Is a Newton Always a Newton?

The presentation with begin at 2 PM EST

Chis Novak

Organizational Information

- All participants' **microphones** are **muted** during the webinar.
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Chris Novak

- Bachelor's degree in Electrical Engineering from Cleveland State University
- Business Development Manager with HBK
- Previously – Global Applications Engineer with Honeywell for Test & Measurement
- Has 25+ years of sensor experience

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Agenda

1. Introduction: Why is metrological traceability important?
2. National Metrology Institutes (NMI´s)
3. Calibration of your load cells
4. Reference load cells
5. Q & A

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Introduction: Why is metrological traceability important?

Processes are defined by values such as

- Temperature
- Time
- Pressure
- Masses
- Voltage
- Current
- Force
- Torque

A reliable production requires defined production parameters of the quantities

Introduction: Why is metrological traceability important?

- Development Center
- Production facilities

If we want to have the same quality in every production facility, we need to have the same understanding of a certain quantity. For force: The same understanding of a Newton!

=> *Definition of the Newton*

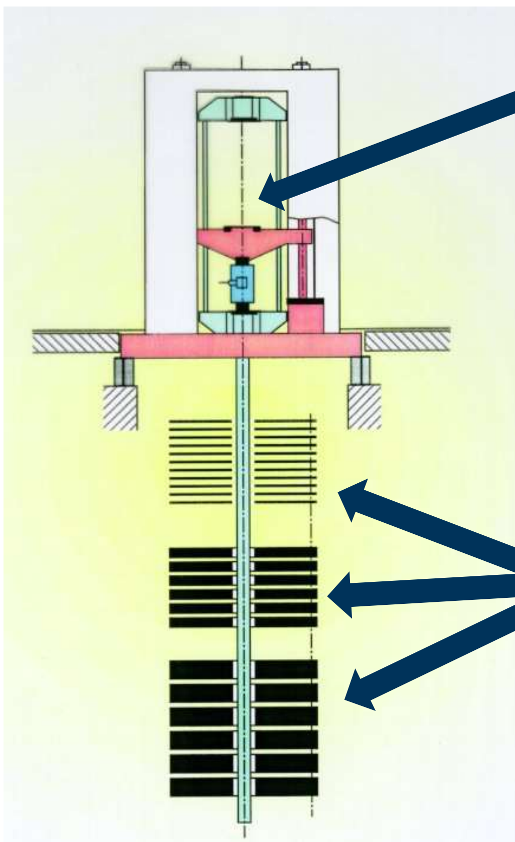
National Metrology Institutes (NMI)

The National institutes define the Newton (and many other units).

- Germany: PTB (Physikalisch Technische Bundesanstalt)
- Korea: *KRISS* (*Korea* Research Institute of Standards and Science)
- USA: *NIST* (National Institute of Standards and Technology)
- Italy: *INRiM* (Istituto Nazionale di Ricerca Metrologica)
- UK *NPL* (National Physical Laboratory)

National Metrology Institutes (NMI)

Dead load force calibration machine



Force Transducer

Dead weights

$$F = m \cdot g \cdot \left(1 - \frac{\rho_{air}}{\rho_m} \right)$$

Mass of the dead weights

local gravitational acceleration

Typical uncertainty:	**2 * 10E-5** **= 0.002 %**

Relative to the force measured; For k=2

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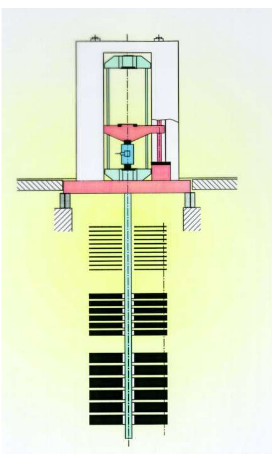
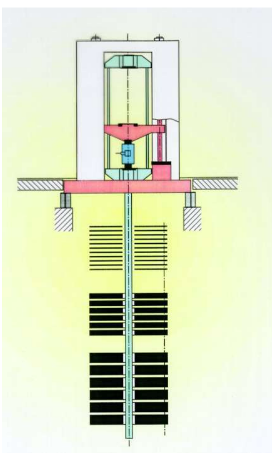
National Metrology Institutes (NMI)

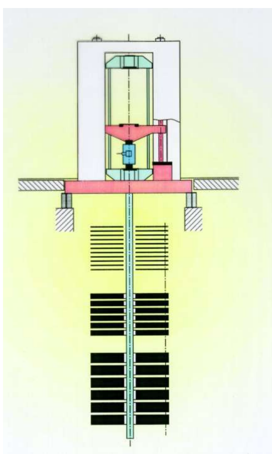
The NMI´s compare the results of their calibration machines on a regularly base by using the same sensor in each institute



