Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

Report of the CCM WG Force

16th CCM Meeting at BIPM in May 2017

Rolf Kumme, PTB

CCM Meeting
18 – 19 May, 2017

Meetings of the CCM WG Force

**The CCM WG Force meeting take place once in three years.
If possible the meeting should be arranged with other international events in which most of the members of the CCM WG Force participates, like for example IMEKO TC3 or ISO TC164.**

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

**Next CCM WG Force Meeting at PTB in Braunschweig, Germany
6th to 8th June 2017**

Terms of reference of CCM WG Force

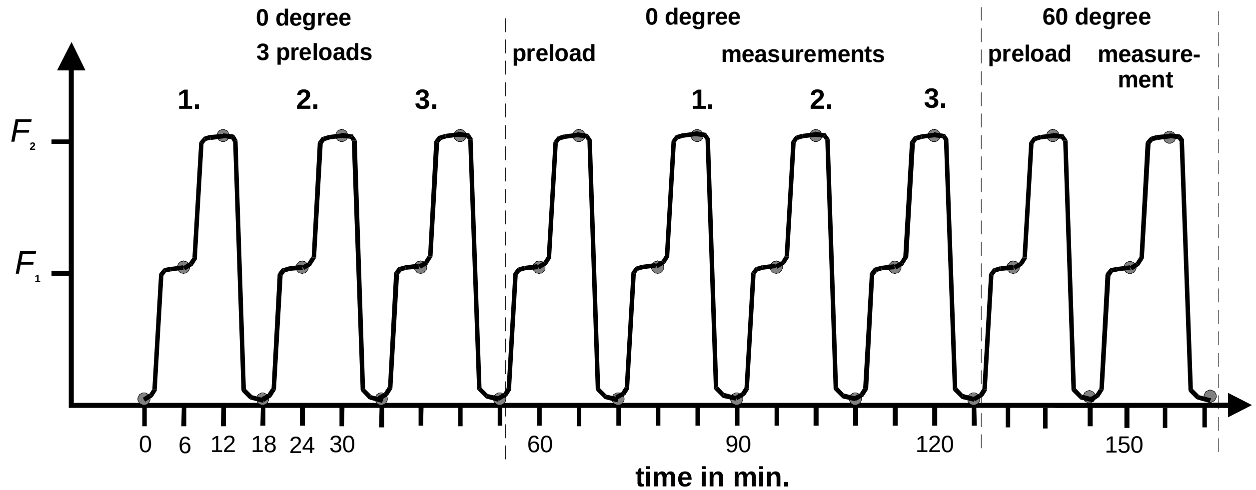
- To study issues related to force and torque metrology, including dissemination, and to advise the CCM on these topics as well as on anticipated developments in this field;
- To define, organize and approve the necessary key comparisons;
- To provide guidance to accept CMCs on force and torque;
- To 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
  New data evaluation considering the comments obtained from participants during and after last CCM WG Force Meeting finished, consistency of the data could be achieved with new evaluation and will be presented and discussed next CCM WG Force meeting
- 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

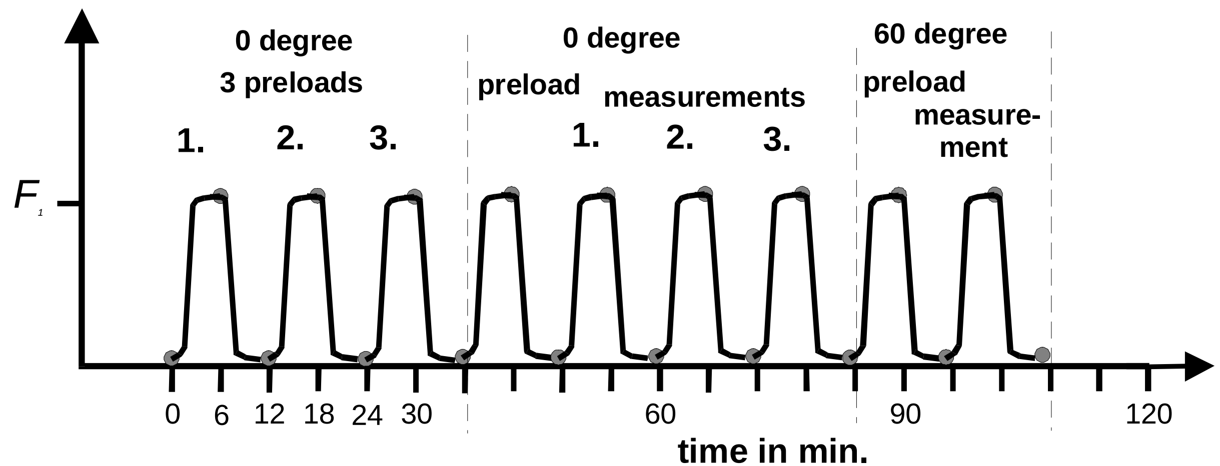
- Measurement Procedure in Group A



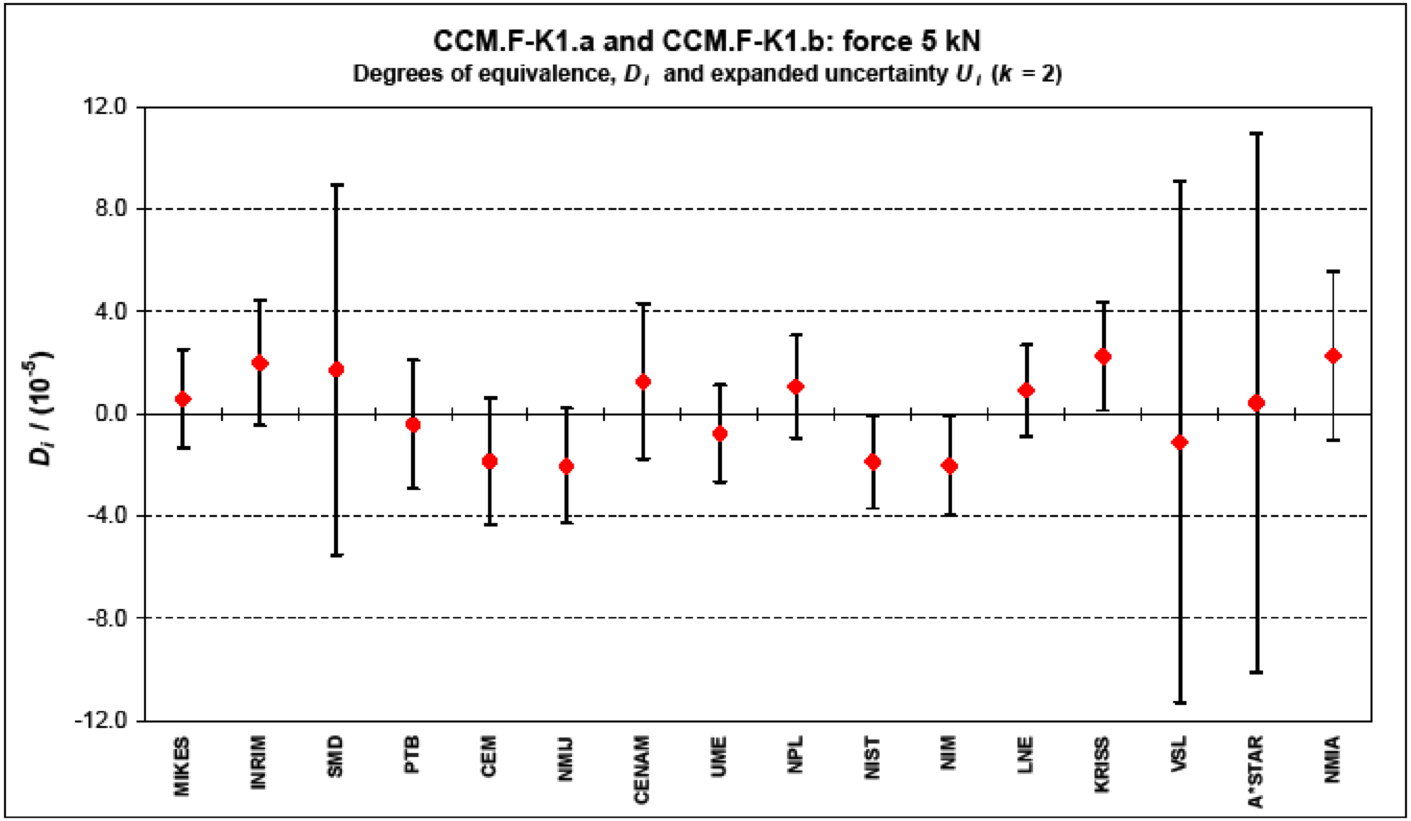
1 preload +
1 measurement
cycle in position

