R. Kumme 2008-09-30
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Technical Protocol of the Bilateral Key Comparison on Force measurement at: 0 kN, 5 kN, 10 kN

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1. General Information about Force Key Comparion

The objective of the present bilateral comparison is to facilitate the demonstration of metrological equivalence between the national laboratory force standards of NCM Bulgaria and PTB Germany. The purpose of the comparison is to support the CMC's submitted from NCM.

2. General information about the Force Key Comparison in the 10 kN range

The intercomparison is organised by the pilot laboratory PTB and carried out in two laboratories. Two compression force transducers were selected by the pilot laboratory with the nominal force 20 kN (used up to 10 kN) and 10 kN.

3. Time schedule

The proposed time schedule is as follows:

40th WOY (29. Sep ff)	Measurement PTB
41st WOY (6th Oct ff)	Transport to NCM
43nd WOY (21th Oct ff):	Measurement NCM
45rd WOY (3th Nov ff)	Transport back to PTB
46th WOY (10th Nov ff)	Measurement PTB

For the case that there is any delay the pilot laboratory will inform the participant and the participant has to inform the pilot laboratory also in case of any delay.

4. Measurement devices

PTB has selected two different force transducers which are shown in the photograph below.

Fig. 1: Force transducers and accessories

Fig. 2: Force transducer mounted on the auxiliary plate

The details of the transducers and other instruments are shown in the following table:

Item No. No.	Description	Weight (kg)	Height (mm)	Size (mm)
1	Force Transfer Standard HBM Capacity 10 kN, Typ Z30 Serial number 051630022	2.7	100	Ø 95
2	Force Transfer Standard GTM Capacity 20 kN, Typ KTN Serial number 40278	3	90	Ø 95
3	Bridge Calibration Unit HBM Typ BN 100 A Serial number 07109	6.5	170	370×255
4	Temperature Data Logger synoTECH Typ Ho-o32-o2	0.11	60	Ø 100
5	basic plate with rings	7.2	60	Ø 170

Table 1: Instrument details

The fittings are provided by the pilot laboratory. All force introduction parts are included in the transport box. Each laboratory must clean the fittings and the plates of the force standard machine before the transducer is mounted to the machine and before starting the measurements.

The basic plate and the force transducer with loading pad have to be aligned to the centre of the machine axis. The basic plate remains in the same position and the transducer will be rotated on this plate. During the measurement no other devices should be connected to the DMP 40.

The participant takes his own DMP 40. The DMP 40 should operate with 230 V at 50 Hz and a bridge voltage of 5 V is used. The DMP 40 must be calibrated before and after each measurement with a BN 100 A which is supplied by the pilot laboratory (Item no. 3). The BN 100 A must also be operated with 230 V and 50 Hz.

A temperature and humidity data logger (item no.4) is used to record the temperature and humidity during the transport. This data logger should be placed near the transducer during the measurement.

5. Transportation of the equipment

PTB provides a transportation box. The transportation box contains the force transducers, the fittings, the BN 100 A, and a data logger for recording the temperature and humidity during the transportation. The duration of the transport between pilot laboratory and participant should not exceed 2 weeks. Therefore PTB will organize the transportation in both directions and will inform the participant about the transportation details. The pilot laboratory has to be informed about the arrival and departure time and about the results of the visual inspection as soon as possible. Therefore the forms of the transportation protocol should be filled out and sent to the pilot laboratory. Special instructions for packing, unpacking and cleaning of the devices are described in this document and in the pictures which you will find in the transportation box. To protect the devices from humidity the transportation box has to be sealed with a plastic foil.

6. Preparation of measurement

After arrival the equipment has to be tempered on (20.0 ± 0.2)°C. It is recommended to start with the measurements one day after the devices are placed in the laboratory. For the warm-up procedure the transducer has to be connected to channel 1.1 and the BN 100 A to channel 1.2, DPM 40 switched on.

But it is very important that all measurements have to be carried out on the same channel 1.1.

Therefore all devices have to be disconnected from the DMP 40 and only the used device (transducer or BN 100 A) has to be connected to channel 1.1. Before each device is used for a measurement the internal auto calibration of the DMP 40 has to be carried out. It is strongly recommended to check the control signal of the DMP 40. If there is a deviation of more than a few digits repeat the internal auto calibration of the DMP 40 several times. The internal auto calibration must switched ON during the measurements.

All measurements related to one force transducer must carried out within one day:

1. Calibration procedure of DMP 40 with BN 100 A.
2. The measurement with the force transducer.

3. Calibration procedure of DMP 40 with BN 100 A.

All readings and the calibration signals must be recorded in the protocol.
The default settings at PTB are:
Excitation voltage : 5 V
Measuring range: 2.5 mV/V, “absolute” mode.
Filter setting: 0.1 Hz Bessel.
Resolution : 0.000001 mV/V

7. Environmental data during the measurements

The ambient temperature should be (20 ± 0.2)°C. The air temperature near the force transducer, the relative humidity of the air in % and the air pressure in hPa must be recorded in the protocol. In addition PTB sends a data logger for temperature and humidity to record the environment conditions during the transport. This device should be placed near the transducer during the measurement.

8. Measurement procedure

The pilot laboratory and the participant coordinated the following measurement procedure:

All preloadings and measurement series are carried out in the same time schedule, i.e. the readings should be taken six minutes after the change of force step.