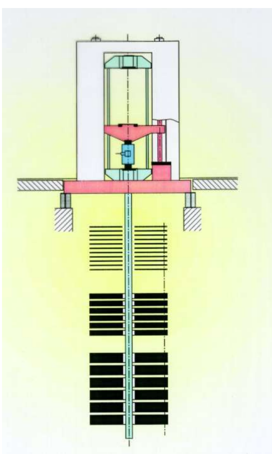
NMI 1



NMI 2

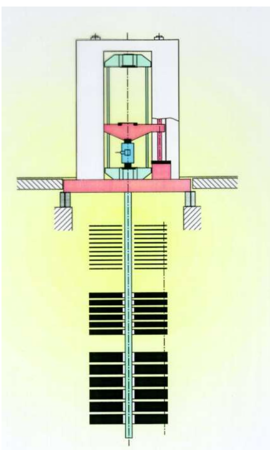


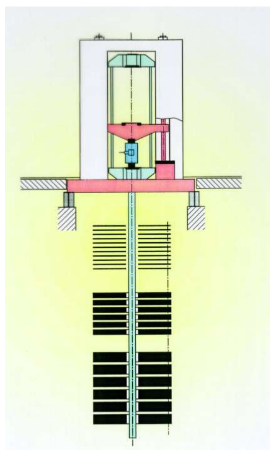
NMI 3

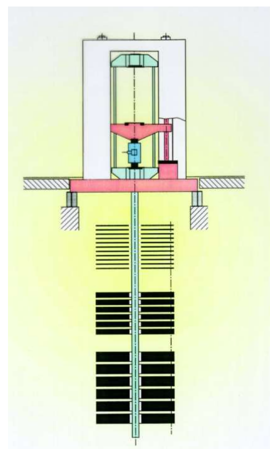


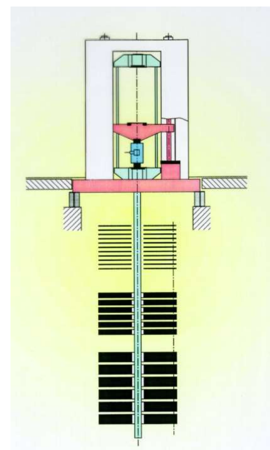
NMI 4

National Metrology Institutes (NMI)









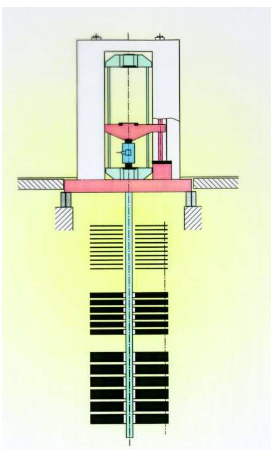
NMI 1

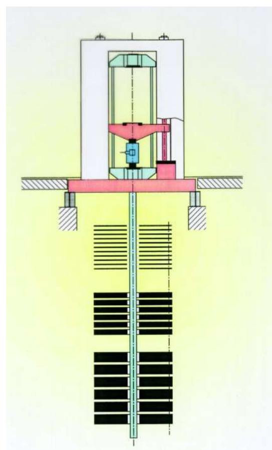
NMI 2

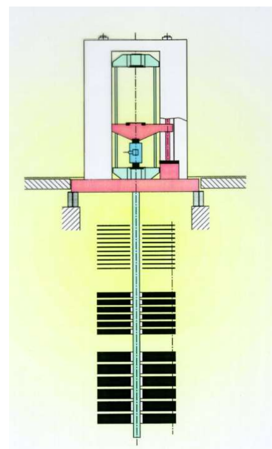
NMI 3

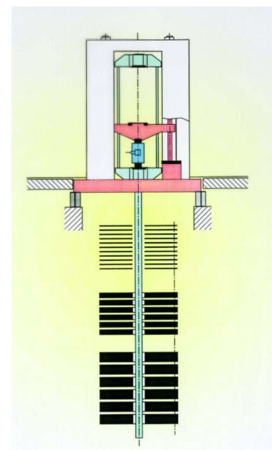
NMI 4

National Metrology Institutes (NMI)









