TECHNICAL PROTOCOL

FORCE KEY COMPARISON
CCM.F.K1 (5 kN and 10 kN)

Pilot laboratory

TUBITAK National Metrology Institute (TUBITAK UME), Turkey

TUBITAK UME
Force Laboratory

(Rev. 1.2)
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Contents

1. Introduction

The working group force and torque of the CCM decided to make a comparison in 5 kN and 10 kN at the meeting held on line in April 2021. It was decided that TUBITAK UME will be the pilot of this comparison at the meeting.

The aim of the comparison is to compare the force defined by the participants at 10 kN and 5 kN force ranges.

TUBITAK UME is acting as the pilot laboratory. The travelling standards will be provided by TUBITAK UME. TUBITAK UME will be responsible to monitoring standard performance during the circulation and the evaluation and reporting of the comparison results.

2. Travelling Standard

The traveling standards will be supplied by TÜBİTAK UME. There are 3 force transducers as traveling standards. Their identifications are as follows:

Table 1. Details of the travelling standards and selected force steps

Capacity	Measurement Steps (kN)	Device
10 kN	5 kN, 10 kN	10 kN HBM SN:193930010
10 kN	5 kN, 10 kN	10 kN GTM SN:45078
5 kN	5 kN	5 kN HBM SN:193930015

Only 2 force transducers will be sent to each participant. Two 10 kN force transducers will be sent to the laboratories that will participate in the 5 kN and 10 kN measurements. If there are laboratories that will only participate in the 5 kN measurement, one 5 kN and one 10 kN force transducers will be sent to the participant.

These standards were chosen for its high accuracy and stability in time.

In addition, the HBM BN 100 model device with the force transducer will be sent for the control of the DMP 40 or DMP 41 device.

2.1. Readout electronic and electrical traceability

Measurements of the force sensors will be made using a bridge such as the DMP 40 or DMP 41 from HBM. To ensure coherence between the measurement of the pilot and the participant, a BN 100 reference bridge will be circulated with transducers to correct the difference between the participant's bridge amplifier and the pilot.

2.2. Circulation of the transfer standard

A schedule will be made further in the organization of the comparison. Each laboratory involved in planning is allocated two weeks for measurement and two weeks for transporting the transfer standard.

Once a participant has completed their measurements and is ready to ship the travelling standards the next scheduled participant along with the pilot institute should be notified. See section 2.2. All items should be inspected and packed into the original carrying case and sent to the next participant promptly so as to avoid delay.

There will be an ATA report card for the equipment to be circulated. The use of ATA Carnet will be used for transport between all lands outside the EU and when traveling within or outside the EU. Some kind of declaration has to be made for customs to avoid VAT tax.

2.3. Transportation

Each participant supports the fees for his link for the shipment from and to the pilot laboratory. UME can organize the shipment then send a bill to the participant or the participant is free to organize all the shipment through its own infrastructure.

Participants shall inform the pilot laboratory by e-mail or fax when the travelling standard has arrived using the following form given in Table 2.

Table 2. The form for the information of arrival of the travelling standard.

Confirmation Note For Receipt		
Date of Arrival		
NMI		
Name of Responsible Person		
Telephone no. and E-mail		
Traveling standard	☐ Damaged	☐ Not Damaged
ATA Carnet	☐ Received	☐ Not Received
Declaration of ATA Carnet	☐ Customs Declared	☐ No Declaration
Additional Notes:		

Upon completion of measurements participants shall inform the next participant and the pilot laboratory by e-mail or fax about the shipment of the travelling standards using the following form given in Table 3.

Table 3. Sample form for the information of dispatch of the travelling standard.

Confirmation Note For Dispatch	
Date of Shipment	
NMI	
Name of Responsible Person	
Telephone no. and E-mail	
Shipment Information (company name etc.)	
ATA Carnet	☐ Enclosed
Declaration of ATA Carnet	☐ Customs Declared ☐ No Declaration
Additional Notes:	

2.4. Transport Case

Participating laboratories will receive 2(two) item force transducers and 1(one) item BN 100 device in a box. The travelling standard is packed in a transport case of size (about 70 cm x 56 cm x 52 cm) and a total weight of approximately 30 kg. The transport case can easily be opened for customs inspection.

2.5. Failure of Travelling Standard

On receipt of the travelling standards the participant must inspect each standard for damage. If any damage is observed this must be reported to the pilot institute prior to continuation of the measurement See section 2.3 for details.

In case of any damage or malfunction of the travelling standard, the comparison will be carried out after the travelling standard is repaired.

