



This project 18SIB08 COMTRAFORCE has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme

ComTraForce – WP4

Developing a force traceability chain for metrological services for dynamic forces

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Unit Calibration

Purpose of Work Package 4 (WP4)

In General – Material Testing System

Concept of Measurements

All-in-one

Procedure

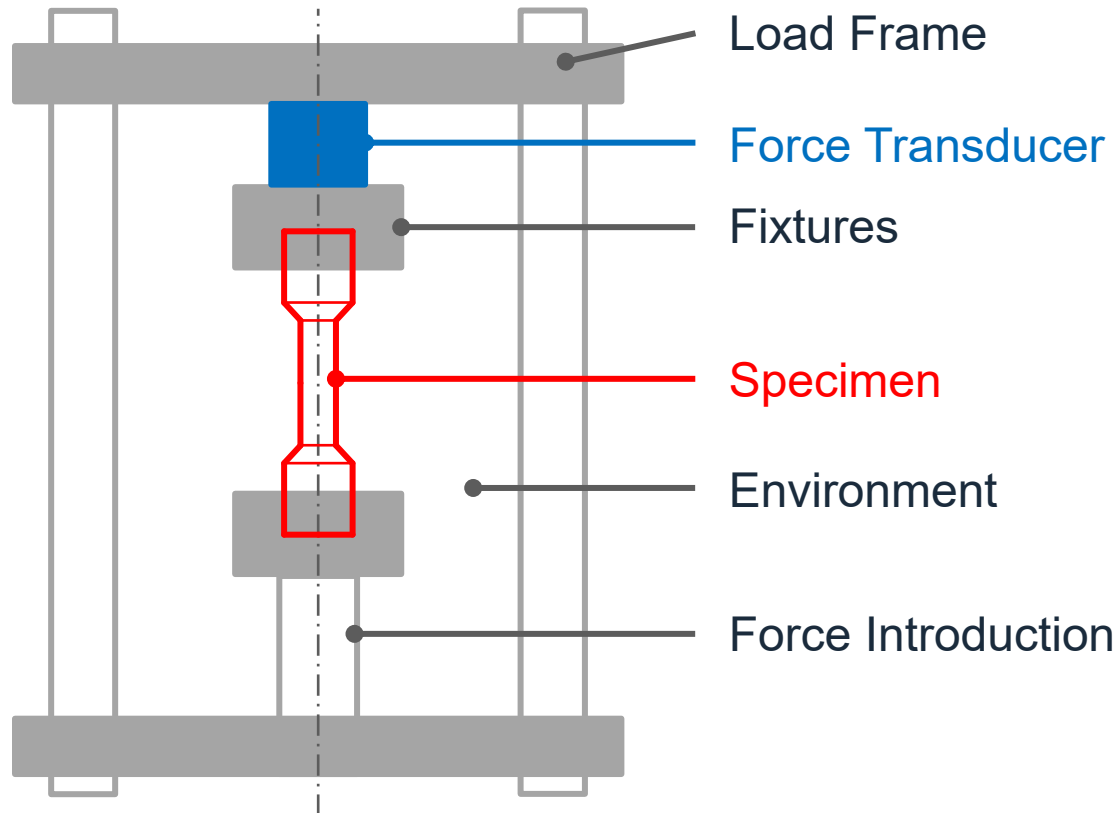
Impact of Bending Strains

Impact of Additional Masses

Summary and Conclusions

The aim of this work package is to develop a ***traceability chain for dynamic force measurement*** for metrological services in the field of material testing.

- *Measurement procedure* for dynamic measurements in testing machines
- *Compensation techniques* for inertial forces
- Development of a *model for the dynamic force measurement* in applications
- Estimation of the *measurement uncertainty*



Masses and elastic behaviour

Cyclic Loading

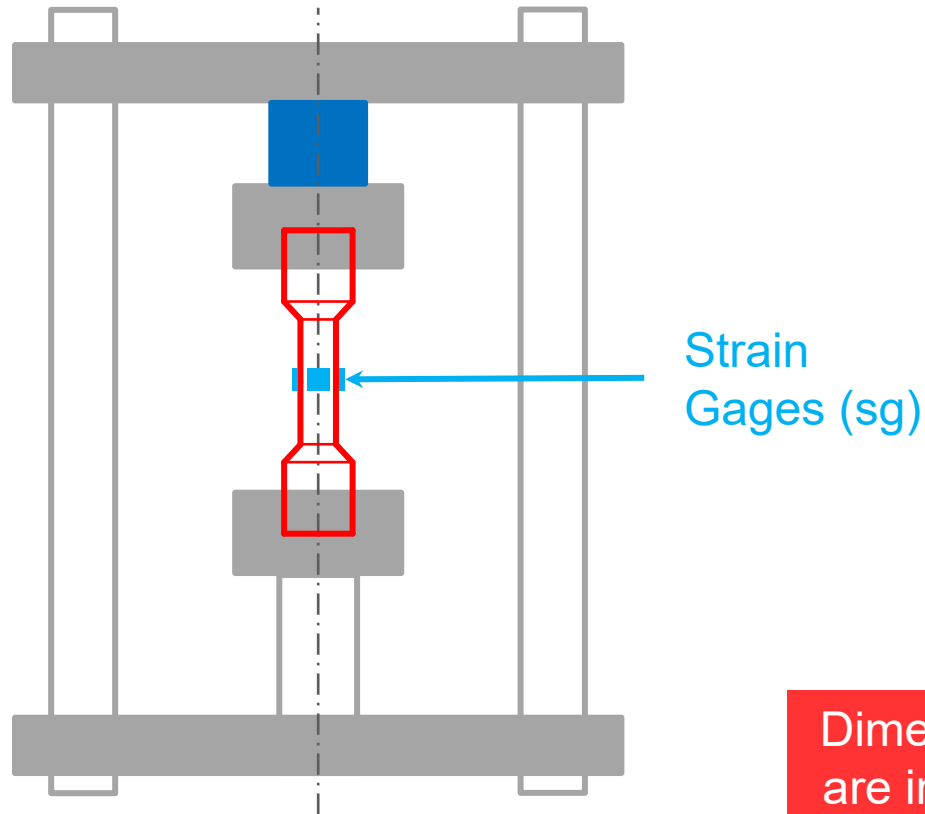
- Accelerated masses (e.g. fixtures)
- Stiffness (e.g. specimen)
- Frequency

Mass-Spring Model

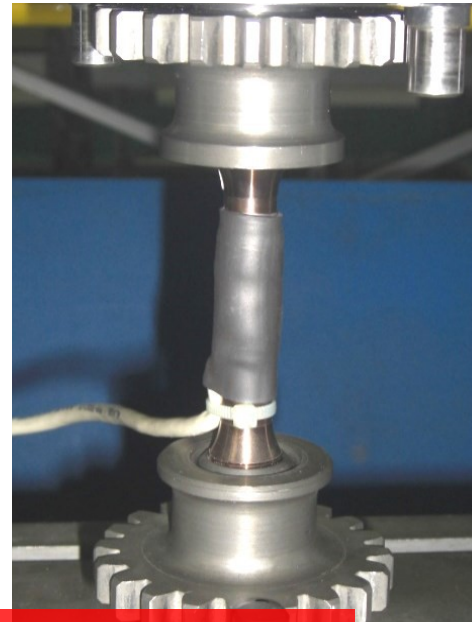
Calibration as closed as possible
to material testings

Additionally

- Bending strains (load train alignment)
- Temperature (environment)



[DKD-R 3-10 Sheet 3,
Edition 05/2019, Page 9]