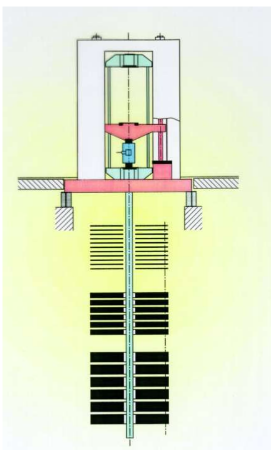
NMI 1

NMI 2

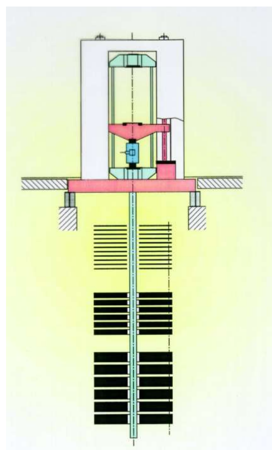
NMI 3

NMI 4

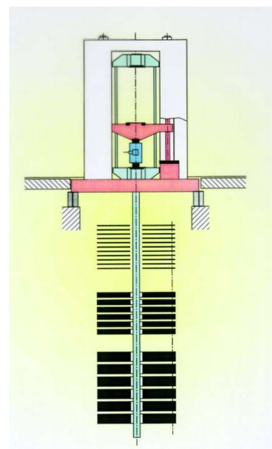
Round Robin Tests



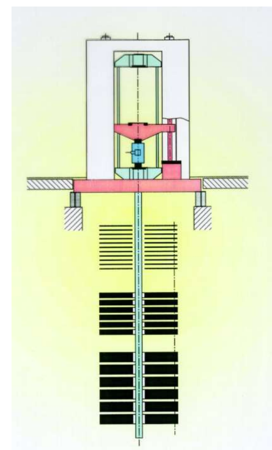
NMI 1



NMI 2

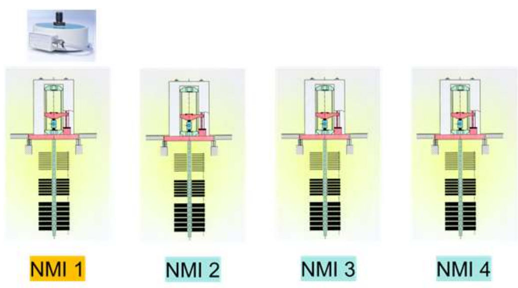


NMI 3



NMI 4

National Metrology Institutes (NMI)



Result:
- All institutes have the same understanding of a Newton in a certain measurement range.
- The uncertainty of the calibration machines is known
- The Newton is the same around the world

Next step: Transfer measurements between the national institute and the calibration labs such as HBK.
How? Same method! Comparison by using a high end reference sensor

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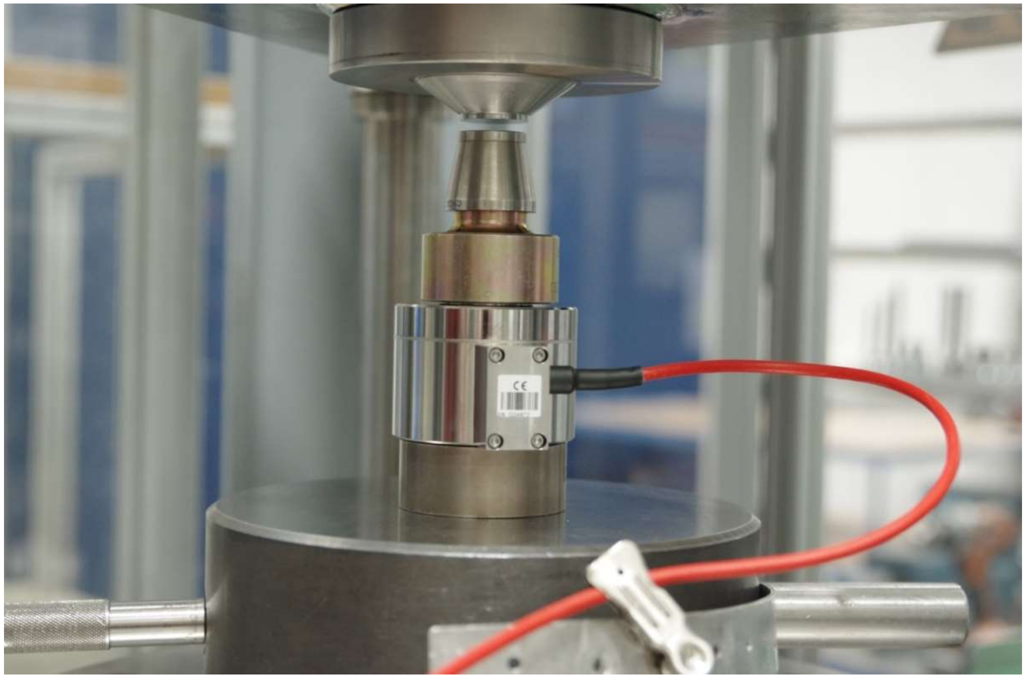
After this procedure:

- The Newton at HBK is the Newton of the PTB
- We know the uncertainty of the HBK calibration machine

Calibration of your load cells

What does traceable calibration mean?

Having an unbroken chain of calibrations with known uncertainties from the national standard to the sensor in use



Calibration of your load cells

Why perform a calibration for the load cells?