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

- Measurement Procedure in Group B

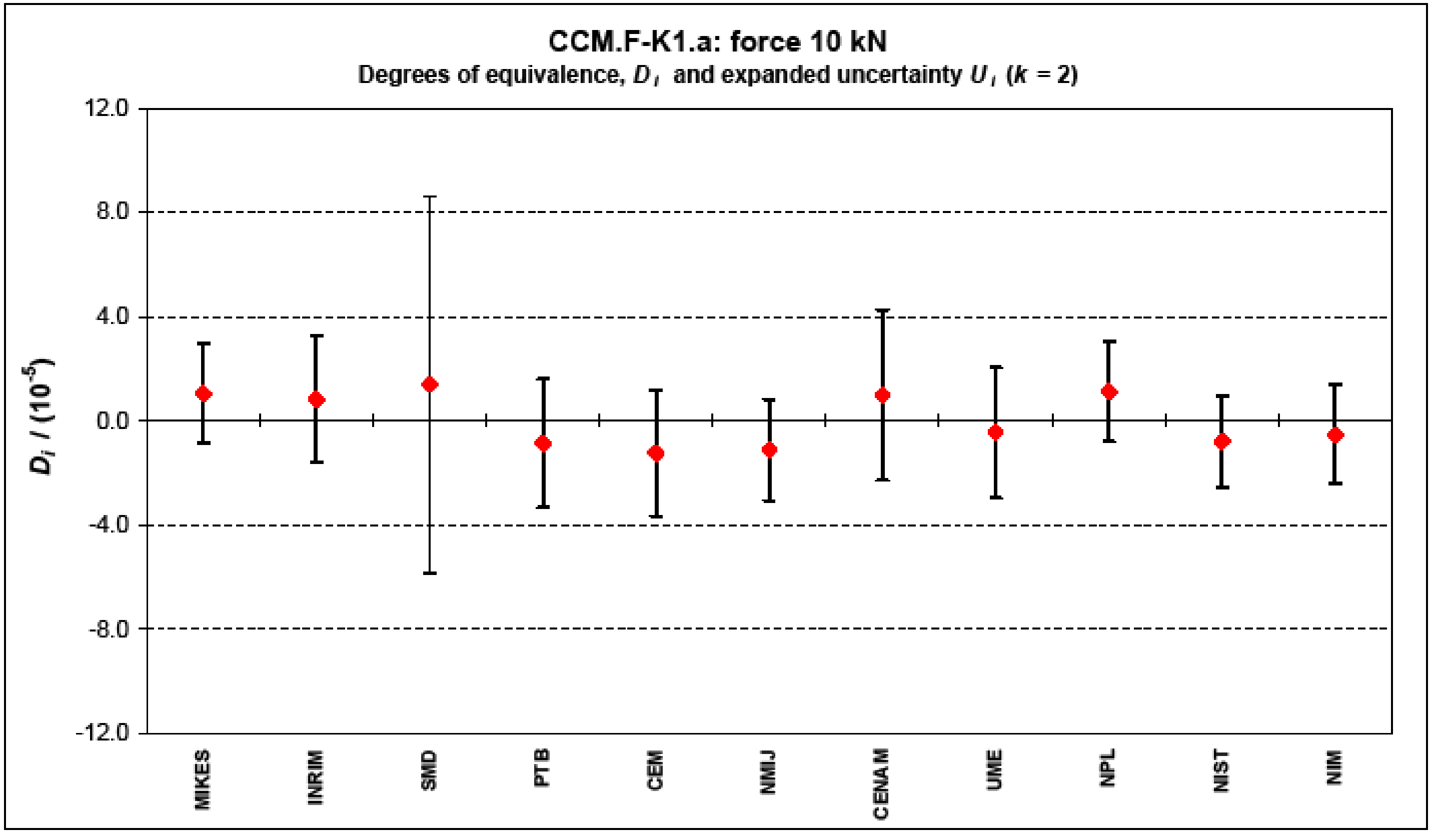


CCM.F-K1.a (load cell up to 10 kN) and .b (up to 5 kN)



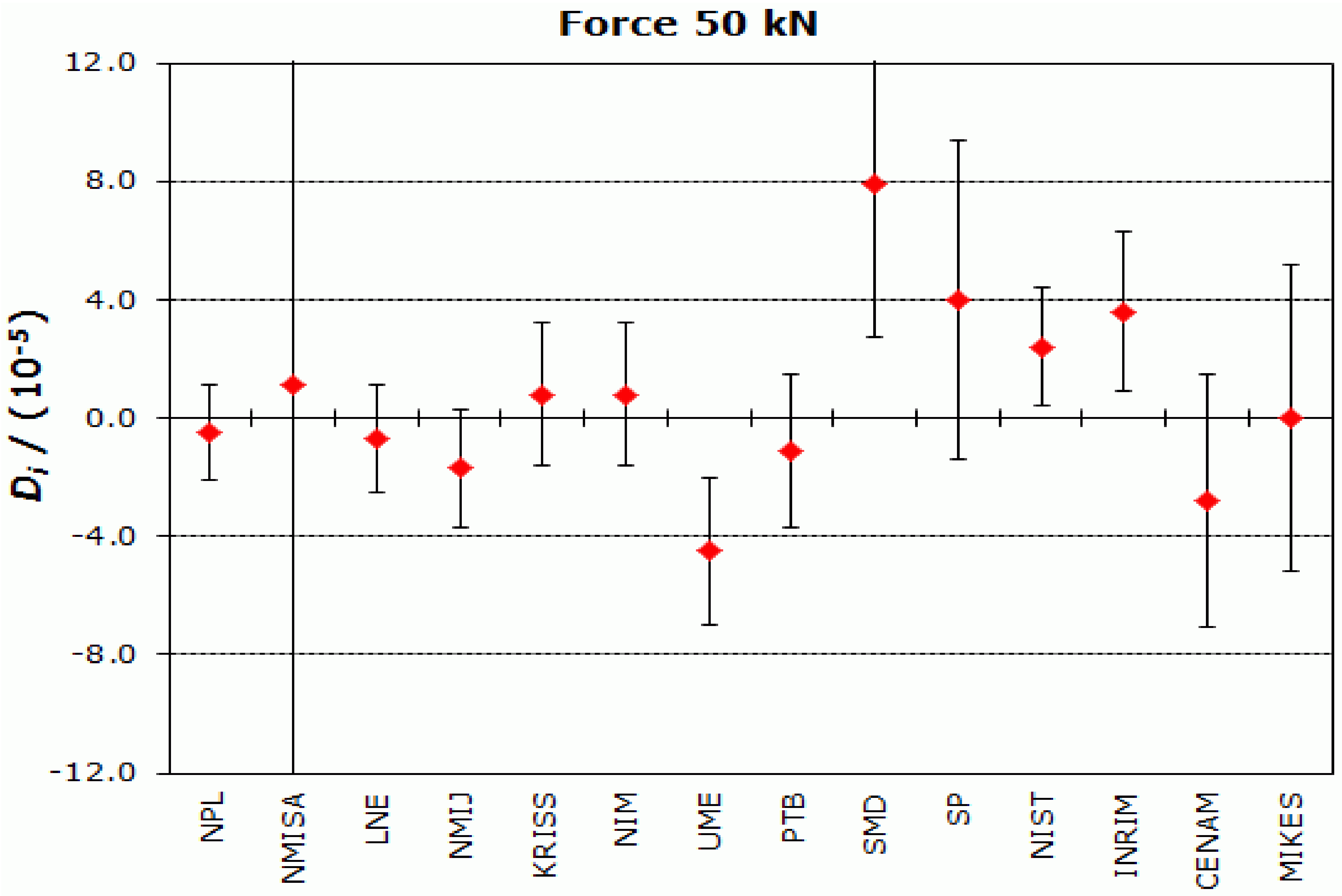
The BIPM key comparison database, May 2009 7/8