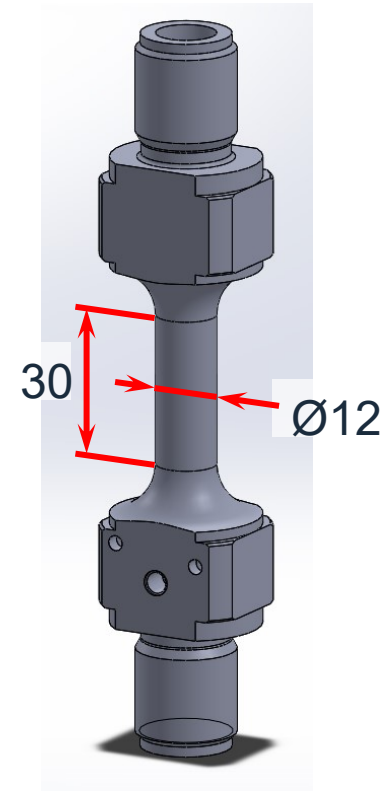
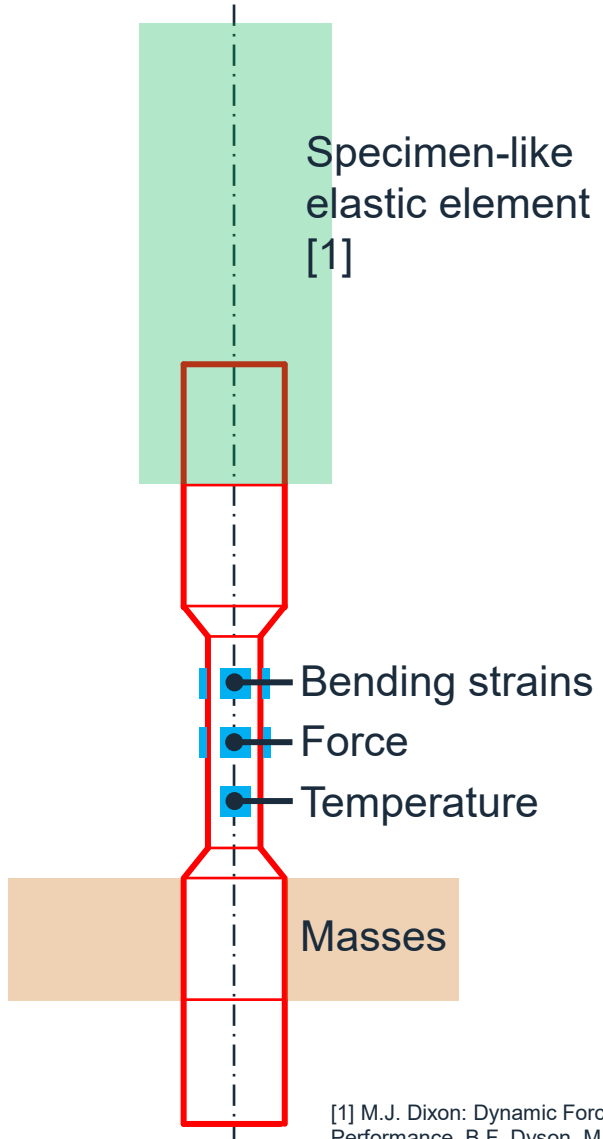


Dimensions and materials
are in an almost unlimited
diversity

Aim 1 Procedure and
1 Setup for all

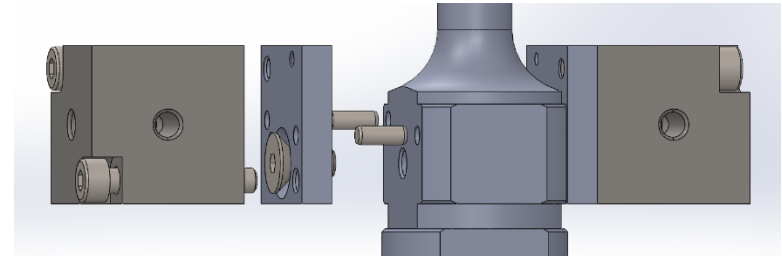
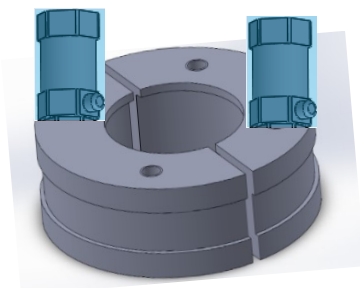
- Accelerated masses
- Stiffness
- Frequency
- Bending strains
- Temperature

All-in-one Solution - Concept and Design

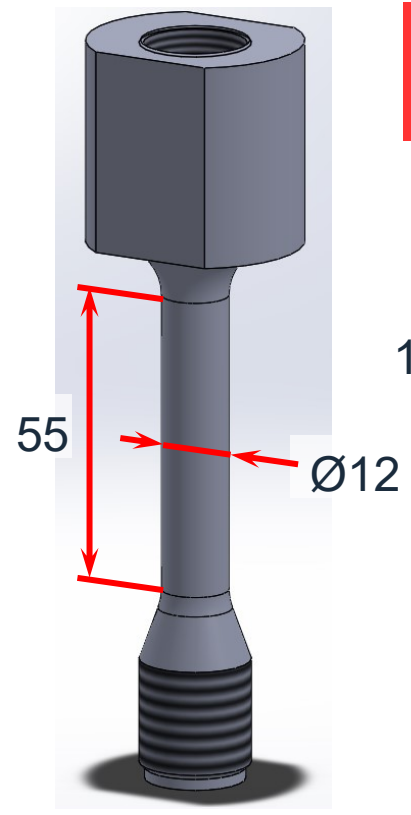


Dynamometer:
Fatigue resistant,
1.6580QT

Accelerometer on
additional masses



Stiffness Adapter: Fatigue
resistant, EN AW 7075-T6



$$c = \frac{E \cdot A}{l}$$

140 kN/mm

[1] M.J. Dixon: Dynamic Force Measurement, in Materials Metrology and Standards for Structural Performance, B.F. Dyson, M.S. Loveday, M.G. Gee [Editors], Chapman & Hall, 1st Edition, London, 1995

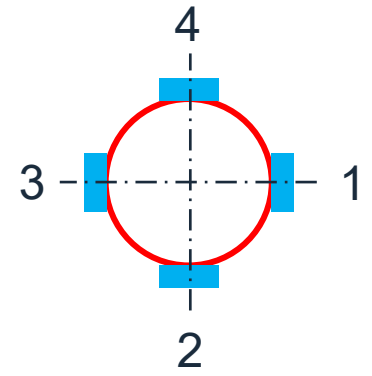
All-in-one Solution - Design of Measurements