- Make sure that the readings are right
- Fulfill the requirements of the quality department or your customers
- Increase the accuracy of your measurements

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Calibration of your load cells

Method one:

Send your load cells for calibration to a accredited laboratory (such as HBK)

- Precise Calibration results
- Measurement uncertainty given in the calibration certificate
- Calibration certificates fulfil the requirements of the relevant quality standards
- Sensor must be dismounted

Force	Best measurement capability	
	tension	compression
2.5 N – 200 N	0.008 %	0.005 %
50 N – 2.5 kN	0.008 %	0.005 %
500 N – 25 kN	0.008 %	0.005 %
5 kN – 240 kN	0.01 %	0.01 %
50 kN – 1MN	0.02 % (500 kN)	0.01 %
100 kN – 5 MN	0.02 %	0.02 %

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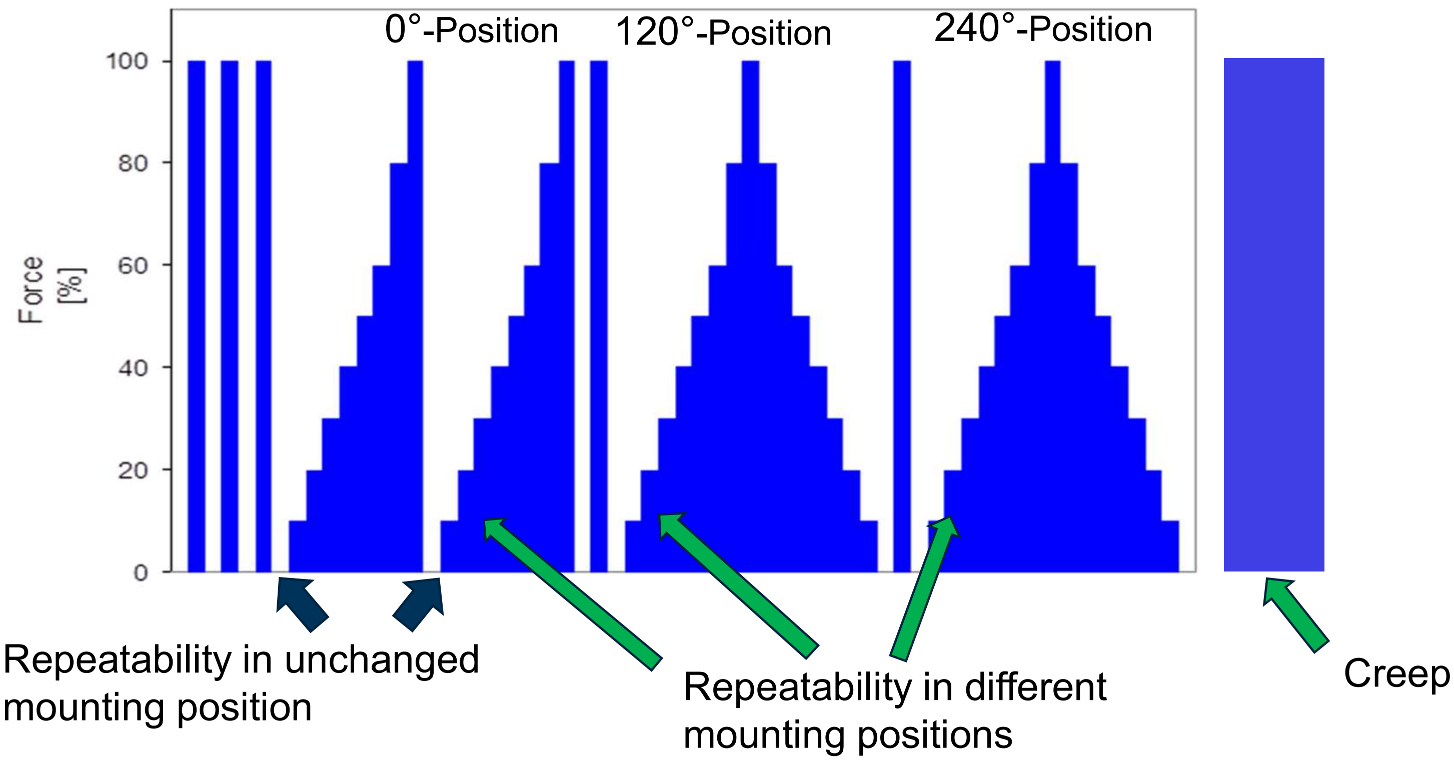
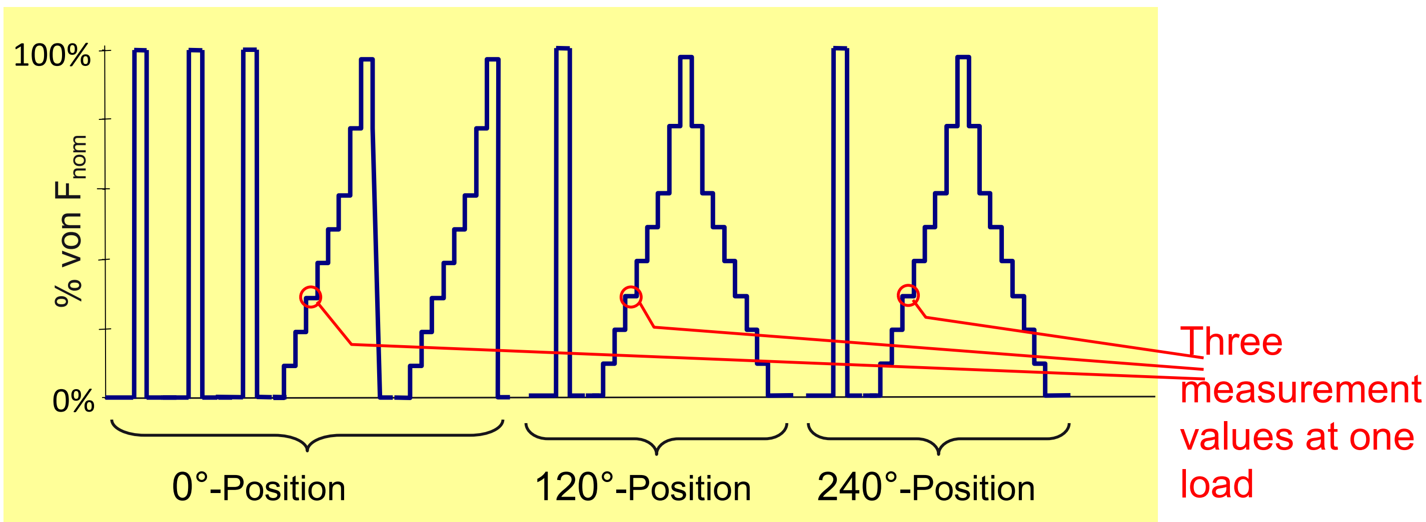
Calibration of your load cells: ISO376

