comparison in the mN force range will be a topic for future comparisons because there are no CMC values yet. A problem is, that there are no good transfer standards available for this range.
- In the high MN range was the comparison up to 4 MN which is at present sufficient to cover this range. The 3 largest hydraulic amplification machines have participated in this comparison. It will be interesting to perform a comparison in the highest range up to 16.5 MN and 20 MN, but this will be quite labour- and cost-intensive due to the large dimensions of the transfer standards. This may be further discussed in future.

Force comparisons

RMO Force key comparisons

- APMP.M.F-K2.a and b (force transducer 50 kN, 100 kN)
- APMP.M.F-K3.a (force transducer 500 kN, 1000 kN)
- APMP.M.F-K3.b (force transducer 500 kN)
- APMP.M.F-K4.b (force transducer 2000 kN)
- COOMET.M.F-S1 (Force: 20 kN, 50 kN, 100 kN, 250 kN, 500 kN, 1000 kN and 2000 kN)
- COOMET.M.F-S2 (Force: 10 kN, 14 kN, 16 kN, 20 kN, 50 kN, 60 kN, 80 kN and 100 kN)
- EUROMET.M.F-K1 (force transducer 5 kN, 10 kN)
- EUROMET.M.F-K2 (force transducer 50 kN, 100 kN)
- EUROMET.M.F-K3 (force transducer 500 kN, 1000 kN, 2 MN, 4 MN)

Other RMO comparisons related to Force

RMO Force key comparisons

- SIM.M.F-S1 (Calibration of a force testing machine in compression, Force: 10 kN to 100 kN)
- SIM.M.F-S2 (Calibration of a force testing machine in compression, Force: 10 000 N to 100 000 N)
- SIM.M.F-S3 (Charpy V-notch reference specimen: 20 J and 100 J)
- SIM.M.F-S4 (force transducer 50 kN, 100 kN)

CCM Torque Key Comparisons

CIPM Torque key comparisons

- CCM.T- K1
  2005 – 2006, 500 N·m, 1000 N·m, Approved for equivalence, Results available

- CCM.T- K1.1
  2007, 500 N·m, 1000 N·m, Approved for equivalence, Results available

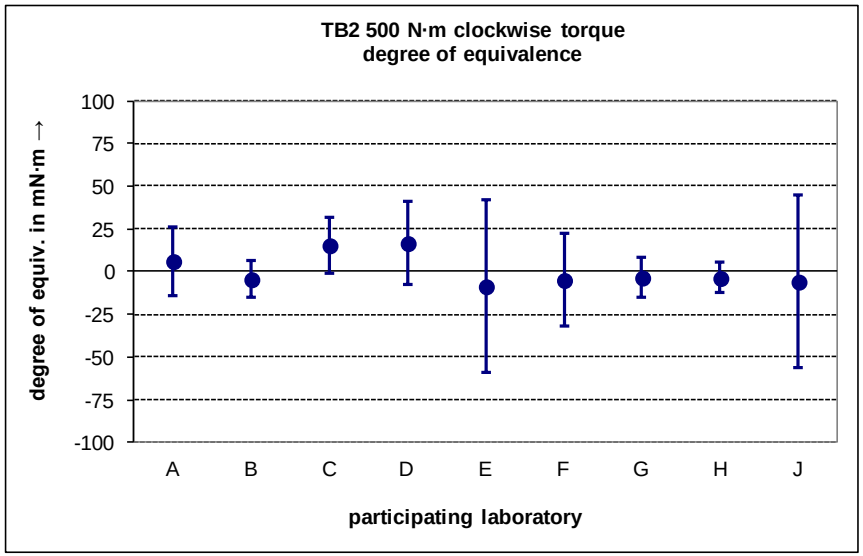
- CCM.T- K1.2
  2007, 500 N·m, 1000 N·m, Report in progress, Draft B