$F_N: \epsilon_{\max}(\text{Steel}) = \epsilon_{\text{Dauerfest}}(\text{sg})$



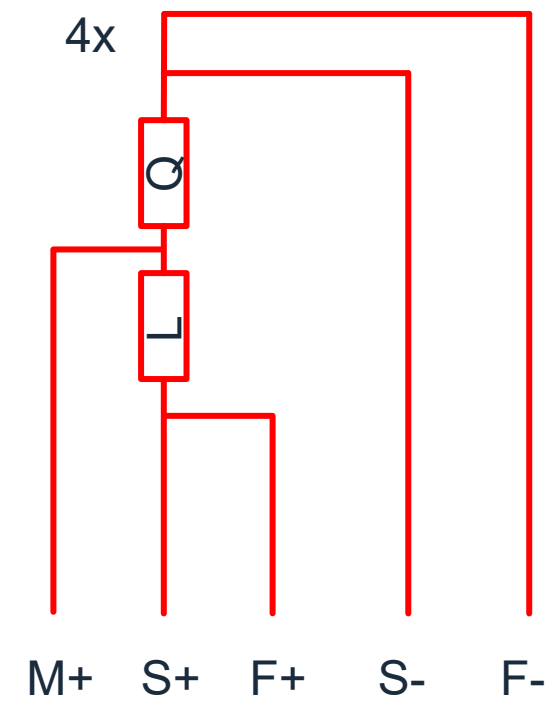
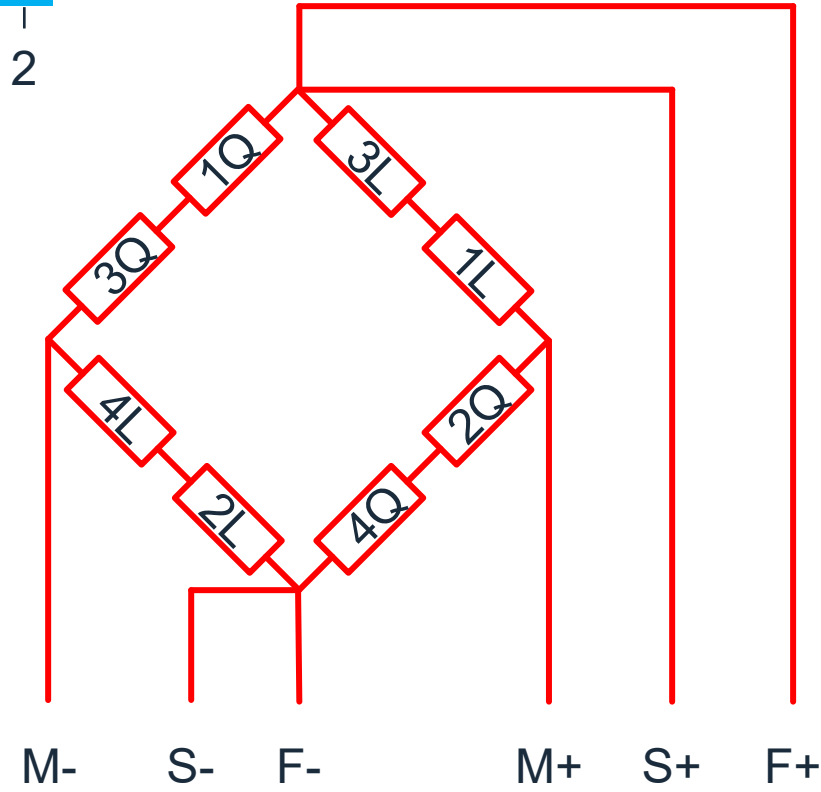
Bending strains
Force
Temperature



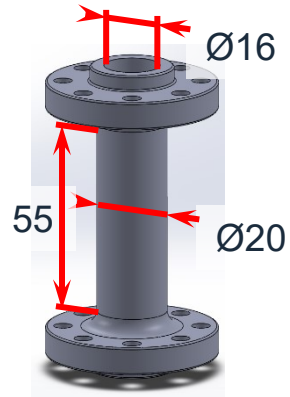
Temperature: sg + R-Network = Halfbridge

Force plane

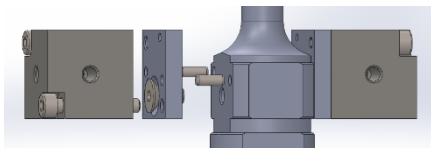
Bending plane



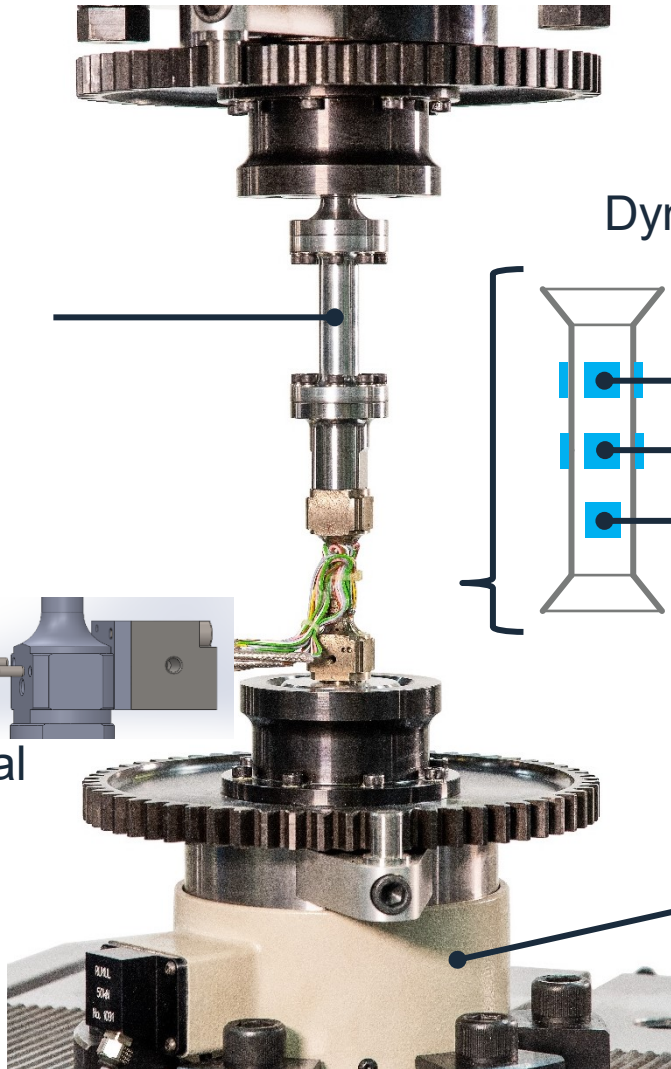
All-in-one Calibration Setup (Modif. after First Proving)



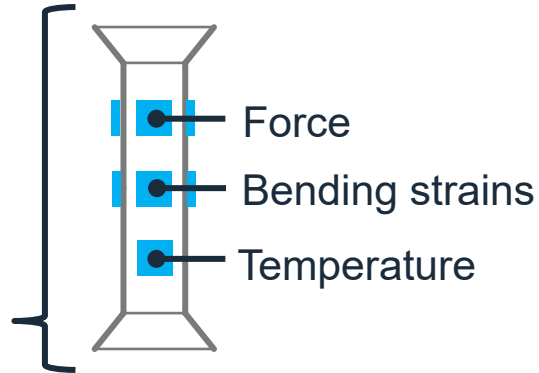
Stiffness adapter



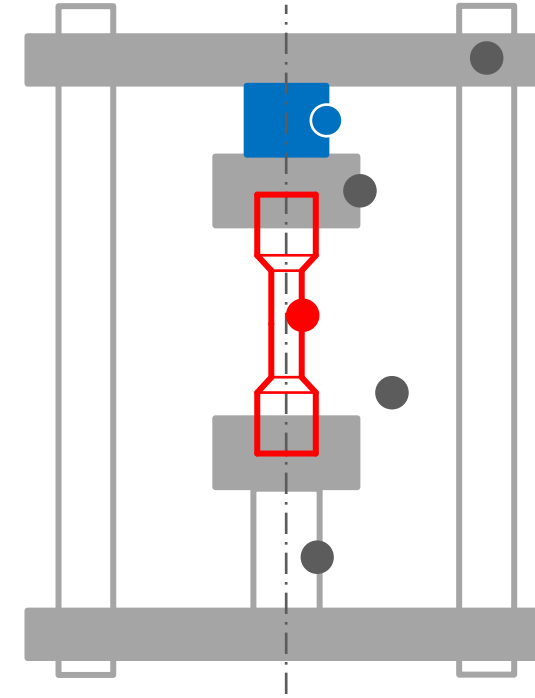
Additional masses



Dynamometer



Force Transducer of Rumul testing system



Evaluation of effects of

- Accelerated, uncompensated masses
- Stiffness / Frequency
- Bending strains
- Temperatures