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

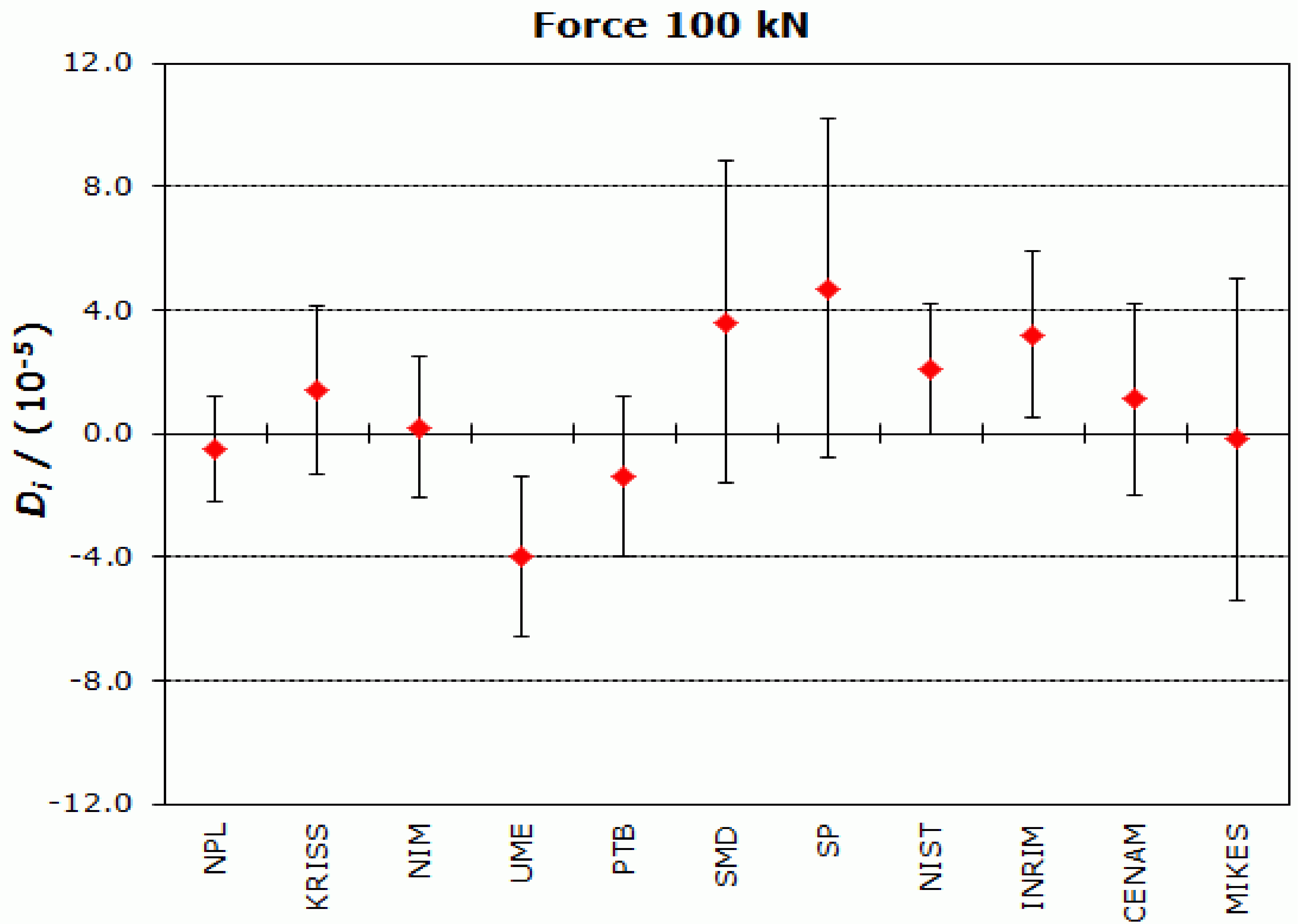


The BIPM key comparison database, May 2009 8/8

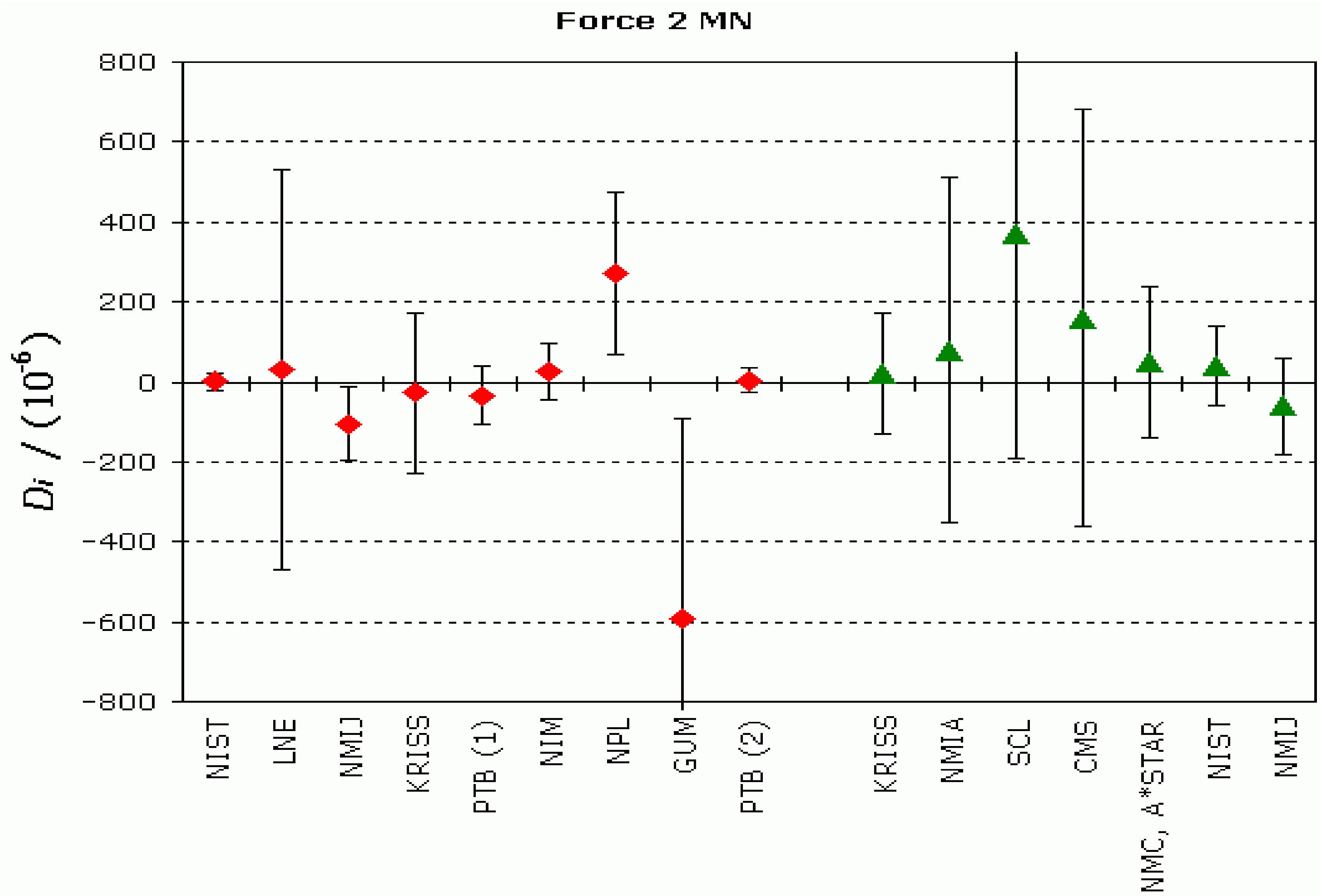
CCM.F-K2.a (load cell up to 100 kN) and .b (up to 50 kN)