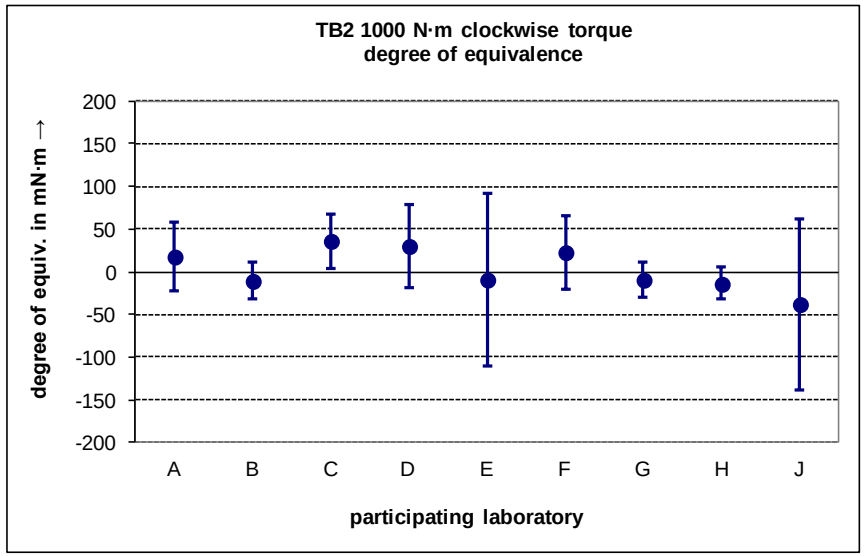
- CCM.T- K1.3
  2010 – 2011,
  500 N·m, 1000 N·m
  20 N·m, 50 N·m
  1 kN·m, 2 kN·m, Report in progress, Draft B

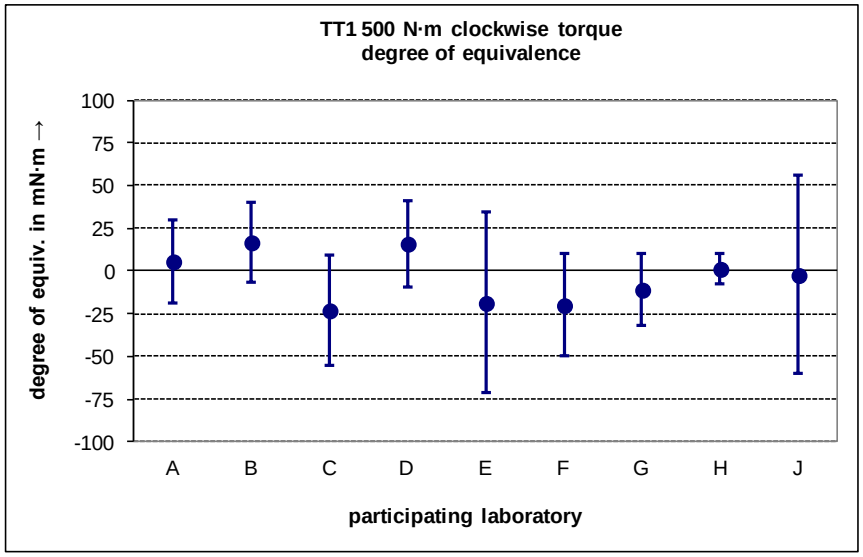
- CCM.T- K2
  2005, 10 kN·m, 20 kN·m, Report in progress, Draft B