Calibration according the ISO standard

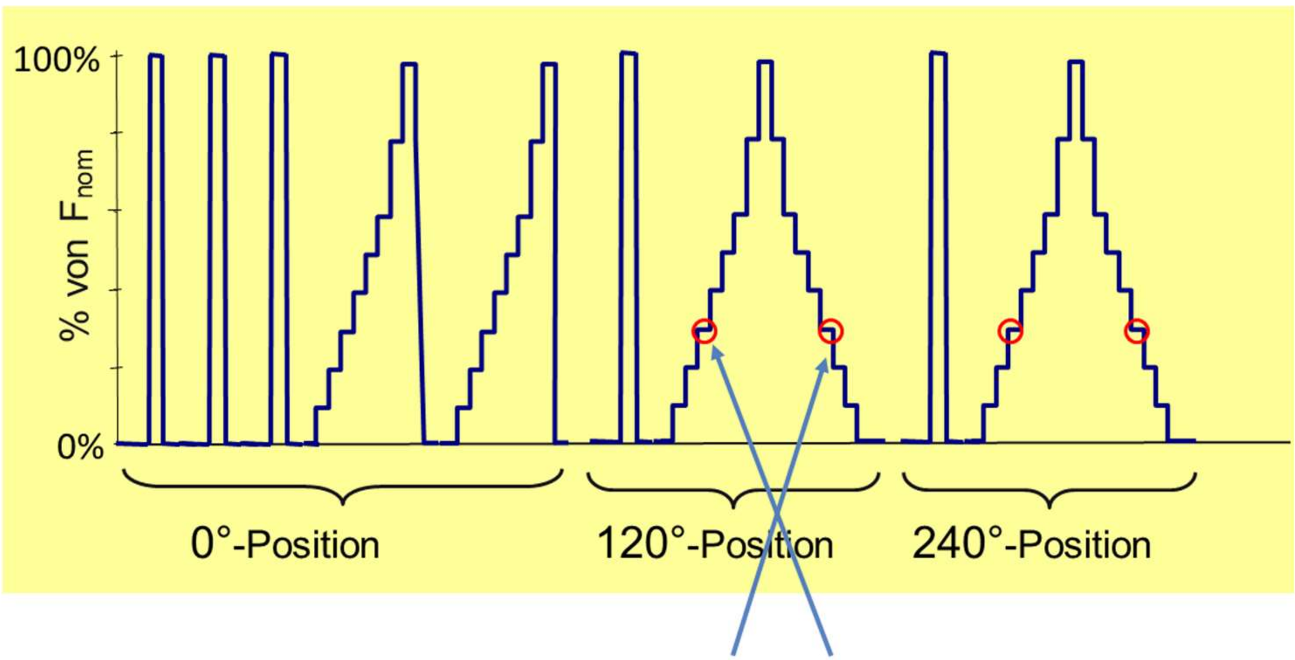


Calibration of your load cells: ISO376



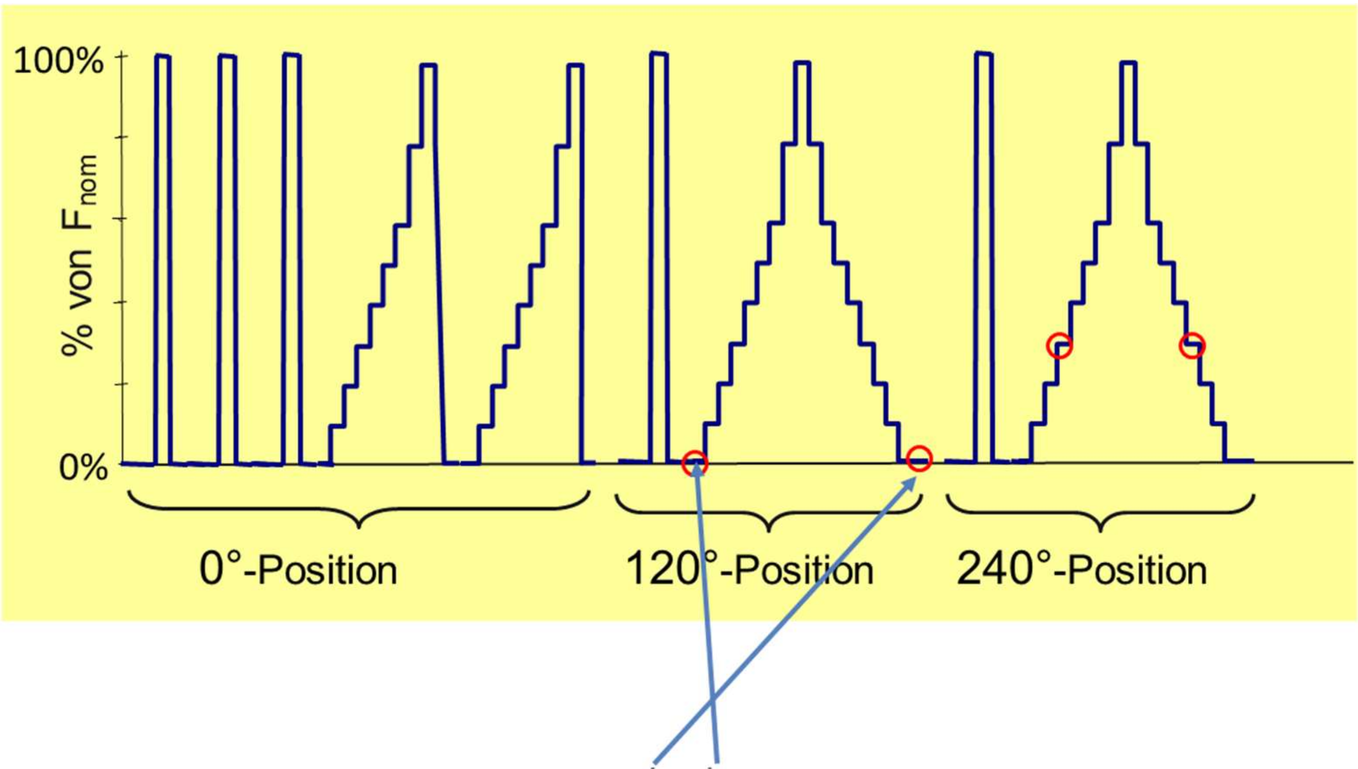
$$b_{30\%} = X_{30\%,\max} - X_{30\%,\min}$$

Calibration of your load cells: ISO376



$$\upsilon = \left| \frac{X_4 - X_3}{X_3} \right|$$

Calibration of your load cells: ISO376



$$f_0 = \frac{i_f - i_0}{X_N}$$

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Calibration of your load cells: ISO376

Class	Relative error of the force-proving instrument %						Expanded uncertainty of applied calibration force (95 % level of confidence) %
	of reproducibility b	of repeatability b'	of interpolation f_c	of zero f_0	of reversibility v	of creep c	
00	0,05	0,025	±0,025	±0,012	0,07	0,025	±0,01
0,5	0,10	0,05	±0,05	±0,025	0,15	0,05	±0,02
1	0,20	0,10	±0,10	±0,050	0,30	0,10	±0,05
2	0,40	0,20	±0,20	±0,10	0,50	0,20	±0,10