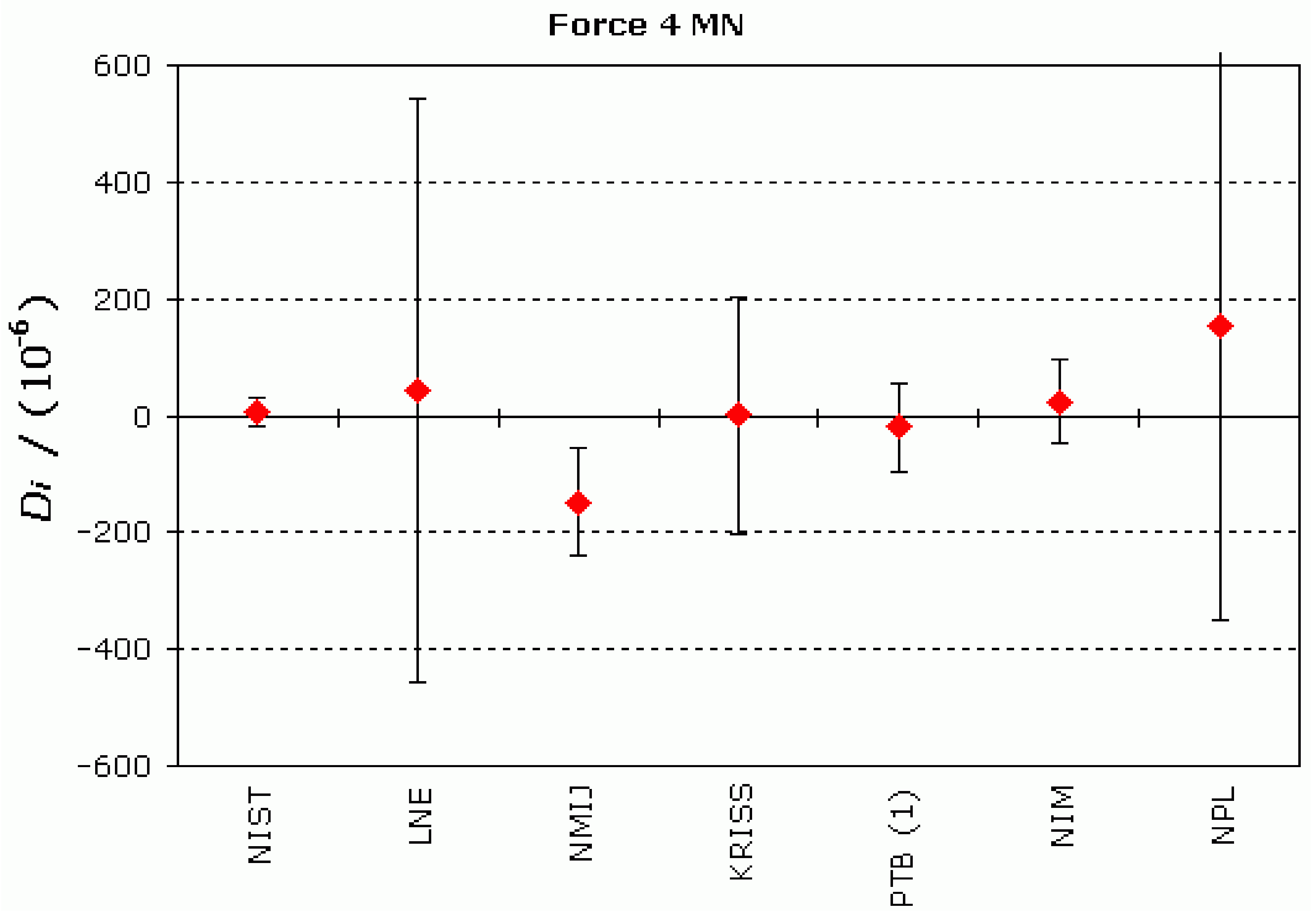
CCM.F-K2.a (load cell up to 100 kN)



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

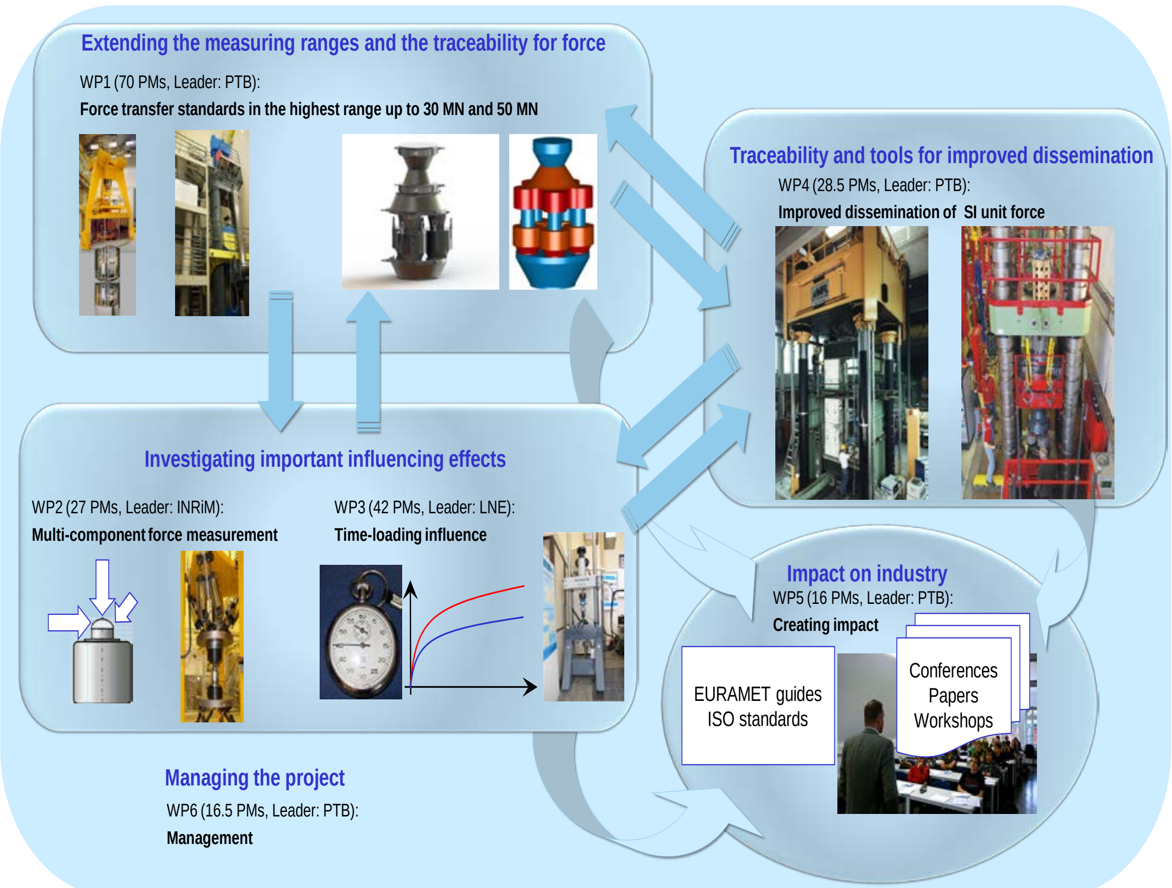
Future CCM Force Key Comparisons

- 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.
- It was decided that only laboratories with uncertainties of at least 2×10^{-5} should participate.
- The pilot laboratory will be decided next CCM WG Force meeting in June 2017

Discussion of Future Force Key Comparisons

- In the mN force range there are facilities in BEV, PTB, KRISS and METAS. A comparison or pilot study in the mN force range will be a topic for the future 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.
- Build-up systems up to 50 MN see EMRP SIB63 Force

EMRP SIB63 Force
Force Traceability in the Meganewton Range finished



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

Force comparisons

RMO Force key and supplementary comparisons

- APMP.M.F-K2.a and b (force transducer 50 kN, 100 kN)
  Report in progress, Draft A
- APMP.M.F-K3.a (force transducer 500 kN, 1000 kN)
  In progress
- APMP.M.F-K3.b (force transducer 500 kN)
  In progress
- APMP.M.F-K4.b (force transducer 2000 kN)
  Approved for equivalence, Results available
- COOMET.M.F-S1 (Force: 20 kN, 50 kN, 100 kN, 250 kN, 500 kN, 1000 kN and 2000 kN)
  Report in progress, Draft B
- COOMET.M.F-S2 (Force: 10 kN, 14 kN, 16 kN, 20 kN, 50 kN, 60 kN, 80 kN and 100 kN)
  Approved and published
- EUROMET.M.F-K1 (force transducer 5 kN, 10 kN)
  Report in progress, Draft B
- EUROMET.M.F-K2 (force transducer 50 kN, 100 kN)
  Approved for equivalence, Results available
- EUROMET.M.F-K3 (force transducer 500 kN, 1000 kN, 2 MN, 4 MN)
  In progress, Measurements 500 kN, 1000 kN to be finished in 2017