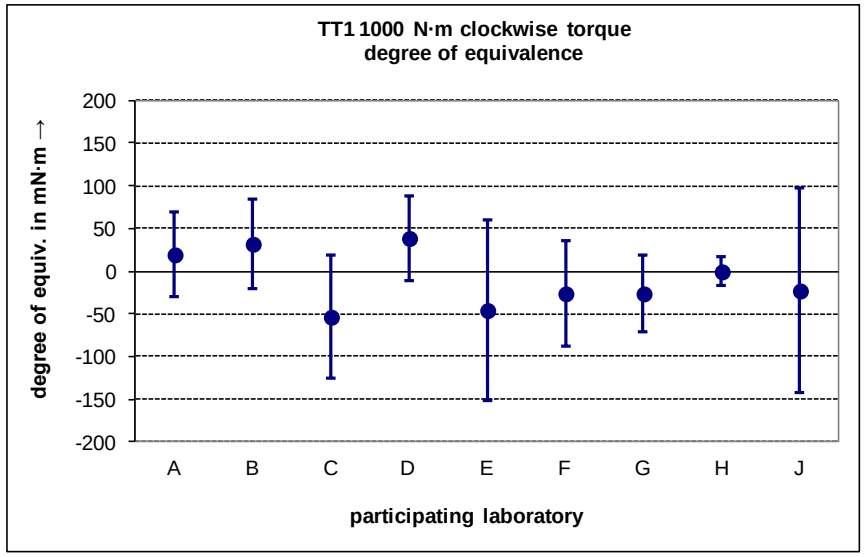
Torque comparisons

CCM.T- K1.2: Clockwise results



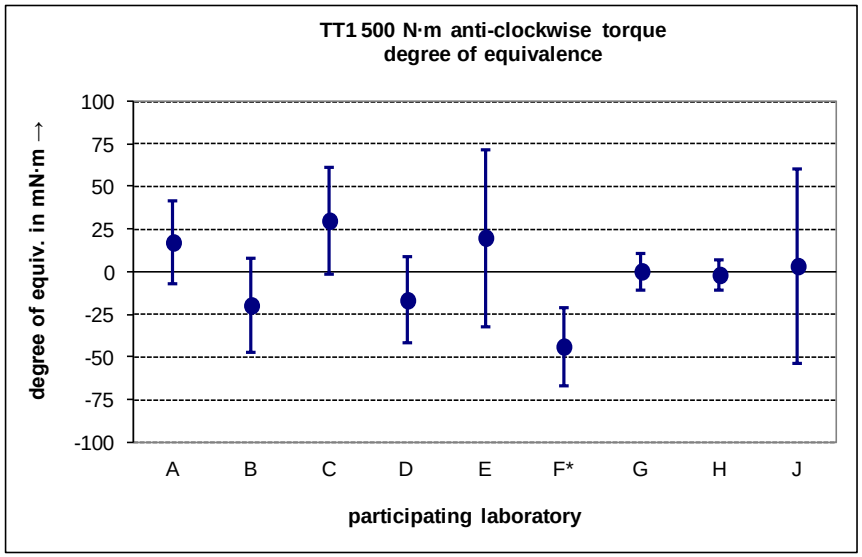


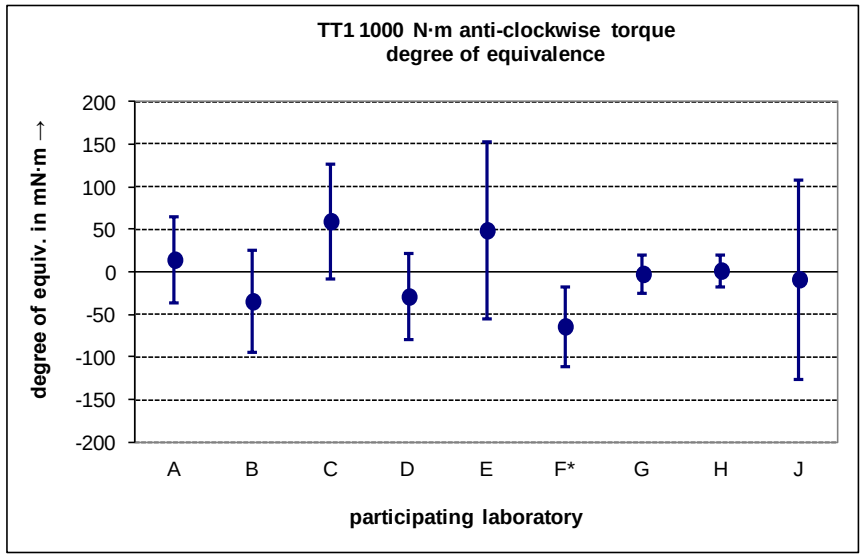


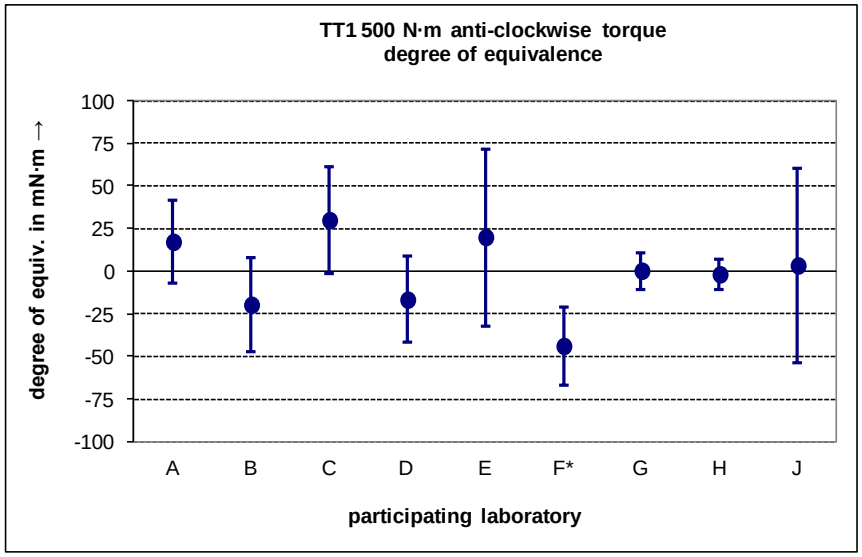


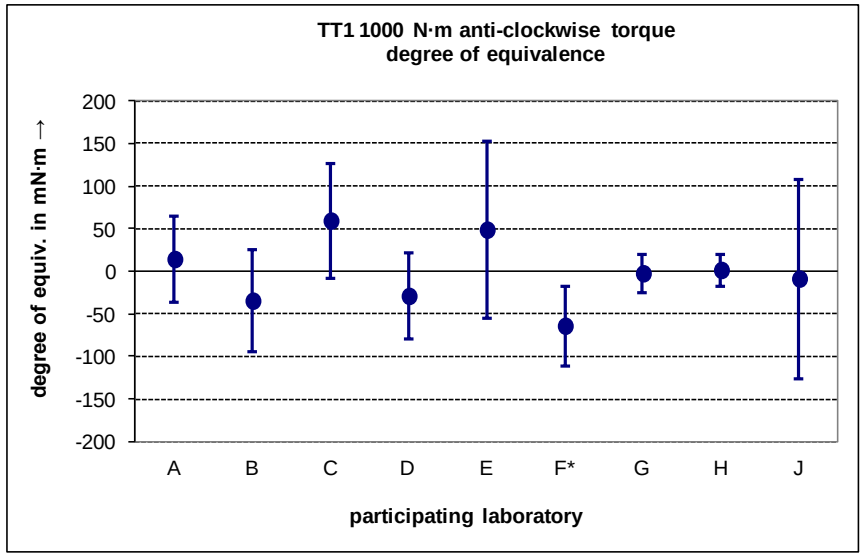
Torque comparisons

CCM.T- K1.2: Anti-clockwise results