Laboratory

The measurements in laboratory are carried out with two force steps (5 kN and 10 kN).

Measurement sequence:

0°	3 initial preloadings (steps: 0, 5 kN; 10 kN);
0°	1 preloading (steps: 0, 5 kN; 10 kN);
	3 measurement cycles (steps: 0, 5 kN; 10 kN)
60°	1 preloading (steps: 0, 5 kN; 10 kN);
	1 measurement cycle (steps: 0, 5 kN; 10 kN)
120°	ditto
180°	ditto
240°	ditto
300°	ditto
360°/0°	ditto
60°	ditto
120°	ditto
180°	ditto
240°	ditto
300°	ditto
360°	ditto

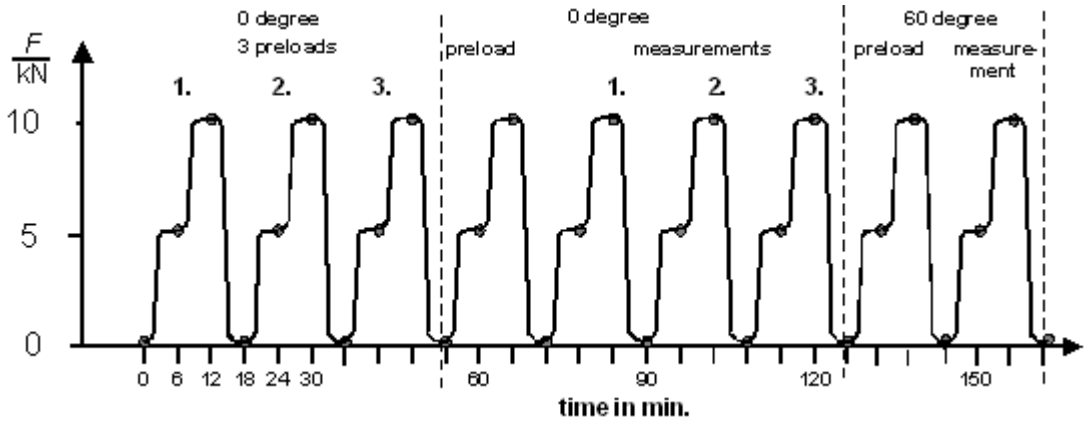

Fig.2 *Measurement sequence in laboratory (one transducer will take about 9½)*

Important remark to the rotation of the transducer:

The transducer has to be rotated in the next position directly after unloading and the zero value is taken in the new rotation position according to the time schedule.

Important remark to loading of the transducers:

The transducers should only be loaded according the time schedule of the CCM Force Key Comparison procedure (0 kN, 5 kN, 10 kN and 6 minutes time interval) to reduce effects related to the history of the transducer. Since the start of the Key Comparison the transducer are applied only according to this procedure. Any other procedure may have an effect on the stability.

9. Recording the Measurement Data

The measurement data has to be recorded in an Excel spreadsheet, which will be delivered by the pilot to the laboratory by E-Mail. For each transducer one EXCEL file has to be used. From the readings the deflections are calculated. They are the basis for further evaluation of the measurement data. Each deflection value is defined as the reading at the force step minus the zero reading directly before applying the force step. Deflections, mean values, repeatability and reproducibility are calculated in the spreadsheet. ´

10. Measurement result and measurement uncertainty

The measurement results have to be calculated from the original readings.

The measurement result is the mean deflection calculated from the 12 values measured in 12 orientations (60° to 360° for two rotations) of the force transducer. This result has to be given for the measurements with the own DMP 40. The measurement uncertainty has to be calculated for the mean deflection measured with the transducer and the own DMP 40. No DMP 40 correction is applied in these first results. The pilot laboratory will make a proposal for the DMP 40 correction including the long-term stability of the BN 100 A in the final evaluation.

The uncertainty has to be determined based on the principles laid out in the Guide to the Expression of Uncertainty in Measurement, published in ISO. Therefore each participant has to calculate the measurement uncertainty of the measurement carried out in the used force standard machine. According to the decision of the CCM Working Group Meeting at NIST in

Washington in October 2001 different uncertainty components have to be taken into account. The details are given in the annex of the measurement uncertainty calculation.

The Spreadsheets with the original readings should be sent to the pilot laboratory as soon as possible so that the pilot can verify the conditions of the devices by the measurement data.

The whole measurement data including the measurement uncertainty should be sent to the pilot latest within 6 weeks.

10. Final evaluation of the comparison

The pilot laboratory will evaluate the measurement data of all participants and will prepare a report which will be sent to the participants. The results will also be discussed in the CCM Working Group Meeting “Force”. The key comparison reference value will be calculated from all measurements of this intercomparison. The drift of the force transfer standard can be a considerable effect which must be taken into account in the calculation. Therefore the star type formation was chosen. PTB will use for all measurements the 20 kN deadweight force standard machine to verify the stability of the transducers always with the same loading time. And the drift effect is calculated from the measurements carried out in the pilot laboratory.

CCM Force Key Comparison in the 10 kN range

Send this form by Fax or E-Mail to the following contact person of the pilot laboratory:

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Transportation protocol (arrival)

Date of arrival:	09.10.2008
Transportation company:	Schenker Deutschland AG

Conditions of the transfer standards on arrival

Transportation box:	OK
Transfer standards:	Without problems
Other remarks:	No