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# Technical Protocol of the Bilateral Supplementary Comparison, Measurand Force in the scope of 200 N – 1000 N

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## 1. General Information

The bilateral force supplementary comparison will be carried out between the *Physikalisch-Technische Bundesanstalt* (PTB) of Germany as the reference laboratory linked to the KCDB and the *Instituto Nacional de Tecnología Industrial* (INTI) of Argentina as the pilot laboratory. The *Instituto Nacional de Metrologia, Qualidade e Tecnologia* (INMETRO) of Brazil will act as a receiver of the values measured by both PTB and INTI, as well as for the results analysis.

PTB in Braunschweig and Berlin is the National Metrology Institute and highest technical authority of the Federal Republic of Germany for the field of metrology and certain sectors of safety engineering.

INTI is the National Metrology Institute and the reference in the technological field in Argentina.

For this comparison, INTI will provide one force transducer with 2 kN as nominal force value.

## 2. Measurement device

For this comparison, INTI has selected one reference force transducer with the following characteristics:

- *HBM Z30A, s/nº 123430023, 2 kN capacity.*

Fitting pads (load button and thrust piece) and the connection cable are provided by the pilot laboratory. Each laboratory must check that all load transfer surfaces, both transducer and the deadweight machine used are clean and in good conditions before mounting and measuring. The transducer must be carefully mounted, paying special attention to its alignment in the machine before starting the measurements.

Each laboratory will use its own DMP40 amplifier. They will be operated according to the following setup:

- Supply voltage: 220 / 240 V at 50 Hz
- Excitation voltage: 5 V at 225 Hz
- Measuring range: 2.5 mV/V
- Low-pass filter: 0,22 Hz Bessel[1].
- Resolution: 0.000001 mV/V
- Measurement mode: Absolute
- Auto-calibration: On[2]
- Measuring channel: Defined by the laboratory[3]

[1] Depending on electrical and/or mechanical influences, another filter frequency could be chosen by the laboratory.
[2] It is also allowed to perform the auto-calibration just after taking the value.
[3] Only the transducer under measurement will be connected to the DMP40 amplifier in the channel selected.

### 3. Transport of devices and schedule

The devices will be shipped in watertight cases along with other transducers. The measurement scheme will be:

| | |
|---|---|
| INTI – Initial measurement | July 2021 |
| PTB | October 2021 |
| INTI – Final measurement | December 2021 |

### 4. Preparation of measurement

After receiving the transducers, all devices will be kept at laboratory conditions. The following minimum time intervals are recommended before measurement:

> *14 days since the devices traveled by air, 7 days in the laboratory facilities, 2 days in the laboratory where the measurements will be made, as close as possible to the machine to be used, 12 h mounted in the measurement position and connected to the digital amplifier to be used.*

The measurement temperature range is 21.0 ºC ± 0.5 K.

The measurement protocol must be carried out without interruptions in each mounting position. Between the ending of one mounting position and the start of the next, it should not take more than 5 minutes. If this time is exceeded, it is recommended to carry out at least one additional preload without being recorded.

All readings must be recorded in the measurement protocol. The 0.22 Hz Bessel filter will be used, unless there is a problem related to it, in which case a 0.1 Hz Bessel filter will be used instead. For this reason, it is recommended to pay special attention that the force is stable and there are no disturbances at least 30 s before recording the value, including the autocalibration of the DMP40 amplifier.

The air temperature near the force transducer in ºC will be recorded with each measured value, excluding preloads. The relative humidity in % and the air pressure in hPa will be recorded at the beginning and at the end of measurements.

The load button provided will be adjusted by hand, while the thrust piece will be mounted so that the mark made on it is aligned with the cable connector. When the transducer is rotated, clockwise viewed from above, the thrust piece will rotate with it to keep the mark aligned with the cable connector.

## 5. Measurement protocol

The following measurement schedule was agreed:

All pre-loadings and measurement series are carried out in the same time interval, which is three minutes between taking values. This time includes the time needed to change the load and its stabilization. The value is taken just before starting the load change.

The measurements are carried out in the following force steps:

0, 200 N, 400 N, 600 N, 800 N, 1000 N

The measurement sequence is as follows:

0º Preload at 1000 N (Three times)
0º 0, 200 N, 400 N, 600 N, 800 N, 1000 N, *800 N, 600 N, 400 N, 200 N, 0* (Twice)

90º Preload at 1000 N (Once)
90º 0, 200 N, 400 N, 600 N, 800 N, 1000 N, 0 (Twice)

180º Preload at 1000 N (Once)
180º 0, 200 N, 400 N, 600 N, 800 N, 1000 N, 0 (Twice)

270º Preload at 1000 N (Once)
270º 0, 200 N, 400 N, 600 N, 800 N, 1000 N, 0 (Twice)

INTI carries out the measurements on its 1 kN deadweight force standard machine ($W = 5 \cdot 10^{-5}$, $k = 2$).
PTB carries out the measurements on its 2 kN deadweight force standard machine ($W = 2 \cdot 10^{-5}$, $k = 2$).

The measurement data must be recorded raw in the "*PTB-INTI 1 kN SC protocol*" spreadsheet "*raw_data*" tab, which will be delivered by the pilot laboratory. A new tab can be added to this spreadsheet to consider correction factors that the laboratory deems necessary.

## 6. Measurement results, uncertainty, and evaluation

Deflections are calculated from the readings. Each deflection value is defined as the reading at the force step minus the corresponding zero reading before applying the force step.

Deflection, mean value, repeatability and reproducibility is calculated in the spreadsheet.

Measurement results are calculated from the original readings. The measurement result is the mean deflection calculated from the eight measured values in four mounting positions of the force transducer. The measurement uncertainty is calculated for the mean deflection measured from the transducer and the used DMP 40. No DMP 40 correction is applied in these results.

Only ascending runs will be part of the mean values. The measurement data acquired in descending runs will be used to compare the deviation between both laboratories.

The pilot value will be the mean between initial and final measurements, that is the loop value.

The uncertainties to be considered by each laboratory will be based in DKD (PTB) method with four mounting positions. The sources to consider will be:

- Laboratory CMC.
- Reproducibility.
- Resolution.
- Correction and uncertainty of the DMP40 according to the calibration certificate.
- Temperature.
- Long term drift. A rectangular distribution will be taken.

The following parameters will be indicated in the report but will not be quantified within the measurement uncertainty:

- Repeatability.
- Reversibility.

## 7. Results evaluation

After taking the measurements and completing the spreadsheet, it will be sent to INMETRO. Once INMETRO has both the initial and final measurements carried out in INTI as well as the measurement carried out in PTB, it will send the three spreadsheets to both INTI and PTB.

INTI will carry out the evaluation of this comparison together with INMETRO.

The values to be compared will be the mean value between the initial and final measurements obtained at INTI, this is the loop value, versus the mean value obtained at PTB. The normalized error will be used as an indicator of the results quality.