Torque comparisons

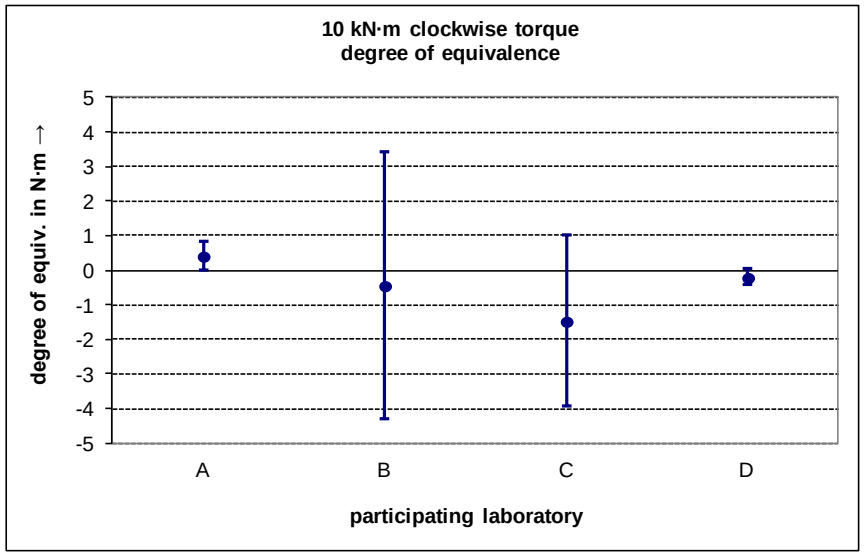
CIPM Torque key comparisons

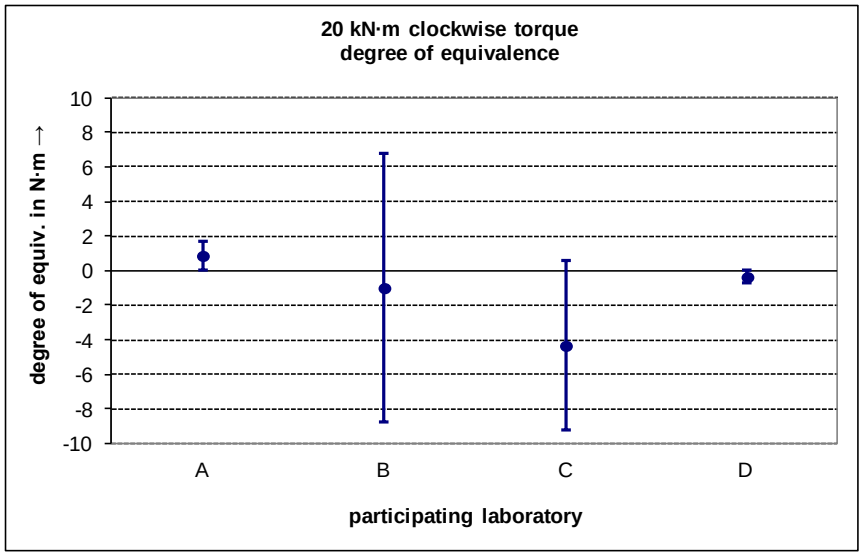
- CCM.T- K2
  2005, 10 kN·m, 20 kN·m, Report in progress, Draft B

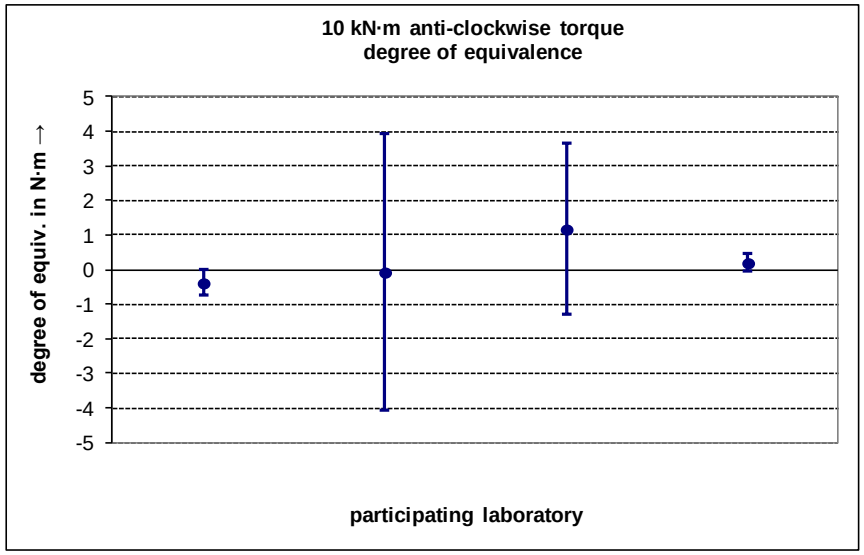
- Participants: C – NIM (China), B – MIKES (Finland), D – PTB (Germany), A – NMIJ (Japan), E – CENAM (Mexico)
- Dead-weight torque machines
- Changes to the Draft Report
  - CENAM results are included but were not counted for the KCRV
  - one result is calculated instead of two (one for each transducer)
  - Changes in names of participants were introduced: NIM (SMERI) and MIKES
  - Further discussion?