Guideline **Dynamic Calibration of Material Testing Machines**
DKD-R 9-4

Edition 2022A

<https://doi.org/...>



DKD	Dynamic Calibration of Material Testing Machines https://doi.org/	DKD-R 9-4	
		Ausgabe:	2022A
		Revision:	0

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		Revision:	0

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Introduction
Preliminary Work
Calibration Work
Uncertainty
Appendices

Impact of Bending Strains - Setup

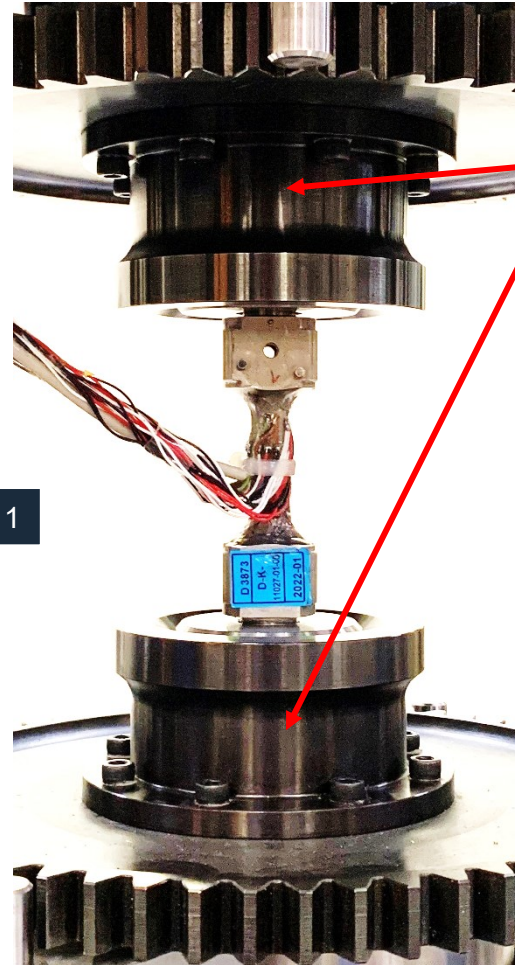
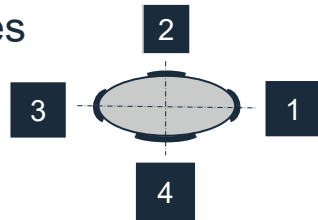


RUMUL 50 kN

20-DynProto

Dewetron TRIONet
DC, 5V, 5kHz, filter off

Positions of the Strain Gages



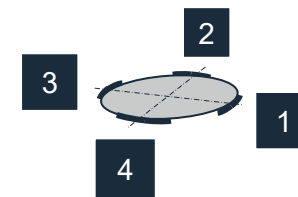
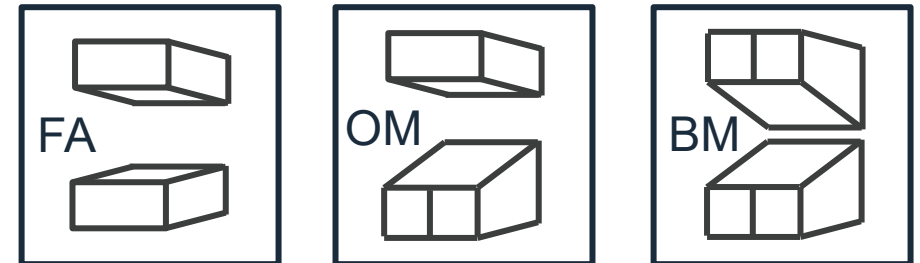
Parallel Discs

[mm]