2.6. Financial aspects

Each participant laboratory is responsible for its own costs for the measurements as well as any damage that may occur within its country. The overall costs for the organization of the comparison are covered by the pilot laboratory. The pilot laboratory has no insurance for any loss or damage of the travelling standard.

3. Pilot and Participant Laboratories

The pilot institute for this comparison is TÜBİTAK UME (Turkey). The contact details of the coordinator and participant institutions are given below:

Table 4. Participants and pilot institution information

Pilot Institute:	TUBITAK National Metrology Institute (TUBITAK UME)
Coordinator :	Dr. Bulent Aydemir
Contact mail :	ume.force@tubitak.gov.tr

Laboratory	Organiza-tion (RMO)	Address	Contact person
UME (Pilot)	EURAMET COOMET GULFMET	TUBITAK UME Gebze Yerleskesi Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze / KOCAELİ / TURKEY	Dr. Bulent Aydemir + 90 262 6795000 ext. 5600 bulent.aydemir@tubitak.gov.tr ume.force@tubitak.gov.tr
GUM	EURAMET	Mass Laboratory, Force and Hardness Section Central Office of Measures ul. Elektoralna 2, 00-139 Warsaw, Poland	Janusz Fidelus +48 22 581 9426 janusz.fidelus@gum.gov.pl
INRIM	EURAMET	Italy	
IPQ	EURAMET	IPQ- Instituto Português da Qualidade Rua António Gião, 2 2829-513 Caparica Portugal	Contact: Isabel Spohr ispohr@ipq.pt +351 212948173
LNE	EURAMET	Laboratoire national de métrologie et d'essais 1 rue Gaston Boissier 75724 Paris Cedex 15 - lne.fr France	Madame Carole DUFLON Carole.duflon@lne.fr +33 1 40 43 39 51
METAS	EURAMET	Switzerland	
NPL	EURAMET	National Physical Laboratory Hampton Rd Teddington Middlesex UK TW11 0LW UK	Andy Knott +44 20 8943 6180 andy.knott@npl.co.uk
PTB	EURAMET COOMET	Germany	Dirk Röske +49 531 592 1210 dirk.roeske@ptb.de
VTT MIKES	EURAMET	Finland	
KRISS	APMP	Korea	
NIM	APMP	China	
NMC/A*STAR	APMP	National Metrology Centre, A*STAR (NMC, A*STAR) 8 CleanTech Loop, #01-20, CleanTech 3, Singapore 637145	Lee Shih Mean +65 6279 1900 lee_shih_mean@nmc.a-star.edu.sg

NMIA	APMP	Australia	
NMIJ	APMP	Force and Torque Standards Group National Metrology Institute of Japan (NMIJ) Japan	HAYASHI Toshiyuki +81 29 861 4391 t-hayashi@aist.go.jp
NPLI	APMP	India	
IDIC	SIM	Chile	
CENAM	SIM	Mexico	
INMETRO	SIM	National Institute of Metrology, Quality and Technology (Inmetro) Brazil	Rafael Soares de Oliveira, Tel.: +55 21 2679-9037 rsoliveira@inmetro.gov.br
INTI	SIM	Av. General Paz 5445 (1650) San Martín - Buenos Aires - Argentina	Alejandro Savarin +54 11 4724 6200 ext. 6713 asavarin@inti.gob.ar
NMISA	AFRIMET	CSIR Campus, Building 5, Meiring Naude Road, Brummeria Pretoria 0182 South Africa	Sipho Dlamini +27 12 841 3481 sdlamini@nmisa.org force@nmisa.org

The application form for the participating laboratories is given in the annex of the technical protocol. According to the information received, a list of participating laboratories will be rearranged.

4. Measurement Quantities and Points

The quantities to be measured and the measurement force points are given in Table 5.

Table 5. Measurement quantity and points

Quantity	Measurement Steps (kN)
Force	5 kN
	10 kN

5. Standards and measurement methods of the participants

All participants applied the international force comparison procedure (methods) given in detail below sections to compare their standards with transfer force standards.

5.1. Before the Measurements

- It should be allowed to stabilize in a temperature and humidity controlled environment for at least 1 days before commencing measurements.

5.2. Environmental Conditions

- The ambient temperature and humidity must be measured. The corrections will be performed for temperature and humidity effects.
- Preferably, the measurements should be carried out at the ambient conditions given below;

  Temperature : (21 ± 0,2) ˚C

  Relative humidity : (45 ± 10) %rh

5.3. Transfer Standards

Transfer standards or travelling standards are given in Table 1. There are 2 force transducers as transfer standards. These force transducers belong to TÜBİTAK UME, have been used in previous inter-laboratory comparisons with national laboratories of other countries as well. Accordingly, the long term stability behaviour of these transducers was already well known.