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)
  Approved and published
- SIM.M.F-S2 (Calibration of a force testing machine in compression, Force: 10 000 N to 100 000 N)
  Planned
- SIM.M.F-S3 (Charpy V-notch reference specimen:
  20 J and 100 J)
  Report in progress, Draft B
- SIM.M.F-S4 (force transducer 50 kN, 100 kN)
  Protocol complete
- SIM.M.F-S5 Comparison of force testing machines
  Approved and published

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

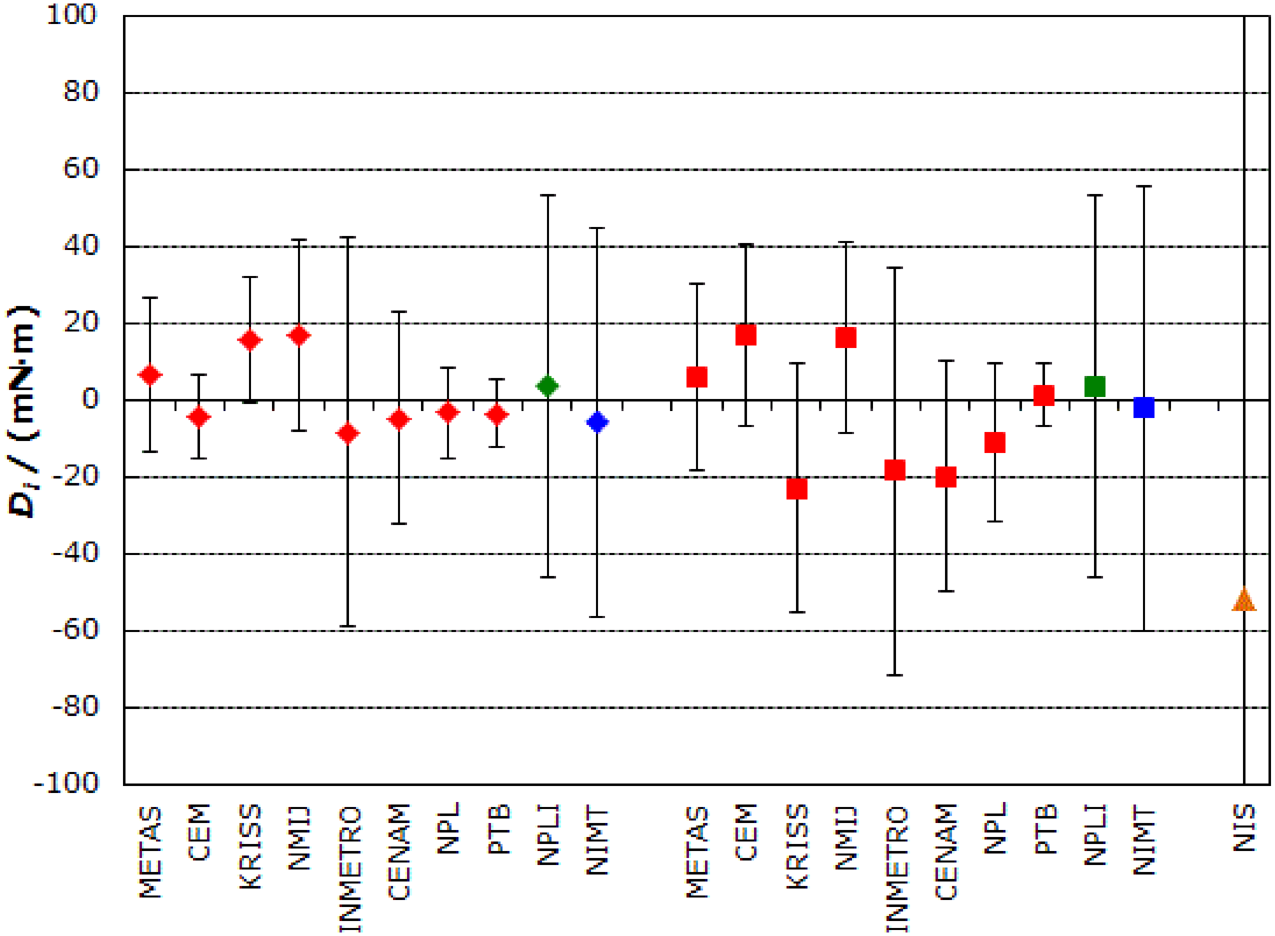
- CCM.T- K1.2
  2007, 500 N·m, 1000 N·m, Approved for equivalence, Results available

- CCM.T- K1.3
  2010 – 2011,
  500 N·m, 1000 N·m
  20 N·m, 50 N·m
  1 kN·m, 2 kN·m, Approved for equivalence, Results available

- CCM.T- K2
  2005-2010, 10 kN·m, 20 kN·m, Approved for equivalence, Results available

Torque comparisons

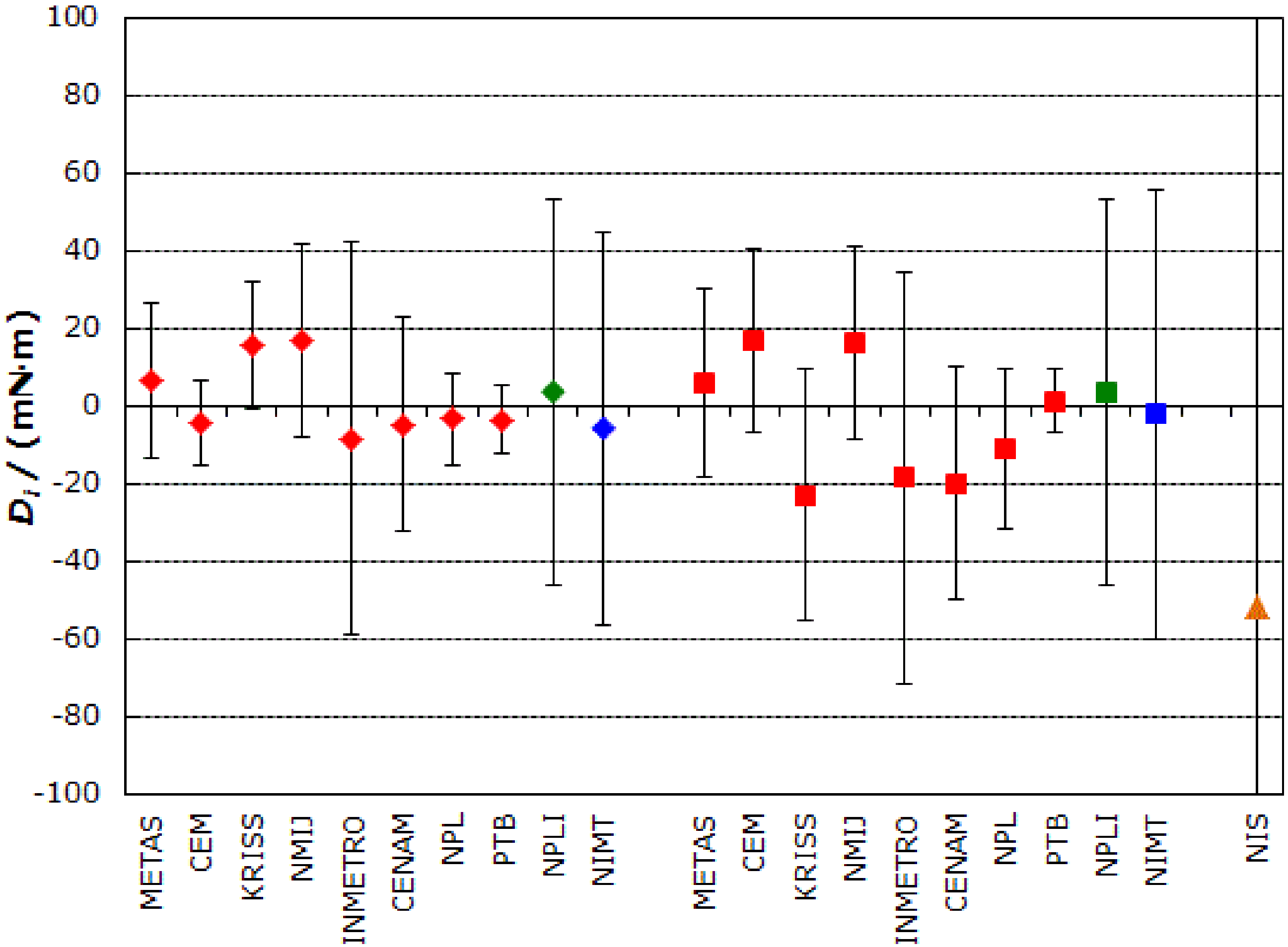
CCM.T-K1, CCM.T-K1.1, CCM.T-K1.2, and CCM.T-K1.3: 500 N.m clockwise torque