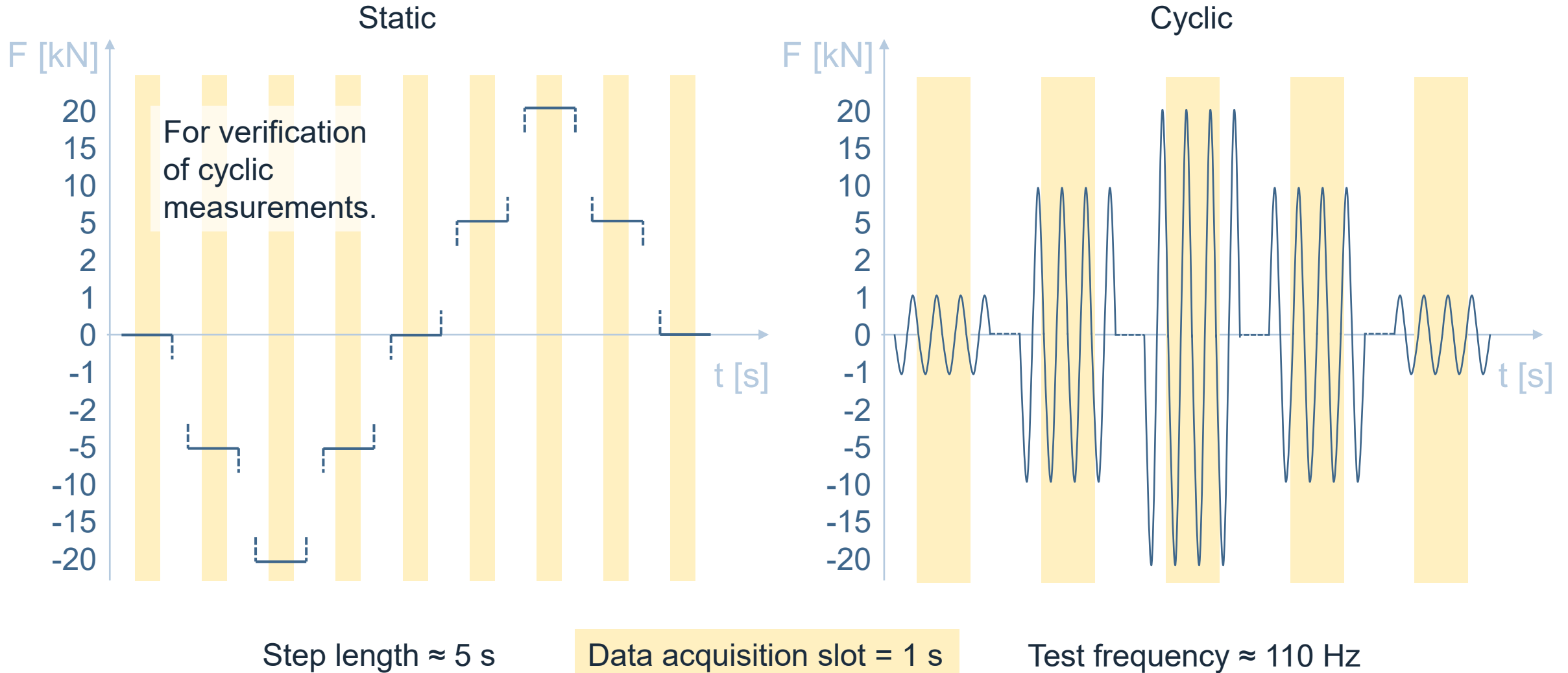
Inclined Block



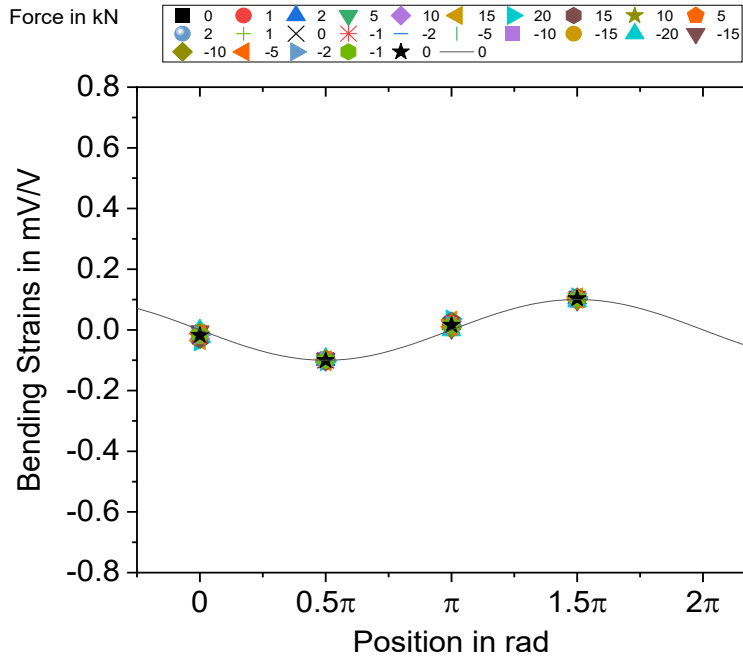
Defined misalignment



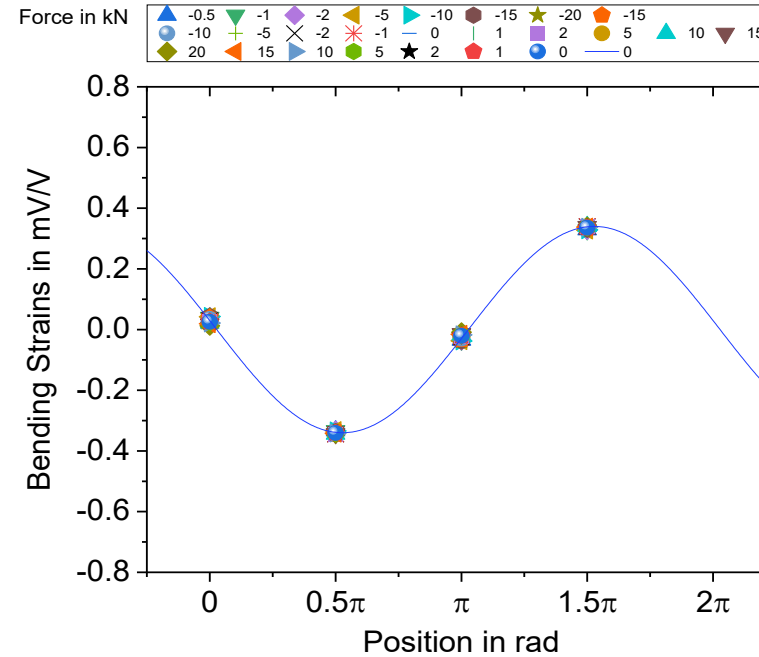
Impact of Bending Strains - Measurements



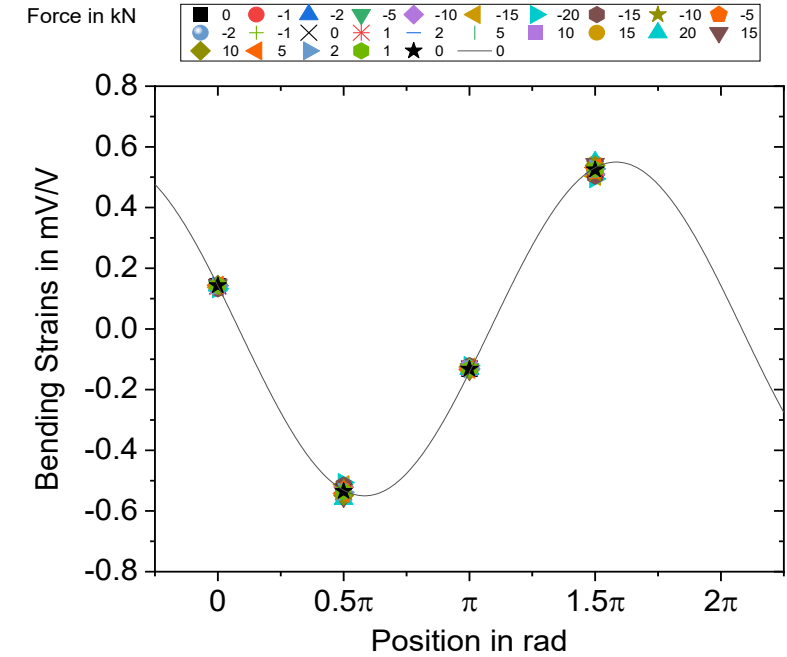
Impact of Bending Strains – Amount of Bending (Static Meas.)



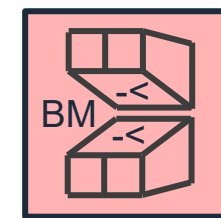
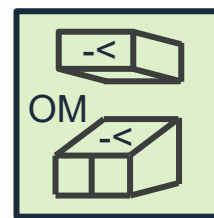
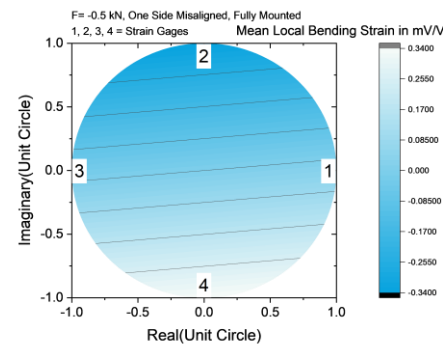
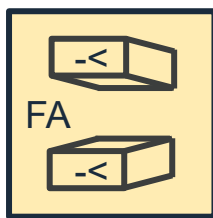
[Data: 1-2_Bending_static_2022-12-14.opju]



[Data: 2-1_Bending_static_2022-12-29.opju]



[Data: 2-3_Bending_static_2022-12-12.opju]