To minimize the uncertainty associated with the indicating instrument a high resolution, 1 ppm, indicators having good stability (HBM, type DMP 40 or DMP 41) should be used in comparison. Participants will use their own indicators (HBM, type DMP 40 or DMP 41). The pilot lab will send a calibrator device to avoid differences between indicators. At the same time, in order to check DMP 40 or DMP 41 indicating device, a BN 100 type HBM product calibrating device will be checked before and after the measurements (shown in Fig.1).

DMP 40 or DMP 41 is adjusted as absolute value (ABS), 0.1 Hz Bessel filter, 5 V excitation voltage, the six-wire technique, 0,000001 mV/V resolution, self-calibrating “on” mode and ± 2.5 mV/V measuring range values during measurements.

Figure 1. Precision indicating instrument (DMP 40) and BN 100 calibrator of TÜBİTAK UME

5.4. Measurement procedures

The procedure for performing the comparison measurements is described two increase series on each position. The results of all transfer force transducers evaluated in the range 50% to 100%.

Local heating due to electrical power dissipation may cause this by the strain-measuring bridge. Many measurements and experience show that this effect on force transducer output stabilizes within about 30 minutes.

To minimize the errors due to the non-axial components of deformation, the response of each force transducer is obtained at twelve symmetrically distributed positions relative to the axis of the machine (0˚, 60˚, 120˚, 180˚, 240˚, 300˚, 360˚, 420˚, 480˚, 540˚, 600˚, 660˚, 720˚). In order to get better results, prior to start measurement cycle, the force transducer should be loaded with maximum test load three times at the 0˚ position.

Two different measurement schemes will be applied depending on the range of the transducer. The 10 kN transducer is measured at 5 kN and 10 kN and the 10 kN are measured only at 10 kN. The 5 kN transducer is measured only at 5 kN.

Each force step is held for 4 minutes before taking the measurement. At 0° there are three preloads then three measurements. Then the sensor is rotated 60° and there is one preload and one measurement. Then this last step is repeated as many times as needed to achieve a total rotation of 720°. The loading scheme depicted in figure 1 shows the dual force measurement with 5 kN and 10 kN transducers and figure 2 shows the load scheme for a single step (5 kN or 10 kN). The total time needed, from before the preload to the end of all measurements is 5 hours 44 minutes in the case of dual force step measurement (Fig 2 and Fig 3).

All measurement results and system information are filled in the excel data form by the participant laboratory.