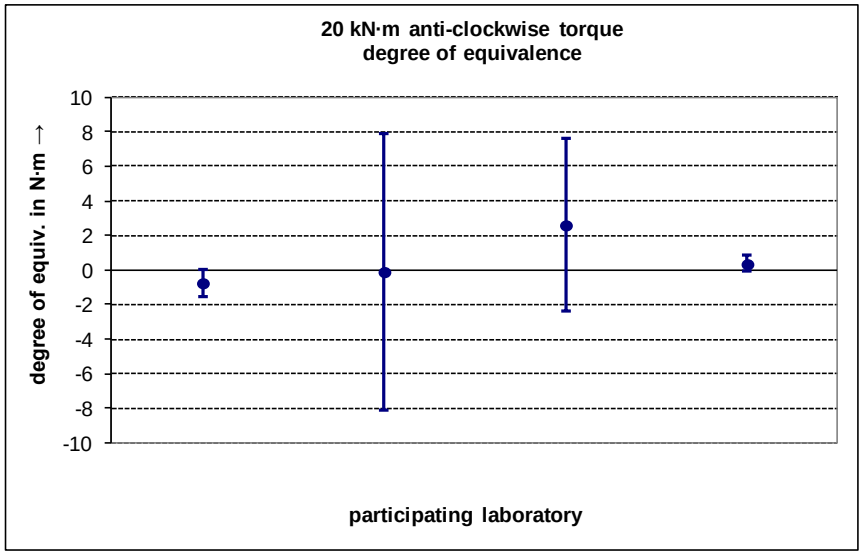
Torque comparisons

CCM.T- K2: Results









Torque comparisons

RMO Torque key comparisons

- APMP.M.T- K1
  2015 – 2016, 500 N·m, 1000 N·m, Planned

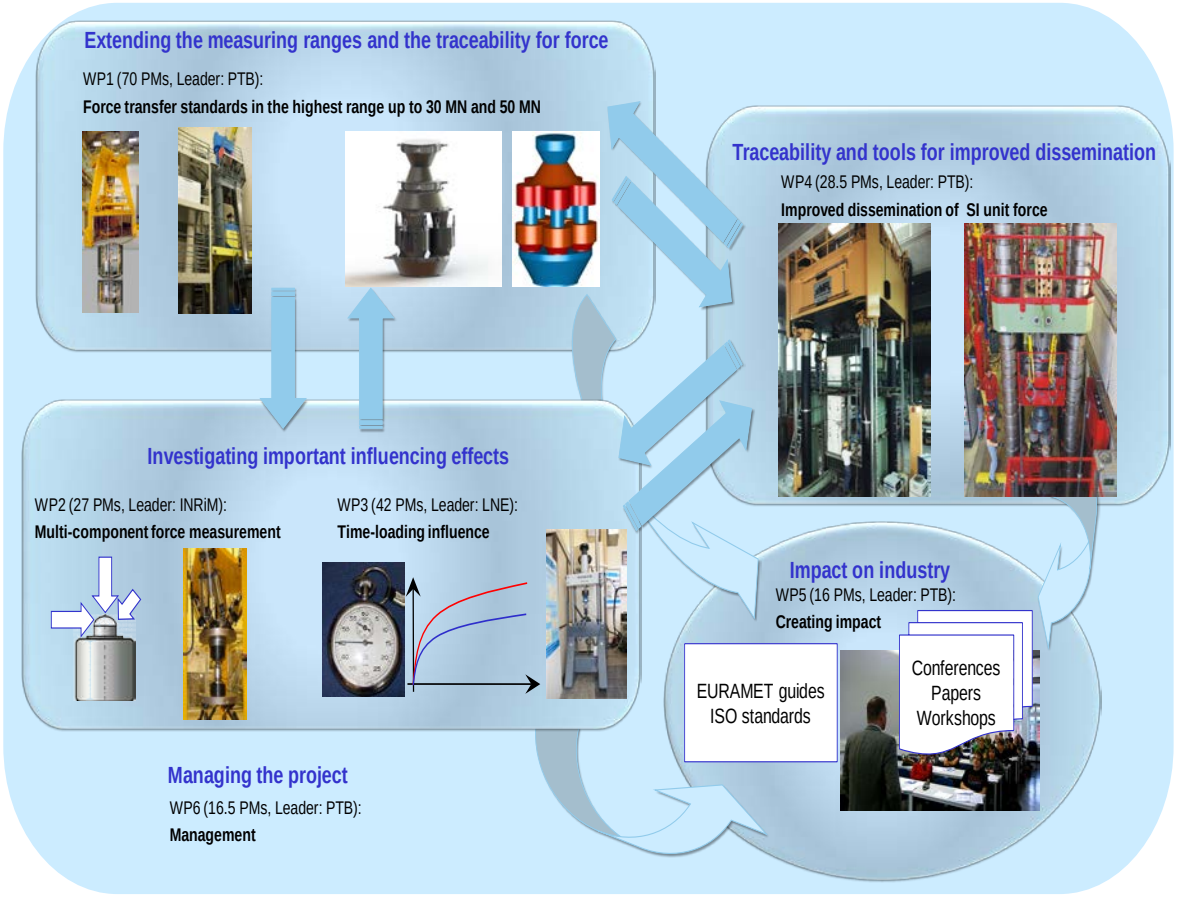
- COOMET.M.T- S1
  2012 – 2014, 100 N·m to 2500 N·m, Report in progress, Draft A