Impact of Bending Strains to Static and Cyclic Forces



0,05 mV/V = 1 kN

Static

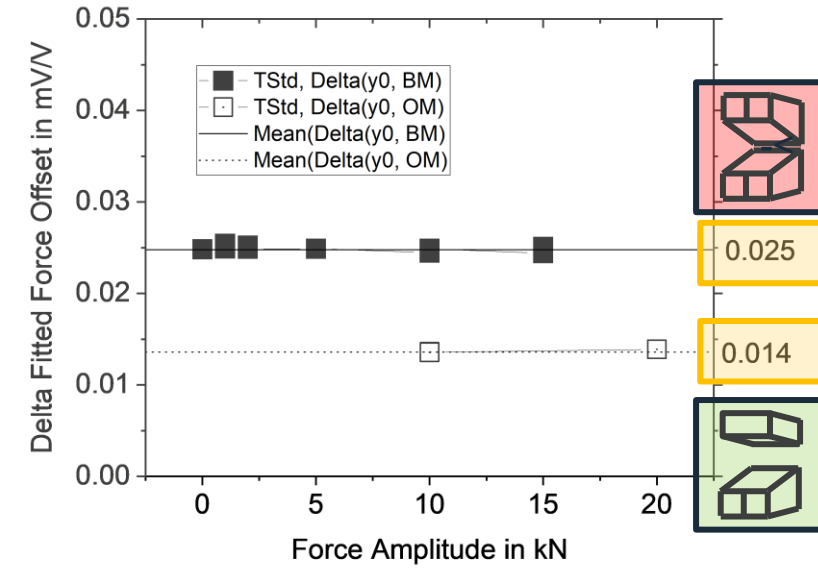
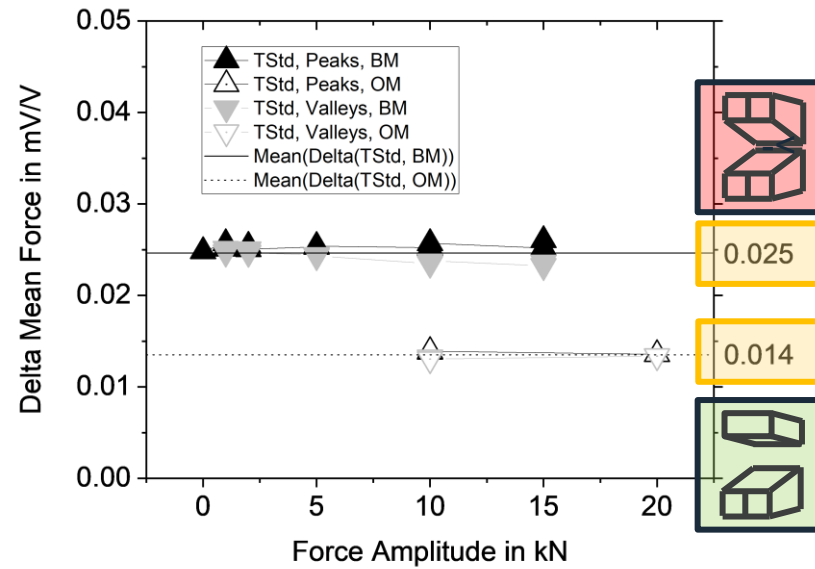
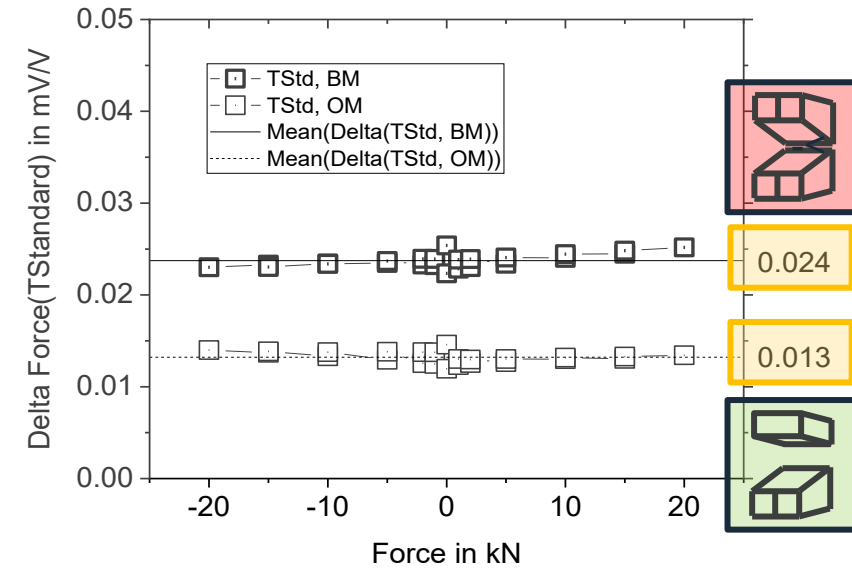
Cyclic, Measured Extrema

Cyclic, Fitted Sine Offsets

Deviations to the Fully Aligned Setup

Deviations to the Fully Aligned Setup

Deviations to the Fully Aligned Setup



[Data: Forces_static_2022-12-12.opju]

[Data: Forces_cyclic_2022-12-28c.opju]

[Data: Forces_cyclic_2022-12-28c.opju]

Impact of Masses - Setup



PTB Masses + Stiffness Adapters

RUMUL 50 kN (USTUTT)

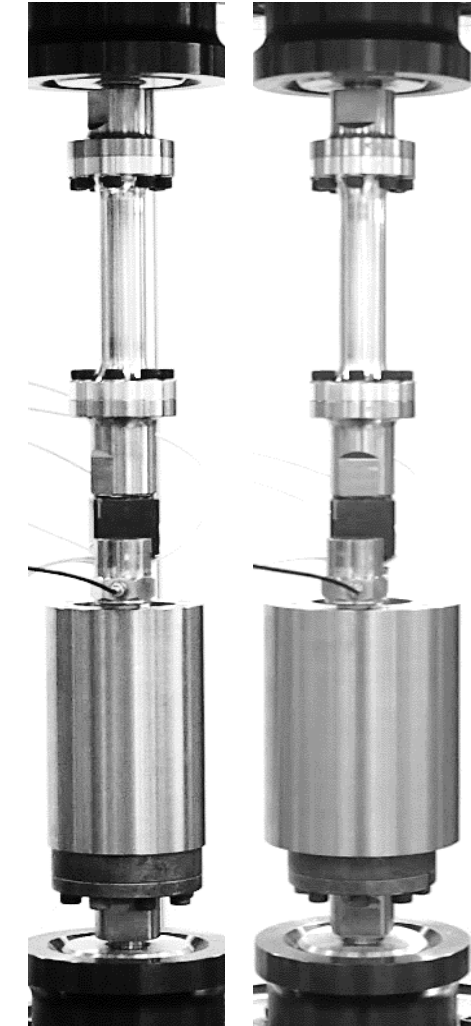
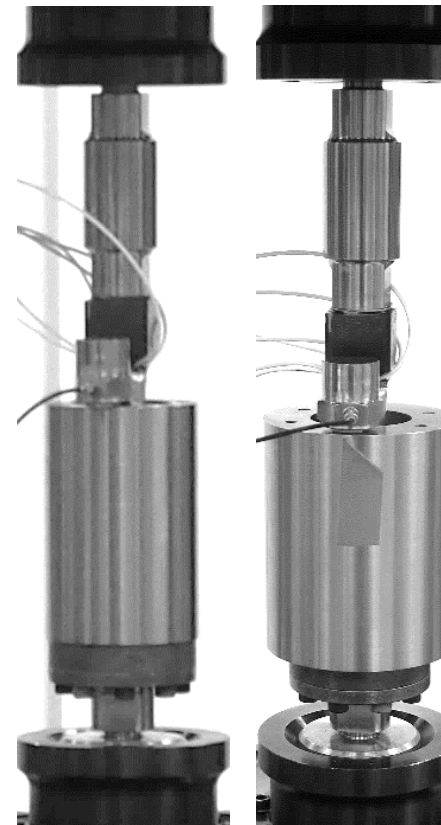
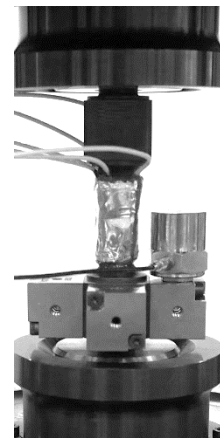
20-Dynamometer-A (PTB, PTB-Configuration)

Dewetron Signal Conditioner (PTB),
Dewesoft Acquisition System (PTB),
5V, 5kHz, filter off

Cubes

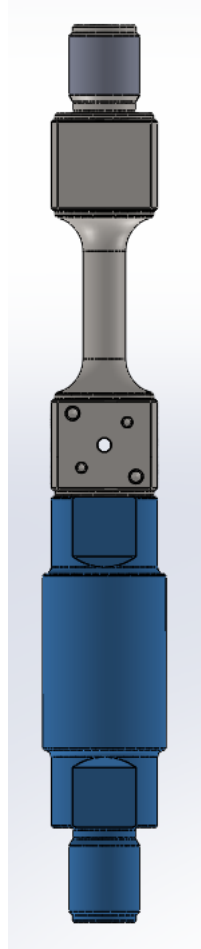
PTB Masses

Accelerometer was always
located on key flat 1 of the
Dynamometer.