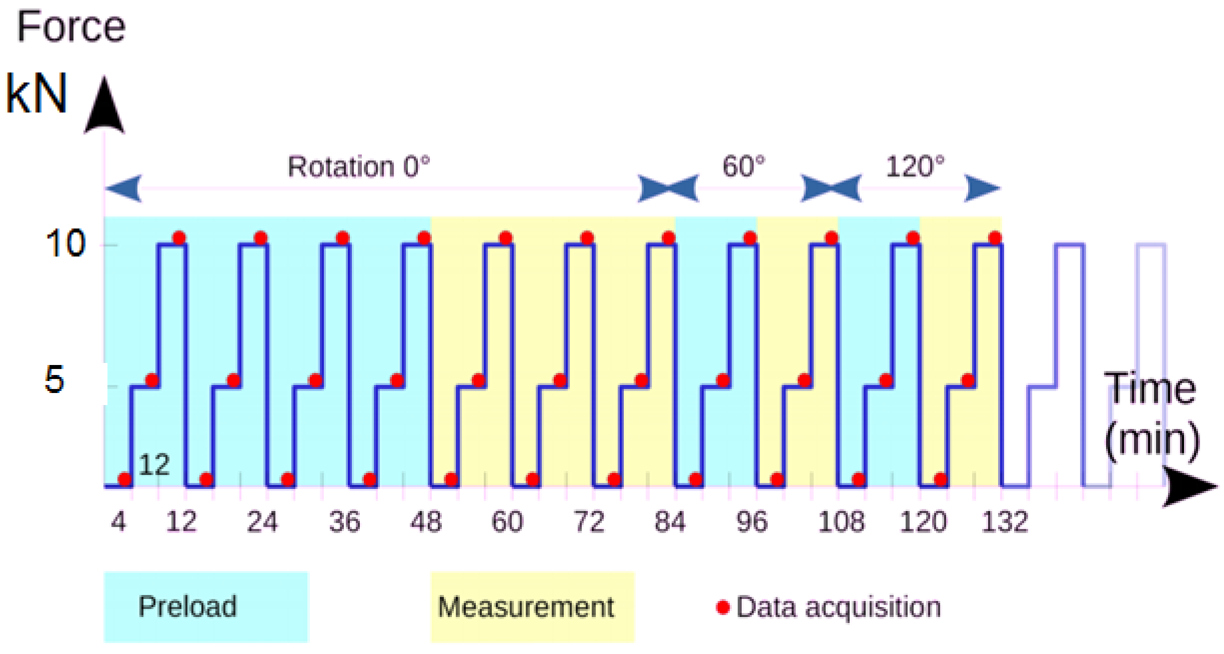

Figure 2. Load scheme used for dual force measurements (5 kN and 10 kN with 10 kN sensor)

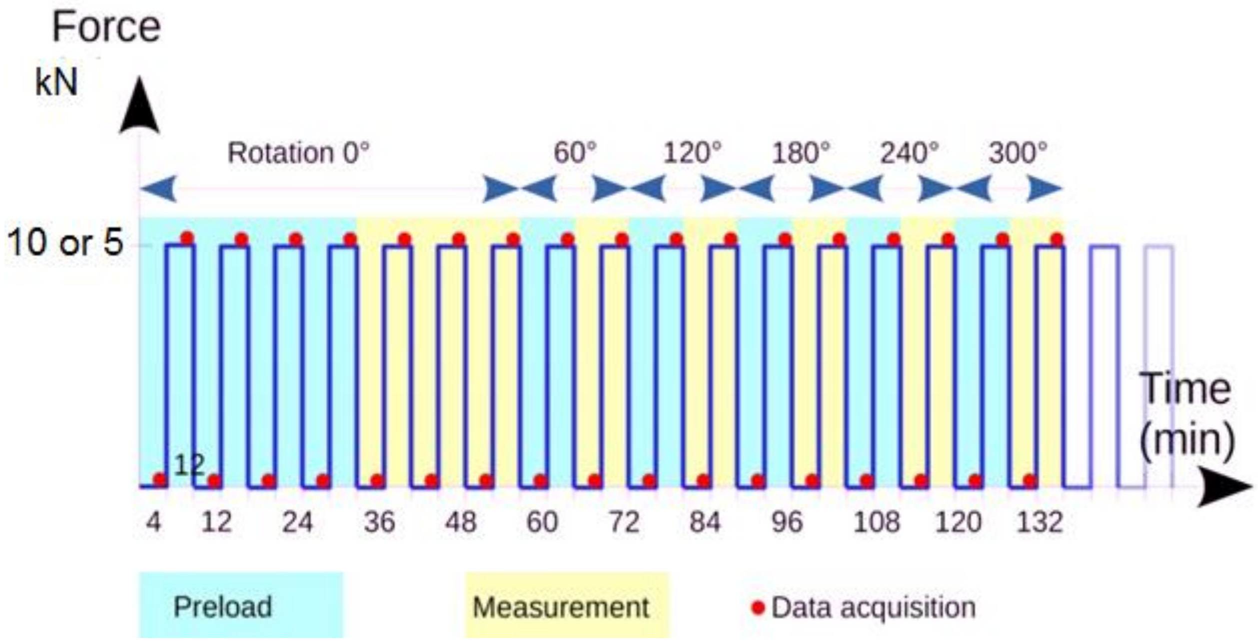

Figure 3. Load scheme used for single force measurement (10 kN with 10 kN sensor, and 5 kN with 5 kN sensor)

6. Measurement Uncertainty

The measurements made by the participants will be considered as independent from each other because even if the same transducer is used the drift may well be larger than the uncertainty of the participants. Each participant is linked with the machine of the pilot laboratory which has a type B uncertainty but which is supposed to provide a stability of measurements much smaller than the type B uncertainty or the reproducibility of the transfer standards.

Each participant will provide the type B uncertainty of his measurement system.

6.1. Weighted mean for each participant.

For each sensor and each participant a type A uncertainty will be determined based on the reproducibility of the measurement at the pilot laboratory and at the participant laboratory and including the drift observed by the sensor before and after the transport. A weighted mean will be made on all the sensors used by a given participant for the link with the pilot laboratory at a given force step. The type A uncertainty obtained after the weighted mean will be combined (uncoherent summation) with the type B uncertainty of the participant.