- EURAMET.M.T- S1
  2008, 1 N·m, 5 N·m, 10 N·m, 50 N·m, 200 N·m, 500 N·m, and 1000 N·m, Approved and published

- EURAMET.M.T- S2
  2008, 10 N·m, 20 N·m, 40 N·m, 60 N·m, 80 N·m, and 100 N·m, Report in progress, Draft A

- EURAMET.M.T- S3
  2010, 10 N·m, 20 N·m, ... 1 kN·m (torque wrenches), Approved and published

EMRP SIB63 Force
Force Traceability in the Meganewton Range



JRP Coordinator

PTB, Germany

Funded JRP Participants

BAM, Germany

CEM, Spain

CMI, Czech Republic

METAS, Switzerland

INRiM, Italy

LNE, France

MG, Poland

MIKES, Finland

NPL, United Kingdom

TUBITAK, Turkey

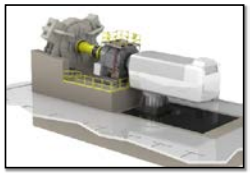
- JRP website address: http://www.ptb.de/emrp/forcemetrology.html

EMPIR 14IND14 MNm Torque

Torque measurement in the MN•m range

WP 1 Inventory (RWTH)

- Overview of conditions and measurement systems at existing test stands

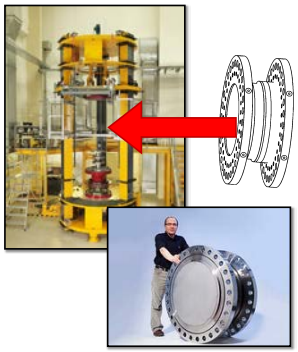


WP 6 Creating impact (PTB)

- Interaction with stakeholders
- Publications
- Workshops
- Standard meetings

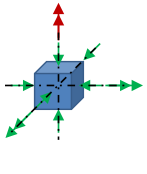
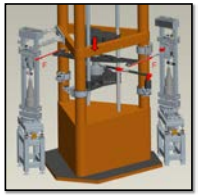
WP 2 Torque transfer standards (PTB)

- Design of a torque transfer standard
- Development of extrapolation procedure



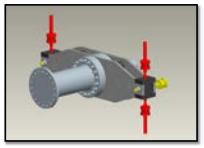
WP 3 Multi-component investigations (PTB)

- Development of design principles for multi-component torque transducers

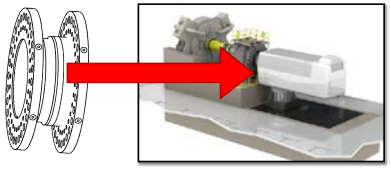
WP 4 Force lever system (CEM)

- Design of a torque transfer standard based on force and lever




WP 5 Calibration procedure (RWTH)

- Develop calibration procedure for torque loads in nacelle test benches
- Exemplarily realise the procedure in a nacelle test bench



WP 7 Management

Consortium

Coordinator

PTB, Germany

Partner

CEM, Spain

CMI, Czech Republic

MIKES, Finland

CENER, Spain

Fraunhofer IWES, Germany

RWTH Aachen, Germany

Next CCM WG Meetings:

Next CCM WG Force Meeting is planned in 2017 in PTB.

A short meeting is planned after the EURAMET TC Mass & rel. Quantities Meeting on 17th April 2015 in Sarajevo.

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Bundesallee 100
38116 Braunschweig

Dr. Rolf Kumme
Department 1.2 „Solid Mechanics“

Telephone: +49 531 592-1200
E-mail: rolf.kumme@ptb.de
Web: www.ptb.de