Red diamonds: transducer TB2 S/N 044430025
Green diamond: TB2, participant in CCM.T-K1.1
Blue diamond: TB2, participant in CCM.T-K1.2
Red squares: transducer TT1 S/N 36079-01
Green square: TT1, participant in CCM.T-K1.1
Blue square: TT1, participant in CCM.T-K1.2
Orange triangle: participant in CCM.T-K1.3

Torque comparisons

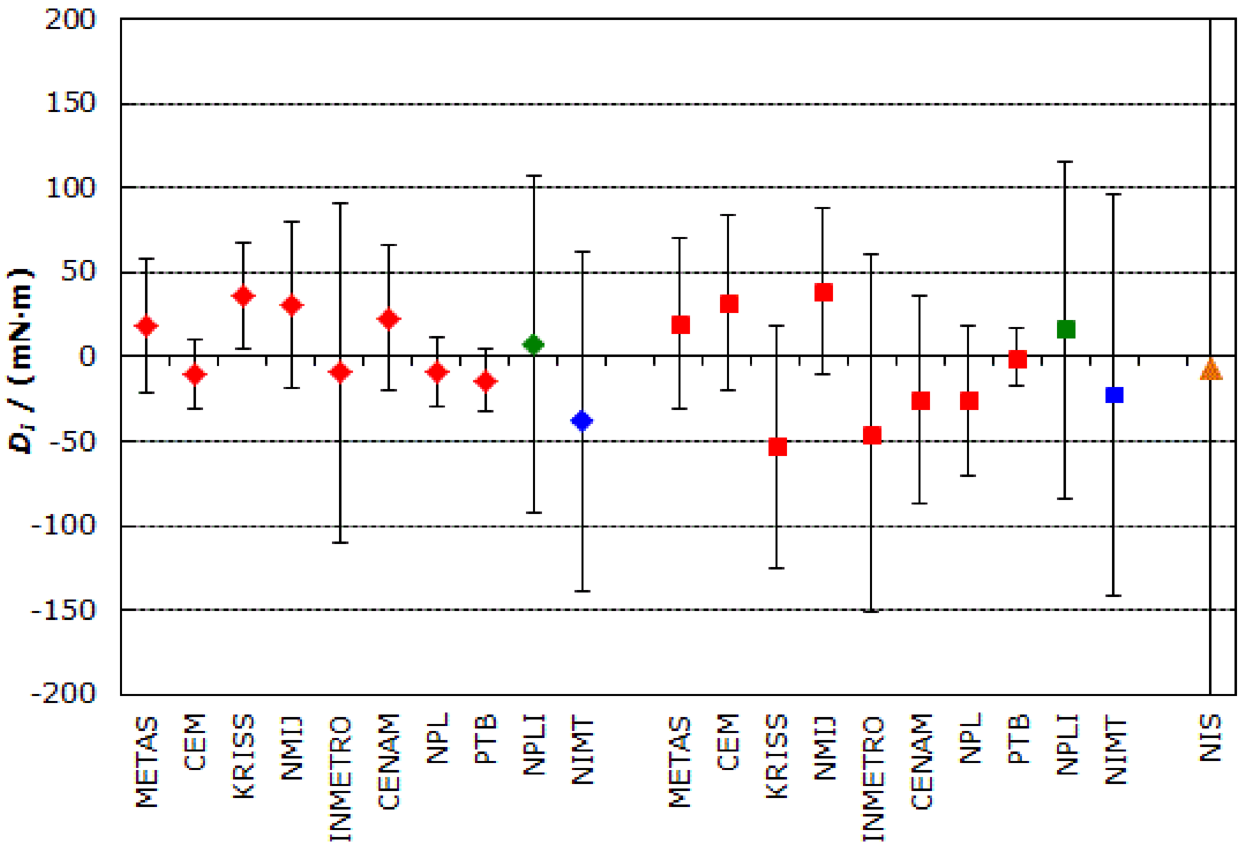
CCM.T-K1, CCM.T-K1.1, CCM.T-K1.2, and CCM.T-K1.3: 500 N.m anti-clockwise torque



?
Red diamonds: transducer TB2 S/N 044430025
Green diamond: TB2, participant in CCM.T-K1.1
Blue diamond: TB2, participant in CCM.T-K1.2
Red squares: transducer TT1 S/N 36079-01
Green square: TT1, participant in CCM.T-K1.1
Blue square: TT1, participant in CCM.T-K1.2
Orange triangle: participant in CCM.T-K1.3

Torque comparisons

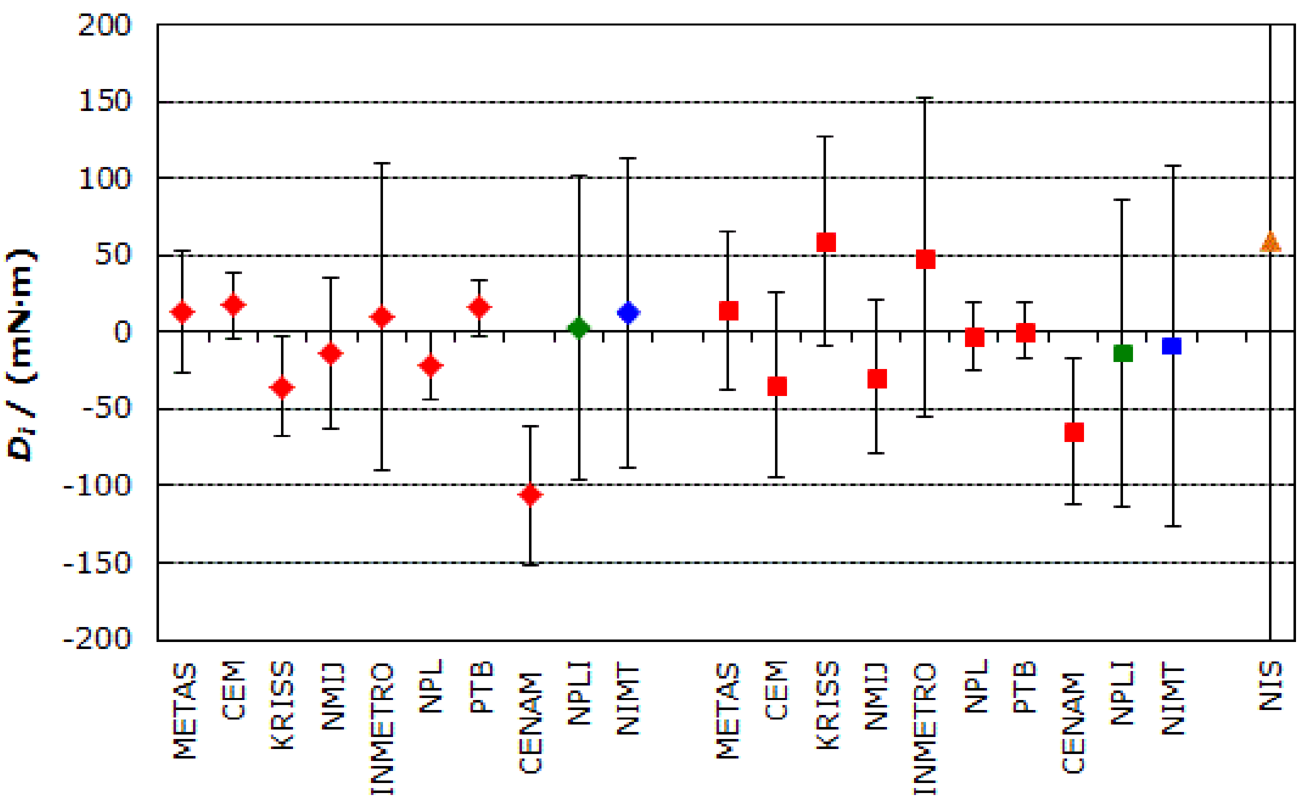
CCM.T-K1, CCM.T-K1.1, CCM.T-K1.2, and CCM.T-K1.3: 1000 N.m clockwise torque