6.2. Reference value.

The reference value will be a weighted mean between all the results of the participants, including the pilot laboratory.

6.3. Degree of equivalence

The offset respective to the reference value as well as the uncertainty associated to the offset will be provided. In order to facilitate a further link in a RMO comparison and to reduce the uncertainty of such a link the uncertainty of each offset will be dissociated in a type A uncertainty (related to sensors and repeatability of the system) and a type B uncertainty (related to the force reference standard of the participant) that will be correlated in a further RMO comparison.

7. Reporting of Results

The results should be prepared and send to the pilot institute after completing the measurements.

Results shall be reported to the pilot laboratory. The report must contain at least:

- Details of participating laboratory,
- The date of the measurements,
- A detailed description of the measurement method and system used,
- The environmental conditions during the measurements,
  - ambient temperature
  - relative humidity
- Results of measurement; the measurement results shall be provided according to the excel file format.

8. Final Report of the Comparison

The pilot laboratory is responsible for the preparation of a comparison report.

The draft version of the comparison report will be issued within three months after receiving the participant report by the pilot laboratory. Draft report will be sent to all participants for discussion and approval. This draft will be confidential between the participants.

The participants will have one months to send their comments on Draft Report. After approval, Draft Report will become the Final Report.

9. References

[1] CCEM Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons, 2007 (available on the BIPM website: http://www.bipm.org/utils/common/pdf/CC/CCEM/ccem_guidelines.pdf)

[2] Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement (GUM), JCGM 100, First edition, September 2008 (available on the BIPM website: http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf)

[3] EA Publication EA-4/02, Expression of the Uncertainty of Measurement in Calibration

[4] ISO / IEC 17043 “Conformity assessment — General requirements for proficiency testing”, International Standardization Organization”, 2010

[5] Calibration Guide EURAMET/cg-04/v.02 (03/2011)-Uncertainty of Force Measurements

[6] CIPM MRA-G-11 − Measurement comparisons in the CIPM MRA, 2021

ANNEX A

PARTICIPANT INFORMATION

1. PARTICIPANT INFORMATION

Acronym of Institute / Laboratory Name	
Contact Person Name	
Organization (RMO)	
Phone No / Fax No	
E-mail	
Shipping Address	

2. REFERENCES USED IN MEASUREMENT

Instrument Name	Manufacturer	Type / Model	Serial No	Uncertainty (k=2, 95%)

3. COMPARISON MEASUREMENT CHOISE

Measurement type	10 kN sensor	5 kN sensor
Dual measurement		
Single measurement		

4. MEASUREMENT RESULTS

It will be sent as an excel file.

ANNEX B

TIMETABLE FOR THE COMPARISON

Measurement (2 weeks) + transportation (2 weeks) = 1 month

Year	Time period	Laboratory	Address
2021	October 2021	UME (Pilot)	Turkey
	November 2021	PTB	Germany
	December 2021	UME (Pilot)	Turkey
2022	January 2022	UME (Pilot)	Turkey
	February 2022	GUM	Poland
	March 2022	UME (Pilot)	Turkey
	April 2022	INRIM	Italy
	May 2022	UME (Pilot)	Turkey
	June 2022	IPQ	Portugal
	July 2022	UME (Pilot)	Turkey
	August 2022	LNE	France
	September 2022	UME (Pilot)	Turkey
	October 2022	METAS	Switzerland
	November 2022	UME (Pilot)	Turkey
	December 2022	NPL	UK
2023	January 2023	UME (Pilot)	Turkey
	February 2023	VTT MIKES	Finland
	March 2023	UME (Pilot)	Turkey
	April 2023	NMISA	South Africa
	May 2023	UME (Pilot)	Turkey
	June 2023	KRISS	Korea
	July 2023	UME (Pilot)	Turkey
	August 2023	NIM	China
	September 2023	UME (Pilot)	Turkey
	October 2023	NMC/A*STAR	Singapore
	November 2023	UME (Pilot)	Turkey
	December 2023	NMIJ	Japan
2024	January 2024	UME (Pilot)	Turkey
	February 2024	NMIA	Australia
	March 2024	UME (Pilot)	Turkey
	April 2024	NPLI	India
	May 2024	UME (Pilot)	Turkey
	June 2024	IDIC	Chile
	July 2024	UME (Pilot)	Turkey
	August 2024	CENAM	Mexico
	September 2024	UME (Pilot)	Turkey
	October 2024	INMETRO	Brazil
	November 2024	UME (Pilot)	Turkey
	December 2024	INTI	Argentina
2025	January 2025	UME (Pilot)	Turkey