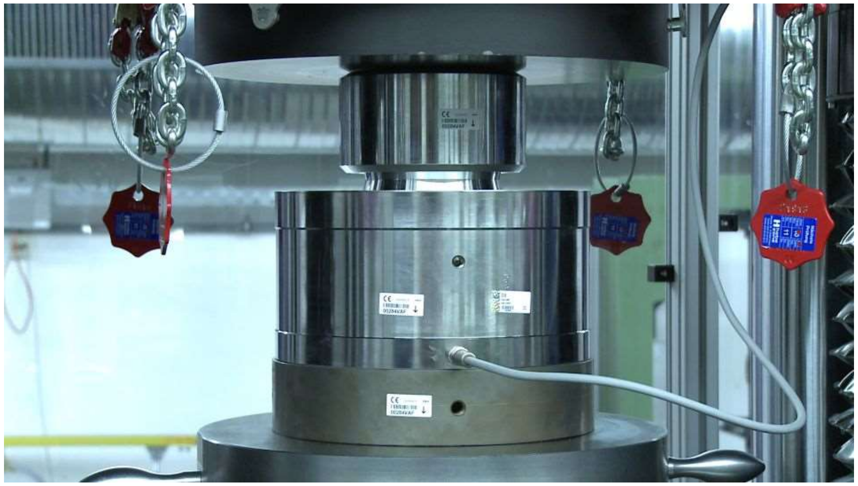
Classification of a load cell according IS0376

- Different characteristics are calculated
- The maximum measurement uncertainty of every single property defines the accuracy class All results are relative to the actual measurement value
- This is not a (HBM)-accuracy class

Calibration of your load cells: ISO376

Results of an ISO376 calibration:

- Sensitivity at different load steps
- Cubic approximation of the sensitivity
- Uncertainty of the load cell for different use cases



	Case A	Case B	Case C	Case D
Reproducibility	✓	✓	✓	✓
Repeatability	✓	✓	✓	✓
Zero error	✓	✓	✓	✓
Applied calibration force	✓	✓	✓	✓
Interpolation error			✓	✓
Reversibility		✓		✓
Creep	✓		✓	

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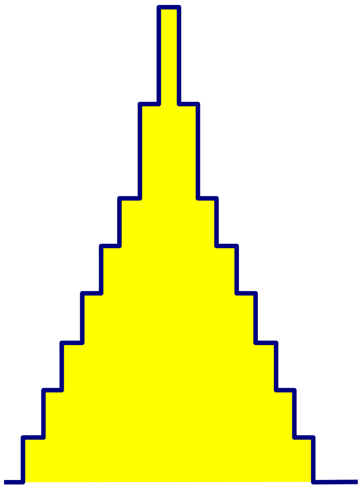
Calibration of your load cells: DKD R3-3

- Only one test run
- Statistical calculation of repeatability in different mounting positions
- Minimum 6 Load steps
- Fulfills requirements of ISO 9001
- Uncertainty for each load step
- Economical solution



Calibration of your load cells

	ISO 376	Data Sheet
Repeatability	yes	yes (typical)
Reproducibility	yes	yes (typical)
Hysteresis	yes	yes (maximum)
Interpolation error	yes	no
Linearity error	no	yes (maximum)
Uncertainty of calibration machine	yes	no
Creep	yes	yes (maximum)
Temperature effect on zero	no	yes (maximum)
Temperature effect on sensitivity	no	yes (maximum)
Influence of bending moment	no	yes (maximum)

Data Sheet:

Rectangular distribution for all technical characteristics

Exception: Repeatability (Typical value)

Calibration certificate:

Calculated uncertainties for k = 2

Complete uncertainty calculation:

- Uncertainty stated in the calibration certificate
- Influences from the surrounding such as temperature, bending moments,..

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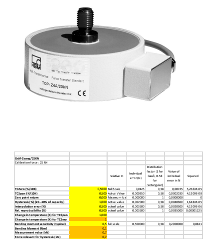
Calibration of your load cells: Calibration in mounting position



Machine with a load cell

Reference sensor with calibration certificate and an uncertainty calculation

HBK has connects the calibration machine with a transfer measurement to the national standard

Unbroken Chain of calibrations with known uncertainties for each step

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Calibration of your load cells: Calibration in mounting position

Load cell with a capacity of 50 kN. Uncertainty at 25 kN, only temperature effects. Change in temperature: 10 K

Tabelle 4 Ausgeglichene Werte, rel. Approximationsabweichung und Messunsicherheiten
table 4 *Equalized value, approximation deviation and uncertainty*

Druckkraft *compression* Kraft in kN *Force*	arith. Mittel in mV/V *average value*	rel. Umkehrsp. in % *rel. hysteresis*	Y1* in mV/V *equaliz. value*	Approx.abw. in % *interpol. dev.*	Erweiterte Messuns. W" in % *Expanded uncertainty*
10	-0,399746	0,016	-0,399775	-0,0072	0,035
20	-0,799507	0,007	-0,799550	-0,0053	0,027
25	-0,999394	0,004	-0,999437	-0,0043	0,024
30	-1,199287	0,003	-1,199325	-0,0031	0,022
40	-1,599094	0,002	-1,599100	-0,0004	0,018
50	-1,998946		-1,998875	0,0036	0,018

Complete uncertainty calculation:

- Uncertainty stated in the calibration certificate (k=2)
- Influences from the surrounding such as temperature, bending moments,..