Red diamonds: transducer TB2 S/N 044430025
Green diamond: TB2, participant in CCM.T-K1.1
Blue diamond: TB2, participant in CCM.T-K1.2
Red squares: transducer TT1 S/N 36079-01
Green square: TT1, participant in CCM.T-K1.1
Blue square: TT1, participant in CCM.T-K1.2
Orange triangle: participant in CCM.T-K1.3

Torque comparisons

CCM.T-K1, CCM.T-K1.1, CCM.T-K1.2, and CCM.T-K1.3: 1000 N.m anti-clockwise torque



Red diamonds: transducer TB2 S/N 044430025

Green diamond: TB2, participant in CCM.T-K1.1

Blue diamond: TB2, participant in CCM.T-K1.2

Red squares: transducer TT1 S/N 36079-01

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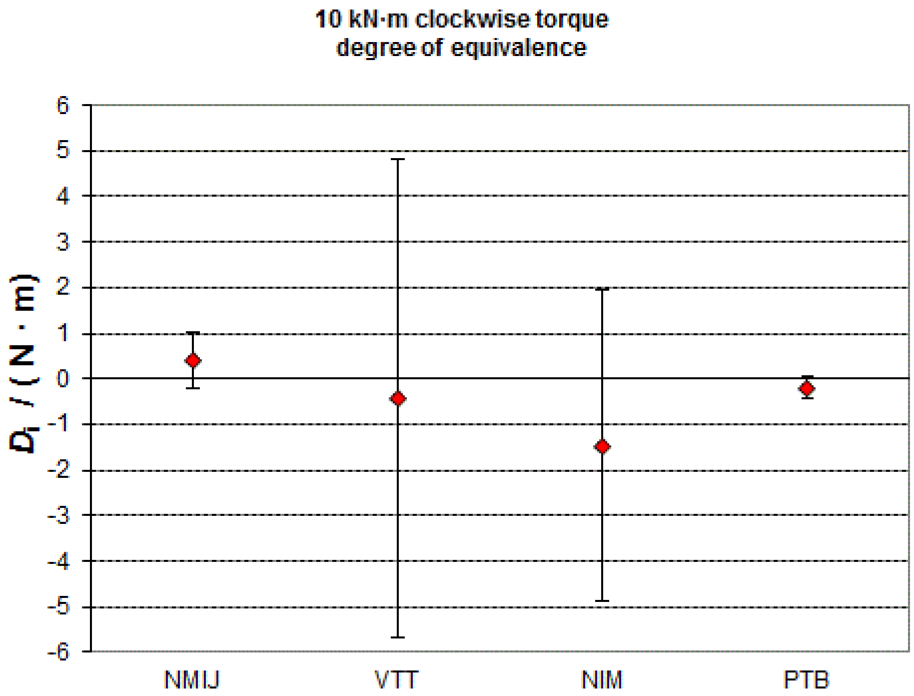
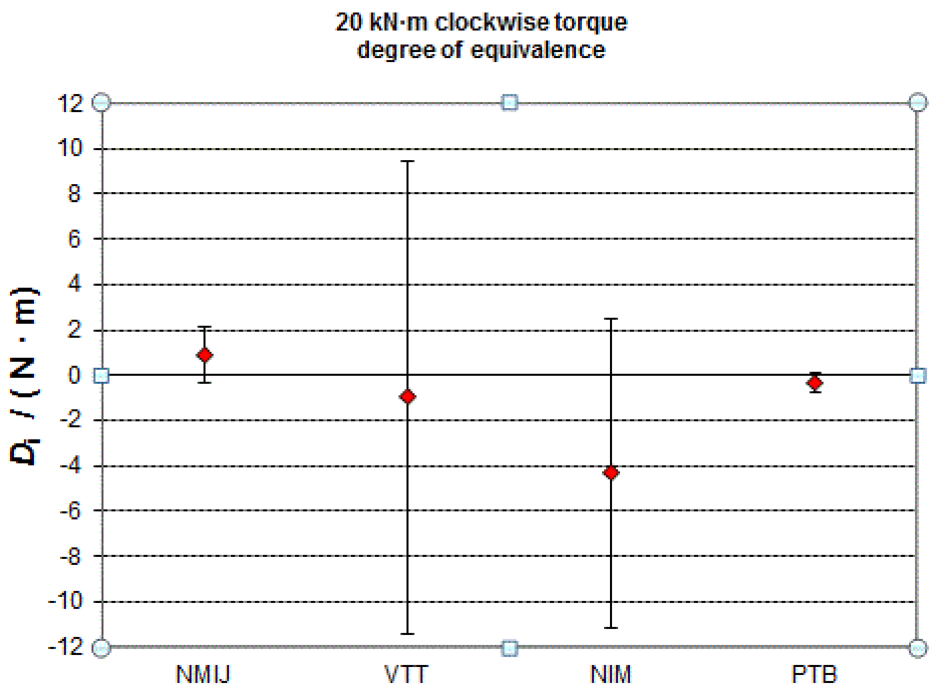
Blue square: TT1, participant in CCM.T-K1.2

Orange triangle: participant in CCM.T-K1.3

Torque comparisons

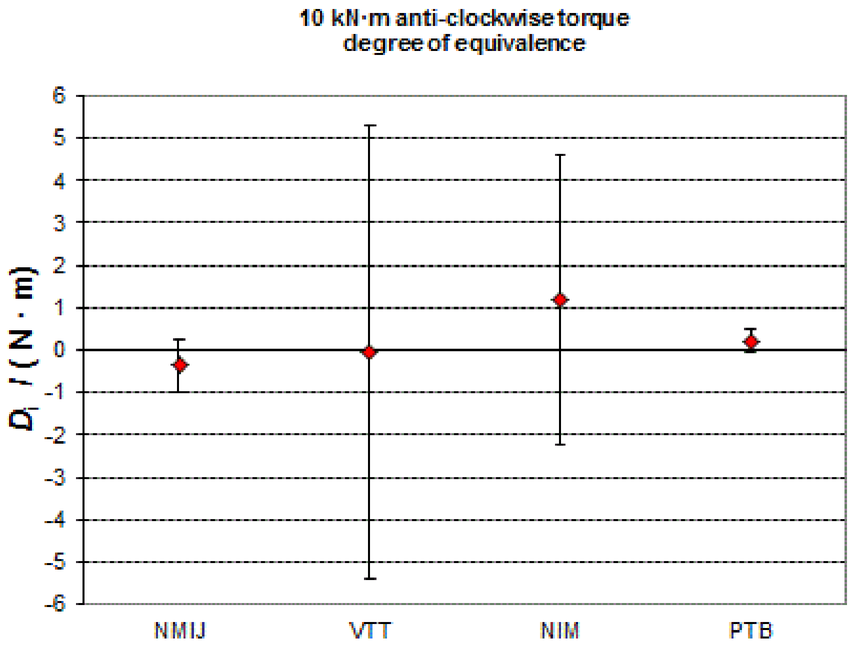
CCM.T- K2: Approved for equivalence, Results available