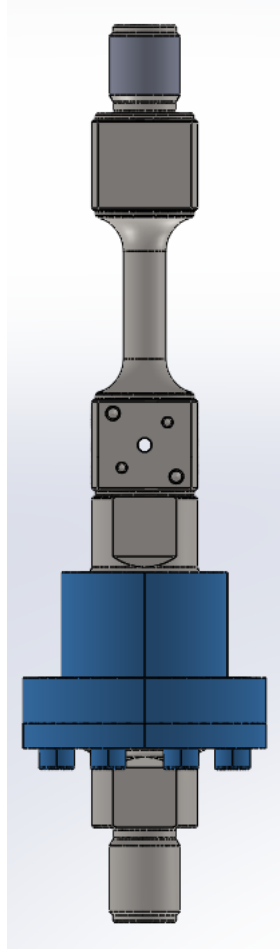


Impact of Masses - PTB Mass Mounting

MassCarrier



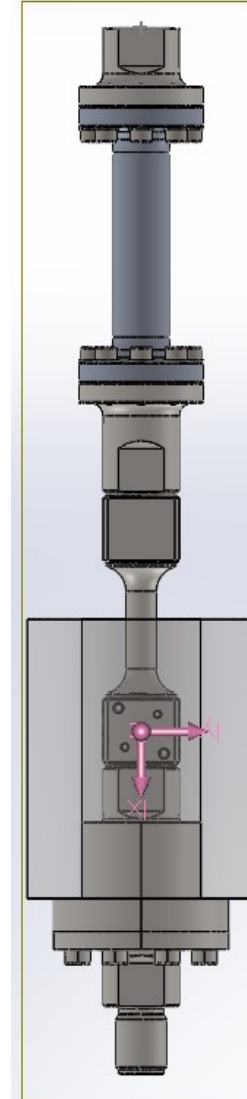
RLK 110 35 x 47



PTB Mass



Setup with
Stiffness
Adapter

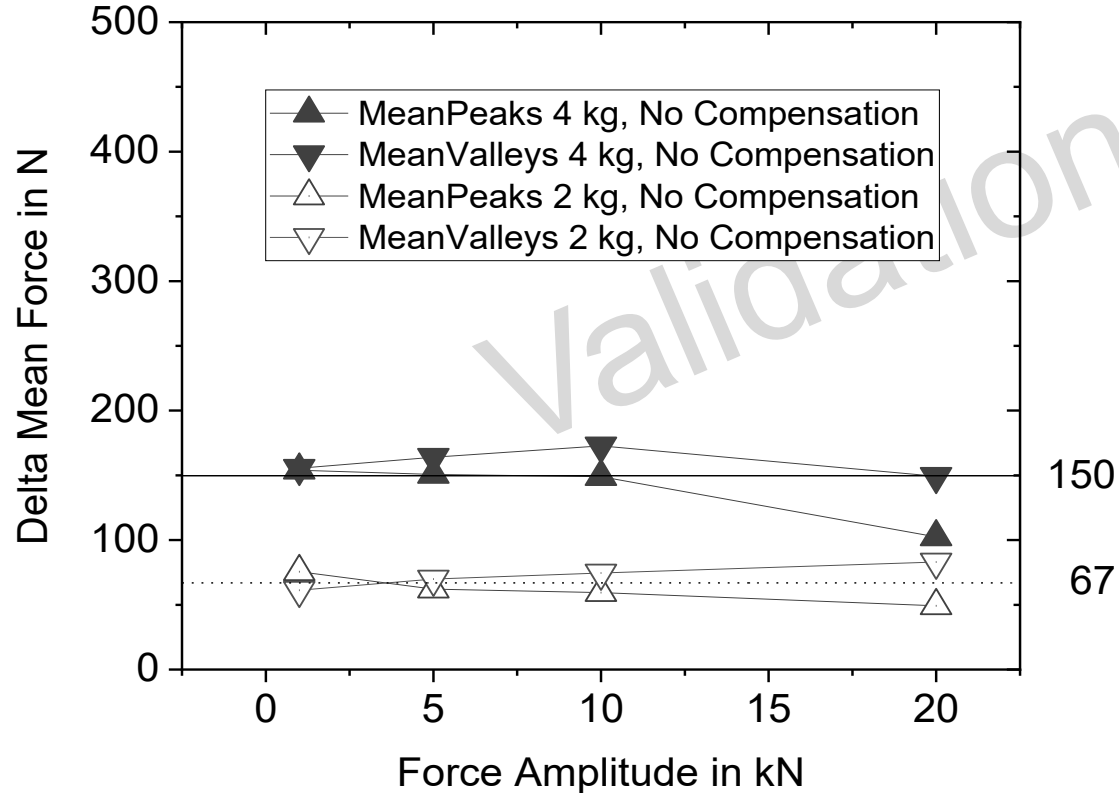


Impact of Masses to the Measurement of Cyclic Forces

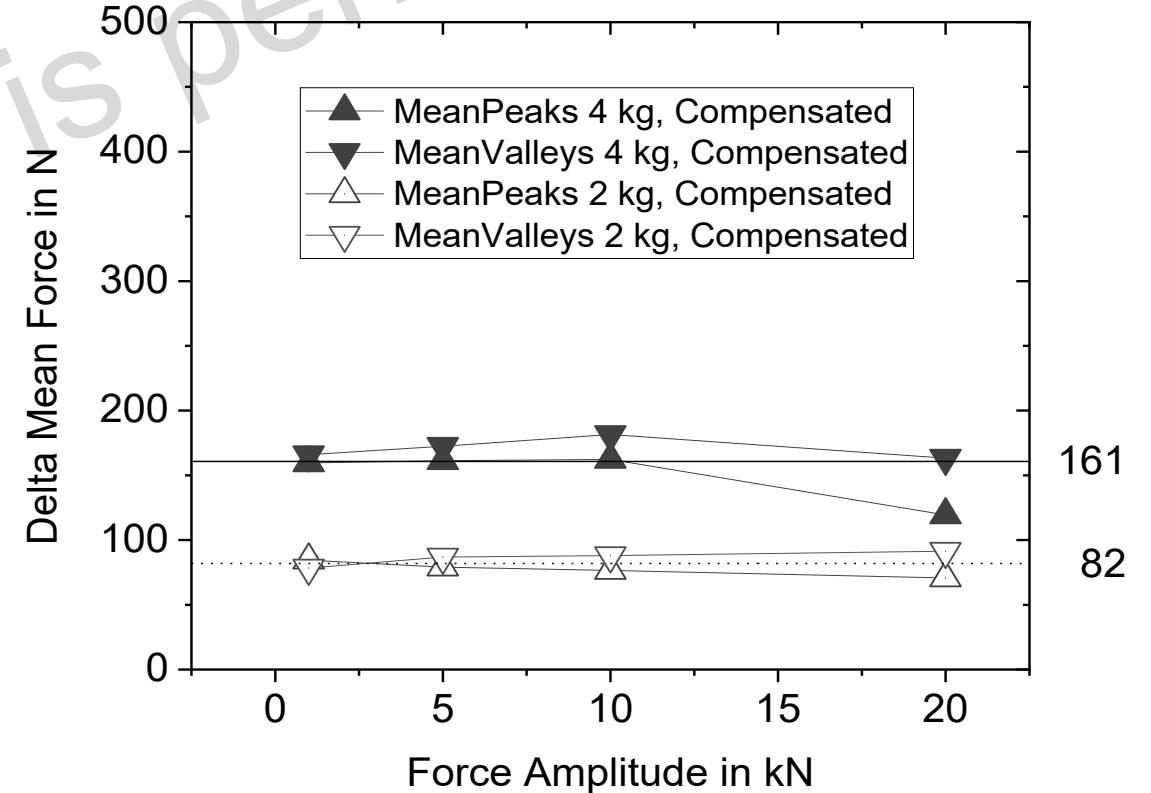


[Data: Masses_cyclic_2023-01-19_last3secondswithoutBending_PVA.opju]