TCZero:	0,05 % / 10K:	0,05 % of 50 kN = 0,025 kN
TCSpan:	0,1 % /10K:	0,1 % of 25 kN = 0,025 kN
W´´:	0,024 %	(0,024 % of 25 kN)/2 = 0,003 kN

$$U = \sqrt{(0.025)^2+(0.025)^2+(0.003)^2}$$

$U = 0,035\ kN$ (for k=1)

$U = 0,07\ kN$ (for k=2)

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Reference load cells

Requirements to transfer standards:

- Excellent repeatability in different mounting position
- Low creep
- Low hysteresis effect
- Very good zero return

The ISO 376 is an international standard for calibration method and classification of reference force transducers

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Reference load cells


10MN, CL „00“

Standard load cells for forces up to 5 MN

Reference load cells

	Z4a	Topz4a
relative repeatibility error without rotation	0,020%	0,003%
relative repeatibility error with rotation (Tensile)	0,030%	0,016%
relative repeatibility error with rotation (compression)	0,030%	0,008%
Zero point return	0,008%	0,004%
Hystereses	0,060%	0,030%

	Z30a	TopZ30a
relative repeatibility error without rotation	0,020%	0,002%
relative repeatibility error with rotation (Tensile)	0,040%	0,010%
relative repeatibility error with rotation (compression)	0,040%	0,005%
Zero point return	0,008%	0,004%
Hystereses	0,060%	0,030%

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Reference load cells

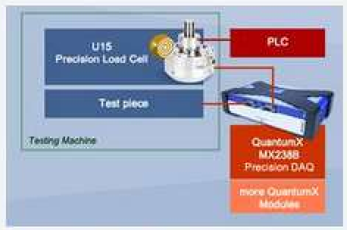
- Fulfil the requirements ISO376 standard between 10 % and 100 % of capacity
- TCZero: Just 75 ppm/10k!
- Output: > 2 mV/V for all capacities up to 10 kN, > 4 mV/V for all capacities larger than 10 KN

2.5 kN … 1 MN

2.5 kN … 2.5 MN

Reference load cells

A complete measuring chain: Perfect precision for a perfect price.



Using the double-bridge configuration, the U15/MX238B measuring chain can be easily used e.g. in testing machines.

The combination of the reference transducer U15 and the precision measuring amplifier module QuantumX MX238B results into an extremely cost-effective precision measuring chain. Thanks to the modular design of the QuantumX modules, you can also easily extend this measuring chain by a number of additional measuring variables, e.g. Temperature, voltage, angle of rotation.

Learn more on MX238B

The MX238B is a pretty good partner for the C15:

- Economical pricing but advanced precision
- Input ranges of the amplifier fit to the output signal of the C15
- Measuring chain calibration for optimized results
- 225 Hz technology- traceability on an international scale

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Questions?

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WEBINARS:

- **Electric Motors 201 for N&V Engineers**

April 14, 2021 4:00 PM CET / 10:00 AM EST
Register here: https://www.hbm.com/en/10082/electric-motors-201-for-n-v-engineers-2/

- **4 Steps to Easily Integrate Optical Sensors**

May 20, 2021 4:00 PM CET / 10:00 AM EST
Register here: https://www.hbm.com/en/10155/4-steps-to-integrate-optical-sensors/

- **Calibration and Re-calibration of Torque Transducers**

May 20, 2021 5:00 PM CET / 11:00 AM EST
Register here: https://www.hbm.com/en/10106/webinar-calibration-re-calibration-of-torque-transduce/

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Schedule training in 2021! Our online calendar is updated and includes courses open for registration.

- **Strain Gauge Workshop, Canton, MI,** April 20-21, 2021
Register here: https://www.hbm.com/index.php?id=5788&no_cache=1
- **Measuring Torque Correctly, Online,** April 26-28, 2021
Register here: https://www.hbm.com/en/9277/online-seminar-with-costs-torque-measurement/
- **Data Acquisition Systems – Setting the Parameters, Online,** April 22-23, 2021
Register here: https://www.hbm.com/en/10118/online-seminar-setting-the-parameters-correctly-daq2/
- **Working with catman, Online,** May 18-20, 2021
Register here: https://www.hbm.com/en/9141/online-seminar-working-with-catman/

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