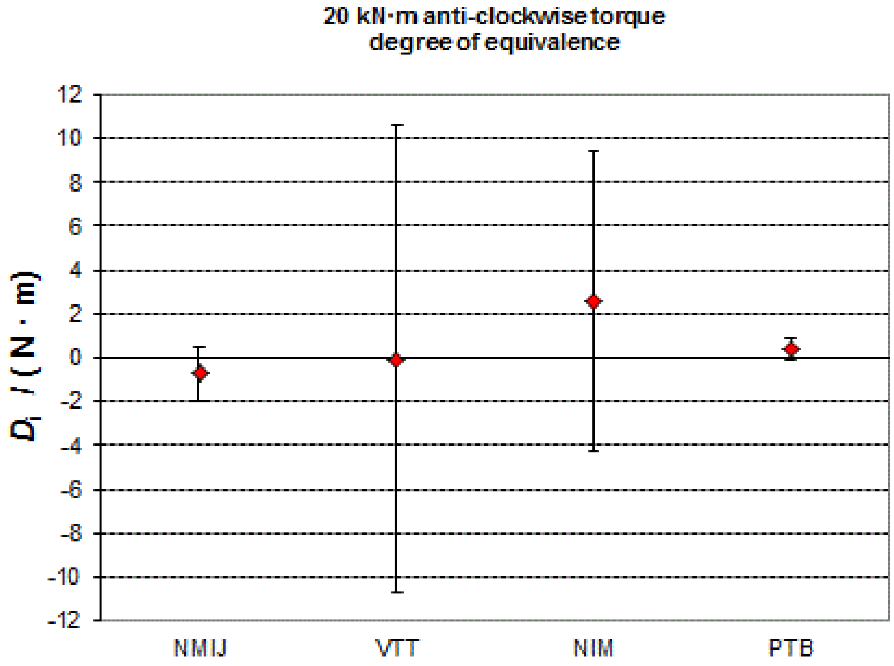




Torque comparisons

CCM.T- K2: Approved for equivalence, Results available





RMO Torque comparisons

- APMP.M.T- K1
  2015 – 2016, 500 N·m, 1000 N·m, Planned
- APMP.M.T-S1
  2016, 1 kN·m to 2 kN·m, Approved and published
- COOMET.M.T- S1
  2012 – 2014, 100 N·m to 2500 N·m, Approved and published
- 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,), Approved and published
- EURAMET.M.T- S3
  2010, 10 N·m, 20 N·m, ... 1 kN·m (torque wrenches), Approved and published
- EURAMET.M.T- S4
  2015, 5 N·m, ... 50 N·m, planned
- SIM.M.T-S1
  2016, 10 Nm, 20 Nm and 50 Nm, in progress

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

Consortium

Coordinator

PTB, Germany

Partner

CEM, Spain

CMI, Czech Republic

MIKES, Finland

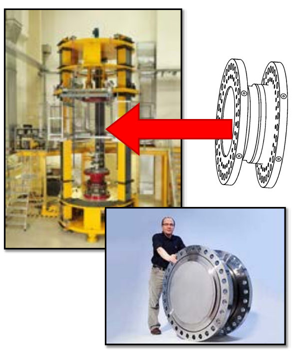
CENER, Spain

Fraunhofer IWES, Germany

RWTH Aachen, Germany

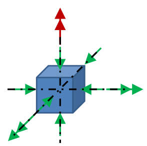
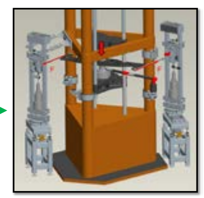
WP 2 Torque transfer standards (PTB)

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



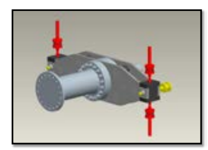
WP 3 Multi-component investigations (PTB)

- Development of design principles for multi-component torque transducers

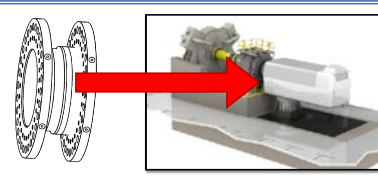
WP 4 Force lever system (CEM)

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




WP 5 Calibration procedure (RWTH)

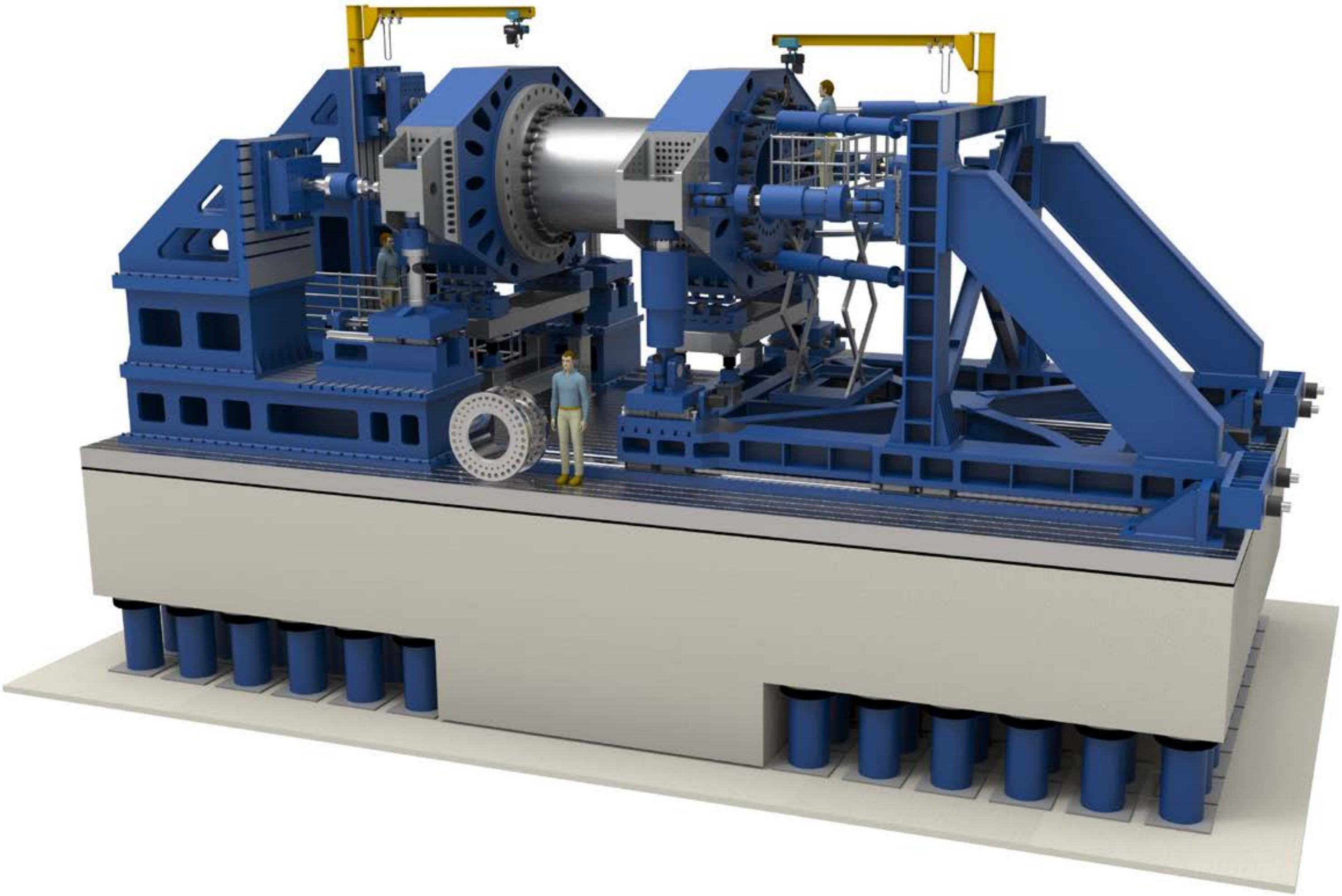
- Develop calibration procedure for torque loads in nacelle test benches
- Exemplarily realise the procedure in a nacelle test bench



WP 7 Management

- JRP website address: https://www.ptb.de/emrp/ind14-home.html

PTB construction of a 5 MN•m torque standard machine for multicomponents possibility of extension to 20 MN•m



Next CCM WG Force Meeting at PTB in Braunschweig from 6th until 8th June 2017

Expected number of participants: ca. 20 persons

Topics:

CCM Force and Torque Key Comparisons

RMO Force and Torque Key Comparisons

Bilateral Comparisons in Force and Torque

Future Comparisons in Force and Torque

Information from the participants about new developments in force and torque

CMCs in Force and Torque: Simplification and Recommendation for CMC Review

Future Topics and future work of the CCM WG Force

- Need for larger Force and Torque Ranges
- Need for smaller Force and Torque Ranges
- Multicomponent Force and Torque Measurement
- Dynamic Force Measurement
- Terms of Reference of CCM WG Force
- Strategy of CCM WG Force
- Program of Work of the WG Force
- Other Topics ?

Visit to PTB Force and Torque Laboratory

Thank you for your attention.

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