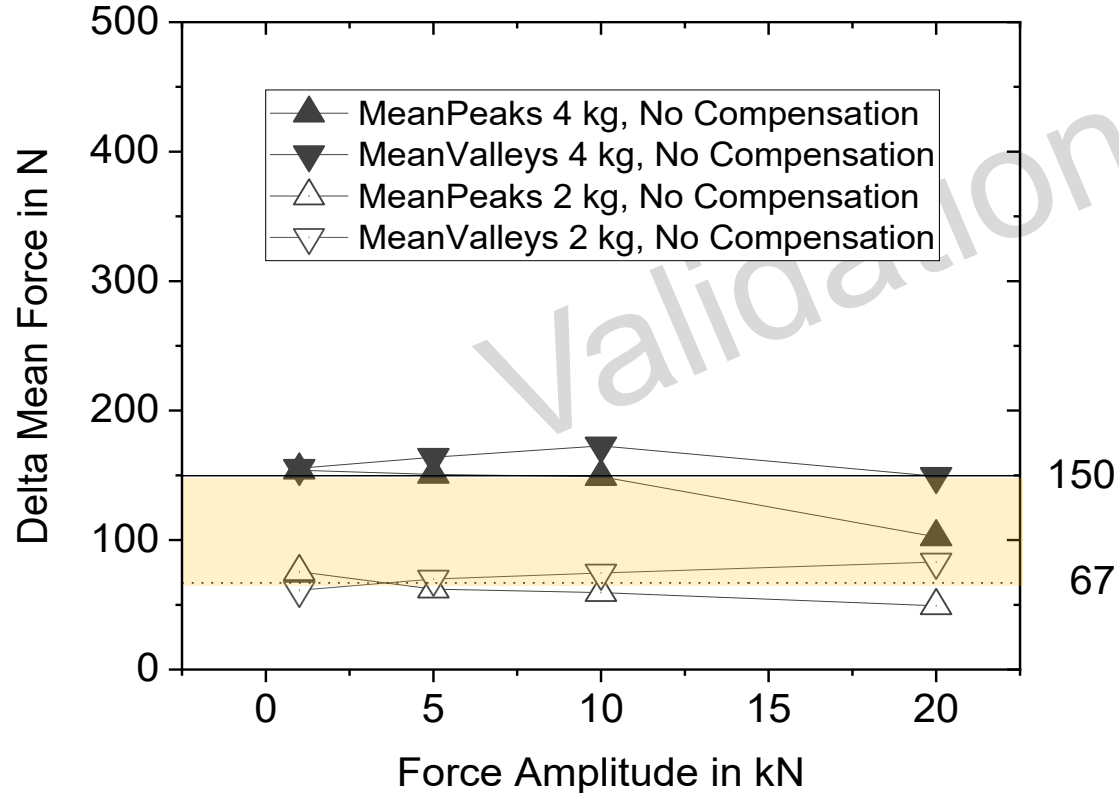
Deviations to the Setup with Cubes



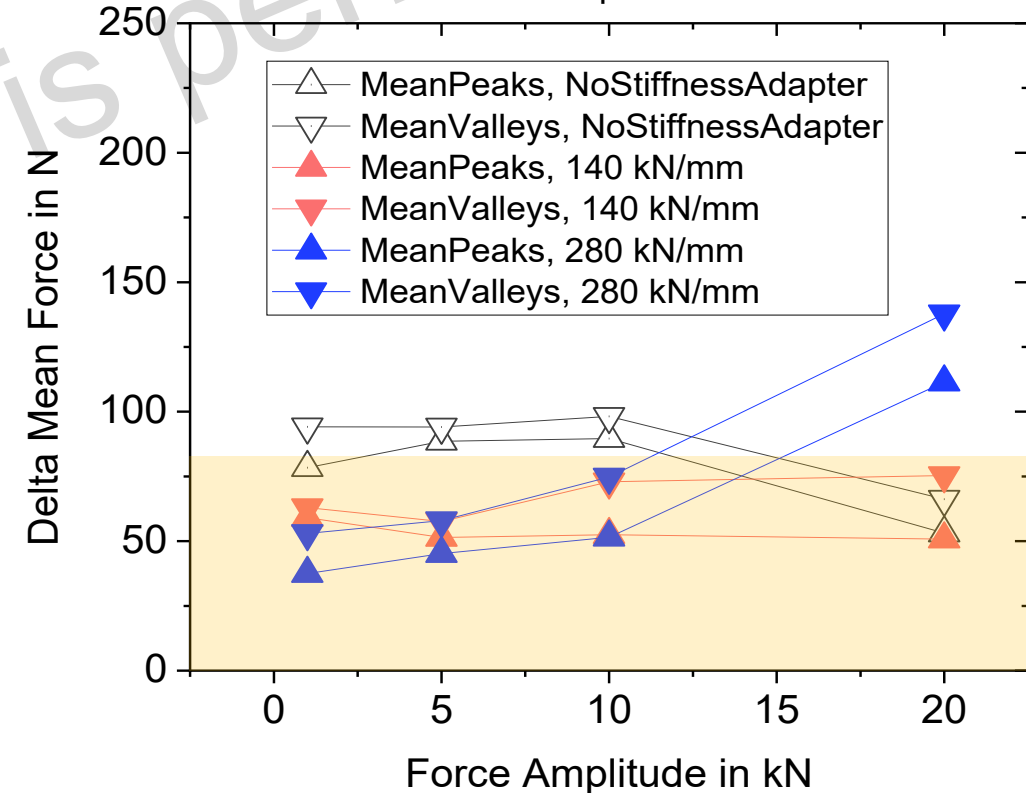
Deviations to the Setup with Cubes



Deviations to the Setup with Cubes

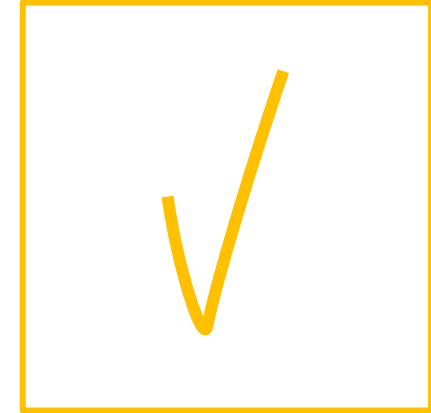


Deviations from 4 kg Setup to 2 kg Setup - No Compensation -



The aim of this work package was to develop a ***traceability chain for dynamic force measurement*** for metrological services in the field of material testing.

- *Measurement procedure* for dynamic measurements in testing machines
- *Compensation techniques* for inertial forces
- Development of a *model for the dynamic force measurement* in applications
- Estimation of the *measurement uncertainty*



Remaining things to do:

- *Deeper proving of the procedure*
- *Further investigations to bending and mass impact*
- *Mathematical considerations of bending and mass impacts in the procedure*
- *Improvement of uncertainty estimation*



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Questions.!?

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